VOLUME – IA
Part I & II

TECHNICAL CONDITIONS OF CONTRACT (TCC)

BHARAT HEAVY ELECTRICALS LIMITED

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VOLUME-IA PART-I CHAPTER-I
PROJECT INFORMATION

The Bidder shall acquaint himself by a visit to the site, if felt necessary, with the conditions prevailing at site before submission of the bid. The information given here in under is for general guidance and shall not be contractually binding on BHEL/Owner. All relevant site data /information as may be necessary shall have to be obtained /collected by the Bidder.

1.1.1.1.	Project Title	:	3 x 800 MW NLC Talabira Thermal Power Project
1.1.1.2.	Plant capacity	:	3 x 800 MW
1.1.1.3.	Type of project	:	Green Field
1.1.1.4.	Owner	:	NLC India Limited
1.1.1.5.	Plant site 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.
1.1.1.6.	Location co-ordinates	:	21° 46' 56.11" N 83° 58' 50.54" E
1.1.1.7.	Nearest Village	:	Kumbhari and Tareikela villages on south west of Brijraj Nagar town
1.1.1.8.	Nearest Town & City	:	Sambalpur
1.1.1.9.	State Capital	:	Bhubaneswar (350 Km)
1.1.1.10.	Nearest Railway Station	:	Jharsuguda (11 Km)
1.1.1.11.	Nearest Airport	:	Raipur (290 Km)
1.1.1.12.	Nearest Seaport	:	Paradip (385 Km)
1.1.1.13.	Nearest Road access	:	Sambalpur – Jharsuguda highway after crossing Bedhan River via state PWD road
1.1.2.	Meteorological Condition		
1.1.2.1.	Altitude	:	203 M above MSL
1.1.2.2.	Ambient Temperature		
(a)	Annual Maximum Mean Temperature	:	33.1°C
(b)	Annual Minimum Mean Temperature	:	20.7°C
(c)	Mean Wet Bulb Temperature	:	26.3 °C
1.1.2.3.	Mean Relative humidity		66% at 8:30 Hrs
1.1.2.4.	Annual Rainfall		
	Average	:	1445 mm (avg.)

1.1.2.5.	Basic Design Wind Pressure	:	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.)
1.1.2.6.	Seismic zone	:	Zone III as per IS:1893 (latest edition)

VOLUME-IA PART-I CHAPTER-II
SCOPE OF WORKS

1.2.THE SCOPE OF THE WORK WILL COMPRISE OF BUT NOT LIMITED TO THE FOLLOWING

(All the works mentioned hereunder shall be carried out within the accepted rate unless otherwise specified.)

1.2.1. The scope of work includes Civil, Structural & Architectural works for "Construction of RCC bridges (2 nos.) on Bhedan River" on Engineering, Procurement and Construction (EPC) basis for 3 X 800 MW NLC TALABIRA THERMAL POWER PROJECT.

The scope of work is given below, but not limited to the given below:

1.2.1.1. 2 Nos. RCC bridges across Bhedan river including site clearance, site levelling & grading, topographical survey, route survey with longitudinal & cross sectional details, bathymetry survey, geotechnical investigation (on shore and off shore) etc.

1.2.1.2. Based on the soil investigation report, design document, construction drawings, design basis and design calculations including suitability of filling earth from various sources shall be vetted by IIT/IISc and submitted to NLCIL for review, before commencement of work.

1.2.1.3. For construction, necessary statutory clearance shall be obtained from the state government/WRD (Water Resources Department) and the same shall be under the EPC scope.

Note: The above provided list is for the bidder's guideline. **Any other building / structure / foundation not mentioned above, but required for completion of the scope of work in total, deemed to have been included in the bidder scope under this contract**.

1.2.2. The works to be performed under this contract shall include providing all labour, supervision, material, scaffolding, construction equipment, tools and plants, temporary works, supplies including POL, transportation and all incidental items not shown or specified but reasonably implied or necessary for the proper completion of work in all respects. Testing of all materials, concrete, earthwork, other allied works, preparation of bar bending schedules on the basis of construction drawings, preparation of fabrication drawings etc. are included in the scope of work. Works shall only be carried out with approved structural fabrication drawings.

1.2.3. The area of work shall be cleared of all vegetation, rubbish and other objectionable matter. The materials removed shall be disposed of as directed by the Engineer-in-Charge. No separate payment for these operations shall be

made. The cost of all these operations shall be deemed to have been included in the quoted price.

1.2.4. All the works areas shall be adequately flood lighted to the satisfaction of the Engineer-in-Charge when the work is in progress during the night shifts.

1.2.5. The price shall include all material, equipment, fixtures, labour, T&P's, temporary works and everything whether of permanent or temporary nature necessary for the completion of job in all respects.

1.2.6. The bidder should fully apprise himself of the prevailing conditions at the proposed site, climatic conditions including monsoon pattern, local conditions, soil strata and site specific parameters and shall include for all such conditions and contingent measures in the bid, including those which may have not been specifically brought out in the specifications.

1.2.7. The bidder shall be responsible for all statutory, obligatory, mandatory requirements of various authorities for the scope of work and take the same into account in the quoted contract price for the work.

1.2.8. Technical Vetting is to be taken from IIT before submission of drawings to BHEL/Customer. Vendor shall utilize the online system provided by BHEL for submission and comments for drawing approval

1.2.9. Hard copy of Drawings (Nos. as required) are to be submitted to BHEL/Customer for approval and work.

1.2.10. Special arrangements to be made for tackling pandemic – Contractor shall make arrangements for stay of workers within their premises as far as possible and/ or adjacent building and for implementation of **STANDARD OPERATING PROTOCOL (SOP)** as per government order. The transportation of workers to work place shall be arranged by the contractor in dedicated transport by ensuring social distance. Any person violating the pandemic measures published vide government order time to time will be liable for legal action as per the government order. Following shall be observed in work place:

1.2.10.1. All work places shall have adequate arrangements for temperature screening and provide sanitizers at convenient places.

1.2.10.2. Work places shall have a gap of one hour between shifts and will stagger the lunch breaks of staff, to ensure social distancing.

1.2.10.3. Use of AROGYA SETU will be encouraged for all employees both private and public.

1.2.10.4. Contractor shall sanitize their work place between shifts.

1.2.10.5. Large meetings to be prohibited. Spitting shall be strictly prohibited. Wearing of face cover is compulsory.

1.2.10.6. Government order (state/ center) being issued time to time for protective measures of pandemic shall be complied with strictly until government (state/ center) declares end of pandemic.

1.2.10.7. Standard operating procedure for social distancing for workplace and offices

1.2.10.7.1. The following measures shall be implemented by contractor for their office and workplaces:

- All areas in the work premises including the following shall be disinfected completely using user friendly disinfectant mediums:
- Entrance gate of work place, office, if any
- Cafeteria and canteens, if any
- Meeting room, conference halls/ open area available/ verandah/ entrance gate of site, bunkers, porta cabins, buildings, etc.
- Equipment and lifts
- Washroom, toilet, sink, water points, etc.
- Wall/ all other surfaces

1.2.10.7.2. For workers coming from outside, special transportation facility shall be arranged without any dependency on the public transport system. These vehicles shall be allowed to carry man power as per existing Govt. norms.

1.2.10.7.3. All vehicles and machinery entering the premise should be disinfected by spray mandatorily.

1.2.10.7.4. Mandatory thermal scanning of everyone entering and exiting the work place to be done.

1.2.10.7.5. Medical insurance for the workers to be made mandatory.

1.2.10.7.6. Provision for hand wash & sanitizer preferably with touch free mechanism shall be made at all entry and exit points and common areas. Sufficient quantities of all the items should be available.

1.2.10.7.7. Large gatherings or meetings of 10 or more people to be discouraged. Seating at least 6 feet away from others on job sites and in gatherings, meetings and training sessions.

1.2.10.7.8. Not more than 2/4 persons (depending on size) will be allowed to travel in lifts or hoists.

1.2.10.7.9. Use of staircase for climbing should be encouraged.

1.2.10.7.10. There should be strict ban of gutka, tobacco, etc. and spitting should be strictly prohibited.

1.2.10.7.11. There should be total ban on non-essential visitors at sites.

1.2.10.7.12. Hospitals/ clinics in the nearby areas, which are authorized to treat pandemic patients, should be identified and list should be available at work place all the times.

Note :

1. **Vendor shall visit site and quote lump sum price after referring the relevant chapters of Technical Conditions of Contract.**

2. **FOR FURTHER DETAILED SCOPE OF WORKS REFER RELEVANT CHAPTERS IN THIS BOOK**

VOLUME- IA PART-I CHAPTER – III
FACILITIES IN THE SCOPE OF CONTRACTOR / BHEL (SCOPE MATRIX)

Sl.No	Description PART I	Scope to be taken care by BHEL	 Bidder	Remarks
1.3.1.1.	**ESTABLISHMENT**			
1.3.1.1.1.	FOR CONSTRUCTION PURPOSE:			
A	Open space for office	Yes		
B	Open space for storage	Yes		
C	Construction of bidder's office, canteen and storage building including supply of materials and other services		Yes	
D	Bidder's all office equipment's, office / store / canteen consumables		Yes	
E	Canteen facilities for the bidder's staff, supervisors and engineers etc.		Yes	
F	Firefighting equipment's like buckets, extinguishers etc.		Yes	
G	Fencing of storage area, office, canteen etc. of the bidder		Yes	
1.3.1.1.2.	FOR LIVING PURPOSES OF THE BIDDER			
A	Open space		Yes	
B	Living accommodation		Yes	
1.3.1.2.	**ELECTRICITY**			
1.3.1.2.1.	Electricity For construction purposes			
1.3.1.2.1.1.	Single point source	Yes		chargeable
1.3.1.2.1.2.	Further distribution for the work to be done which include supply of materials and execution		Yes	
1.3.1.2.2.	Electricity for the office, stores, canteen etc. of the bidder which include:		Yes	
1.3.1.2.2.1.	Distribution from single point including supply of materials and service		Yes	
1.3.1.2.3.	Supply, installation and connection of material of energy meter including operation and maintenance		Yes	

Sl.No	Description PART I	Scope to be taken care by		Remarks
		BHEL	Bidder	
1.3.1.2.4.	Duties and deposits including statutory clearances for the above		Yes	
1.3.1.2.5.	Facilities for office use including charges.		Yes	
1.3.1.2.6.	Demobilization of the facilities after completion of works		Yes	
1.3.1.2.7.	Electricity for living accommodation of the bidder's staff, engineers, supervisors etc. on the above lines		Yes	
1.3.1.3.	**WATER SUPPLY**			
1.3.1.3.1.	For construction purposes:			
1.3.1.3.1.1.	Making the water available at single point		Yes	
1.3.1.3.1.2.	Further distribution as per the requirement of work including supply of materials and execution		Yes	
1.3.1.3.2.	Water supply for bidder's office, stores, canteen, etc.			
1.3.1.3.2.1.	Making the water available at single point		Yes	
1.3.1.3.2.2.	Further distribution as per the requirement of work including supply of materials and execution		Yes	
1.3.1.4.	**LIGHTING**			
1.3.1.4.1.	For construction work (supply of all the necessary materials) At office storage area At the preassembly area At the construction site / area		Yes	
1.3.1.4.2.	For construction work (Execution of the lighting work / arrangements) At office storage area At the preassembly area At the construction site /area		Yes	
1.3.1.5.	**COMMUNICATION FACILITIES for site operations of the bidder**	-		
1.3.1.5.1.	Telephone, Fax, internet, intranet, email etc		Yes	

Sl.No	Description PART II	Scope to be taken care by		Remarks
		BHEL	Bidder	
1.3.2.	**CONSTRUCTION FACILITIES**			
1.3.2.1.	**Engineering works for construction**			
1.3.2.1.1.	Providing the construction drawings for all the equipment covered under this scope		Yes	Approval by BHEL
1.3.2.1.2.	Drawings for construction methods		Yes	In consultation with BHEL
1.3.2.1.3.	As-built drawings – wherever deviations observed and executed and also based on the decisions taken at site- example – routing of small bore pipes		Yes	”
1.3.2.1.4.	Shipping lists etc. for reference and planning the activities		Yes	”
1.3.2.1.5.	Preparation of site construction schedules and other input requirements		Yes	In consultation with BHEL, As per requirement of BHEL targets
1.3.2.1.6.	Review of performance (Form-14) and revision of site construction schedules in order to achieve the end dates and other commitments		Yes	
1.3.2.1.7.	Weekly construction schedules based on Sl No 1.3.2.1.5		Yes	
1.3.2.1.8.	Daily construction / work plan based on Sl No 1.3. 2.1.7		Yes	For daily monitoring meeting at site
1.3.2.1.9.	Periodic visit ofthe senior official of the bidder to site to review the progress so that works are completed as per schedule. It is suggested this review by the senior official of the bidder should be done once in every two months.		Yes	
1.3.2.1.10.	Preparation of preassembly bay		Yes	
1.3.2.1.11.	Laying of racks for gantry crane if provided by BHEL or brought by the contractor / bidder himself			Not applicable

1.3.3. OPEN SPACE:

1.3.3.1. Area for fabrication, batching plant, office, storage area etc. for construction purpose shall be provided as per availability free of cost. Land will be allocated with certain time frame and to the extent available/ considered necessary, and will be reviewed by BHEL depending upon the area availability. The contractor will be responsible for handing back all lands, as handed over to him by BHEL. Availability of land within plant boundary is very limited and the contractor has to plan and use the existing land considering the use of land by other Civil /mechanical/ electrical contractors and the storage of plant machineries and materials. The existing land shall be shared by all executing agencies.

1.3.4. CONSTRUCTION WATER:

1.3.4.1. The contractor shall make his own arrangements of water suitable for construction purpose till commissioning of the construction water intake system by BHEL.

1.3.4.2. The contractor has to provide the pump at the sump of intake system, construct sump, at their own cost, for storage of water in the area allocated to contractor (preferably in working area), of adequate size (BHEL approval, for the size, shall be taken prior to construction). The required pumps & accessories, pipes for drawing water from the given point and further distribution will be arranged by the contractor at their cost to go on without interruptions.

1.3.4.3. All the tools and plants required for satisfactory completion of the work have to be arranged by the contractor.

1.3.5. ELECTRICITY:

1.3.5.1. Contractor shall make his own arrangements of Electricity at his own cost for construction purpose through DG sets till commissioning of the construction Power system by BHEL.

1.3.5.2. Construction power, as given by customer, shall be provided to the contractor at one single point by BHEL on chargeable basis. The contractor has to provide necessary meter for measuring the power consumption. The contractor shall make his own arrangement for further distribution with necessary isolator/LCB etc. The scheme for Construction Power distribution shall be approved by BHEL before installation.

1.3.5.3. Necessary “Capacitor Banks” to improve the Power factor to a minimum of 0.9 shall be provided by the contractor at his cost. Penalty if any levied by customer on this account will be recovered from contractor’s bills.

1.3.5.4. Any duty, deposit involved in getting the Electricity shall be borne by the bidder. As regards contractor’s office shed also all such expenditure shall be borne by the contractor.

1.3.5.5. Provision for distribution of electrical power from the given single central common point to the required places with proper distribution boards, approved cables and cable laying including supply of all materials like cables, switch boards, pipes

etc., observing the safety rules laid down by electrical authority of the State / BHEL / their customer with appropriate statutory requirements shall be the responsibility of the tenderer / contractor.

1.3.5.6. Contractor has to make their own arrangements for electricity requirement for labour colony at his own cost.

1.3.5.7. As there are bound to be interruptions in regular power supply, power cut/ load shedding in any construction sites, contractor should make his own arrangement for alternative source of power supply through deployment of adequate number of DG sets at their cost during the power breakdown / failure to get urgent and important work to go on without interruptions. No separate payment shall be made for this contingency.

1.3.6. MATERIAL SUPPLY:

All materials required for the work are in the scope of the contractor.

1.3.7. CONSUMABLES

The contractor shall provide all consumables required for carrying out the work covered under this scope of work.

1.3.8. LIGHTING FACILITY:

Adequate lighting facilities such as flood lamps, hand lamps and area lighting shall be arranged by the contractor at the site of construction, and contractor's material storage area etc. at his cost.

1.3.9. CONTRACTOR'S OBLIGATION ON COMPLETION:

On completion of work, all the temporary buildings, structures, pipe lines, cables etc. shall be dismantled and leveled and debris shall be removed as per instructions of BHEL by the contractor at his cost. In the event of his failure to do so, the expenditure towards clearance of the same will be recovered from the contractor. The decision of BHEL Engineer in this regard is final.

1.3.10. LABOUR COLONY:

The contractor has to make their own arrangement for labour colony at their own cost.

The contractor shall make his own arrangements for electricity requirement for labour colony, water for labour colony at their own cost.

1.3.11. DEWATERING

Contractor shall ensure at all times that his work area & approach/ access roads are free from accumulation of water, so that the materials are safe and the erection/ progress schedule are not affected. No separate claim in this regard shall be admitted by BHEL. No separate payments for dewatering of subsoil, surface water or catchments water, if required, at any time during execution of the work including monsoon period shall be considered by BHEL.

1.3.12. BID DRAWINGS

Plot plan drawing enclosed is only tentative & for information purpose and this may get revised during execution.

VOLUME-IA PART – I CHAPTER – IV
T&PS and MMEs TO BE DEPLOYED BY CONTRACTOR

1.4.1. All the tools and plants required for satisfactory completion of the work have to be arranged by the contractor.

VOLUME-IA PART – I CHAPTER - V
T&Ps AND MMEs TO BE DEPLOYED BY BHEL ON SHARING BASIS

1.5.1. BHEL will not provide any T & Ps for this scope of work.

1.5.2. In case if the contractor fails to provide T&P and other equipment's, BHEL will arrange for the same and the cost will be recovered from the contractor's bill with BHEL overheads, as applicable from time to time which may vary during contract period.

VOLUME-IA PART – I CHAPTER-VI
TIME SCHEDULE

1.6.1. TIME SCHEDULE

1.6.1.1. The entire works of Engineering, Design, Construction of RCC bridges across Bhedan river & associated civil works as detailed in the Tender Specification shall be completed within 30 (Thirty) months from the date of LOI.

1.6.1.2. During the total period of contract, the contractor has to carry out the activities in a phased manner as required by BHEL.

1.6.2. MOBILISATION

1.6.2.1. The Contractor has to subsequently augment his resources in such a manner to achieve the COMPLETION SCHEDULES as stipulated in the tender and as per site requirement.

1.6.3. In order to meet above schedule in general, and any other intermediate targets set, to meet customer / project schedule requirements, contractor shall arrange & augment all necessary resources from time to time on the instructions of BHEL

1.6.4. SUBMISSION OF L3 SCHEDULE

The contractor shall submit a detailed area/structure wise L2 and L3 schedule within 15 days in consultation with BHEL. The detailed L2 and L3 schedule shall be approved by BHEL and same shall be implemented. Bidder shall submit L2 and L3 schedule to meet the agreed schedule covering various mile stone activities and their split up details such as construction, procurement of materials, fabrication & erection activities. This schedule shall also clearly indicate the interface facilities/inputs

1.6.5. GUARANTEE PERIOD

Guarantee period of 12 months shall commence from the date of completion of the work in the scope, as certified by the BHEL Engineer.

VOLUME-IA PART – I CHAPTER-VII
TERMS OF PAYMENT

1.7. TERMS OF PAYMENT

1.7.1. Secured Advance

Not applicable

1.7.2. Advance for Mobilization

1.7.2.1. Interest bearing advance for Mobilization, limited to 5% of the contract value will be paid against submission of bank guarantee of at least 110% of the advance valid for the contract period, which will be recovered from the first running bill onwards. The advance for mobilization shall be paid as under.

1.7.2.2. 2% of contract value after receipt of initial Security Deposit and additional security deposit as applicable if any, as per relevant clauses in the GCC/TCC along with unqualified acceptance of detailed letter of intent.

1.7.2.3. 1.5% of contract value on completion of site Mobilization of Machinery & T&P as given below and on certification by site in-charge for compliance.

- 1 No. excavator equivalent to capacity of Pocklain CK90
- 1 No. batching plant
- 1 No. transit Mixer
- 2 Nos. Back hoe loader like JCB

1.7.2.4. 1.5% of contract value on completion of site Mobilization of Machinery & T&P as given below in addition to the above, and on certification by site in-charge for compliance.

- 1 No. excavator equivalent to capacity of Pocklain CK90
- 2 Nos. transit Mixers
- 1 No. Back hoe loader like JCB

1.7.2.5. Payment and recovery of the advance will be as per clause 2.13 of GCC. Option of availing the interest bearing mobilization advance is left with the bidder.

1.7.3. Interim Payment

1.7.3.1. Interim bills in the form of monthly running bills prepared by the contractor in soft as well as Hard copies shall be based on the quantities executed and measured.

1.7.3.2. The successful bidder shall submit detailed Billing Break Up for approval of BHEL/ NLCIL, as applicable.

1.7.3.3. Payment shall be as per mutually agreed Billing Break Up, and as detailed below:

- 85% progressive payment,
- 5% on Submission of quality documents,
- 5% on completion of punch points and signing of completion protocol,

- Balance 5% shall be Retention Amount

1.7.3.4. Refund of the above 5% Retention amount shall be made as follows:

- 50% of retention amount along with 'Final Bill'
- Balance 50% of retention amount shall be retained towards 'Performance Guarantee for Workmanship' and shall become refundable after expiry of Guarantee period, provided all the defects noticed during the guarantee period have been rectified to the satisfaction of BHEL Site Engineer/BHEL Construction Manager, and after deducting all expenses/other amounts due to BHEL under the contract/other contracts entered into by BHEL with them. This portion of the retention amount can be released on commencement of the Guarantee period, on submission of equivalent Bank Guarantee

1.7.4. Royalty/Seigniorage Charges

1.7.4.1. The quoted price shall be inclusive of all Royalties and the bidders shall quote accordingly. The Royalty amount will not be reimbursed by BHEL. If there is a demand by statutory bodies at a later date for payment of any Royalties, the same will be deducted from the Contractor's Bills progressively, unless receipt in support of payment made to the concerned authorities is provided by the Contractor. Any penalty levied by Statutory bodies in this regard will be to the Contractor's account.

1.7.4.2. Royalty for any other materials is to the bidders account.

1.7.5. Method of Measurement

Mode of measurement shall be as per relevant clauses of technical specification of this tender. In case the same is not available the relevant IS 1200 in conjunction of IS code 3385 shall be adopted. In case the same is also not available, the standard procedure adopted in CPWD shall be adopted. In case the same is also not available in CPWD, the measurement of the work done will be based on the mutual agreement between BHEL and contractor. In all the above cases, the interpretation of BHEL will be final and binding to the contractor.

NO CLAIM WHAT SO EVER MAY BE, WILL BE ENTERTAINED UNDER THIS CONTRACT, AFTER DULY SIGNING THE FINAL BILL ALONG WITH MEASURMENT BOOKS AND ACCEPTED BY BHEL.

1.7.6. Escrow Account:

Payments to the contractor for the subject works shall be made through an Escrow Account.

VOLUME-IA PART – I CHAPTER-VIII
TAXES AND DUTIES

1.8.1. Goods and service Tax (GST) & Cess

1.8.1.1. The successful bidder shall furnish proof of GST registration under GST Law in the State in which the Project is being executed, covering the supply and services under this contract. Registration should also bear endorsement for the premises from where the billing shall be done by the successful bidder on BHEL for this project/ work. The bidder to specify in their offer the category of registration under GST i.e. Registered dealer and composite dealer.

1.8.1.2. Contractor's price/rates shall be exclusive of GST & Compensation Cess (if applicable) (herein after termed as GST). GST along with Cess (as applicable) legally leviable & payable by the successful bidder as per GST Law, shall be paid by BHEL. Hence Bidder shall not include GST along with Cess (as applicable) in their quoted price.

1.8.1.3. However, Seller / Contractor require to specify the applicable GST in the offer and require to ensure that GST mentioned, is as per the existing tariff on the date of the offer and all benefits as per existing laws have been considered.

1.8.1.4. Price quoted by the composite dealer shall be considered as inclusive of GST. In the event of any GST quoted separately by the composite dealer, the same shall be considered for evaluation and ordering purpose. In the event of any change in the status of vendor from composite to regular dealer after the submission of the bid but before the supply, no reimbursement of additional GST will be made. However, the vendor has to raise the invoice strictly, as per the law, by adjusting their ex-works price.

1.8.1.5. It is the responsibility of the seller/ Contractor to issue the Tax Invoice complying with GST Invoice Rules (Section 31 of GST Act & Rules referred there under) and comply to the timelines for issue of the same. Invoices shall be submitted on time to the concerned BHEL Engineer In Charge. Vendor to indicate the proper GSTN registration / HSN /SAC code in their TAX Invoice on the basis of which BHEL will claim the input tax credit in its return. In case of raising any Debit / Credit Note, bidder shall issue the same containing all the details as referred to in Section 34 read with Rule 53.

1.8.1.6. E-invoicing under GST has been implemented by GOI for all the taxable persons having turnover more than the threshold limit in any preceding financial year from 2017-18 onwards. Therefore, for all the taxable persons falling under the purview of E-invoice, it is mandatory to mention a valid unique Invoice Reference No. (IRN) and QR code as generated from E-Invoicing portal of the Government for the purpose of issuing a valid Tax Invoice. Only an E-invoice issued in the manner prescribed under rule 48(4) of CGST Rules shall be treated as valid invoice for reimbursement of GST amount. If the successful Bidder is not falling

under the preview of E-Invoicing, then he has to submit a declaration in that respect along with relevant financial statements. BHEL shall reimburse GST only if all the provisions of E-invoicing are complied with.

1.8.1.7. Bidder should mention the "Bill To "details as below in the Tax Invoice for the supply goods and supply of services respectively

Bill To:

---,

GSTN of BHEL : ----------

1.8.1.8. All payments against Tax Invoice to vendors/contractors shall be released only after:

i). Vendor/ contractor declaring such invoice in the returns as per GST law prevailing at appropriate times.

ii). The tax component charged by the vendor in the invoice should match with the details uploaded by vendor in the GST Returns.

iii). Confirmation of payment of GST and filing of Quarterly / Monthly returns as applicable by vendor on GSTN portal.

1.8.1.9. In case, any GST credit is delayed/denied to BHEL or BHEL has to incur any liability (like interest / penalty) due to non/delayed receipt of goods and/or tax invoice or expiry to timeline prescribed in the relevant GST Act for availing such ITC, or any other reasons not attributable to BHEL, tax amount shall be recoverable from the vendor/contractor along with interest levied/ leviable on BHEL.

1.8.1.10. Bidder shall declare the Invoices raised on BHEL in the GST returns and file returns within the prescribed time as given in the GST Act. Bidder shall note that in case of delay in declaring such invoice in your return and GST credit availed by BHEL is denied or reversed subsequently as per GST Law, GST amount paid by BHEL towards such ITC reversal as per GST law shall be recoverable from the bidder along with interest levied / leviable on BHEL.

1.8.1.11. E-way bills / Transit passes / Road Permits: Successful Bidder has make their own arrangement for E-waybill for any transfer of goods for the execution of the contract. The Bidder has to make their own arrangement at their cost for completing the formalities, if required, with Issuing Authorities, for bringing materials, plants & machinery at site for execution of the works under this contract, and BHEL will not issue any Road Permit/ Way Bill for this purpose.

1.8.1.12. BHEL shall not reimburse any amount paid towards any interest / penalty etc., incurred by contractor. Any additional claim at a later date due to issues such as wrong rates / wrong classification by contractor shall not be paid by BHEL.

1.8.1.13. Wherein GST liability arises on BHEL under reverse charge, any interest levied/leviable due to any reasons not attributable to BHEL shall be recovered

from the vendor/contractor.

1.8.1.14. The applicable TDS under GST/ Goods and Services (Compensation to States) Act will be deducted from the payments.

1.8.2. All taxes and duty other than GST & Cess and BOCW Cess

All taxes/ duties or other charges, except those specifically mentioned in the Contract (other than GST and BOCW (if applicable)) legally levied on the CONTRACTOR in connection with the contract work, shall be borne and paid by the CONTRACTOR and the same shall be deemed to be included in the offer Price.

The contractor shall pay all (except the specific exclusion viz GST &Cess and BOCW Cess both of which are dealt with separately) taxes, fees, license charges, deposits, duties, tools, royalty, commissions, Stamp Duties, or other charges / levies, which may be levied on the input goods & services consumed and output goods & services delivered in course of his operations in executing the contract and the same shall not be reimbursed by BHEL. In case BHEL is forced to pay any of such taxes, BHEL shall have the right to recover the same from his bills or otherwise as deemed fit.

1.8.3. Statutory Variations

1.8.3.1. In general, Statutory variation for GST is payable to the Seller during currency of the contract between Buyer and Seller. Further, for period beyond the currency of the contract, BHEL will reimburse the actual applicable tax even if the same is higher than the amount applicable within the contractual period in case BHEL is able to take the input tax credit. However, the decision of BHEL in this regard will be final and binding on the seller/contractor otherwise vendor/contractor has to bear the differential upward increase in tax and ex- works price is to be adjusted accordingly

1.8.3.2. No other variations (Except GST) including Custom Duty, exchange rate, minimum wages, prices of controlled commodities, any other input etc. shall be payable by the purchaser unless specifically agreed upon.

1.8.4. New Taxes/Levies –

In case Government imposes any new levy / tax after submission of bid during the tenure of the contract, BHEL shall reimburse the same at actual on submission of documentary proof of payment subject to the satisfaction of BHEL that such new levy / tax is applicable to this contract. The decision of BHEL in this regard will be final and binding on the seller/contractor.

Any benefit arising due to new Taxes or levies must be passed on to BHEL.

1.8.5. Direct Tax

1.8.5.1. Seller is required to update himself on its own and comply with provisions of Indian Income Tax Act as notified from time to time. Purchaser shall not be liable

towards liability of income tax accruing to the Seller of whatever nature including variations thereof, arising out of this Order/ Contract, as well as tax liability of the Seller/ Contractor and his personnel

1.8.5.2. Deductions of Tax at source at the prevailing rates shall be effected by the Purchaser before release of payment, as a statutory obligation, if applicable. TDS certificate will be issued by the Purchaser as per statutory provisions. The Seller/Contractor has to mention their Permanent Account Number (PAN) and GSTIN in all invoices.

1.8.6. TCS (Tax collected at Source) under Income Tax Act.

If the vendor is mandated to collect the TCS from BHEL (for sale of Goods) as per the newly inserted sub section(1H) under Section 206C of the Income Tax Act, then the below conditions need to be adhered to:

1.8.6.1. Vendors should mention their TAN and PAN number in the Invoice submitted to BHEL.

1.8.6.2. Where the tender conditions do not specify any PQC on financial parameters, then the reimbursement of IT TCS to the Vendor can be made only on submission of below undertaking on yearly basis.

"I/We_____ have made a total sale, gross receipts or turnover from our business carried exceeds ten crore rupees during the financial year_____ (should be immediate preceding financial year)"

And on submission of TCS paid challan and TCS certificate for the TCS payments made in the last quarter.

1.8.6.3. Amount of TCS and Assessable value on which TCS has been calculated should be specified clearly in the invoice

1.8.6.4. PAN No of BHEL is AAACB4146P, same need to be considered by vendor while filing their TCS returns.

1.8.6.5. Vendor shall issue a TCS Certificate for the amount collected at source within the due dates as per the IT Act.

1.8.6.6. In event of failure to comply with the provisions of the Act or proper certificate was not issued or if tax collected, not remitted to the Government or for any other reason and thereby causing loss to BHEL, the same shall be recoverable from the Vendor towards non- compliance of statutory provisions from the money's due to them with applicable interest.

1.8.6.7. Where the purchases are for one time based on absolute requirements, then the Vendor shall be eligible for reimbursement only upon submission of TCS certificate.

1.8.7. BOCW Act & BOCW Welfare Cess Act

1.8.7.1. The Contractor should Register their Establishment under BOCW Act 1996 read with rules 1998 by submitting Form I (Application for Registration of Establishment) and Form IV (Notice Of Commencement / Completion of Building

other Construction Work) to the respective Labour Authorities i.e.,

a. Assistant Labour Commissioner (Central) in respect of the project premises which is under the purview of Central Govt.–NTPC, NTPL etc.

b. Appropriate State authorities in respect of the project premises which is under the purview of State Govt.

1.8.7.2. The Contractor should comply with the provisions of BOCW Welfare Cess Act 1996 in respect of the work awarded to them by BHEL.

1.8.7.3. The contractor should ensure compliance regarding Registration of Building Workers as Beneficiaries, Hours of work, welfare measures and other conditions of service with particular reference to Safety and Health measures like Safety Officers, safety committee, issue of Personal protective equipments, canteen, rest room, drinking water, Toilets, ambulance, first aid centre etc.

1.8.7.4. The contractor irrespective of their nature of work and manpower (Civil, Mechanical, Electrical works etc) should register their establishment under BOCW Act 1996 and comply with BOCW Welfare Cess Act 1996.

1.8.7.5. Contractor shall make remittance of the BOCW cess as per the Act **only in consultation with BHEL** as per the rates in force (presently 1%). BHEL shall reimburse the same upon production of documentary evidence. Hence Bidder shall not include BOCW Cess (as applicable) in their quoted price. However, BHEL shall not reimburse the Fee paid towards the registration of establishment, fees paid towards registration of Beneficiaries and Contribution of Beneficiaries remitted.

1.8.7.6. Non-compliance to Provisions of the BOCW Act & BOCW Welfare Cess Act is not acceptable. In case of any non-compliance, BHEL reserves the right to withhold any sum as it deems fit. Only upon total compliance to the BOCW Act and also discharge of total payment of Cess under the BOCW Cess Act by the Contractor, BHEL shall consider refund of the amounts.

VOLUME-IA PART – I CHAPTER-IX
ACCOUNTING OF MATERIAL ISSUE

Void

VOLUME-IA PART –I CHAPTER –X
GENERAL

The scope of the work will comprise of but not limited to the following:

(All the works mentioned hereunder shall be carried out within the accepted rate unless otherwise specified.)

1.10.1. Contractors are requested to furnish the following documents at PSSR-HQ, Chennai immediately after release of Letter of Intent (LOI).

i. Security Deposit and additional Security Deposit.

ii. Unqualified Acceptance for Detailed LOI / Work Order.

iii. Rs.100/- Stamp Paper for preparation of Contract Agreement.

1.10.2. Contractors are requested to furnish the proof of documents for the following at PSSR- Site

i. Provident Fund Registration Number.

ii. Labour License Number.

iii. Workmen Insurance Policy Number.

1.10.3. In addition to the clause 2.8 of General Conditions of Contract (Volume-IC of Book-II) the contractor shall comply with the following.

1.10.3.1. **PROVIDENT FUND**

1.10.3.1.1. The contractor is required to extent the benefit of Provident Fund to the labour employed by you in connection with this contract as per the Employees Provident Fund and Miscellaneous Provisions Act 1952. For due implementation of the same, you are hereby required to get yourself registered with the Provident Fund authorities for the purpose of reconciliation of PF dues and furnish to us the code number allotted to you by the Provident Fund authorities within one month from the date of issue of this letter of intent. In case you are exempted from such remittance an attested copy of authority for such exemption is to be furnished. Please note that in the event of your failure to comply with the provisions of said Act, if recoveries therefore are enforced from payments due to us by the customer or paid to statutory authorities by us, such amount will be recovered from payments due to you.

1.10.3.1.2. The final bill amount would be released only on production of clearance certificate from PF / ESI and labour authorities as applicable.

1.10.3.2. **OTHER STATUTORY REQUIREMENTS**

1.10.3.2.1. The Contractor shall submit a copy of Labour License obtained from the Licensing Officer (Form VI) u/r25 read with u/s 12 of Contract Labour (R&A) Act 1970 & rules and Valid WC Insurance copy or ESI Code (if applicable) and PF code no. along with the first running bill.

1.10.3.2.2. The contactor shall submit monthly running bills along with the copies of monthly wages (of the preceding month) u/r78(1)(a)(1) of Contract Labour Rules, copies

of monthly return of PF contribution with remittance Challans under Employees Provident Fund Act 1952 and copy of renewed WC Insurance policy or copies of monthly return of ESI contribution with Challans under ESI Act 1948 (if applicable) in respect of the workmen engaged by them.

1.10.3.2.3. The Contractor should ensure compliance of Sec 21 of Contract Labour (R&A) Act 1970 regarding responsibility for payment of Wages. In case of "Non-compliance of Sec 21 or non-payment of wages" to the workmen before the expiry of wage period by the contactor, BHEL will reserve its right to pay the workmen under the orders of Appropriate authority at the risk and cost of the Contractor.

1.10.3.2.4. The Contractor shall submit copies of Final Settlement statement of disbursal of retrenchment benefits on retrenchment of each workmen under I D Act 1948, copies of Form 6-A (Annual Return of PF Contribution) along with copies of PF Contribution Card of each member under PF Act and copies of monthly return on ESI Contribution – Form 6 under ESI Act 1948 (if applicable) to BHEL along with the Final Bill.

1.10.3.2.5. In case of any dispute pending before the appropriate authority under ID Act 1948, WC Act 1923 or ESI Act 1948 and PF Act 1952, BHEL reserve the right to hold such amounts from the final bills of the Contractor which will be released on submission of proof of settlement of issues from the appropriate authority under the act.

1.10.3.2.6. In case of any dispute prolonged / pending before the authority for the reasons not attributable to the contractor, BHEL reserves the right to release the final bill of the contractor on submission of Indemnity bond by the contractor indemnifying BHEL against any claims that may arise at a later date without prejudice to the rights of BHEL.

1.10.3.3. **DEPLOYMENT OF SKILLED / SEMI-SKILLED TRADESMEN**

The following clause is applicable in case the contract value / contract price is Rs. Five crores and above.

The contractor shall, at all stages of work deploy skilled / semi-skilled tradesmen who are qualified and possess certificate in particular trade from CPWD Training Institute / Industrial Training. Institute / National Institute of Construction Management and Research (NICMAR), National Academy of Construction, CIDC or any similar reputed and recognized Institute managed / certified by State / Central Government. The number of such qualified tradesmen shall not be less than 20% of total skilled / semi-skilled workers required in each trade at any stage of work. The contractor shall submit number of man days required in respect of each trade, its scheduling and the list of qualified tradesmen along with requisite certificate from recognized Institute to Engineer-in-Charge for approval. Notwithstanding such approval, if the tradesmen are found to have inadequate skill to execute the work of respective trade, the contractor shall substitute such tradesmen within two days of written notice from

Engineer-in-Charge. Failure on the part of contractor to obtain approval of Engineer-in-Charge or failure to deploy qualified tradesmen will attract a compensation to be paid by contractor at the rate of Rs. 100 per such tradesman per day. Decision of Engineer-in-Charge as to whether particular tradesman possesses requisite skill and amount of compensation in case of default shall be final and binding.

1.10.3.4. **RECOVERY OF COMPENSATION PAID TO VICTIMS BY BHEL IN CASES OF DEATH/ PERMANENT INCAPACITATION OF PERSON DUE TO AN ACCIDENT DURING THE WORKS**

BHEL shall recover the amount of compensation paid to victim(s) by BHEL towards loss of life / permanent disability due to an accident which is attributable to the negligence of contractor, agency or firm or any of its employees as detailed below.

a. Victim: Any person who suffers permanent disablement or dies in an accident as defined below.

b. Accident: Any death or permanent disability resulting solely and directly from any unintended and unforeseen injurious occurrence caused during the manufacturing / operation and works incidental thereto at BHEL factories/ offices and precincts thereof, project execution, erection and commissioning, services, repairs and maintenance, trouble shooting, serving, overhaul, renovation and retrofitting, trial operation, performance guarantee testing undertaken by the company or during any works /during working at BHEL Units/ Offices/ townships and premises/ Project Sites.

c. Compensation in respect of each of the victims:
In the event of death or permanent disability resulting from Loss of both limbs: Rs. 10,00,000/- (Rs. Ten Lakh)

In the event of other permanent disability: Rs. 7,00,000/- (Rs. Seven Lakh)

Permanent Disablement: A disablement that is classified as a permanent total disablement under the proviso to Section 2 (I) of the Employee's Compensation Act, 1923.

1.10.4. GENERAL

1.10.4.1. **E way Bills to be arranged by contractor whenever required.**

1.10.4.2. All works shall be carried out in proper workmen like manner. Items of works covered by the following specification shall be carried out as per the best practices and according to the direction of the Engineer In-charge / BHEL, Site Engineer and to his satisfaction. Unless otherwise specified in this section or in the description of item, the cost of stage of works mentioned here under shall be deemed to have been included in the rates of items provided in the schedule.

1.10.4.3. Scope of work covered under this specification requires quality workmanship, engineering and construction management. The contractor shall ensure timely

completion of work. The contractor shall have adequate tools, measuring instruments, etc. in his possession. He shall also have adequate trained, qualified and experienced engineers, supervisory staff and skilled personnel. The manpower deployment identified by contractor shall match with above scope of works.

1.10.4.4. It is not the intent to specify herein all details of material. Any item related to this work not covered by this but necessary to complete the system will be deemed to have been included in the scope of the work.

1.10.4.5. Site testing wherever required shall be carried out for all items / materials installed by the contractor to ensure proper installation and functioning in accordance with drawings, specifications and manufacturer's recommendations.

1.10.4.6. The work shall be executed under the usual conditions without affecting the plant construction and in conjunction with other operations and contracting agencies at site. The contractor and his personnel shall co-operate with the personnel of other agencies, co-ordinate his work with others and proceed in a manner that shall not delay or hinder the progress of work as a whole.

1.10.4.7. The Contractor may have to execute work in such a place and condition where other agencies also will be under such circumstances. The contractor shall co-operate with other contractors and agencies so that various activities can be carried out simultaneously in order to achieve an early completion.

1.10.4.8. All the work shall be carried out as per instructions of BHEL engineer. BHEL engineer's decision regarding the correctness of the work and method of working shall be final and binding on the contractor.

1.10.4.9. The contractor will be responsible for the safe custody and proper accounting of all materials in connection with the work.

1.10.4.10. The contractor must obtain the signature and permission of the security personnel of the customer for bringing any of their materials inside the site premises. Without the Entry Gate Pass these materials will not be allowed to be taken outside.

1.10.4.11. Contractor shall retain all T&Ps, Material handling equipments etc at site as per advice of BHEL engineer and same shall be taken out from site only after getting the clearances from Engineer In charge.

1.10.4.12. The contractor at his cost shall arrange necessary security measures for adequate protection of his machinery, equipment, tools, materials etc. BHEL shall not be responsible for any loss or damage to the contractor’s construction equipment and materials. The contractor may consult the Engineer-in-Charge on

the arrangements made for general site security for protection of his machinery equipment tools etc.

1.10.4.13. Any wrong erection shall be removed and re-erected promptly to comply with the design requirements to the satisfaction of Site Engineer.

1.10.4.14. Contractor has to work in close co-ordination with other erection agency at site. BHEL engineer will co-ordinate area clearance. In a project of such magnitude, it is possible that the area clearance may be less / more at a particular given time. Activities and erection program have to be planned in such a way that the milestones are achieved as per schedule/ plans. Contractor shall arrange & augment the resources accordingly.

1.10.4.15. Contractor shall remove all scrap materials periodically generated from his working area in and around power station and collect the same at one place earmarked for the same. Failure to collect the scrap is likely to lead to accidents and as such BHEL reserves the right to collect and remove the scrap at contractor's risk and cost if there is any failure on the part of contractor in this respect. All the package materials, including special transporting frames, etc. shall be returned to the BHEL stores by the contractor.

1.10.4.16. The contractor is strictly prohibited from using BHEL's regular components like angles, channels, beams, plates, pipe / tubes, and handrails etc for any temporary supporting or scaffolding works. Contractor shall arrange himself all such materials. In case of such misuse of BHEL materials, a sum as determined by BHEL engineer will be recovered from the contractor's bill. The decision of BHEL engineer is final and binding on the contractor.

1.10.4.17. No member of the already erected structure / platform, pipes, grills, platform, other component and auxiliaries should be cut without specific approval of BHEL engineer.

1.10.4.18. Contractors shall ensure that all their Staff / Employees are exposed to periodical training programme conducted by qualified agencies/ personnel on ISO 9001 – 2015 Standards.

1.10.4.19. Crane operators deployed by the contractor shall be tested by BHEL before he is allowed to operate the cranes.

1.10.4.20. On completion of work, all the temporary buildings, structures, pipe lines, cable etc. shall be dismantled and leveled and debris shall be removed as per instruction of BHEL by the contractor at his cost. In the event of his failure to do so, the expenditure towards clearance of the same will be recovered from the contractor. The decision of BHEL Engineer in this regard is final.

1.10.4.21. It is the responsibility of the contractor to do the alignment, checking, etc. if necessary, repeatedly to satisfy BHEL Engineer with all the necessary tools and tackles, manpower etc. without any extra cost. Also the contractor should ensure that the alignment is not disturbed afterwards.

1.10.4.22. If any item or equipment not covered but requires being erected, same shall be carried out by the contractor. Equivalent or proportional unit rate shall be considered wherever possible from the BOQ. The rates quoted by the contractor shall be uniform as far as possible for similar items appearing in rate schedule / price bid.

1.10.4.23. The contractor shall ensure that his premises are always kept clean and tidy to the extent possible. Any untidiness noted on the part of the contractor shall be brought to the attention of the contractor's site representative who shall take immediate action to clean the surroundings to the satisfaction of the Engineer-in-Charge.

1.10.4.24. SITE INSPECTION

i). BHEL or his authorized agents may inspect various stages of work during the currency of the contract awarded to him. The contractor shall make necessary arrangements for such inspection and carry out the rectification pointed out by the owner / employer without any extra cost to the owner / employer. No cost whatsoever such duplication of inspection of work be entertained.

ii). BHEL will have full power and authority to inspect the works at any time, either on the site or at the contractor's premises. The contractor shall arrange every facility and assistance to carry out such inspection. On no account will the contractor be allowed to proceed with work of any type unless such work has been inspected and entries are made in the site inspection register by BHEL.

iii). Wherever the performance of work by the contractor is not satisfactory in respect of workmanship, deployment of sufficient labour or equipment, delay in execution of work or any other matter, BHEL shall have the right to engage labour at normal ruling rates and get the work executed through other agency and debit the cost to the contractor and the contractor shall have no right to claim compensation thereof. In such a case, BHEL shall have the right to utilize the materials and tools brought by the contractors for the same work.

1.10.4.25. DOCUMENTATION

i). Record of Quantity of FREE (if any) /Chargeable items issued by BHEL must be maintained during contract execution. Also reconciliation statement to be prepared at regular intervals.

ii). The under mentioned Records/ Log-books/ Registers applicable to be maintained,

a. Hindrance Register
b. Site Order Book.
c. Test Check of measurements.
d. Cement Supply and Consumption Daily Register

e. Records of Test reports of Field tests.

f. Records of manufacture's test certificates.

g. Records of disposal of scraps generated during and after the work completion.

h. List of MMEs deployed by the bidder.

iii). As built drawings:
After successful completion of installation work, drawings / documents shall be updated in line with the actual work carried out and as built drawings / documents shall be submitted by the contractor.

iv). Other documents as specified in PROGRESS OF WORK (VOLUME-IA PART- II CHAPTER-XI)

VOLUME-IA PART – I CHAPTER-XI
PROGRESS OF WORK

The scope of the work will comprise of following but not limited to the following:

PROGRESS AND MONITORING OF WORK

1.11.1. Refer forms F -14 to F-18 of volume I D. Plan and review will be done as per the formats.

1.11.2. Contractor is required to draw mutually agreed monthly construction programs in consultation with BHEL well in advance monthly as per the Form-14. Contractor shall ensure achievement of agreed program and shall also timely arrange additional resources considered necessary at no extra cost to BHEL. Progress review meetings will be held at site during which actual progress during the week vis-a-vis scheduled program shall be discussed for actions to be taken for achieving targets. Contractor shall also present the program for subsequent week. The contractor shall constantly update / revise his work program to meet the overall requirement. All quality problems shall also be discussed during above review meetings. Necessary preventive and corrective action shall be discussed and decided upon in such review meetings and shall be implemented by the contractor in time bound manner so as to eliminate the cause of nonconformities.

1.11.3. The contractor shall submit daily, weekly and monthly progress reports, manpower reports, materials reports, consumables report, T&Ps availability report and other reports as per Performa considered necessary by the Site Engineer as per the BHEL formats.

1.11.4. The contractor shall submit weekly / fortnightly / monthly statement report regarding consumption of all consumables for cost analysis purposes.

1.11.5. The monthly report at the end of every month shall be submitted as a booklet and shall contain the following details :-

a) Colour Progress photographs to accompany the report should be submitted.

b) Construction progress in terms of quantity, CUM,etc., completed as relevant to the respective work areas against planned.

c) Site Organization chart of engineers & supervisors as on the last day of the month with further mobilization plan

d) Category- wise man hours engaged during the previous month under the categories like fitters, electricians, welders, riggers, khalasis, grinder-men, gas-cutters, crane operators, store keepers, lab technicians, helpers, security etc. Data will be spilt up under the work area .

e) Consumables report giving consumption of all types of gases and electrodes during the previous month.

f) Availability report of cranes/T&Ps

g) Safety implementation report in the format

h) Pending material and any other inputs required from BHEL for activities planned during the subsequent month.

1.11.6. The manpower reports shall clearly indicate the manpower deployed, category wise specifying also the activities in which they are engaged.

1.11.7. During the course of construction, if the progress is found unsatisfactory, or if the target dates fixed from time to time for every milestone are to be advanced, or in the opinion of BHEL, if it is found that the skilled workmen like fitters, operators, technicians etc employed are not sufficient BHEL will induct required additional workmen to improve the progress and recover all charges incurred on this account including all expenses together with BHEL overheads from contractor's bills.

1.11.8. It is the responsibility of the contractor to provide all relevant information on a regular basis regarding construction progress, labour availability, equipment deployment, testing, etc.

1.11.9. The progress reports shall indicate the progress achieved against plan, indicating reasons for delays, if any. The report shall also give remedial actions which the contractor intends to make good the slippage or lost time so that further works can proceed as per the original plan the slippages do not accumulate and affect the overall programme.

1.11.10. The contractor to reflect actual progress achieved during the month and will be submitted to BHEL, so that slippages can be observed and necessary action taken in order to ensure that the situation does not get out of control will update the construction schedule forming part of this contract each month.

VOLUME-IA PART – I CHAPTER-XII
MATERIAL HANDLING

1.12.1. Open land shall be provided by BHEL on free of cost basis. Contractor shall maintain one centralized fenced store cum bar bending yard. Hard surfacing of this yard and all round drain shall be carried out by the contractor at his own cost within the quoted rate. Batching plant area, shall be provided and contractor shall make use of the area for installation and operation of the Batching Plant at his own cost. The bidder shall make complete arrangement of necessary security personnel, to safeguard all such materials in his custody.

1.12.2. The system for receipt, storage & issue of materials shall be available with vendors for easy traceability.

1.12.3. Periodic audit of system of purchasing, storing and issue, etc. will have to be carried out by the vendors. BHEL will also audit the same.

1.12.4. The contractor shall construct waterproof cement store for storing and stacking of cement, CGI/ asbestos roofing (slope) with brick masonry wall, PCC flooring. Materials required for the same shall be provided by contractor at his own cost. Cement has to be kept over wooden raised platform. Stacking of cement is to be done as per IS codes with proper illumination and locking arrangements.

1.12.5. The contractor shall in no case be entitled for any compensation or damages on account of any delay in supply or non-supply thereof for all or any such material.

1.12.6. Materials shall not under any circumstances taken out of the project site unless otherwise permitted by BHEL.

VOLUME-IA PART – II CHAPTERS 1 and 2

Chapter 1 and 2 in next 1610 pages is as below:

Vol IA	Part-II: Technical specifications	Chapter	No. of pages
1	Technical Specifications for Civil, Structural & Architectural works for "Construction of RCC bridges"	Chapter-1	1410
2	Corrections/Revisions pertaining to Chapter-1, Part-II, Volume-I	Chapter-2	200

3 X 800 MW NLC TALABIRA THERMAL POWER PROJECT

VOLUME – II B

SPECIFICATION NO PE-TS-N80-682-EMB+BRIDGE-C001

SECTION – A

SCOPE OF WORK

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

1.0 Scope of Work:

The scope of work includes Civil, Structural & Architectural works for "Embankment formation along Bhedan River and Construction of RCC bridge on Bhedan River" 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:

~~Embankment formation along Bhedan river~~

a) ~~Earthen embankment i.e. flood protection bund on right bank (plant side) and left bank (Ash dyke side) of Bhedan river including site clearance, site levelling & grading, topographical survey, route survey with longitudinal & cross sectional details, bathymetry survey, geotechnical investigation, slope protection, inspection road, drain, toe wall/rock toe, chute and side protection/lining etc.~~
b) ~~Bund shall be provided with inspection road, drain, chute and turfing on plant/ash pond side and stone pitching with geotextile filter fabric, toe wall etc., on the river side.~~
c) ~~The left bank (Ash pond side) is to be merged with the proposed NLCIL Talabira Mines protection bund with a suitable gradient avoiding any vertical joints.~~
d) ~~Starting and terminating points of bund shall be designed suitably to prevent entry of water into the plant area by suitable means such as connecting to some high ground or nearby embankment as per site condition.~~
e) ~~Suitable drainage arrangement shall be made at the top of bund to divert surface water through chutes which are to be placed at 30m c/c spacing on the plant/ash dyke side slope.~~
f) ~~Necessary one way sluices with regulating arrangement and supporting structures shall be provided in the country side/plant side for controlled discharge of water into riverside. The size and number of sluice gates shall be designed suitably based upon the intensity of rainfall and catchment area to be drained~~.

g) ~~Based on the soil investigation report, design document, construction drawings, design basis and design calculations~~

~~including suitability of filling earth from various sources shall be vetted by IIT/IISc and submitted to NLCIL for review, before commencement of work.~~

h) ~~For bund construction, necessary statutory clearance shall be obtained from the state government/WRD (Water Resources Department) and the same shall be under the EPC scope.~~

RCC bridge and associated works across Bhedan river

a) RCC bridge across Bhedan river including site clearance, site levelling & grading, topographical survey, route survey with longitudinal & cross sectional details, bathymetry survey, geotechnical investigation (on shore and off shore) etc.

b) The bridges across Bedhan river shall be of RCC and shall be designed as per IRC 112 and all relevant IRC/Indian standards (latest revisions). All other associated civil & structural works are under the scope of Bidder.
c) The bridge connecting Township and Power plant shall have four lanes of roads with walkways. In addition to this necessary provision/ extra width for carrying Ash pipe, any other water line and Makeup water Intake pipe lines shall also be considered suitably as per system requirement.
d) The total width of bridges shall be as per functional requirements. Necessary head room shall be provided for free movement of Boat / Ferry taking High flood level (HFL) into account.
e) Any statutory approvals (including payment of necessary fee, levy and all other related misc. expenditure from the State/Central Govt. authority for obtaining statutory approval) required shall also be under the scope of the successful bidder. Owner shall support by way of giving letters etc. for obtaining approvals for the above.

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

The following facilities are to be routed through RCC bridge across Bhedan river connecting main plant to ash dyke:

1) 12 no. slurry pipes of 250 NB. As per customer specification, material of construction of these pipes shall be as per ASTM A 106 Gr-B Schedule 80 carbon steel seamless pipe or as per ASTM A 53 carbon steel seamless pipe or ANSI B 36.10 carbon steel seamless pipe. Out of the 12 running pipes, 3 will be working at a time.
   The load per unit length for empty pipe is 96 kg/meter and load per unit length for full pipe (i.e., filled with slurry) is 200 kg/meter.
2) Four lane approach road
3) Drinking water line to township. For township, there will be single pipe for potable water terminated at single point. Material shall be Carbon steel (galvanised) and size shall be according to the inputs to be furnished by Township contractor agency.
4) Make up water pipes – 2 no of size 1200 NB. Material shall be Carbon steel. Weight of the pipe is 1600 kg/m.
5) Cable supports required for 33 kV cable over pipe rack structure (required for raw water pipeline) running along the bridge.
   Weight per unit length for cables - 6x4.5 = 27 kg/m.

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) There is no geotechnical data available for proposed Embankment & bridge area. However, preliminary geotechnical data for proposed plant area 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 of plant area attached is for reference only. However, bidder has to carry out detailed Geotechnical Investigation for proposed embankment area and

Bridge 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.

3 X 800 MW NLC TALABIRA THERMAL POWER PROJECT

VOLUME – II B

SPECIFICATION NO PE-TS-N80-EMB+BRIDGE-C001

TECHNICAL SPECIFICATION FOR EMBANKMENT FORMATION ALONG BHEDAN RIVER & CONSTRUCTION OF 2 NO. RCC BRIDGES ACROSS BHEDAN RIVER

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

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-EMB+BRIDGE-C001

SECTION – A

SCOPE OF WORK

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

1.0 Scope of Work:

The scope of work includes Civil, Structural & Architectural works for "Embankment formation along Bhedan River and Construction of RCC bridges (2 no.) on Bhedan River" 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:

~~Embankment formation along Bhedan river~~

a) ~~Earthen embankment i.e. flood protection bund on right bank (plant side) and left bank (Ash dyke side) of Bhedan river including site clearance, site levelling & grading, topographical survey, route survey with longitudinal & cross sectional details, bathymetry survey, geotechnical investigation, slope protection, inspection road, drain, toe wall/rock toe, chute and side protection/lining etc.~~
b) ~~Bund shall be provided with inspection road, drain, chute and turfing on plant/ash pond side and stone pitching with geotextile filter fabric, toe wall etc., on the river side.~~
c) ~~The left bank (Ash pond side) is to be merged with the proposed NLCIL Talabira Mines protection bund with a suitable gradient avoiding any vertical joints.~~
d) ~~Starting and terminating points of bund shall be designed suitably to prevent entry of water into the plant area by suitable means such as connecting to some high ground or nearby embankment as per site condition.~~
e) ~~Suitable drainage arrangement shall be made at the top of bund to divert surface water through chutes which are to be placed at 30m c/c spacing on the plant/ash dyke side slope.~~
f) ~~Necessary one way sluices with regulating arrangement and supporting structures shall be provided in the country side/plant side for controlled discharge of water into riverside. The size and number of sluice gates shall be designed suitably based upon the intensity of rainfall and catchment area to be drained.~~

g) ~~Based on the soil investigation report, design document, construction drawings, design basis and design calculations~~

~~including suitability of filling earth from various sources shall be vetted by IIT/IISc and submitted to NLCIL for review, before commencement of work.~~

h) ~~For bund construction, necessary statutory clearance shall be obtained from the state government/WRD (Water Resources Department) and the same shall be under the EPC scope.~~

RCC bridge and associated works across Bhedan river

a) 2 No. RCC bridges across Bhedan river including site clearance, site levelling & grading, topographical survey, route survey with longitudinal & cross sectional details, bathymetry survey, geotechnical investigation (on shore and off shore) etc.

b) The bridges across Bedhan river shall be of RCC and shall be designed as per IRC 112 and all relevant IRC/Indian standards (latest revisions). All other associated civil & structural works are under the scope of Bidder.
c) The bridge-1(west side) connecting mines shall have four lanes of road with walkways. In addition to this necessary provision/ extra width for carrying Ash pipe line shall also be considered suitably as per system requirement. The bridge shall also be used for routing of HCSD pipelines in future for dumping of combined ash in the mine voids created over a period of time.
d) The bridge-2(eastside) connecting Township and Power plant shall have four lanes of roads with walkways. In addition to this necessary provision/ extra width for carrying Ash pipe, any other water line and Makeup water Intake pipe lines shall also be considered suitably as per system requirement.
e) The total width of bridges shall be as per functional requirements. Necessary head room shall be provided for free movement of Boat / Ferry taking High flood level (HFL) into account.
f) Any statutory approvals (including payment of necessary fee, levy and all other related misc. expenditure from the State/Central Govt. authority for obtaining statutory approval) required shall also be

under the scope of the successful bidder. Owner shall support by way of giving letters etc. for obtaining approvals for the above.

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

The following facilities are to be routed through RCC bridge across Bhedan river connecting main plant to ash dyke:

1) 12 no. slurry pipes of 250 NB. As per customer specification, material of construction of these pipes shall be as per ASTM A 106 Gr-B Schedule 80 carbon steel seamless pipe or as per ASTM A 53 carbon steel seamless pipe or ANSI B 36.10 carbon steel seamless pipe. Out of the 6 running pipes, 3 will be working at a time.
   The load per unit length for empty pipe is 96 kg/meter and load per unit length for full pipe (i.e., filled with slurry) is 200 kg/meter.
2) Four lane approach road
3) Drinking water line to township. For township, there will be single pipe for potable water terminated at single point. Material shall be Carbon steel (galvanised) and size shall be according to the inputs to be furnished by Township contractor agency.
4) Make up water pipes – 2 no of size 1200 NB. Material shall be Carbon steel. Weight of the pipe is 1600 kg/m.
5) Cable supports required for 33 kV cable over pipe rack structure (required for raw water pipeline) running along the bridge.
   Weight per unit length for cables - 6x4.5 = 27 kg/m.

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.
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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.

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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) There is no geotechnical data available for proposed township area. However, preliminary geotechnical data for proposed plant area 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 of plant area attached is for reference only. However, bidder has to carry out detailed Geotechnical Investigation for proposed embankment area and Bridge 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.

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 Meterological 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 (NLCIL)

REGD. OFFICE: 'NEYVELI HOUSE', 135, PERIYAR

EVR HIGH ROAD, CHENNAI – 600 010

TENDER SPECIFICATION

FOR

INFRASTRUCTURE WORKS (SECTION-B)

&

SINGLE PACKAGE ENGINEERING, PROCUREMENT & CONSTRUCTION (EPC)

VOLUME - IB

NLC INDIA LIMITED

NLC TALABIRA THERMAL POWER PROJECT 3x800 MW,

JHARSUGUDA, ODISHA



NLC INDIA LIMITED (NLCIL)

REGD. OFFICE: 'NEYVELI HOUSE', 135, PERIYAR

EVR HIGH ROAD, CHENNAI – 600 010

TENDER SPECIFICATION

FOR

INFRASTRUCTURE WORKS (SECTION-A)

OF

NLC INDIA LIMITED

NLC TALABIRA THERMAL POWER PROJECT

3x800 MW, PHASE - I

JHARSUGUDA, ODISHA

COMMERCIAL & TECHNICAL SPECIFICATIONS

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COMMERCIAL

PART II
TECHNICAL

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CHAPTER I
GENERAL

1. INTRODUCTION

The scope EPC contract shall covers complete design of Civil, Structural and architectural Works, detailed engineering, providing necessary labour, materials construction equipment, tools and plants, appliances, temporary works, supply and delivery to site, storage at site, construction works etc for the proper completion of work for the following **INFRA STRUCTURE** facilities including, obtaining all statutory approvals from Local Authorities / Body including services for completion of the work in all respect for the Coal based Thermal Power Plant to be constructed as Phase-I (3 x 800 MW) near Kumbhari & Tareikela villages, Jharsuguda District, Odisha.. All the execution drawings with detailed design engineering calculations, shall be got approved from NLCIL (through CCMS) prior to commencement of construction works.

2. SCOPE OF WORK

THERMAL POWER PLANT AREA:

List of Works:

1. Site grading of power plant & green belt area
2. Laying of Main Approach road to power plant
3. Construction of Compound wall around plant area
4. Laying of Peripheral fencing and peripheral inspection road (outside fencing) along acquired land boundary
5. Formation of Embankment along Bhedan river along with slope protection and toe drains as per recommendation of area-drainage study
6. Providing Construction water supply
7. Design & Construction of Thermal Project office building (G+1)
8. Design & Construction of Miscellaneous Non plant buildings
    1. Gate complex along with security and time office
    2. Parking lot
    3. Watch tower
    4. CISF – Barracks (G+2), Armoury and quarter guard, Canteen, security check post and toilet block
9. Providing construction power supply

INTEGRATED TALABIRA TOWNSHIP

1. **Preliminary works such as :**
   a) Topographical survey of Township area
   b) Site levelling & grading of township area
   c) Geotechnical investigation of Township area
   d) Establishing construction water supply
   e) Establishing construction power supply

2. **Design, engineering and construction of following buildings including internal electrification, fire safety, water supply, drainage & sewage arrangements within Township area:**
   a) Project head (PH) quarters – 3 Nos.
   b) Type IV Quarter –
      - ✓ RCC Multi-storeyed building (Stilt+4) provided with 2 staircases and 1 lift.
      - ✓ 4 buildings are located in one block provided with common garden and walkway in between
      - ✓ Number of blocks = 2 Nos.
      - ✓ 64 houses each of 1717 sqft area there in one block in four floors.
      - ✓ Number of houses = 64x2 = 128 Nos.
      - ✓ Car parking facility for all houses provided in stilt floor.
   c) Type III Quarter –
      - ✓ RCC Multi-storeyed building (Stilt+4) provided with 2 staircases and 1 lift.
      - ✓ 4 buildings are located in one block provided with common garden and walkway in between.
      - ✓ Number of blocks = 3 Nos.
      - ✓ 64 houses each of 1210 sqft area there in one block in four floors.
      - ✓ Number of houses = 64x3 = 192 Nos.
      - ✓ Car parking facility for all houses provided in stilt floor.
   d) Type II Quarter –
      - ✓ RCC Multi-storeyed building (Stilt+4) provided with 2 staircases and 1 lift.
      - ✓ 4 buildings are located in one block provided with common garden and walkway in between.
      - ✓ Number of blocks = 2 Nos.
      - ✓ 64 houses each of 1012 sqft area there in one block in four floors.
      - ✓ Number of houses = 64x2 = 128 Nos.
      - ✓ Car parking facility for all houses provided in stilt floor

e) Type I Quarter –
   - ✓ RCC Multi-storeyed building (Stilt+3) provided with 2 staircases and 1 lift.
   - ✓ 4 buildings are located in one block provided with common garden and walkway in between.
   - ✓ Number of blocks = 2 Nos.(NLCIL) + 1 (CISF)
   - ✓ 48 houses each of Minimum 680 sqft area there in one block in three floors.
   - ✓ Number of houses in NLCIL area = 48x2 = 96 Nos.
   - ✓ Number of houses in CISF area = 48x1 = 48 Nos.
   - ✓ Two wheeler parking facility for all houses provided in stilt floor.

f) Executive hostel – 4 blocks of G+1 - 96 staff
g) Shopping complex– G+1 structure
h) Guest house – G+1 – 12 rooms
i) Recreation club , Sports office, badminton court, swimming pool and Library
j) Auditorium
k) Community hall
l) Hospital (30 bed) – G+1
m) School – G+1 – 14 classrooms, 4 labs, hall & library
n) Township administration (TA) office – G+1
o) Estate store
p) Two wheeler parking shed
q) Four wheeler parking shed
r) Security building
s) Servant's quarters for PH – 3 Nos.
t) VIP Guest House – G+1 with lift

3. Design, engineering and construction/development/laying of :

a) Compound wall around township area
b) Entrance arch to township and indicative arch at SH-10 entrance
c) Main Approach road from Integrated township to SH-10 (4 lane)
d) Internal main road within township (4 lane)
e) Internal road within township (Single lane)
f) Dedicated approach road from Power plant to township (2 lane)
g) Main Drinking Water pipeline network from Power plant WTP to township
h) Water supply distribution network including Overhead water tank and sump within township
i) Storm water drainage network within township
j) Sewage network with STP within township including recycling of treated water
k) Rain water harvesting scheme
l) Street lighting and external electrification

m) Park and playground
n) Gardening & walkway inside Type I, II, III & IV Blocks area
o) Statue/logo/beautification near main entrance of township

The contractor shall visit the Thermal project site and Township site before quoting rates to ascertain the actual site condition. The contractor's quoted rates are deemed to include everything from the award of work up to & including handing over of completed project and 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 integral part of his scope of work and deemed to be included in his quoted price. All municipal & mandatory approvals required for occupation and completion of the project shall be obtained by the Contractor.

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 is to be followed by bidder.

3. CODES AND STANDARDS

Following is a general listing of Codes and Standards to be used. Specific applicable codes and standards shall be identified in 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:

3.1. 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.

3.2. 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.

3.3. Concrete

a) IS-269 : Specification for 33grade Ordinary portland cement.

b) IS-383 : Coarse and fine aggregate 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.

3.4. 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).

3.5. Loading

a) IS-875 : Code of practice for design loads (other than earthquake) for buildings and structures.

b) IRC : Indian Roads Congress Codes (With latest amendments)

3.6. 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 12894	:	Specification for Pulverized Fuel Ash-Lime Bricks

3.7. 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.

3.8. 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.

3.9. 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.

3.10. 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

3.11. 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.

3.12. 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.

3.13. 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).

3.14. 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.

3.15. 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.

3.16. 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.

3.17. a) Indian Road Congress (IRC) Bridge Codes
b) Indian Railway Standard Bridge Rules

3.18. Environmental Protection

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

4. DESIGN BASIS

General civil material specification for all RCC / Foundation works shall be as mentioned below:

Cement	Cement of the following Grades shall be used for all works. It shall conform to the following standards. All RCC works shall be with OPC Cement. For PCC, Plastering and other works, Portland - Pozzolana Cement IS 1489 (Parts 1 & 2) can be used.
Aggregate	Coarse aggregate - Shall confirm to latest IS 383. Fine aggregate - River sand / M-Sand can be used subject to confirmation of latest IS 383. However, quarry dust shall not be used for construction activities. Approval shall be obtained from NLCIL site in-charge for source of M-Sand.
Water	Potable water confirming to IS 456
Reinforcement	All reinforcement steel used shall confirm IS 1786 and shall minimum Grade Fe500. Binding wire for reinforcement shall be annealed steel wire 20 BWG conforming to IS: 280 “Specification for Mild Steel Wire”. The number of strands shall be as per BIS specification.
Bricks	Bricks shall conform to the requirements laid down in IS: 1077. Class 5 bricks shall be used for the work. Brickwork shall be as per IS: 2212.
Fly Ash Bricks	Fly ash lime bricks shall confirm to latest IS 12894

Minimum Grade of RCC work shall be M25 as per IS standards for all buildings/structures. For all water retaining structure, Minimum grade of RCC work shall be M30 as per IS standards.

The Contractor shall get mix design approved from Govt. Engineering College / NABL accredited laboratories. Advance action should be taken by the contractor for Mix design approval using the locally available coarse & fine aggregates, before commencement of the concreting works.

The buildings/structure shall be designed for loads and load combination as per Indian Standards (latest revisions)

i. **Dead load**: Dead loads shall be self-weight of all structural and nonstructural members as per latest IS 875, Part I

ii. **Live load** : Live loads shall be as per latest IS 875, Part II

iii. **Wind Load**: The wind load parameters shall be considered as per latest IS 875, Part-3.

iv. **Earthquake Load**: All structures shall be designed for Seismic forces for Zone III. Seismic parameters & Importance Factor shall be based on latest BIS: 1893(Part-1).

v. **Vertical Deflection & Horizontal Sway Limits**: The limiting permissible vertical and horizontal deflection for structural members shall be as per latest IS.

All the works shall be carried out as per the relevant I.S. Codes. The contractor has to carry out the work as per the approved drawings and as per the Engineer's instructions. All the material required for the work shall be as per IS specifications and approved by the Engineer.

RCC structures shall be designed based on limit state method of design as given in latest IS: 456 & ductility provision in detailing of RCC structures shall be considered based on latest IS: 13920 for Lateral force resisting elements or the structure.

All buildings shall be designed aesthetically considering the overall appearance and elevation.

The structural design along with STAAD file and detailed drawings of all buildings/structures shall be submitted to NLCIL for approval, before commencement of work.

5. DOCUMENT SUBMISSION

5.1. DRAWING SUBMISSION FOR APPROVAL

The Contractor shall submit the Master Drawing List (MDL) within 15 days from the date of issue of LOA by NLCIL. Categorization of the Drawings according to the priority for approval in line with the Project Time Schedule shall be done by assigning Target Date of first Submission. On approval of MDL, the Soft copy of individual Drawings / Design Calculations / Vendor Documents etc. prepared to meet the requirements of Specifications, safety and statutory regulations of the relevant authority, shall be uploaded, giving priority to the critical Drawings to the Central Contracts Management System (CCMS) Portal, for which access will be given by NLCIL. Further, one Hard Copy of the Drawing for each revision shall

be handed over to the NLCIL Engineering Department for review / return with comments / approval, till the Document is Approved. This review and / or approval of the drawings by NLCIL will not relieve the Contractor from any of his responsibilities under this contract. After approval of each Drawing, 6 Hard Copies shall be submitted for Stamping by NLCIL. Stamped hard copies shall be distributed as below.

- ✓ 2 copies to the Contractor
- ✓ 3 copies to NLCIL Site Engineers
- ✓ 1 copy for NLCIL Records.

5.2. AS-BUILT DRAWINGS AND DOCUMENTS

On completion of the project, '**As built Drawings'** shall be prepared after incorporating all the changes carried out during the execution. As built drawings shall be duly authenticated by contractor and NLCIL Site in-charge and shall be uploaded in CCMS. 1 set of stamped 'As built Drawings' in Hard Copy along with 3 sets of Soft Copies, each set stored in External Hard Drives of minimum 1 TB, shall be submitted.

5.3. CONSTRUCTION DOCUMENT

Based on approved design, detailed drawings for construction shall be prepared by the successful bidder.

- ✓ For reinforced concrete structures and foundations detailed bar bending schedules with approximate quantity involved (both reinforcement and concrete in grade wise) in approved format shall accompany each detailed drawing.
- ✓ For structural steel work the detailed drawing shall have schedule of structural members with approximate quantity of steel involved.

The successful bidder shall prepare detailed fabrication drawing along with bill of materials.

All detailed drawings/ fabrication drawings as decided by Engineer for all structures along with bar-bending schedule/bill of materials need be furnished to Owner at construction site for their review and approval before commencement of work.

5.4. EXECUTION:

The contractor has to carry out the work as per the approved drawings and as per the Engineer's instructions. All the material required for the work shall be as per IS specifications and approved by the Engineer.

5.5. LAYOUT

Before starting the work, the successful bidder shall carry out the setting out of foundation and structures and provide levels, with reference to general existing grid and benchmark. If the successful bidder uses the grid, benchmark and reference pillar made by other agencies, he shall coordinate with that Agency and shall satisfy himself of the accuracy of the reference marks. If he is required to set out the foundation afresh, he shall do so independently with reference to the one existing grid and benchmark, which has been followed by other agency at the instruction of the Engineer. In case any discrepancy is found, it shall be immediately brought to the notice of the Engineer for any rectification / modification necessary. No complaint shall be entertained at a later stage. The successful bidder shall accurately set out the position for holding down bolts and inserts.

If required, in the option of the Engineer, he shall construct and maintain pillars for grid, references and benchmarks and maintain them till the completion of the construction. He shall also help the Engineer with instruments, materials and labour for checking the detailed layouts and levels. The successful bidder shall be solely responsible for the correctness of the layout and levels, and Engineer's approval shall not be deemed to imply any warranty in carrying out the works correctly. The bidders shall take into account the cost of these in quoting their price.

5.6. WORKSMANSHIP

Workmanship shall be of the best possible quality and all work shall be carried out by skilled workmen except for those, which normally require unskilled persons. In case of manufactured materials, the successful bidder shall have, with no additional cost to the Owner, the services of the supervisors of the manufacturers to ensure that the work is being done according to the manufacturer’s specifications.

5.7. TEMPORARY WORK

All scaffoldings, staging, temporary bracing and other necessary temporary work required for proper execution of the Contract shall be provided by the successful bidder at his own cost and inclusive of all materials, labour, supervision and other facilities.

All temporary work shall be so constructed as not to interfere with any permanent work or with the work by other agencies. If it is necessary to remove any of the temporary work at any time to facilitate execution of the work or with the work of other agencies,

such removal and re-erection, if required, shall be carried out by the successful bidder at the direction of the Engineer without any delay and any extra cost on this account shall be borne by the successful bidder.

5.8. INTERFACE WITH STRUCTURES UNDER OTHER'S SCOPE

Modification in layout of foundation/structure during detail engineering stage may be necessary to avoid fouling with other structures. Necessary changes on this account shall be made by the bidder without any extra cost to Owner.

5.9. SEQUENCE OF WORK AND PROGRESS REPORT

The sequence in which the works are to be carried out shall be as approved by the Engineer in accordance with the construction method accepted by the Engineer and to be followed by the successful bidder. A programme of work is to be submitted for the Engineer's review and approval and this has to be periodically updated and modified as per actual progress to enable timely completion.

The successful bidder shall regularly submit to the Engineer progress reports for periods of working as specified by the Engineer showing up to date progress on all-important items of work.

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removal shall be performed in advance of earthwork operations and in accordance with the requirements of these specifications.

5.5.2. **Preservation of Property/Amenities**

All trees, shrubs, any other plants, pole lines, fences, signs, monuments, buildings, pipelines, sewers and all facilities within or adjacent to the work places which are not to be disturbed shall be protected from injury or damage. The Contractor shall provide and install at his own expense, suitable safeguards approved by the Engineer for this purpose. During clearing and grubbing, the Contractor shall take all adequate precautions against soil erosion, water pollution, etc., and where required, undertake additional works to that effect. Before start of operations, the Contractor shall submit to the Engineer for approval, his work plan including the procedure to be followed for disposal of waste materials, etc., and the schedules for carrying out temporary and permanent erosion control works.

5.5.3. **Methods, Tools and Equipments**

Only such methods, tools and equipment as are approved by the Engineer and which will not affect the property to be preserved shall be adopted for the Work. If the area has thick vegetation/roots/trees, a crawler or pneumatic tyred dozer of adequate capacity may be used for clearance purposes. The dozer shall have ripper attachments for removal of tree stumps. All trees, stumps, etc., falling within excavation and fill lines shall be cut to such depth below ground level that in no case these fall within 500 mm of the existing ground level. Also, all vegetation such as roots, under-growth, grass and other deleterious matter unsuitable for incorporation in the embankment/filling low level areas shall be removed between fill lines to the satisfaction of the Engineer.

All excavations below the general ground level arising out of the removal of trees, stumps, etc., shall be filled with suitable material and compacted thoroughly so as to make the surface at these points conform to the surrounding area.

Ant-hills both above and below the ground, as are liable to collapse and obstruct free subsoil water flow shall be removed and their workings, which may extend to several metres, shall be suitably treated.

5.5.4. **Disposal of Materials**

All materials arising from top soil removal operations shall be the property of NLCIL and shall be disposed of by the Contractor as hereinafter provided or directed by the Engineer. Also boulders, stones and other materials usable for construction shall be neatly stacked as directed by the Engineer. Stacking of stumps, boulders, stones etc., shall be done at specified spots with all lifts and up to a lead of 3KM.

All products of clearing and grubbing which, in the opinion of the Engineer, cannot be used or auctioned shall be cleared away from the site in a manner as directed by the

Engineer, Care shall be taken to see that unsuitable waste materials are disposed of in such a manner that there is no likelihood of these getting mixed up with the materials meant for embankment, filling works.

5.6. CONTROL OF ALIGNMENT, LEVEL AND SURFACE REGULARITY

All works performed shall conform to the lines, grades, and cross sections and dimensions shown on the drawings or as directed by the Engineer.

5.7. QUALITY CONTROL TESTS DURING CONSTRUCTION

5.7.1. General

The materials supplied and the works carried out by the Contractor shall conform to the specifications prescribed in the preceding Clauses. For ensuring the requisite quality of construction, the materials and works shall be subjected to quality control tests, as described hereinafter. The testing frequencies set forth are the desirable minimum and the Engineer shall have the full authority to carry out additional tests as frequently as he may deem necessary, to satisfy himself that the materials and works comply with the appropriate specifications.

5.7.2. Tests on Earthwork for Embankment, filling the low level areas.

5.7.2.1. **Borrow material:**

The following tests on representative samples of identified sources of materials shall be carried out:

(a) Grain size analysis [IS: 2720 (Part4)]: 2 tests per 10,000 cubic metres of soil,

(b) Moisture Content Test [IS: 2720 (Part-2)]: One test for every 10,000 cubic metres of soil.

(c) IS: 2720 Part-8- Heavy compaction test for each 10,000 cubic metres of soil.

5.7.2.2. Compaction Control: Control shall be exercised on each layer by taking

i. at least one measurement of density for each 1000 cubic metres of compacted soil,
ii. in areas where the degree of compaction is doubtful
iii. in areas where filling operation are concentrated, i.e., On the same day two or more layers are placed one over the other
iv. closer as required to yield the minimum number of test results for evaluating a day's work on statistical basis.

The determination of density shall be in accordance with IS: 2720(Part-28) or IS: 2720 (Part-29).Test locations shall be chosen only through random sampling techniques. Density can be also be determined using proctor compaction needle.

Control shall not be based on the result of anyone test but on the mean value of a set of 5-10 density determinations. The number of tests in one set of measurements shall be 6 (if non-destructive tests are carried out, the number of tests shall be doubled) as long as it is felt that sufficient control over borrow material and the method of compaction is

being exercised. If considerable variations are observed between individual density results, the minimum number of tests in one set of measurement shall be increased to 10. The acceptance criteria shall be subject to the condition that the mean density is not less than the specified density plus:

[1.65-(1.65/No.of samples^0.5)] times of standard deviation.

Test failures are to be immediately notified to the Owner 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.

5.7.3. WORKS TO BE KEPT FREE OF WATER

The Contractor shall arrange for the rapid dispersal of water collected/accumulated on the earthwork or completed formation during construction or on the existing roadway or which enters the earthwork or any other item of work from any source, and where practicable, the water shall be discharged into the permanent outfall of the drainage system. The arrangements shall be made in respect of all earthworks including excavation for pipe trenches, foundations or cuttings.

The Contractor shall provide, where - necessary, temporary water courses, ditches, drains, pumping or other means for maintaining the earthwork free from water. Such provisions shall include carrying out the work of forming the cut sections and embankments in such manner that their surfaces have at all times a sufficient minimum cross fall and, where practicable, a sufficient longitudinal gradient to enable them to shed water and prevent ponding. The works involved in keeping the earthwork or any other items of works free of water shall be deemed as incidental to the respective item of work and as such no separate payment shall be made for the some.

5.8. Excavation - General: All excavations shall be carried out in conformity with the directions laid here-in -under and in a manner approved by the Engineer. The work shall be so done that the suitable materials available from excavation are satisfactorily utilized as decided upon beforehand. While planning or executing excavations, the Contractor shall take all adequate precautions against soil erosion, water pollution etc. and take appropriate drainage measures to keep the site free of water.The excavations shall conform to the lines, grades, side slopes and levels shown on the drawings or as directed by the Engineer. The Contractor shall not excavate outside the limits of excavation, subject to the permitted tolerances, any excess depth/ width excavated beyond the specified levels/dimensions on the drawings shall be made good at the cost of the Contractor with suitable material of characteristics similar to that removed and compacted to the requirements. All debris and loose material on the slopes of cuttings shall be removed. No backfilling shall be allowed to obtain required slopes excepting that when boulders or soft

materials are encountered in cut slopes, these shall be excavated to approved depth on instructions of the Engineer and the resulting cavities filled with suitable material and thoroughly compacted in an approved manner.

After excavation, the surface area of site and the sides of excavated area shall be trimmed and the area graded to the specified level allowing for natural drainage to take place.

5.9. LABORATORY

The contractor shall set up the laboratory with at least the following equipments in order to carry out all required tests and quality control wok as per the specification and/or as directed by the engineer.

Description	Qty
Oven-(Electrically operated thermostatically controlled) IS:2720 (Part-5)	1No
Electronic Balance IS:2720 (Part-3)	2Nos
Set of IS Sieve with lid and pan i) 450mm diameter 75mm,63mm,53mm,37,5mm,26.5mm,19mm,13.2mm,9.5mm,6.7mm and 4.75mm size. ii) 200mm diameter 2.36mm,2.0mm,1.18mm,600micron,425mcron,300micron,150 micron and 75micron	1Set 2Sets
Dry Bulk Density apparatus (Sand pouring cylinder, tray, can etc.) complete. IS:2720 (Part-28)	1Set
Core Cutter apparatus 10cm dia,10/15 cm height, complete with dolly rammer etc. IS:2720 (Part-29)	1Set
Proctor needle to measure the penetration resistance	1Set
Desiccators with suitable desiccating agent.	1Set
All the apparatus required for determination of water content-dry density relation using heavy compaction. IS:2720 (Part-8)	1Set
All the apparatus required for determination of moisture content. IS:2720 (Part-2)	1Set
All the apparatus required for determination of density index (relative density) of cohesion less soil. IS:2720 (Part-14)	1Set

8.2. CISF COMPLEX

- ✓ CISF Barracks G+2 (1no) CISF Armoury and quarter guard, CISF security check post and toilet block shall be designed and constructed as per approved layout of power plant.
- ✓ Work involves design, engineering and construction of CISF Barracks G+2(01No), CISF Armoury and quarter guard, CISF security check post and toilet block including electrification, water supply, drainage & sewage arrangements wherever applicable.
- ✓ The necessary provisions as required for the construction of CISF Complex shall be adopted from the technical specification, joinery schedule and finishing schedule of the thermal office building.

S.No.	Building	Type	Units	Reference annexure drg No.
1	Armoury & Quarter Guard Office	Framed structure, GF only, RCC Flat roof	1	B15
2	Security Posts	Steel truss roof with Galvalume sheet, with 250 mm thick RCC wall	4	B17
3	RCC fencing	RCC wall with spiral fencing on Y Post	1	B16
4	Barbed Fencing	Precast Y type fence posts with spiral fencing	1	B21
5	Barracks Building	Framed structure, (G+2), RCC Flat roof	1	B14
6	Canteen Building	Steel truss roof with Galvalume for Dining with false ceiling, RCC Flat roof for remaining area	1	B19
7	Toilet Block	Steel truss roof with Galvalume sheet	1	B18
8	Steel Gate	4 m width	1	B20

8.2.1. TECHNICAL REQUIREMENT

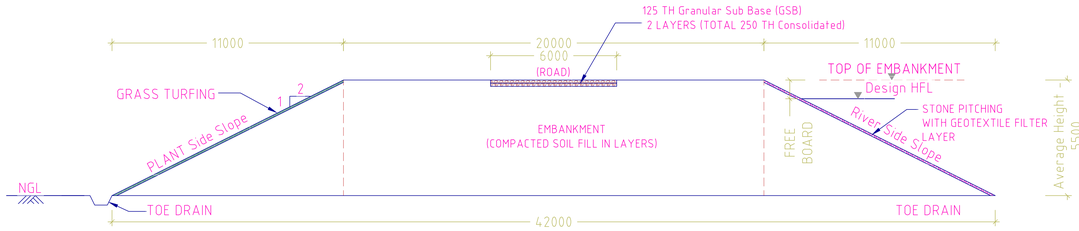
1. In Armoury and Quarter Guard Office building,

CHAPTER VI
DRAWINGS

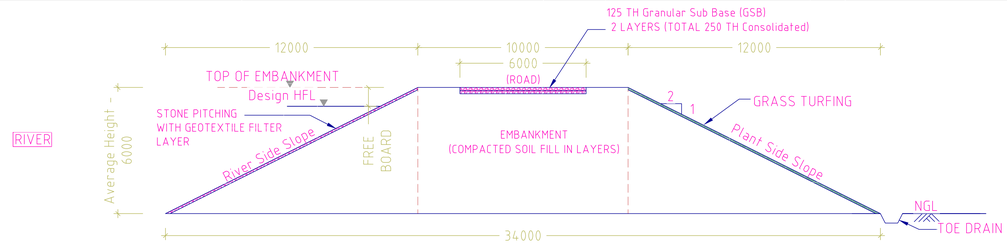
CONTENTS

DESCRIPTION	ANNEXURE DRG NOS
~~THERMAL POWER PLANT AREA~~	**~~B1 to B21~~**
INTEGRATED TALABIRA TOWNSHIP	**C1 to C28**

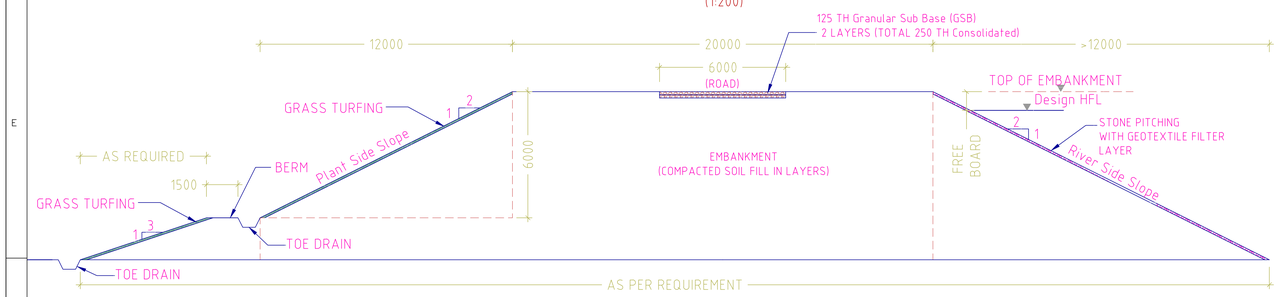
Annex drg No.	List of Annexure drawings
(B) THERMAL POWER PLANT AREA	
B1	Site grading layout
B2	Approach road c/s
B3	Compound wall
B4	Peripheral fencing
B5	Peripheral road c/s
B6	Bund cross section and layout
B7	Thermal Project Office
B8	Gate complex
B9	Security office
B10	Time office
B11	Two wheeler parking shed
B12	Four wheeler parking shed
B13	Watch tower
B14	CISF Barracks
B15	CISF Armoury guard
B16	CISF Armoury guard layout
B17	CISF Security check post
B18	CISF Toilet block
B19	CISF Canteen
B20	CISF Gate
B21	CISF fencing



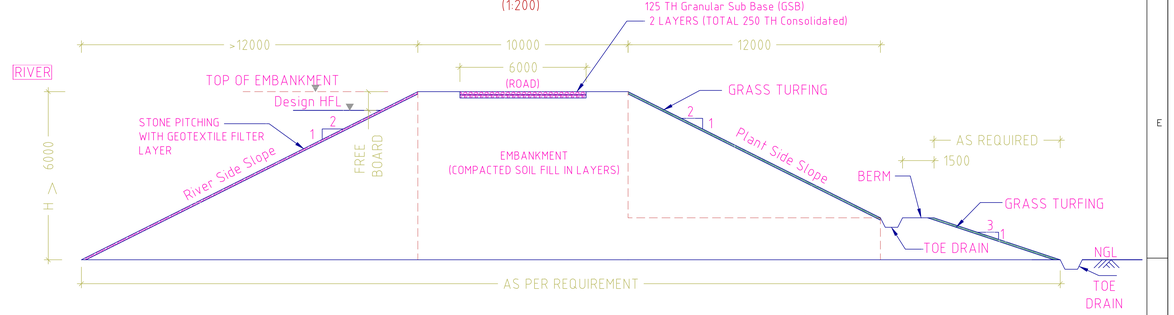
RIGHT BANK
(THERMAL SIDE)
(1:200)



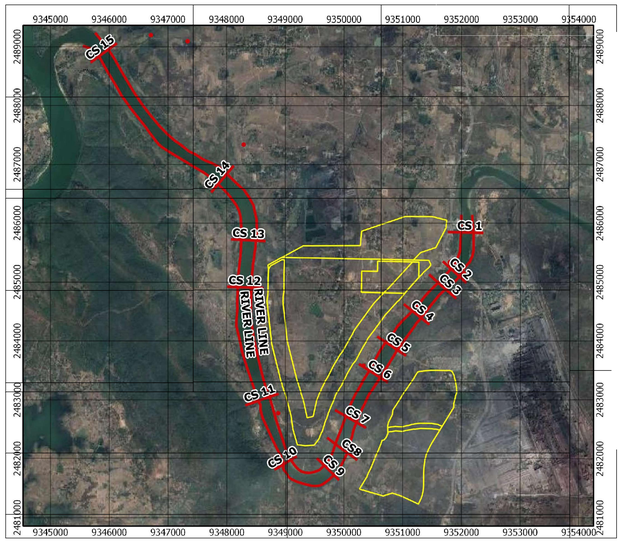
LEFT BANK
(ASH POND SIDE)
(1:200)



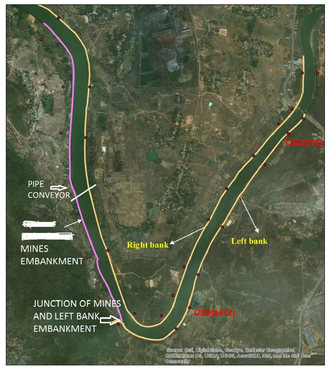
TYPICAL CROSS SECTION OF RIGHT BANK(THERMAL SIDE)
FOR (H > 6)
(1:200)



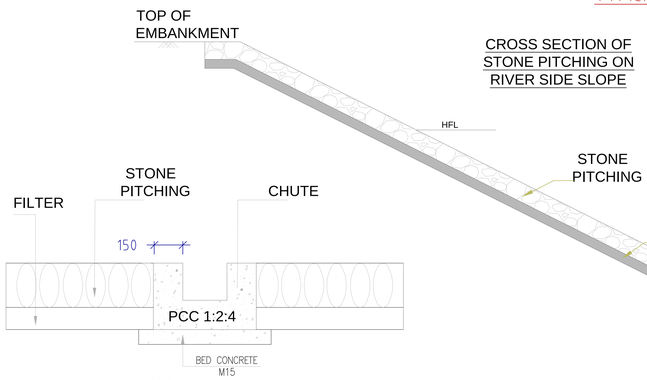
TYPICAL CROSS SECTION OF LEFT BANK (ASH POND SIDE)
FOR (H > 6)
(1:200)



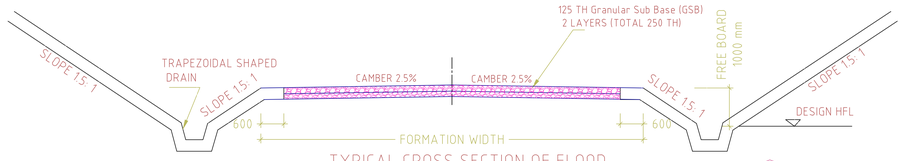
Location of river cross-section



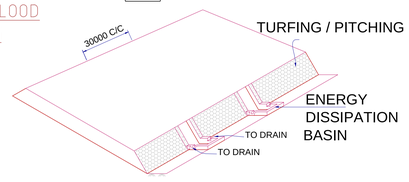
Alignment of proposed embankments over satellite images.

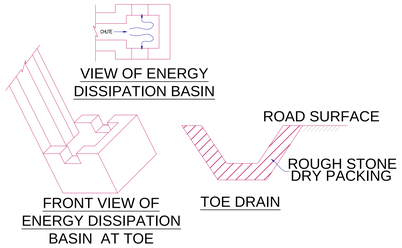


CROSS SECTION OF CHUTE



TYPICAL CROSS SECTION OF FLOOD
EMBANKMENT IN CUTTING





NOTE
1. ALL DIMENSIONS ARE IN mm & LEVEL IN metres.
2. HFL - HIGH FLOOD LEVEL.
3. MINIMUM FREE BOARD SHALL BE 1000mm.
4. RIGHT BANK(THERMAL SIDE) EMBANKMENT IS FROM CROSS SECTION -1 TO CROSS SECTION 15 COVERING A LENGTH OF 13KM(APPROX) AND AVERAGE BUND HEIGHT 5.5M
5. LEFT BANK (ASH POND SIDE) EMBANKMENT IS FROM CROSS SECTION -2 TO CROSS SECTION-10 COVERING A LENGTH OF 5KM (APPROX) AND AVERAGE BUND HEIGHT 6M.
6. LOCATION OF BERM IS 6 M FROM THE TOP OF EMBANKMENT.
7. ALL LENGTHS OF BUND GIVEN ARE INDICATIVE.
8. FOR BUND CONSTRUCTION, NECESSARY STATUTORY CLEARANCE SHALL BE OBTAINED FROM THE STATE GOVERNMENT/WRD WHICH UNDER THE EPC SCOPE.
9. THE BUND DESIGN BASIS, CALCULATIONS, SECTIONS AND EXECUTION DRAWINGS SHALL BE VETTED BY INSTITUTIONS LIKE IIT FOR CONSTRUCTION.
10. LEFT BANK CS-10 WITH E-808498.37 AND N-2408375.4 SHALL BE TAKEN AS APPROXIMATE JUNCTION COORDINATE BETWEEN MINES EMBANKMENT AND AND ASH POND SIDE EMBANKMENT.
11. AT THE JUNCTION OF MINES FLOOD PROTECTION BUND AND LEFT BANK ASH POND BUND PROPER OVERLAPPING KEY ARRANGEMENT SHALL BE MADE TO AVOID VERTICAL JOINT.
12. THE EMBANKMENT SHALL BE FORMED USING HOMOGENOUS SOIL AS FILL MATERIAL IN LAYERS AND WELL COMPACTED.
13. THE EMBANKMENT AND FILLING UP MATERIAL SHALL BE SPREAD IN LAYERS OF UNIFORM THICKNESS NOT EXCEEDING 200 MM LOOSE THICKNESS OVER THE ENTIRE WIDTH OF EMBANKMENT BY MECHANICAL MEANS, FINISHED BY A MOTOR GRADER AND COMPACTED AS PER TECHNICAL SPECIFICATION.
14. EACH LAYER OF FILL SHOULD BE THOROUGHLY COMPACTED BY VIBRATORY ROLLER TO AT LEAST 95% OF STANDARD PROCTOR DENSITY.
15. CAMBER SHALL BE 2.5% TOWARDS COUNTRY SIDE.
16. STONE PITCHING OVERLAID ON SAND LAYER AND WOVEN GEOTEXTILE FABRIC 120 GSM POLYESTER TO BE PROVIDED ON RIVER-SIDE
17. STONE PITCHING OVERLAID ON SAND LAYER AND WOVEN GEOTEXTILE FABRIC 120 GSM POLYESTER TO BE PROVIDED FOR 1 M WIDTH ON EITHER SIDE OF CHUTES IN PLANT SIDE.
18. CHUTES SHOULD BE MADE OF P.C.C. 1:2:4 LAID ON M15 CONCRETE BED @ 30 M C/C SPACING.
19. TOE DRAIN SHALL BE IN STONE MASONRY OR ROUGH STONE DRY MASONRY.
20. TURFING IN PLANT-SIDE SLOPE OF EMBANKMENT TO BE MADE AS PER IS 11532
21. ONE WAY SLUICE WITH REGULATING ARRANGEMENT ARE TO BE PROVIDED ON PLANT SIDE AND ASH POND SIDE TO DRAIN OUT WATER AT REQUIRED LOCATIONS
22. THE SIZE OF SLUICE SHALL BE BASED ON INTENSITY OF RAINFALL AND CATCHMENT AREA TO BE DRAINED.
23. REQUIRED VERTICAL CLEARANCE FOR SHALL BE MAINTAINED FOR VEHICLE MOVEMENT ON THERMAL SIDE EMBANKMENT AT PIPE CONVEYOR CROSSING BEDHAN RIVER FROM MINES TO THERMAL POWER PLANT.

Right Bank Water level with Embankment for 100year Return period

LOCATION (Chainage in m)	WATER LEVEL WITH EMBANKMENT	TOP OF EMBANKMENT	UTM Coordinates of Right bank	
			Easting	Northing
CS1(0)	203.5	204.5	811500	2412300
CS2(665)	203.5	204.5	811130.78	2411622
CS3(972)	203.1	204.1	810929.5	24114O1.8
CS4(1570)	202.9	203.9	810550.52	2410921.3
CS5(2208)	202.9	203.9	810139.98	2410425.7
CS6(2727)	202.5	203.5	809865.26	2409960.7
CS7(3529)	202.2	203.2	809496.91	2409245.6
CS8(4011)	202.2	203.2	809332.63	2408812.4
CS9(4412)	202.1	203.1	809154.97	2408511.3
CS10(5259)	201.6	202.6	808753	2408534.2
CS11(6328)	201.5	202.5	808345.22	24094.92
CS12(8126)	200.8	202	808014.8	2411197.3
CS13(8866)	200.6	202	808075.06	2411961.4
CS14(9952)	200	202	807599.6	2413001.6
CS15(12748)	200	202	806000	2414000

Left Bank Water level with Embankment for 100year Return period

LOCATION (Chainage in m)	WATER LEVEL WITH EMBANKMENT	TOP OF EMBANKMENT	UTM Coordinates of Left bank	
			Easting	Northing
CS2(665)	203.5	204.5	811300.72	2411477.8
CS3(972)	203.1	204.1	811070.5	2411261.3
CS4(1570)	202.9	203.9	810719.91	2410780.6
CS5(2208)	202.9	203.9	810360.57	2410269.7
CS6(2727)	202.5	203.5	810076.72	2409846.4
CS7(3529)	202.2	203.2	809708.96	2409124.3
CS8(4011)	202.2	203.2	809580.45	2408626.8
CS9(4412)	202.1	203.1	809376.44	2408308.3
CS10(5259)	201.6	202.6	808498.37	2408375.4

ANNEXURE DRG NO.
B06

PRELIMINARY DRAWING FOR
TENDER PURPOSE ONLY

	SIGNATURE	DATE
DRN BY	ESAKKIMUTHU.S.S	
GET/D		
DEE/D		
ADGM/D		
DGM/D		
DGM/C		

INDIA
CREATING WEALTH
FOR WELL BEING

NLC India Limited
(formerly Neyveli Lignite Corporation Limited)
('Navratna' - A Government of India Enterprise)
NEYVELI- 607 801,TAMIL NADU

OFFICE OF THE CHIEF GENERAL MANAGER / CIVIL / CTO

EMBANKMENT FOR
NTTPP

A2	SCALE: 1:200, 1:100	SECTIONS &DETAILS	DRG No: CGMC/ /2020

12/11/2020 S:\Design_Comments\ODISHA\2020\CTO WORKS IN EPC SCOPE\THERMAL EMBANKMENT\TENDER DRAWING\B6-Embankment -FINAL.dwg

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
JHARSUGUDA, ODISHA

TENDER SPECIFICATION

PACKAGE NAME	:	ENGINEERING, PROCUREMENT AND CONSTRUCTION
SPECIFICATION NUMBER	:	18A03-SPC-G-001
JOB NUMBER	:	DCPL-18A03
CLIENT	:	NLC INDIA LIMITED

VOLUME: II-A

LEAD SPECIFICATION

ISSUE	DATE	PREPARED	REVIEWED	APPROVED
FINAL	18.11..2020	A. DEY	K. MUKHERJEE	B. LAHIRI
FINAL DRAFT	14.11..2020	A. DEY	K. MUKHERJEE	B. LAHIRI
DRAFT	10.10.2020	A. DEY	K. MUKHERJEE	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

ENGINEERING, PROCUREMENT & CONSTRUCTION

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VOLUME-II : Technical Specification

VOLUME-III : Bid Proposal Sheets [Technical Part]

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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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SECTION-III	:	SPECIFIC DESIGN REQUIREMENTS - STRUCTURAL
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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)
SECTION-VII	:	NOT USED
SECTION-VIII	:	GUIDELINE FOR FABRICATION OF STRUCTURAL STEEL
SECTION- IX	:	GUIDELINE FOR ERECTION OF STRUCTURAL STEEL WORK
SECTION- X	:	GUIDELINE FOR ROADS AND DRAINAGE
SECTION-XI	:	NOT USED

VOLUME: II-G/2 / PART B

GUIDELINE FOR ARCHITECTURAL WORKS

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SECTION-II	:	GUIDELINE FOR ANTI-TERMITE TREATMENT
SECTION-III	:	GUIDELINE FOR MASONRY AND ALLIED WORK
SECTION-IV	:	GUIDELINE FOR FINISH TO MASONRY AND CONCRETE
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SECTION-VI	:	GUIDELINE FOR CARPENTRY AND JOINERY
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SECTION- XVI	:	GUIDELINE FOR SHEETING WORK IN ROOF AND SIDING
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SECTION-XVIII	:	GUIDELINE FOR DRAINAGE AND SANITATION
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SECTIONS **DESCRIPTION**

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SECTIONS		DESCRIPTION
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SECTIONS		DESCRIPTION
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SECTIONS		**DESCRIPTION**
SECTION-I	:	EFFLUENT TREATMENT PLANT
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SECTION-I

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-II

QUALIFYING REQUIREMENTS – TECHNICAL

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SECTION-II

QUALIFYING REQUIREMENTS - TECHNICAL

1.00.00 PRIME BIDDER

For qualifying requirements of Prime Bidder, please refer Volume- I of this specification.

2.00.00 MAINPLANT PROVENNESS CRITERIA

2.01.00 PROVENNESS OF TURBINE SET

a) The turbine set offered shall be built up using proven design modules of HP, IP (or Combined HP-IP, if applicable) and LP turbines of the Foreign / Indian Qualified Steam Turbine Manufacturer*. The offered HP turbine module should have been in successful operation with Super critical pressure and Main steam temperature of 593 deg C or higher for a period of not less than one (1) year as on the date of Tender opening. The offered IP turbine module should have been in successful operation with Reheat steam temperature of 593 deg C or higher for a period of not less than one (1) year as on the date of Tender opening. In case Combined HP-IP turbine module is offered it shall meet the respective requirements of HP turbine and IP turbine modules as above. The offered LP turbine module should have been in successful operation for a period of not less than one (1) year as on the date of Tender opening. The Bidder shall furnish experience list of HP, IP (or Combined HP-IP) and LP turbine modules offered to substantiate their provenness along with the techno commercial Bid as per the format enclosed in **Annexure I** of this Section.

b) The turbine to be supplied under this Contract shall be manufactured, assembled and tested in a factory where **turbines** of at least 500MW rating have been manufactured in the past. Alternatively the same can also be manufactured in the Indian Manufacturing Company under supervision of Qualified Steam Turbine * Manufacturer.

Note : * The Qualified Steam Turbine Manufacturer means

a) The Indian Qualified Steam Turbine Generator Manufacturer.

OR

b) Foreign Qualified Steam Turbine Manufacturer, with whom the Bidder / Associate is having the Technology **Transfer** Agreement OR with whose technology, support and strength, the Bidder / Associate/ Indian Qualified Steam Turbine Generator Manufacturer have acquired technology for Supercritical Steam Turbine.

2.02.00 **PROVENNESS OF GENERATOR**

a) The generator offered shall be of proven design of the Qualified Generator Manufacturer*, of 800 MW or above rating, which is in successful operation for a minimum period of one (1) year as on the date of Tender opening.

b) The offered generator shall be similar in design and construction to the above proven generator in respect of:

1). Cooling medium (e.g. water, Hydrogen etc.) and number of shaft mounted fans.

2). Thermal Class of Insulation for stator and rotor windings.

3). Core support system (e.g. spring type, rigid type etc.)

4). Type of Excitation system.

c) The generator to be supplied under this contract shall be manufactured, assembled and tested in a factory where generator of at least 500 MW rating have been manufactured in the past. Alternatively the same can also be manufactured in the Indian Manufacturing Company under supervision of Qualified Generator Manufacturer*.

The Bidder shall furnish experience list for offered Generator to substantiate it's provenness along with the techno commercial Bid as per the format enclosed in **Annexure II** of this Section.

Note : * The Qualified Generator Manufacturer means the

a) Indian Qualified Steam Turbine Generator Manufacturer

OR

b) Qualified Generator Manufacturer with whom the Bidder / Associate is having the Technology Transfer Agreement OR with whose technology, support and strength , the Bidder / Associate / Indian Qualified Steam Turbine Generator Manufacturer have acquired technology for the Generator of the rating specified.

3.00.00 QUALIFYING REQUIREMENTS FOR SUB-CONTRACTORS

This section details Qualifying Requirements (QR) for the sub-Contractors of Flue Gas Desulphurisation (FGD) System and various sub-packages of BOP for selection of sub-Contractor. For the purpose of qualification of Bidders / Sub-vendor(s), experience shall be reckoned as on the date of consideration for approval but not later than one year after award date of EPC package unless otherwise specified in the respective clauses.

3.01.00 **General**

The Bidder shall comply with the following criteria for selection of Sub – Contractor:

a) The Contractor having qualified on EPC basis, can engage the sub-Contractors, as required, who satisfy the QR stipulated in 3.02.00 below.

(b) The Sub Contractor shall be a company incorporated in India under the Companies Act of India unless otherwise specified in the respective Qualifying Requirement.

(c) Sourcing of equipment / systems by the Bidder / Sub- Contractor shall be as per Volume- II A , Section- XIV.

3.02.00 Qualifying Requirements

3.02.01 **Coal Handling System**

Bidder /Sub-Contractor should have executed one number integrated bulk material handling plant of minimum 2000 TPH of coal, other minerals or cement of equivalent volumetric capacity (essentially comprising of conveying and crushing) including mechanical and electrical works involving design, manufacture / procurement, supply, erection, testing & commissioning which has been commissioned during the last ten years, which should have completed satisfactory operation for a period of not less than one year as on date of LOA.

OR

Bidder / Sub-Contractor who has only conveying experience of any material should have collaborated with design agency having experience of designing the conveying plus crushing plant of required capacity for coal or equivalent volumetric capacity for other minerals during last ten years and whose designed plant should have completed satisfactory operation for a period of not less than one year as on date of LOA.

3.02.02 **Ash Handling System**

Bidder / Sub-Contractor should have executed at least one number ash handling plant/system during last ten years involving design, engineering, manufacture / procurement, supply, erection and commissioning of the following system which should have completed satisfactory operation for a period of not less than one year as on date of LOA.

i) Pneumatic Fly Ash handling system for conveying fly ash from ESPs to silos through ISH/Buffer hoppers shall be combination of Vacuum cum Pressure conveying system. For each Unit, the vacuum conveying ash evacuation capacity per stream from ESPs to ISH/Buffer hoppers shall be minimum 60TPH or more and the Pneumatic pressure conveying (transportation) system for transporting

fly ash from ISH/Buffer hoppers to silos shall be having a minimum capacity of 60TPH per stream for a conveying distance not less than 500m including fly ash storage Silos.

ii) The Bidder should have designed Bottom ash handling system comprising jet pump system in conjunction with water impounded bottom ash hopper designed for 30TPH capacity (dry ash basis) or more for pulverized coal fired boilers.

iii) The bidder should have designed High Concentration Slurry Disposal system (HCSD) for a capacity of 80TPH which includes HCSD piston diaphragm pumps, mixing tank, Ash Retention Tank, charge pumps, garlanding of ash dyke, etc.

iv) The Bidder should have designed Dewatering bin system for a 210MW capacity coal fired boiler which includes dewatering bin, sedimentation tank and surge tank for separating ash & water from the slurry of Bottom ash hopper and coarse ash tank.

3.02.03 **IDCT:**

Bidder / Sub-Contractor should have designed, engineered, constructed and commissioned/supervised commissioning of at least one number Induced draught cooling tower of RCC construction during last fifteen years as on the original date of Tender Opening , with cooling water flow not less than 40,000 m^3/hr for a thermal power plant which should have completed satisfactory operation for a period of not less than one year as on the date of original date of Tender Opening.

3.02.04 **RCC Chimney**

The Bidder / Sub-Contractor should have designed, engineered, constructed and commissioned/supervised commissioning of at least one number RCC Steel flue can chimney for at least 150 m height with slip-form shuttering for a thermal power plant during last seven years as on the date of original date of Tender Opening and the chimney should have completed satisfactory operation for a period of not less than one year as on the date of original date of Tender Opening .

3.02.04a Raw water reservoir and Ash dyke:

The Bidder may engage one or more Civil Sub-Contractor for constructing the Raw Water Reservoir and / or Ash Dyke. The Civil Sub-Contractor should have designed, engineered, constructed and commissioned/supervised commissioning of at least one number Water Retaining Structure like a Earthen Water Reservoir or an Earthen Ash dyke with a minimum Holding capacity of 15 lakh cum or more during the last seven years as on original date of Tender Opening and Water Reservoir or an Ash dyke should have completed satisfactory operation for a period of not less than one year as on date original date of Tender Opening .

Alternatively if the Main Bidder desires to do the design and engineering through themselves or through Main Bidder's Civil Consultant, the Civil Construction Sub contractor should have constructed and commissioned/supervised commissioning of at least one number Water Retaining Structure like a Earthen Water Reservoir or an Earthen Ash dyke with a minimum Holding capacity of 15 lakh cum or more. In this case, the credentials of the Civil construction sub-contractor should meet the QR stipulated in the above para except design & engineering only.

3.02.04b RCC Bridge across Bedhan River (2 Bridges):

The Bidder may engage one or more Civil Sub-Contractor for constructing the RCC Multi Span Bridge across Bedhan River. The Civil Sub-Contractor should have designed, engineered, constructed and commissioned /supervised commissioning of at least one number RCC Multi Span Bridge across a River/Water Body with a minimum length of 100 M or more during the last seven years as on the original date of Tender Opening and RCC Multi Span Bridge across the River should have completed satisfactory operation of traffic for a period of not less than one year as on the original date of Tender Opening.

Alternatively if the Main Bidder desires to do the design and engineering through themselves or through Main Bidder's Civil Consultant, the Civil Construction Sub-contractor should have constructed and commissioned/supervised commissioning of at least one number RCC Multi Span Bridge across a River/Water Body with a minimum length of 100 M or more during the last seven years as on the original date of Tender Opening. In this case, the credentials of the Civil construction sub-contractor should meet the QR stipulated in the above para except design & engineering only.

3.02.05 **765 kV & 400 kV GIS Switchyard**

(i) The Bidder/Sub-contractor should have designed, manufactured, supplied, erected and commissioned minimum three (3) Gas Insulated Switchgear (GIS) installation having at least six (6) bays of 765kV or more voltage class with short circuit current of not less than 50 kA for 1 second, which should have been in successful operation for minimum two (2) years as on date of LOA.

AND

(ii) The above Bidder/Sub-contractor should have established manufacturing facilities in India and all the GIS bays shall be supplied from the Indian manufacturing facility.

3.02.06 **DM Plant (Ion Exchange based)**

Bidder / Sub-Contractor should have designed, supplied, erected and commissioned during last ten years at least one number Ion Exchange based DM plant of minimum capacity of 65 m^3/hr which should have completed satisfactory operation for a period of not less than one year as on date of LOA.

3.02.07 **Circulating Water System**

The Bidder / Sub-Contractor should have designed / engineered, erected / supervised erection and commissioned / supervised commissioning of at least one no Circulating Water System of capacity 40,000 m3/hr or more, comprising at least the CW pump house with Concrete Volute Pumps, its fore bay and CW supply / return piping during last fifteen years which should have completed satisfactory operation for a period of not less than one year as on date of LOA.

.Bidder / Sub Contractor shall source the Concrete Volute Pumps only from the approved sub-vendor(s) as stipulated elsewhere in the specification.

3.02.08 **Fire Protection System**

The Bidder / sub-Contractor should have designed, supplied, installed, erected and commissioned atleast one number of Fire Protection System consisting of the types described in a, b c, d & e below, in Thermal power Plants/ Refineries/ Fertiliser plants, or other industrial/ commercial installations and such system should have been designed to the recommendations of Tariff Advisory Committee (TAC) /NFPA/FM/OISD/Equivalent and be in successful operation for a period of not less than One year as on date of LOA

a) Hydrant type Fire Protection System comprising of steel water tanks, Fire Pumps, pipe work, Hydrant valves, Deluge valve, Water Monitor and all other accessories

b) Automatic high / medium velocity water spray fire protection system.

c) Fire detection and alarm system comprising smoke and heat detectors and fire alarm panel.

d) Foam system

e) Inert gas system

For the purpose of meeting a, b, c,d & e above, if the individual system of hydrants, sprayers system, fire detection and alarm system, foam system, inert gas system have been commissioned in different Thermal power stations/ Refineries / Fertilizer plants or other industrial / commercial installations, it will be considered as a complete Fire protection system.

3.02.09 **Interplant Communication**

The Bidder / sub-contractor should have supplied and commissioned at least one no. Telephone Exchange (Digital EPABX) of 200 lines or more within the last 5 years and the system should have been in satisfactory operation for a minimum period of one year as on date of LOA.

3.02.10 **Roof Top Solar Power System**

The Bidder / Sub - Contractor should have experience of, supplied, erected and commissioned Roof top Solar photovoltaic grid connected power plants of cumulative installed capacity of 500 KW or more capacity, out of which at least one plant should have been of 200 KW capacity or above. The reference plant of 200 KW or above capacity must have been in successful operation for at least one year as on date of LOA

3.02.11 **Civil & Structural Works**

The Main Contractor may engage one or more sub-contractor for carrying out civil & Structural works. However, the Civil & Structural sub-Contractor shall have the following qualifying requirements.

a) Civil works(except construction of Chimney :

i) Bidder / Sub - Contractor shall have experience in carrying out civil engineering works for Industrial buildings / equipment foundations / high-rise buildings (three storied and more) etc.

ii) Bidder / Sub - Contractor should have executed not less than 20,000 m^3 of R.C.C work in a single agreement in a year.

iii) The work in Sl.No. i) & ii) should have been completed within the past seven (7) years, as on date of LOA.

iv) Bidder to furnish necessary fool proof crystal clear documentary evidence without any ambiguity and interpretation to prove the above requirements and get approval from the Owner, prior to engaging them for civil works.

b) Structural steel works(for buildings and structures under the scope of civil as specified in Volume II G/ 1 & G/2):

- **For structural steel fabrication works:**

i) Bidder / Sub - Contractor shall have experience in carrying out structural fabrication works for Industrial buildings/ Power plant structures / high-rise buildings etc.

ii) Any structural steel fabrication works of quantity not less than 2500 MT in a single agreement in a year.

iii) The work in Sl.Nos.i) & ii) should have been completed within the past seven (7) years, as on date of LOA.

iv) Bidder to furnish necessary fool proof crystal clear documentary evidence without any ambiguity and interpretation to prove the above requirements and get approval from the Owner, prior to engaging them for structural fabrication works.

- **For Structural steel Erection Works:**

  i) Bidder / Sub - Contractor shall have experience in carrying out structural steel erection works for Industrial buildings / Power plant structures / high-rise buildings etc.

  ii) Any structural steel erection works of quantity not less than 2500 MT in a single agreement in a year.

  iii) The work in Sl.No.i) & ii) should have been completed within the past seven (7) years, as on date of LOA.

  Bidder to furnish necessary fool proof crystal clear documentary evidence without any ambiguity and interpretation to prove the above requirements and get approval from the Owner, prior to engaging them for structural erection works.

3.02.12 **Sewage Treatment Plant**

The Bidder /Sub-Contractor should have supplied, erected and commissioned a Sewage Treatment Plant based on FAB/MBBR technology during the last ten years with a minimum capacity of 1 cum/hour and the plant should have been in successful operation for at least one year as on date of LOA.

3.02.13 **Effluent Treatment Plant**

The Bidder /Sub- Contractor should have designed , supplied, erected and commissioned during the last ten years at least one number sea water reverse osmosis plant with a permeate water capacity of minimum 30 m^3 / hour. which should have been in successful operation for a period of not less than one year as on date of LOA..

3.02.14 **Flue Gas Desulphurisation system**

Bidder or Bidder's sub-vendor shall be a company incorporated in India under the Companies Act of India and shall meet the qualifying requirements stipulated in any one of the qualifying routes i.e Route-1 or Route-2 or Route-3 or Route-4 including requirements stipulated in sub clauses of the respective Route.

3.02.14.1 **Route 1: Qualified Wet Limestone based Flue Gas Desulphurisation (FGD) System Manufacturer (QFGDM)**

The Bidder or Bidder's sub-vendor should have designed, engineered, manufactured / got manufactured, supplied, erected / supervised erection, commissioned / supervised commissioning of at least one (1) number of Wet Limestone based Flue Gas Desulphurisation System, having flue gas treatment capacity of not less than 20,00,000 Nm3/hr, with desulphurisation efficiency of at least 90% operating in a pulverised coal fired power plant. The above wet limestone based Flue Gas Desulphurisation system should have completed successful operation for a period of not less than one (1) year..

3.02.14.2 **Route 2: Wet Limestone based Flue Gas Desulphurisation System Manufacturer with Collaboration and Technology Transfer Agreement with QFGDM**

The Bidder or Bidder's sub vendor should have designed, engineered, manufactured / got manufactured, supplied, erected/ supervised erection, commissioned/ supervised commissioning of at least one (1) number of Wet Limestone based Flue Gas Desulphurisation System, having flue gas treatment capacity of not less than 6,00,000 Nm3/hr, with desulphurisation efficiency of at least 85% operating in a pulverised coal fired power plant. The above wet limestone based Flue Gas Desulphurisation system should have completed successful operation for a period of not less than one (1) year.

In such a case, the Bidder or Bidder's sub-vendor should have a valid ongoing collaboration and technology transfer agreement with a QFGDM meeting requirements of clause 3.02.14.1 on its own, valid minimum up to the end of the warranty period of the contract. Such Bidder or Bidder's sub vendor can either source the FGD System from the QFGDM or manufacture/get manufactured the FGD System as per the design and manufacturing drawings of such QFGDM.

The Bidder or Bidder's sub vendor shall furnish a Letter of support from the QFGDM for successful performance of the FGD System valid minimum upto the end of the warranty period of the contract as per format enclosed with the tender documents, before the placement of order for FGD system.

3.02.14.3 **Route 3: Steam Generator Manufacturer / Indian JV company of Steam Generator manufacturer or QFGDM/ Indian Subsidiary company of Steam Generator manufacturer or QFGDM with Collaboration and Technology Transfer Agreement with QFGDM**

3.02.14.3.1 Bidder or Bidder's sub vendor should have designed engineered, manufactured / got manufactured, supplied, erected / supervised erection and commissioned / supervised commissioning of atleast one (1) no. of pulverised coal fired steam generator for 200 MW or higher capacity unit or having minimum 600T/hr steaming capacity. Further, such Steam Generator should have completed successful operation for a period not less than one (1) year.

Alternatively

3.02.14.3.2 The Bidder or Bidder's sub vendor shall be a Joint Venture (JV) Company incorporated in India under the Companies Act of India, as on the original scheduled date of Bid opening, promoted by (i) an Indian Company registered in India under the Companies Act of India and (ii) a Steam Generator Manufacturer meeting requirements of clause 3.02.14.3.1 or a QFGDM meeting requirements of Clause 3.02.14.1, created for the purpose of manufacturing/supplying in India steam generator sets/Flue Gas Desulphurisation System. The Steam Generator Manufacturer/QFGDM shall maintain a minimum equity participation of 26% in the JV Company for a lock-in period of 7 years from the date of incorporation of JV Company and one of the promoters shall be a majority stakeholder who shall maintain a minimum

equity participation of 51% in the JV Company for a lock in period of 7 years from the date of incorporation of JV Company or up to the end of warranty period of the contract, whichever is later. Further, Bidder or Bidder's sub vendor should have executed any project(s)/order(s) pertaining to Steam generator sets/Flue Gas Desulphurisation System, during the last five (5) years, with the total value of such project(s)/order(s) being INR 500 Crore or more.

Alternatively

3.02.14.3.3 The Bidder or Bidder's sub vendor shall be an Indian Subsidiary Company of a Steam Generator Manufacturer meeting requirements of clause 3.02.14.3.1 or an Indian Subsidiary Company of a QFGDM meeting requirements of clause 3.02.14.1, registered in India under the Companies Act of India, as on the original schedule date of Bid opening, for manufacturing/supply of Steam Generator sets/Flue Gas Desulphurisation System. The subsidiary Company shall remain a subsidiary company of the Steam Generator Manufacturer/QFGDM for a minimum period of 7 years from the date of incorporation of such Subsidiary Company or up to the end of warranty period of the contract, whichever is later. Further, Bidder or Bidder's sub vendor should have executed any project(s)/order(s) pertaining to Steam generator sets/Flue Gas Desulphurisation System, during the last 5 years, with the total value of such project(s)/order(s) being INR 500 Crore or more.

3.02.14.3.4 In such a case, the Bidder or Bidder's sub vendor (3.02.14.3.1, 3.02.14.3.2 & 3.02.14.3.3) should have a valid ongoing collaboration and technology transfer agreement with a QFGDM meeting requirements of clause 3.02.14.1 on its own, valid minimum up to the end of the warranty period of the contract. Such Bidder or Bidder's sub vendor can either source the FGD System from such manufacturer or manufacture/get manufactured the FGD System as per the design and manufacturing drawings of such QFGDM.

The Bidder or Bidder's sub vendor shall furnish a Letter of support from the QFGDM for successful performance of the FGD System valid minimum upto the end of the warranty period of the contract as per format enclosed with the tender documents.

3.02.14.4 **Route 4: EPC Organization with Collaboration and Technology Transfer Agreement with QFGDM**

The Bidder or Bidder's sub vendor should be an Engineering, Procurement and Construction (EPC) organization and should have executed, in the last 10 years, large industrial projects on an EPC basis (with or without civil works) in the area of power, steel, oil & gas, petro-chemical, fertilizer, Flue Gas Desulphurisation and / or any other process industry with the total value of such projects being INR 500 Crore or more. At least one of such projects (in single or multiple contracts) should have a total contract value of INR 200 Crore or more. Such project(s) should have completed successful operation for a period of not less than one (1) year.

In such a case, the Bidder or Bidder's sub vendor should have a valid ongoing collaboration and technology transfer agreement with a QFGDM

meeting requirements of clause 3.02.14.1 on its own, valid minimum up to the end of the warranty period of the contract. Such Bidder or Bidder's sub vendor can either source the FGD System from such manufacturer or manufacture/get manufactured the FGD System as per the design and manufacturing drawings of such QFGDM.

The Bidder or Bidder's sub vendor shall furnish a Letter of support from the QFGDM for successful performance of the FGD System valid minimum upto the end of the warranty period of the contract as per format enclosed with the tender documents.

Notes for QR clause 3.02.14:

1) **Definitions**

(i) "QFGDM" (Qualified Wet Limestone based Flue Gas Desulphurisation System Manufacturer) means a manufacturer meeting requirements stipulated at 3.02.14.1.

(ii) Whenever the term 'coal fired' is appearing above, "Coal" shall be deemed to also include bituminous coal/brown coal/ anthracite coal.

(iii) "Flue Gas Desulphurisation System" or "FGD System" wherever appearing above shall mean consisting of at least Absorber System.

(iv) The word "executed" in Clause 3.02.14.3.2 / Clause 3.02.14.3.3 means the Bidder or Bidder's sub vendor should have:

- In case of Project(s), commissioned the project(s) specified in the Clause 3.02.14.3.2 / Clause 3.02.14.3.3 even if the contract has been started earlier and / or is not completed / closed.

- In case of Order(s), completed the scope of work under the order(s) specified in the Clause 3.02.14.3.2 /Clause 3.02.14.3.3 even if the contract has been started earlier and / or is not closed.

2) **Erection/Commissioning**

Where erection / supervision of erection and commissioning / supervision of commissioning has not been in the scope of the Bidder or Bidder's sub vendor as mentioned in clause 3.02.14.1, 3.02.14.2 & 3.02.14.3.1, the Bidder or Bidder's sub vendor should have acted as an advisor for erection and commissioning. Necessary documents / certificates from the client, in support of above shall be furnished.

3) **Direct / Indirect order**

The Bidder or Bidder's sub vendor / QFGDM shall also be considered qualified, in case the award for executing the reference works has been received by the Bidder or Bidder's sub vendor / QFGDM either directly from owner of plant or any other intermediary organization. However, a certificate from such owner of plant or any other intermediary organisation shall be required to be furnished by the Bidder or Bidder's sub vendor in support of the Bidder's or Bidder's sub vendor's / QFGDM's claim of meeting the qualification requirement as per clause 3.02.14.1, 3.02.14.2, 3.02.14.3 & 3.02.14.4 above. Further, certificate from owner of the plant shall also be furnished by the Bidder or Bidder's sub vendor for the successful operation as specified at clause 3.02.14.1, 3.02.14.2, 3.02.14.3 & 3.02.14.4 above.

4) **Holding Company as a Qualified Wet Limestone based Flue Gas Desulphurisation system Manufacturer**

A Holding Company, singularly or collectively along with its Subsidiaries (held either directly or indirectly), meeting the requirements of clause 3.02.14.1 above shall also be considered as QFGDM.

5) **Technology Transfer Agreement (Applicable for Clause 3.02.14.2, 3.02.14.3.1, 3.02.14.3.2, 3.02.14.3.3 & 3.02.14.4)**

The Bidder or Bidder's sub vendor shall have a technology transfer agreement before the placement of order for FGD system, between the Bidder or Bidder's sub vendor & QFGDM which shall necessarily cover transfer of technological know-how for Wet Limestone based Flue Gas Desulphurisation System, in the form of complete transfer of design dossier, design softwares, drawings and documentation, quality system manuals and imparting relevant personnel training to the Bidder or Bidder's sub vendor.

6) **Equity Lock in period**

Wherever equity lock in period requirement or subsidiary status requirement is indicated, the Bidder or Bidder's sub vendor would be required to furnish a Letter of Undertaking from the promoter(s), supported by Board Resolution as per the format enclosed in the tender documents, for maintaining the required minimum equity for the specified lock in period, before the placement of order for FGD system.

3.02.15 **Hydrogen Generation Plant**

The Bidder /Sub-Contractor should have supplied, erected / supervised erection and commissioned / supervised commissioning a Hydrogen Generation Plant based on Proton Exchange Membrane (PEM) technology during the last ten years with a minimum capacity of 8 Nm^3 /hour and the

plant should have been in successful operation for at least one year as on date of LOA.

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3.02.16 **Sub-contractor for Erection Works**

In case the Bidder / sub-Contractor wants to engage any Erection Contractor, such sub-contractor for erection of the particular sub package shall satisfy the following Qualification Requirement.

(i) **For Mechanical works:**

Bidder to furnish documentary evidence to prove that similar mechanical erection as the case may be and installation work in 500MW unit capacity or above had been carried out by the Sub-contractor.

(ii) **For Electrical works:**

Bidder to furnish documentary evidence to prove that similar electrical erection as the case may be and installation work had been carried out by the Sub-contractor.

(iii) **For Control and Instrumentation items:**

In case the main Contractor is engaging a sub-contractor for C&I works, Documentation proof shall be furnished in the form of Bid award copy of C&I erection & installation activities along with Commissioning /handing over protocols mentioning the project name from end user/main Contractor/DCS Vendor for minimum 500 MW or above capacity power plant.

3.02.17 **Make in India**

The Bidder shall ensure compliance to Ministry of Power (MOP) Order No.11/05/2018-Coord, dt:28/07/2020 & 17/09/2020 , as per Department for Promotion of Industry and Internal Trade (formerly, Department of Industry Policy and Promotion), Ministry of Commerce and Industry, Government of India, Public Procurement (Preference to Make in India) Order 2017 – Revision; Dt: 16.09.2020 for purchase preference (linked with local content) in respect of Power sector, and subsequent amendments (if any), while sourcing of equipment from Sub Vendors.

The Bidder shall ensure compliance to Guidelines regarding Bidder / Supplier /Service Provider from Border Sharing Countries with reference to Department of Expenditure Order (Public Procurement No.: 1 & 2), Order No. 6/18/2019-PPD, Dt: 23.07.2020 and further orders (if any).

The bidder shall ensure compliance to Ministry of Power Order 25-11/6/2018-PG, dated.02.07.2020 to protect the security, integrity and reliability of the strategically important and critical Power Supply System & Network in the country.

Annexure I

EPC PACKAGE FOR NLC Talabira THERMAL POWER PROJECT, (3 X 800 MW)
BIDDING DOCUMENT NO. : ……
(Experience Details - Applicable to all the Bidders)

Bidder's Name and Address :

To
NLC India Limited,
Neyveli.

Details of Provenness for the offered Steam Turbine as per Clause No. 2.01.00, Section-II Vol-II A of Bidding Documents.

Sl.No	Item Description	Plant Name	Module No.	Operating Steam Parameters (MS Pressure, MS Temp & RH Steam Temp)	Date of Commencement of Successful operation	Offered Module Same as Reference Module ? Bidder to Confirm (Yes /No)
1.	Provenness of HP Turbine Module					
2.	Provenness of IP Turbine Module					
3.	Provenness of Combined HP and IP Turbine Module (if applicable)					
4.	Provenness of LP Turbine(s) Module					

Certified that the offered Steam Turbine Set shall be built up using above proven HP, IP and LP turbine modules of M/s..... (Name of Steam Turbine Manufacturer). The Turbine to be supplied under this contract shall be manufactured assembled and tested at ..... (Name of the Factory) where turbine of at least 500 MW rating have been manufactured in past/the Indian manufacturing company under supervision of ..... (Qualified Steam Turbine Manufacturer).

Certificate(s) from Owner that the aforesaid Steam Turbine Modules are in successful operation for atleast one (1) year as on the date of Tender opening and caused no serious problem in past, are furnished along with techno-commercial Bid at Annexure.. to this **Attachment-**.....

Date :

Place :

Signature……..

Printed Name …….

Designation ……

Common Seal ……

Annexure II

EPC PACKAGE FOR NLC Talabira THERMAL POWER PROJECT, (3 X 800 MW)
BIDDING DOCUMENT NO. : ……
(Experience Details - Applicable to all the Bidders)

Details of Provenness for the offered Generator as per Clause No. 2.02.00, Section-II Vol-IIA of Bidding Documents.

Bidder's Name and Address :		To NLC India Limited, Neyveli.	
Sl.No	**Item Description**	**Details**	**Offered Design and Construction is similar to Reference Design? Bidder to Confirm (Yes /No)**
1.	Name of the Station and its Location		
2.	Client Name and its Address, Fax and Tel. No.		
3.	Name and Designation of the responsible person in Client's Organisation		
4.	Date of commencement of successful operation		
5.	Generator Make		
6.	Model No.		
7.	MVA Rating		
8.	MW Rating		
9.	Compliance to IS/IEC Standard		
10.	Cooling medium (e.g. Water, Hydrogen etc.) (i) **Stator Core** (ii) **Stator Winding** (iii) **Rotor**		
11.	Number of shaft mounted fans		
12.	Thermal Class of Insulation (i) **Stator** (ii) **Rotor**		
13.	Details of Core & Core support system (e.g. Spring type/ Rigid type etc.)		
14.	Type of Excitation system		
15.	Factory /Works where the Generator rating equal to 500MW or more was Manufactured, assembled & tested		
16.	Factory/works where the offered Generator is proposed to be Manufactured, assembled and tested		

Certificate(s) from Owner that the Generator with above mentioned technical parameters is in successful operation for a minimum period of one (1) year as on the date of Tender opening and caused no serious problem in past, are furnished along with techno-commercial Bid at Annexure… to this **Attachment-**…..

Date :

Place :

Signature……..

Printed Name ……..

Designation ……

Common Seal ……

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SECTION-III

PROJECT SYNOPSIS AND GENERAL INFORMATION

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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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SECTION-IV

SCOPE OF SUPPLY AND SERVICES, TERMINAL POINTS AND EXCLUSIONS

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SECTION-IV

SCOPE OF SUPPLY AND SERVICES, TERMINAL POINTS AND EXCLUSIONS

1.00.00 SUPPLY OF EQUIPMENT AND SYSTEMS

The works as detailed hereinafter for 3x800 MW coal based Thermal Power Station for NLC India Limited (NLCIL) at Jharsuguda, Odisha shall be executed on EPC basis.

The Works, as detailed hereinafter, for 3x800 MW Super-Critical Units,) shall be contracted on complete Engineering, Procurement, Erection/installation of various equipment under mechanical, electrical and C&I with complete civil/structural/ architectural works including unloading storage and handling at site, site testing, commissioning, trial run, performance and guarantee tests and other services including supply co-ordination, engineering and project management.

Bidder shall supply mandatory spares, tools and tackles, first charge and subsequent charging of lubricating oil, Transformer oil & all consumables including operating chemicals till the provisional takeover / successful completion of trial operation of the Unit / Sub-Systems.

Bidder shall generally supply quantity of not less than 10% of the full charge of each variety of lubricants, servo fluids and gases used which is expected to be utilized during the first year of operation unless stated elsewhere in the relevant section of the specification.

Additional Chemicals quantity as defined elsewhere in the specification shall be supplied in a phased manner, as decided by Owner.

This additional quantity shall be supplied in separate Containers.

1.01.00 Three (3) numbers of Super-Critical once through, Single Pass (Tower type) / Double Pass (as per Bidder's proven practice), using either spiral wound plain (inclined) or vertical rifled type water wall tubing in furnace evaporator portion minimum upto the combustion zone (Bidder to provide only the type for which he is qualified) ,dry bottom, balanced draft, semi-outdoor, pulverized Coal fired, with oil as start-up and stabilising fuel Steam Generating units, each complete with all auxiliary plant and equipment consisting of, but not be limited to, the following

a) Furnace, evaporator complete with water walls , separators, headers, 1x 100% circulation pumps (for low load and start up), as required for once through supercritical boiler.

b) Economiser, Superheater, Reheater, other Pressure Parts, Attemperation system, Soot Blowing System etc.

c) Integral pipe work, valves and specialties along with supporting system.

d) Draft plant including PA Fans, FD fans, ID fans , Booster fan (if applicable), Air Preheaters, ducting and accessories .For all fans under draft plant, 2 x 100% lube oil pumps are to be provided.

e) Fuel (Coal) bunkers, transportation upto pulverizers and firing systems including start-up & stabilisation system with fuel oil.

f) Integral instrumentation, safety interlocks and controls for steam generator.

g) Galleries, platforms and structural steelwork.

h) Mill reject handling system.

i) Electrostatic precipitators(minimum six(6) numbers).

j) Thermal Insulation, boiler casing, cladding etc.

k) De-NO_X system with Selective Catalytic Reduction (SCR) System.

For detailed Scope, refer to Volume: II-B of this specification.

1.02.00 Fuel Oil Unloading & Pressurizing System considering LDO/HSD, consisting with storage tanks& pumps as detailed in Volume: II-B of this specification.

1.03.00 One number outdoor installation type, natural circulation, pressurized furnace, water tube Auxiliary boiler suitable for firing LDO/HSD, complete with necessary Electrical, Instrumentation and Control System. Minimum Capacity of Auxiliary boiler shall be 70TPH or as envisaged by the Bidder(whichever is higher) having steam parameters at superheater outlet as 19 kg/sq.cm(g) and 315^0 C respectively. For detailed scope, please refer to Volume: II-B of this specification.

1.04.00 Three (3) nos. multi-cylinder (with separate HP, IP & LP casing or combined HP-IP & separate LP casing) double casing (for HP & IP turbines) tandem compound, single reheat, regenerative, condensing type turbine-generator sets each complete with all related auxiliaries and consisting of, but not limited to, the following sub-systems:

a) Steam turbine proper along with auxiliary systems e.g. gland sealing, turbine lube oil and control oil system for lubrication, protection and governing, water spray, steam washing systems etc. as applicable.

b) Stop and control valves on Main Steam (MS) and Hot Reheat (HR) inlet with strainers, quick closing non-return valves on extraction lines and Cold Reheat (CR) line, H.P. & L.P. Bypass valves etc. together with hydraulic actuation system, etc. as necessary.

c) All integral piping for turbine steam, drain and vent systems including flash boxes, oil, air and water systems.

d) Condensate Polishing System.

e) Generator coupled to steam turbines and complete with auxiliary systems e.g. excitation, seal oil, hydrogen cooling, stator cooling, carbon dioxide purging systems etc. as necessary.

f) Integral instrumentation, safety interlocks and controls for the turbo-generator.

g) Thermal Insulation and acoustic cladding (as applicable).

For detailed Scope, refer to Volume : II-C of this specification.

1.05.00 Water cooled, horizontal surface condensers for each unit complete with integral accessories, CW line pressure balanced expansion joints, butterfly valves, water box handling devices, air evacuation, on load tube cleaning system etc. as specified in Volume: II-C of this specification.

1.06.00 All power cycle pumps and drives as required for each unit including Boiler Feed Pumps and feed regulating station, Condensate Extraction Pumps, Heater Drain Pumps (if applicable); the pumps are to be complete with accessories for sealing and lubrication, flexible/hydraulic couplings, gear box, integral instrumentation, handling devices, etc. and Auxiliary steam turbine and ancillaries for turbine driven Boiler feed pumps as specified in Volume: II-C of this specification.

1.07.00 Low pressure and high pressure feed heaters and deaerator for each unit complete with integral instrumentation and valves, supports, platforms, rails, handling devices etc. as specified in Volume: II-C of this specification.

1.08.00 Turbine oil purification system for each unit and central turbine oil storage and Purification system common for the units as specified in Volume: II-C of this specification.

1.09.00 Complete piping, valves and specialties for each of the units and common systems comprising, but not limited to, the following:

a) Power cycle piping consisting of main steam, hot reheat, cold reheat, extractions, auxiliary steam, HP & LP Bypass piping, Spray piping for High capacity & Low capacity PRDS necessary drain &vent piping along with flash tanks, valves and specialties etc., air evacuation, cascade drains, condensate, feed water, cycle make-up, drains to waste and atmospheric vents etc. Blanking devices for emergency stop and reheat stop valves and other items as required for steam blowing operation along with steam blowing piping and quick opening valve as specified in Volume: II-D/1 of this specification.

b) Control valves with actuators and accessories

1.10.00 All other low pressure piping, valves and specialties with tanks for each of the units and common system comprising, but not limited to the followings:-

a) Large diameter piping for condenser & auxiliaries Cooling Water Systems, cross country and inplant underground raw water and clarified water transportation system as detailed in Volume II-D/2 of this specification.

b) Low pressure piping for various water (cooling, service, drinking, plant make-up etc.) air (instrument, plant service etc.), steam (other than that covered in item 1.09.00[a] above) and other services as detailed in Volume: II-D/2 of this specification.

1.11.00 Steel storage tanks / vessels such as Condensate Storage Tanks, DMCW Make-up water Tanks to be constructed under this specification, waste drain and other tanks not specifically mentioned but required for completion of various systems supplied under this specification. Refer Volume: II-D2 of this specification for detailed scope.

1.12.00 Thermal insulation including cladding material as required for conservation of heat and for personnel protection for all the units, as specified in Volume: II-D1 of this specification.

1.13.00 Chemical dosing system as specified in Volume: II- C of this specification.

1.14.00 Control & instrumentation (C&I) systems required for each unit and common system shall comprise of but not be limited to the following. Any item not specifically mentioned herein but required for completion of the total C&I system shall be included. Refer specification Volume II-E for further details.

a) Latest state of art microprocessor based Centrally operated Integrated Distributed Digital Control, Monitoring and Information System (DDCMIS) for control, monitoring, data acquisition, alarm and sequence of events recording for Steam Generator Integral control, Turbo-Generator Integral control, Steam Generator auxiliaries, Turbine Generator auxiliaries, station C&I equipment, Electrical distribution system and other auxiliaries system including SCR (Plant DDCMIS).

b) Latest state of art microprocessor based distributed digital control, monitoring & information system (DDCMIS) for BOP Off-site Plants (Coal Handling System, Ash handling System, Plant Water System and associated Auxiliaries) (BOP-DDCMIS)

c) Latest state of art microprocessor based distributed digital control, monitoring & information system (DDCMIS) for FGD Plant Control system

d) GPS based Master & Slave Clock System.

e) Human-Machine-Interfaces including servers/ work stations/ LVS etc.

f) Unit Performance calculation & Plant Performance Analysis, Diagnostic and Optimization (PADO) system.

g) Operator Training Simulator

h) Vibration Monitoring and Analysis system

i) HART Management System (HMS)

j) Computerized Maintenance and Inventory Management System (CMIMS)

k) Steam and Water Analysis System (SWAS)

l) Continuous Emission Monitoring System (CEMS) and Flue Gas Analyzers

m) Ambient Air Quality Monitoring System (AAQMS)

n) I&C Laboratory System

o) Fire Water Pump Control System (PLC based)

p) Hydrogen Generation Plant (HGP) Control System (PLC based)

q) Microprocessor based compressor skid mounted proprietary control system with overall control facility from DDCMIS.

r) System cabinets unit control panel, control Desks & control room furniture, Junction boxes and local control panels etc.

s) Measuring instruments not limited to transmitters, switches, temperature elements and gauges.

t) Flow elements with root valves and accessories.

u) Steam Generator, Turbine-Generator, FGD and BOP related special Instruments and Systems

v) Erection hardware for instrument process hook up viz. impulse pipes, isolation valve, instrument blow down valves, fittings, tubes etc.

w) Erection hardware for the pneumatic hook up viz. tubes, fittings, valves etc.

x) Local instrument racks and enclosures.

y) All instrumentation signal & control cables, extension & compensating cables, special cables and optical fiber cables

z) Cable erection hardware including cable tray, conduits, supports, glands, ferrules and others.

aa) C&I earthing.

1.15.00 Complete cooling water system for three units consisting of, but not limited to, the following major equipment:

: a) Condenser Circulating Water (CW) pumps, drives and accessories.

b) Auxiliary Cooling Water (ACW) pumps, drives and accessories.

c) Cooling Towers for CW and ACW Systems

d) Closed circuit DM cooling water pumps, drives and accessories.

e) Heat exchangers for closed circuit DM cooling water systems.

f) DM Service Water pumps and Condensate Transfer Pumps.

For detailed scope, refer to Volume: II-IA of this specification.

1.16.00 Complete water transportation system within the plant and Raw water intake system as specified in Volume: II-IB/1 of this specification. The system consists of, but not limited to the following

a) Raw water intake system including Raw water intake piping from Intake Pump House to Plant raw water reservoir.

b) Vertical wet-pit Raw Water Intake pumps and drives located in Intake water Pump House near Hirakud reservoir downstream of Rambella bridge for supplying raw water to Plant raw water reservoir.

c) Vertical wet-pit Raw Water make-up Pumps/AHP make-up pump and drives located in raw water reservoir Pump House for supplying raw water to Water Pre-treatment plant for clarification purposes and make-up to ash water sump during emergency.

d) Vertical wet-pit pumps and drives in Clarified Water Pump House for supplying clarified quality water to various plant areas.

e) Horizontal pumps and drives for transferring demineralised quality water from DM Water Storage Tanks to Condensate Storage Tanks and during start-up / emergency requirement of the unit.

f) Low pressure and large diameter piping systems including valves and specialties for conveying water to various areas of the plant.

g) Control and instrumentation for operation of the plant

For detailed scope, refer to Volume: II-IB/1 of this specification.

1.17.00 Water Pre-treatment Plant as specified in Volume II-IB/2

1.18.00 Ion exchange based Demineralisation (DM) Plant as specified in Volume II-IB/3

1.19.00 Effluent Treatment Plant & Sewage Treatment Plant consisting of the following major components:

a) Tilted Plate Interceptor, along with collection sump for Power House Transformer yard, switchyard Oily Waste etc.

b) API for Fuel oil Handling Area run-off.

c) Settling ponds for effluents from CHP Dust Suppression System and Coal Pile Area run-off.

d) Collection of sanitary waste from different buildings of the plant into the common collection sumps located at the two separate STP plants area by gravity.

d) FAB/MBBR technology based modular type STP Plants followed by disinfection by Hypo and necessary tertiary treatment.

e) Collection sump for effluent from Fly Ash Silo area washing including pumps.

f) Central Monitoring Basin (Guard Pond).

g) Effluent collection from different sources of the plant.

h) ETP clarifier along with associated chemical dosing.

i) ETP UF-RO Plant.

j) ETP Reject treatment plant.

k) Necessary pumps, piping, valves, fitting, specialties and other accessories as required including level switches for operating sump pumps & screw pumps etc.

l) Water quality monitoring instrumentation and control.

For detailed Scope, refer to Volume: II-IB/4 of this specification.

1.20.00 Complete compressed air system for supplying instrument air to various pneumatic instruments supplied under this specification as well as for supplying plant (service) air to power house and other auxiliary buildings mentioned elsewhere in this specification.

For detailed scope, refer to Volume: II-J of this specification.

1.21.00 Ventilation and Air-conditioning system including all equipment, piping, false ceiling, insulation, ducting etc. as required for the main power house/TG building and other auxiliary buildings as covered in Volume-II-J of this specification.

For detailed scope, refer to Volume: II-J of this specification.

.1.22.00 Complete Ash Handling System for collection & disposal of ash generated in the three (3) units consisting of, but not limited to, the following systems:

a) Collection, Storage and Removal of Bottom Ash.

b) Collection, Storage and Removal of Fly Ash.

c) Associated HP, BALP and, Compressed Air system etc.

d) Ash Slurry disposal system (HCSD) from silo.

For detailed scope, refer to Volume: II-H1 of this specification.

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1.23.00 Complete Coal Handling System for 3 x 800 MW units.

For detailed scope, refer to Volume: II-H2 of this specification.

1.24.00 Three (3) nos. limestone based Flue Gas Desulphurisation system each complete with all related auxiliaries and consisting of, but not limited to, the following sub-systems:

- Limestone Grinding and Slurry makeup system to absorber
- Absorber System
- Gypsum Dewatering System
- Process Water Storage & Pumping System
- Waste Water System.
- Limestone Handling System
- Gypsum Handling System
- Auxiliary equipment like Suspended Magnets, Belt Scales, Dust Suppression and Dust Extraction System, etc.

For detailed specification of Limestone based Flue Gas Desulphurisation, Limestone Handling and Gypsum Handling Systems refer to Volume: II-H3 of this specification.

1.25.00 Fire Protection System for the entire plant including protection of strategic areas/buildings/equipment of Main Plant area, FOPH , Ammonia Handling System, Coal Handling System (CHS), Ash Handling System (AHS), Flue Gas Desulphurisation (FGD) , Plant Water System (PWS) and Balance of Plant comprising of, but not limited to the following:

a) Hydrant Protection System.

b) Spray Water System.

c) Foam System.

d) Smoke/Fire Detection System.

e) Inert Gas Flooding System

For detailed scope, refer to Volume: II-J of this specification. Broad area of overall plant layout is shown in the Plot Plan [17A08-DWG-M-002A] enclosed in Volume II-L of the specification.

For detailed scope, refer Volume: II-J of this specification

1.26.00 Diesel Generator Sets comprising of diesel engine and generators, diesel oil tanks, engine-cooling system with associated electrical and controls for 3x 800 MW units. For details, refer Volume: II-J of this specification.

1.27.00 Sump Pumps complete with drives and accessories for drainage of pits for the entire Plant.

For detailed scope, refer Volume: II-K of this specification.

1.28.00 Miscellaneous Cranes complete with drives, electrical and all other accessories as required 3x800 MW units.

For detailed scope, refer Volume: II-K of this specification.

1.29.00 Miscellaneous hoists & Lifting devices complete with drives and accessories in all auxiliary buildings within the Plant area for handling during operation & maintenance of any equipment weighing above 200 Kg supplied but not covered by any of the cranes covered under item 1.28.00. For detailed scope refer Volume: II-K of this specification.

1.30.00 Elevators complete with drives, electricals, control and instrumentation and all other accessories as required 3x800 MW units:

For detailed scope, refer Volume: II-K of this specification.

1.31.00 Fire Tender & Portable fire extinguishers for the Power House and all other ancillary buildings and facilities for 3x800 MW units and non-plant buildings as indicated in detail in Volume: II-J of this specification.

1.32.00 Chemical laboratory equipment are not in Bidder's scope of supply. However, Chemical laboratory building along with associated AC ventilation, power points etc. shall be in Bidder's scope.

For detailed scope, refer Volume: II-K of this specification

1.33.00 Hydrogen Generation Plant with H_2, CO_2 and N_2 gas cylinders as required for 3x800 MW units.

For detailed scope, refer Volume: II-J of this specification

1.34.00 Workshop Equipment.

1.35.00 Complete Electrical equipment and accessories for Single Package EPC shall include but not limited to the following:

a) Generated power will be evacuated at 765 kV level through 765kV Transmission Line and forming 400 kV Bus using 2 nos. of (765/√3)/ (400/√3)/33 kV Interconnecting Transformer.

765kV GIS comprising of three (3) nos. of GT bays, two (2) nos.. (765 / √3) / (400/ √3) / 33 kV of ICT bays, one (1) no. of Bus reactor bay, four (4) nos. of outgoing line bays, One spare Bay and Space for one dia of future bay..

400 kV GIS comprising of three (3) nos.. of ST bays, two (2) nos. (765 / √3) / (400/ √3) / 33 kV of ICT bays, two(2) nos. of Bus reactor bay, two (2) nos. 30MVA, 400/34.5kVInter Bus Transformer bays, two (2) nos. of outgoing line bays, one (1) no. spare line bay and space for, one (1) dia future line bay.

b) 33 kV Gas Insulated Indoor Switchgear will be provided for power requirement of feeders for Mines, Township and Intake Pump House.

33 kV GIS comprising of two (2) nos. 30MVA, 400/34.5 kV Transformers, two (2) Nos. of outgoing line feeders for Mines, two(2) nos. outgoing line feeder for Township, 2 Nos. outgoing line feeders for Intake Pump House, one (1) no. Bus coupler, two(2)nos spare feeders.

c) Generator and its associated Auxiliaries.

d) Excitation System and its Accessories.

e) Isolated Phase Bus Duct.

f) Generator Transformer – 315 MVA, 10 nos. * kV / 765 / √3 kV

g) Station Transformer – 130MVA, 3 nos. 400 / 11.5 / 11.5 kV.

h) Interconnecting Transformers: Two (2) sets, 765/√3 / 400/√3 / 33kV, 3X500MVA

i) Inter Bus Transformers: Two (2) sets, 400 / 34.5kV, 30 MVA

j) Unit Transformer – 50 MVA, 6 nos. *kV / 11.5 kV.

k) 11/3.45 kV – Auxiliary Transformers.

l) 11kV and 3.3kV Switchgear.

m) Segregated Phase Bus Duct.

n) 11/0.433 kV Service transformers.

o) Non-Segregated Phase Bus Duct.

p) 415V Switchgear (PMCC / MCC / ACDB / WRDB / MLDB).

q) DC system and its Distribution.

r) Plant System and its Distribution.

s) UPS system with battery for Simulators

t) 765 kV & 400kV GIS bus duct

u) Power Cables (33kV, 11kV, 3.3kV, 415V).

v) Control and Signal Cables.

w) Illumination System.

x) Complete Earthing and Lightning Protection.

y) AC & DC Motors, Electric Motor Actuators.

z) Variable Frequency Drives as applicable.

aa) All Cables, Cable trays / racks interconnecting various equipment supplied under the package and interfacing with other plant facilities as specified.

bb) Neutral Grounding Resistors.

cc) Electrical Control & Relay, Protection and Metering System.

dd) Energy Management System & Relay Management System.

ee) Substation Automation System.

ee) Plant Communication System for entire plant including non-plant building.

ff) Roof Top Solar System.

gg) Emergency DG Set and its Accessories.

hh) ESP Electricals along with Rectifier Transformer set and its accessories.

ii) Electricals for Non – Plant Buildings including Internal Electrification.

jj) Electrical system for Raw Water intake pump house covering 33 kV Double circuit Transmission line, 33 kV Cable, Fiber cables, Cable carrier system at river/road/rail crossings, 33 kV, 3.3kV and 415V Switchgears, 33/3.3 kV and 3.3/0.415 kV Transformers, DC system, UPS system, Plant communication system, CCTV, illumination system, DG set, Power and control cables, earthing & Lightning protection system, etc.

kk) Any temporary contingency arrangement to derive 33 kV Power for Raw inter intake system from the 33 kV incoming construction power supply system, in case of delay in arranging the start-up power supply through 400 kV /33 kV Switchyard.

For further details, refer to Volume: II-F/1 & F/2 of this specification.

1.36.00 Complete civil, structural, architectural & building service works for main power house and its auxiliaries including TG deck and foundation, Boiler Bunker Building and its auxiliaries, Buildings/structures for FGD system, miscellaneous plant buildings, Non plant buildings, RCC Chimney, IDCT, Raw Intake System and Plant Raw water reservoir, complete roads and RCC drains including RCC box culverts, complete storm water drainage system & sewerage system for the entire project, etc. & other indoor/outdoor facilities as included in this package including supply of materials, labour, tools & machinery as required. The services shall include but not be limited to the following:

a) Foundation for all the equipment supplied under this package including installation of anchor bolts, sleeves and other embedded fixtures.

b) Fabrication & erection of all types of steel work as required for buildings, platforms, stairs, ladders, hangers & supports, pipe racks, etc.

c) Raw water Intake system and plant raw water reservoir.

d) Clarified water tank.

e) Land grading over existing grades as necessary for installation of equipment/structures, excavation, backfilling, disposal of excess soil, concrete paving, laterite/ stone bolder soling of various areas as specified.

f) Brickwork, plastering, flooring and floor finish, doors, rolling shutters, windows/louvers, internal partitions, glazing, false ceiling, , external cladding, roof protection, painting, sanitary & plumbing works etc. as specified and necessary for all the buildings constructed under this package.

g) Permanent & construction roads for entire power plant, RCC box culverts and area drainage as specified elsewhere in this specification.

All Civil & Structural and Architectural works but not limited to items mentioned below.

- Topographical Survey

  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 shall be carried out by Bidder. Also, final micro leveling is to be done by the successful Bidder as the area may get disturbed due to construction and monsoon activities

- Geo-Technical investigation

- Plant Roads and RCC Box Culverts within the plant area as shown in the Plot Plan.

- Fencing around buildings, if required from statutory point of view (switchyard, transformers area, stores, etc.)

- Storm water Drainage network for entire plant including Rain water harvesting Pond and pumping arrangements..

- Water supply, drainage and sewerage works within plant area.

- Blasting will not be permitted for excavation of foundation irrespective of the soil strata encountered.

Apart from the power house building the following miscellaneous plant buildings/structures will be required to be constructed under the scope of this specification:

i) TG foundation including column & deck slab

ii) Boiler foundation including fans, Mills etc. (Fans and Mills shall be with VIS)

iii) ESP Foundations & Equipment foundations

iv) ESP control Building (One no for each unit).

v) Bunker Building

vi) Fuel Oil Unloading Cum Pressurising Pump house with adjacent Electrical & Control room (common three units).

vii) Plant air Compressor House

viii) Fuel Oil Dyke

ix) Auxiliary Boiler foundations and Electrical & Control Room (common for three units)..

x) Boiler Maintenance Building (common for three units).

xi) Bottom Ash Overflow pumps with tanks adjacent to BA hopper

xii) MCC/Operator room for SCR (common for all the three units)

xiii) RIO room (for Boiler Metal Temperature Measurement, AC Plant (if applicable), Boiler Bunker area etc. including RIO's in the BOP areas)- VFD panel room - if applicable (One no for each unit).

xiv) Inter plant Pipe cum Cable rackincluding foundations, pipe & cable trenches, duct bank etc.

. xv) Condensate Transfer Pump Shed & Condensate Storage Tank foundation.

xvi) ACW Pump House

xvii) Transformer yard foundations with complete RCC paving of the entire transformer yard including DG Set

xviii) Service Building with associated parking lot.

xix) CPU Regeneration Building.

xx). Blowdown Tank/Atmospheric flash tank with drain receiving vessel

xxi) **Coal Handling Plant and its related Auxiliaries**

- Coal Handling Plant maintenance building
- Crusher House
- Drive House
- Junction Towers and Receiving Tower
- Conveyor gallery and Trestles
- Control room cum Switchgear room
- DFDS/Misc. Pump & compressor house
- Bull Dozer Shed
- Equipment Foundations
- Civil works related to Dust Extraction System, Bunker Ventilation System and dust suppression system.
- Civil Works related to Stockpile Wind Barrier
- Layout arrangement of monorails and supply of the same along with the hoist and all necessary fixing structural members such as brackets, bracings, etc., is in the scope of Bidder including

erection and fixing of the same on the structures.

- RCC paving for Coal Stockpile, Foundations for Stacker cum Re-claimers, Coal pile run off drains, roads along with associated items. .

xxii) **Ash Handling System and its related Auxiliaries**

- Compressor House including switchgear room and Main control room
- Water impounded Bottom Ash Hoppers
- Ash Water Pump house including Sump
- Silo utility building cum HCSD pump house including switchgear room and RIO room
- Seal Water Sump at ash water pump house
- RCC Fly Ash Silos
- Structural steel Buffer hoppers for ESP hopper Fly Ash
- Structural steel Dewatering bins, Common Sedimentation Tank & Common Surge Tank
- Ash water transfer pump house common all the units
- RCC Pedestals for HCSD slurry disposal including garlanding in proposed ash dyke
- All Civil and Structural Works related to Pipe racks for Ash Pipe Lines, Air Pipe Lines, Water Pipe Lines, Misc. drain Sump, Cable racks, Cable Trenches and supporting structures.
- Equipment Foundations
- Ash Dyke Storage capacity as mentioned in Mechanical volume including strengthening of Nallah bund nearby ash dyke
- RCC Bridge across Bedhan river for Ash pipe line to ash dyke and Raw water pipe line and Road transport.(Eastern side).
- RCC Bridge across Bedhan river for Ash pipe line to Mines and Road transport.(Western side).
- Weighbridge

xxiii) **Raw Water Makeup System**

- Raw water Intake Pump House

- Raw Water pump house
- Equipment Foundations
- Plant Raw Water Reservoir with storage capacity as mentioned in Mechanical specification including all Civil and Structural Works related to raw water intake pipe lines from Intake water pump house to raw water reservoir inside Plant boundary.
- All Civil and structural works related to 33kV transmission line from raw water intake to power plant .
- Bridge across Bedhan river for Ash pipe line shall be utilized for Raw water pipe line also.
- BT inspection road from raw water intake to power plant.
- Supporting steel structures / RCC Pedestals with GI grating walkway for pipes crossing waterbody

xxiv) **Water Treatment System**

- PT Plant Chemical House.
- Chemical Laboratory
- Chlorination plant building
- DM plant building with switchgear room, control room
- DM Water Storage Tanks
- Acid / Alkali Storage Tanks
- Clarified Water Tank
- Clarified Water pump house.
- Equipment Foundations
- Stilling chamber, Clarifier, inlet channels etc. along with associated facilities for Pre-Treatment Plant
- Sludge Pit & Neutralization Pit as per system requirement

xxv) **Circulating Water System**

- CW pump house With Switchgear Room and RIO room
- CW Treatment cum Chlorination plant building
- Equipment Foundations

- All related Civil and Structural Works for valve chambers, Sump, Forebay, Channels from Cooling Tower

xxvi) **Induced Draught Cooling Tower**

- All Civil and structural works for RCC Induced Draft Cooling Tower
- Switchgear Room for each Cooling tower
- Cold Water Basin, wall & Associated works, connecting channels
- Other auxiliaries, stairs etc.

xxvii) **Effluent Treatment Plant**

- ETP building including pump house and control room
- ETP RO plant building with effluent disposal system
- Guard Pond / Central Monitoring Basin
- ETP reject treatment plant building
- Equipment Foundations

xxviii) **Sewage Treatment Plant- Two (2) Nos.**

- STP building
- All Civil Works related to Sewage Conveying and disposal System including construction of sewage network and RCC sewer manholes.

xxix) **Single Flue Chimney- Three (3) Nos.**

- All Civil and structural works for RCC Chimney with internally lined (borosilicate) steel flue enclosed by RCC Wind Shield to suit MOEF norms with Rack &Pinion Elevator.
- Other Auxiliaries, Internal Steel Platforms, External RCC Platforms, ladders, elevator etc.
- Internal Structural steel staircase upto the top most internal platform and cage ladder from there roof of the chimney
- Aviation lighting arrangements for the chimney.

xxx) **Fire Protection & Detection System**

- Fire Water Storage Tanks.

- Fire Water Pump House Booster pump House and Foam pump house
- All related civil works for Fire detection and protection for laying fire hydrant lines within the entire plant zone including BTG Area, transformer yard area etc.
- Equipment Foundations

xxxi) **765 kV, 400 kV & 33 kV GIS Switchyard**

- GIS Control Room
- GIS Building for 765 kV, 400 kV and 33 kV Switchyard
- Equipment Foundation

xxxii) **Flue Gas Desulphurisation Plant**

Limestone Based System

- Limestone Storage Building
- Limestone Crusher House
- Limestone Grinding Building
- Oxygen Blower House
- Absorber Pump House
- Electrical & Control Building
- Gypsum De-watering House
- Gypsum Storage Building
- Equipment Foundation.

xxxiii) **Roof Top Solar System**

Civil works for roof top solar system for the buildings as per the list mentioned elsewhere

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xxxiv) **General Plant Illumination**

All Civil and Structural Works related to General Plant Illumination System.

xxxv) All Civil and Structural Works related to SCR, Ammonia Storage and Handling System Area.

xxxvi) All Civil and Structural Works related to Hydrogen Generation Plant Area.

xxxvi) **Non Plant buildings under this scope of work:**

- Canteen
- Fire Station
- Weigh-bridge(Three(3) numbers of 100T capacity each) shall be provided in the following areas:

  1). Near Limestone storage area.

  2). Near Gypsum storage area

  3). Near dry ash silo
- Workshop
- First Aid Centre
- Permanent Stores
- Construction Store
- Car and Cycle / Scooter stand at Service Building
- Rain water harvesting pond.
- Toilet Blocks

Note: Above list of Plant & Non Plant Buildings is not exhaustive. Buildings necessary for the smooth operation of the Power Plant shall be within this scope of work of the Bidder. All related approach roads and roads within the system requirement along with RCC drains and sewage network.

For further details refer Volume-II G/1 & G/2 of this specification.

1.37.00 Supply of all mandatory spares and tools & tackle as detailed in Section-IX of Volume II-A of this specification.

1.38.00 The maintenance scope of Contractor covers all the maintenance works as defined in Volume-I-B. In case of any delay or dispute by the Contractor, the Owner may carry out the maintenance works on necessity and back charge the Bidder during the above said period.

1.39.00 All the plant layouts shall be made in computerized 3D modelling system and submitted to Purchaser as detailed in the Specification. Further , the Bidder shall Supply &Commission commercially available software and necessary hardwares for 3-D model design review, and provide training for Purchaser's personnel as stipulated in Clause 8.07.00 Section-VII / Volume II A of this Specification.

2.00.00 SERVICES TO BE RENDERED BY THE BIDDER

The services to be rendered by the Bidder shall include but not be limited to the following:

2.01.00 Services for complete engineering, co-ordination and project management as detailed in Section-VI of this specification volume.

2.02.00 Services for shop tests and quality assurance, etc. as detailed elsewhere in this specification.

2.03.00 Services for construction, fabrication, equipment erection, testing as well as trial run & commissioning of various equipment and accessories under the contract. The details of such services are indicated in detailed elsewhere in this specification volume. Bidder shall arrange tower crane for erection and construction work, wherever necessary. Minimum three (3) numbers of 650T capacity tower cranes shall be arranged under the scope of service in addition to the required resources for erection and construction of boiler.

2.04.00 Supply of all consumables required for the works as per provision of respective clauses specified in conditions of contract.

2.05.00 Furnishing of all document, drawings, design basis reports, optimization, study reports, instruction manuals, etc. including "As built" drawings, as called for in the specification both in requisite no. of hard copies and in soft form (Hard Disk).

2.06.00 Operation and Maintenance training.

2.07.00 Obtaining approval from statutory bodies in India. However, Owner will provide assistance to do so.

2.08.00 Equipment shop painting.

For details of painting, please refer Section-XII of this specification Volume.

2.09.00 Any other service, although not specifically called for but required for a turn-key contract of the size and nature indicated in this specification.

2.10.00 For details of services under clause B, subsequent sections of this Lead specification may be referred.

2.11.00 Contingency power supply arrangement : In case of any delay in getting the start up power supply, Bidder has to make temporary power supply arrangement required to meet the commissioning time schedule of all system under their scope.

2.12.00 Right of Way (ROW) : Bidder has to facilitate the Owner in getting ROW wherever required in the areas coming under their scope including Raw water intake system scope. This facilitation will also cover the area required for the

Raw water intake pipe lines, 33 KV Raw water intake Transmission lines and inspection road along the raw water intake pipe lines.

2.13.00 33 KV power supply arrangement from 33 KV Switchyard outgoing gantries: 33 KV cabling shall be done wherever layout restrictions are there and while crossing water bodies, Roads, Railway lines etc., 33KV under ground burial, termination and straight through joints wherever required are included in the scope. In addition to this, OPGW fiber cable associated with 33KV Raw water intake system, underground burial, termination and joints with optical cables while crossing the above said facilities along with the 33KV cable are included in the scope.

3.00.00 EXCLUSIONS

i) Supply of Coal, Anhydrous Ammonia , Limestone , LDO and Diesel Oil.

ii) Coal handling plant upstream of Receiving Tower (within Plant boundary)

iii). Lease line for CEMS , EQMS and AAQMS connectivity from Analyser Panels to CPCB/ Odisha PCB.

iv). Power evacuation and transmission system beyond the battery limits as defined in terminal points. Necessary coordination with Transmission package supplier shall be the responsibility of the Bidder under this contract.

4.00.00 TERMINAL POINTS

The terminal points for the entire scope of supply under this specification shall be as specified in **Annexure-I** of this section. For all terminal points with flanged connection(as applicable), scope of this specification shall consider supply of mating flanges, gaskets, bolts, nuts etc. and including any isolation valve.

Annexure-I

TERMINAL POINTS

Sl. No.	Items/Description	Terminal Point	Scope of EPC Bidder	Connecting Package and it's scope
1.0	**Raw Water Intake System**	Upstream of Raw water Intake Pump House forebay. Refer tender drawing no. 18A03-DWG-M-001R in this regard.	Bidder shall supply and install raw water intake pump house including forebay and intake piping from pump house to raw water reservoir inside plant with necessary valves and accessories. All civil works after TP will be in Bidder's scope.	Bidder
2.0	**Coal Handling Plant**	Discharge of Mine conveyor (Pipe conveyor) at Receiving Tower (within plant boundary)- as per Plot Plan, approx. Co-ordinate: E: 808523, S : 2411568. .	Complete Coal handling Plant for feeding Coal to Coal bunkers and stacking of crushed Coal at Coal stockpiles starting from discharge point of mine conveyor (Pipe conveyor)	Owner.
3.0	**Fuel Oil System**	Road Tanker unloading flange.	Complete fuel system comprising unloading, storage, pressurizing system from Tanker unloading flange outlet upto steam generator is in Bidder's scope.	Supply of LDO through road tanker by Owner.

Sl. No.	Items/Description	Terminal Point	Scope of EPC Bidder	Connecting Package and it's scope
4.0	**Ammonia system**	Road Tanker unloading flange.	Complete ammonia storage handling system comprising unloading, storage from Tanker unloading flange outlet up to steam generator is in Bidder's scope.	Supply of ammonia through road tanker by Owner.
5.0	**Limestone system**	Road Truck unloading.	Complete limestone system comprising unloading, storage from Truck up to FGD system is in Bidder's scope.	Supply of limestone through road truck by Owner.
6.0	**Chemicals for water treatment system (PT plant, DM Plant, ClO_2, ETP, CW Treatment etc.,) and Condensate Polishing system.**	Road Tanker / Truck	Complete chemicals comprising unloading, storage from Tanker / Truck up to respective storage area is in Bidder's scope.	Scope of supply of chemicals as specified elsewhere in the specification.
7.0	**Electrical**			

Annexure-I

Sl. No.	Items/Description	Terminal Point	Scope of EPC Bidder	Connecting Package and it's scope
a).	**765kV, 400 kV & 33kV Gas Insulated Substation (GIS).**	765KV, 400KV & 33KV Switchyard outgoing line gantries.	Complete 765kV& 400 kV Gas Insulated Substation (GIS) up to and including outgoing line gantry is in Bidder's scope. The line side insulators ,clamps & connectors for droppers to equipment connections shall be in Bidder's scope.	Terminations of outgoing lines at the switchyard line take off gantries for 765kV&, 400kV) are not in Bidder's scope. Necessary coordination with Owners Transmission package supplier shall be the responsibility of the EPC Bidder under this Contract
	33kV Gas Insulated Substation (GIS)	(i). 33 kV supply to Township:33 kV :Incomer terminal of 33 kV RMU Switchgear provided by Section-A Contractor	Complete 33 kV Gas Insulated Substation (GIS) and outgoing 33 kV Cable upto the incomer of 33 kV RMU Switchgear (Section-A) is in Bidder's scope.	33 kV RMU switchgear is in Section-A package scope
		(ii) 33 kV Supply to Mines : 33 kV, 4 Pole structure near 33 kV RMU Switchgear (For Power supply to Mines)	Complete 33 kV Gas Insulated Substation (GIS), outgoing 33 kV Cables, 33 kV transmission line and terminal 4 Pole structure near 33 kV RMU switchgear(Section-A) is in bidder's scope.	Further Transmission (beyond the 4 pole structure) of 33 kV Line to Mining is in Section-A package scope

Sl. No.	Items/Description	Terminal Point	Scope of EPC Bidder	Connecting Package and it's scope
		iii) 33kV Supply to Raw water intake system: Complete power supply (33 kV,3.3 kV, 415V system) for Raw water intake PH is in bidder's scope.	Complete power supply (33 kV,3.3 kV, 415V system) for Raw water intake PH is in bidder's scope including 33 kV lattice transmission tower & other Civil works	
b).	**Following Non Plant Buildings** • **Canteen** • **Fire Station** • **First Aid centre** • **Safety office Cum stores**	415, 3 Phase, 4 wire supply at the outgoing feeders of Owner's PDB (Section-A) at Miscellaneous Electrical Building. (Separate power supply for each Non Plant Building)	For each Non plant building, receiving 415V supply from the Owner's PDB outgoing feeder terminal and routing the cables upto the buildings and internal electrification are in bidder's scope.	Providing 415V, 3 phase, 4 wire power supply for each non plant building at the outgoing feeder terminal of Owner's PDB (Section-A).
c)	**Construction Power Supply**	At the 11 kV outgoing terminal of Construction Power Switchgear	2 nos. of 11 kV feeder shall be provided to EPC Bidder from Owner's Construction Power Supply kiosk near power plant boundary Gate	11 kV Outdoor Construction Power kiosk including its 33kV upstream is in the scope of Section-A Contractor.
8.0	**Continuous Emission Monitoring System (CEMS) and Ambient Air Quality Monitoring System (AAQMS), Effluent Quality Monitoring System (EQMS)**	CEMS, EQMS and AAQMS Analyser Panel outlet	Design, supply and installation of complete CEMS, EQMS and AAQMS including necessary hardware and software for connecting to CPCB/ OSPCB is in Bidder's scope.	CEMS, EQMS and AAQMS connectivity to CPCB/ Odisha PCB by Owner

Sl. No.	Items/Description	Terminal Point	Scope of EPC Bidder	Connecting Package and it's scope
9.0	**Plant Drainage**	Outfall point - Rain water harvesting pond with over flow of pond connected to Bhedan river.	Plant main storm network is under Bidder's scope. Carrying the storm water of the entire plant Rain water harvesting pond with over flow of pond connected to Bhedan river is within the scope of EPC Bidder.	
10.0	**ETP Reject RO Plant discharge**	ETP Reject RO Plant Reject discharge to be terminated at Ash dyke	Sludge sump, transfer pumps, pipe lines & pedestal up to ash dyke and inside ash dyke shall be under Bidder's scope. Distribution of Waste Water inside the Ash dyke for evaporation shall be in Bidder's scope.	

Note:

1) The terminal points indicated above shall be read in conjunction with Scope of Supply as detailed in respective technical volumes and Tender Drawings listed under Volume: II-L of this specification.

2) The Specification includes all items of plant, equipment and accessories within the terminal points set out above and on the Specification Drawings. Where no terminal points are specified then all plant and equipment are included in the scope of the Bidder within the boundary limit. The specification also includes responsibilities for the design, supply of necessary terminating materials and erection of all pipe and duct terminations between this and other package, except as specifically excluded. At each such terminal point the following are to be included as applicable unless otherwise specified elsewhere.

   a) Weld preparation specification

b) Welding procedure including post weld heat treatment specification
c) Boss, flange or suitable connection
d) Jointing materials
e) Nuts, bolts, washers
f) Execution of connection work
g) Examination and Testing of weld or joint.

3). At interface points matching/counter flanges and jointing material i.e. bolts, nuts, gaskets etc. wherever required shall be supplied by EPC Bidder

4). EPC Bidder shall note that if there are minor changes in the coordinates of the terminal points and elevations during detailed engineering, same shall be accepted without any commercial implication to the Owner (Minor changes to be mentioned).

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SECTION-V

GENERAL TECHNICAL REQUIREMENTS

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SECTION-V

GENERAL TECHNICAL REQUIREMENTS

1.00.00 CODES AND STANDARDS

1.01.00 Except where otherwise specified, the Plant shall comply with the appropriate Indian Standard or an agreed internationally accepted Standard Specification as listed in the annexure to this Section and mentioned in detailed specifications, each incorporating the latest revisions at the time of tendering. Where no internationally accepted standard is applicable, the Bidder shall give all particulars and details as necessary; to enable the Owner to identify all of the Plant in the same detail as would be possible had there been a Standard Specification.

1.02.00 The Bidder shall submit along with his bid the list of main codes and standards proposed to be used for the design, construction and testing of the plant. Where the Bidder proposes alternative codes or standards he shall include in his tender one copy (in English) of each Standard Specification to which materials offered shall comply. In such case, the adopted alternative standard shall be equivalent or superior to the standards mentioned in the specification.

1.03.00 Wherever specified or required the Plant shall conform to various statutory regulations such as Indian Boiler Regulations, Indian Electricity Rules, Indian Explosives Act, Factories Act etc. Wherever required, approval for the Plant supplied under the specification from statutory authorities shall be the responsibility of the Successful Bidder.

1.04.00 In the event of any conflict between the codes and standards referred above, and the requirements of this specification, the requirements, which are more stringent, shall govern. And if they are equally stringent, the Bidder shall follow the hierarchy as follows:

i) Local regulations
ii) Local codes and standards
iii) This Technical Specifications
iv) Industry codes and standards

1.05.00 In case of any change of code, standards and regulations between the date of purchase order and the date the Successful Bidder proceeds with manufacturing the Owner shall have the option to incorporate the changed requirements. It shall be the responsibility of the Successful Bidder to advise Owner of the resulting effect.

1.06.00 Combining or mixing of codes and standards of different institutions with respect to individual engineered components/ equipment shall not be permitted without the written approval of the Owner.

2.00.00 RESPONSIBILITY FOR DESIGN

2.01.00 The Bidder shall assume full responsibility for the design of the whole and every portion of the Plant, whether or not the design work was undertaken specifically in relation to the Contract and whether or not the Successful Bidder was directly involved in the design work.

2.02.00 Notwithstanding the Owner's wish to receive the benefits of new, advanced and improved technologies, a prime requirement is that all the systems and components proposed shall have been already adequately developed and shall have demonstrated good reliability under similar, or more arduous conditions as per the stipulation furnished elsewhere in the specification.

2.03.00 The Bidder shall carry out optimization studies for selection of pipe size and equipment wherever required. The result of such studies shall be included as part of bid proposal.

The successful Bidder shall have to carry out surge analysis and other transient condition studies as may be necessary and as required by the Owner as per proven engineering practice.

2.04.00 The Bid shall include a detailed discussion on the development status of and the reasons for any changes made in proposed systems or components for the Plant, as compared with similar items previously supplied in other installations cited by the Bidder as reference plants.

3.00.00 DESIGN CRITERIA & OPERATIONAL REQUIREMENTS

3.01.00 Gross Capacity

The Steam Turbine Generator & Auxiliaries shall be capable of delivering Gross Capacity of not less than 800 MW on continuous basis, with rated steam parameters, design condenser pressure and 1% cycle make up .The Turbine shall be capable of running in VWO condition (105% of Gross capacity).The Boiler shall be capable of delivering 2475 T/Hr steam at rated parameter or 102% of VWO with 1% cycle make up ,whichever is higher. This output shall be guaranteed and demonstrated by the Bidder for STG & auxiliaries units, as described in GCC.

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3.02.00 Equipment Sizing Margins

The equipment sizing design margins shall be used, as specified in the relevant clauses of the Design Specification.

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3.03.00 Number of Starts

The expected number of unit start-ups during 25 years of design life should be considered as minimum (Based on duration of shut down)

Cold start-up (shutdown >72 hours) : 150 starts.

Warm start-up (10 - 72 hours shutdown) : 1000 starts.

Hot start-up (2 - 10 hours shutdown) : 4000 starts.

Start-ups and load cycles together the TG & auxiliaries unit should be designed for minimum of 5150 cycles.

Following definitions shall apply for Cold start, Warm start, Hot start and Very Hot Start:

(a) Cold Start: start after a continuous shut-down period exceeding 72 hours (metal temperatures below approximately 40 % of their fully-load values in ^{o}C).

(b) Warm Start: start after continuous shutdown period between 10 hours and 72 hours (metal temperatures between approximately 40 % and 80 % of their fully-load values in ^{o}C).

(c) Hot Start: start after continuous shutdown period less than 10 hours (metal temperatures above approximately 80 % of their fully-load values in ^{o}C).

3.04.00 Minimum Load

3.04.01 The Steam Generator unit will be able to operate continuously at 40% rated output load without oil support and with worst type of Coal under automatic control.

3.04.02 Mill Turndown ratio: minimum 3:1

3.05.00 House Load Operation

In the event of total load rejection and disconnection from the external network, the unit shall be able to operate safely at the `House Load' feeding only the unit auxiliary services for an expected period of more than one (1) hour. In this case of load rejection, Boiler firing rate shall be brought down to 60% BMCR by suitably cutting out the pulverisers.

3.06.00 Mode of Operation

Modified sliding pressure operation

a) 0 to 40% TMCR : Constant Pressure Operation

b) 40% TMCR to 100%TMCR : Modified Sliding Pressure Operation (with throttle margin which can cater 5% load variation).

c).100% TMCR to VWO : Constant Pressure Operation.

3.07.00 Load Change Rate and Temperature Variation

3.07.01 Load change

a)	Step load change	Minimum ± 10%
b)	Ramp Rate	Minimum ± 3% per minute above 30 % to 50% load
		Minimum ± 5% per minute (50% to 100% load)

3.07.02 Maximum temperature variations

a) Under steady state condition : ± 5°C for SH and RH

b) During Load change

i) 3% per minute : ± 10°C for SH

ii) 3% per minute : ±10°C for RH

3.08.00 Operating Capability:

1) The operating capability of various systems, equipment and associated auxiliaries in the scope of the Bidder is specified elsewhere in the Technical Specification.

2) The plant, it's unit (s) and its all auxiliaries equipment/systems shall be designed to operate with all the specified margins for continuous operation without any limitations under any of the conditions indicated in the Technical Specification.

The major operating capabilities for the unit(s)/plant shall be as follows:

a) Operate continuously with turbine under VWO condition with rated steam parameters, design condenser pressure and 1% cycle make up.

b) Sliding Pressure Operation from rated pressure down to 40% of rated pressure with as well as without any throttle reserve. For modified sliding pressure condition, at any operating load, the throttle reserve shall be sufficient so as to achieve an instantaneous increase in turbine output by 5% of the corresponding load, by opening turbine control valves wide open. However the output after instantaneous increase shall be limited to 105% of TMCR Load. The throttle reserve shall be 0% for pure sliding pressure mode of operation.

c) Operate continuously with HP heaters out of service with 89 mm Hg(a) condenser pressure.1% cycle make up and normal

auxiliary steam requirement being tapped from cold reheat line, to generate maximum output without over stressing turbine components. The power output of the unit under this operating condition shall not be less than 800 MW or output corresponding to design BMCR heat duty, whichever is lower.

d) In case of sudden reduction in demand (load throw off), the unit should get safely unloaded and stabilized for operation at house load with HP-LP bypass open to full capacity.

e) HP-LP bypass operation under rated steam conditions with bypass valve open to full capacity and turbine on house load.

f) Automatic run back capability of the unit load on loss of critical auxiliary equipment, ensuring smooth and stable runback of the Steam Generator and Steam Turbine Generator equipment and systems.

g) Continuous TG output of 800 MW under rated steam conditions, 89 mm Hg(a) condenser pressure, 1% cycle make-up and 47.5 Hz grid frequency.

h) The equipment and auxiliaries shall be suitable for continuous operation in the frequency range of 47.5 Hz to 51.5 Hz.

i) Unit shall be capable of increasing the load through condensate flow regulation in order to meet the load cycling requirement. Necessary measurements and logics shall be provided for implementation of the same. During condensate flow regulation condensate tank level may be maintained through excess condensate dump line to condensate storage tank.

3) All the systems/equipment/auxiliaries under Bidder's scope shall be designed to cater to the above operating conditions envisaged for the unit(s)/plant by the Owner. Unless specified otherwise in the Technical Specification the design should cater to the above operating conditions with adequate margin as per standard practice prevailing in the fossil fired power plants.

4) The plant shall be suitable for load cycling which implies that it should be designed to operate continuously under two shift mode (daily start stop with one shift off) and load follow mode as specified. The design would cover adequate provision for quick start-up and loading of the units to full load at a fast rate. The unit shall have minimum rate of loading or unloading of 5% per minute above the control load (i.e. 50% MCR). Plant shall be capable of minimum N1 number of daily load cycles (N1 shall not be less than 2) from load variation from 100% to 50 % (and vice versa) of MCR with a minimum ramp rate of 5% per minute without affecting the design life of boiler and turbine systems. In addition, the plant shall also be capable of minimum N2 number of

daily load cycles (N2 shall not be less than 1) from 50% MCR to boiler minimum once through load (and vice versa) with a minimum ramp rate of 3% per minute without affecting the design life of boiler and turbine systems. Bidder shall fill the values of N1 and N2 in the relevant Attachment of the bidding document and shall demonstrate the same during initial operation. The main plant and its auxiliaries with their controls would be designed to permit operation of the units on house load without there being any necessity to shut down the units in the event of sudden loss of total load due to tripping of transmission lines or any other grid disturbances. The design of the plant equipment and control system would permit participation of the plant in automatic load frequency control.

5) Bidder shall furnish, within 6 (six) months from the date of placement of award / during detail engineering, following details:

a) 'Fatigue Damage', resulting from

i) The number of Cold start up, Warm start up and Hot start up as defined elsewhere in the specification and

ii) Load cycling during defined plant life.

b) 'Creep damage'

c) Creep-Fatigue interaction curve for materials (selected for vulnerable locations) for which fatigue and creep damage have been computed along with the reference used for creep fatigue interaction curve.

d) The combined creep fatigue damage shall lie within acceptable limits.

e) Material data used for determining the fatigue and creep damage.

f) Code used for determining fatigue and creep along with details of its validation.

g) Details of specific changes in design to accommodate the defined load cycling.

h) For the steam generator, in addition to the above requirement, specific design features incorporated and design/process improvements which are being offered for N1/N2 cycles shall be submitted along with the bid. Such design features and design/process improvements over and above conventional design shall be clearly brought out by the bidder in its bid. The Bidder shall provide references for earlier supplied steam generators which meet the specified cyclic duty requirements.

The analysis and design/process improvements for cyclic operation suitability shall include all critical boiler components like headers (final Super heater outlet, economizer outlet, final reheater outlet etc.), membrane wall construction elements (tubing attachments, tension bars etc.), wind-box elements, boiler recirculation pump casing, superheater/reheater attachments, dissimilar weld joints etc. The

Bidder shall provide information to the process adopted and analysis carried out for the design and operational improvements. Following shall be necessarily included:

a) Header thickness reduction: the intervention may include improvement in proper-ties of materials or materials, increase in number of headers etc.

b) Use of full penetration welds for header/stub welds and header ligament design improvements

c) Design improvement in the mechanical design of water walls

d) Design improvements to prevent economizer steaming

e) Stress concentration improvements: identification of critical zones, fatigue analysis, operational feedback of regular de-signs; analysis/redesign of water-walls tube/fin system, SH/RH attachments, BRP (boiler recirculation pumps) casing design etc.

f) Water chemistry improvements

g) Vent/drain/spray system sizing improvements

h) Expansion joints design improvements and fatigue tests

i) Refractory improvements

Analysis of designs shall include CFD and FEM investigations. The bid proposal may be developed by the bidder based on earlier studies/investigations. CFD studies and FEM investigation shall be specifically carried out for the equipment/component selected /designed for the subject project/package. Necessary reports for the analysis (CFD and FEM) shall be furnished to the Purchaser. The performance data required for the analysis shall be developed using dynamic modelling for the steam generator.

Visual/NDE protocols additionalities for critical components/equipment, analysis of fatigue damage and load cycling consideration as per the BS-EN 12952-3 or other equivalent code etc.

Results of design analysis which are required to be submitted as part of the Master Drawing List shall be tied up with the Bidder. The Bidder

shall be required to establish the design additionalities (changes in design, dimensions etc.) for making the steam generator suitable for load cycling as part of the bid proposal. The same shall be submitted as a separate document which shall be identified under the MDL. The document shall comprehensively cover each of the above-mentioned areas/components and others identified by the bidder. The process of analysis and results shall include in the document along with conceptual designs. The Bidder shall be required to help Purchaser's engineer run through the complete analysis (as many areas shall not form part of the submitted document).

Periodic inspection shall be carried out by the Bidder during the warranty period of all pre-identified areas with stress concentration. The specifications include thermo-couples and other instruments to collect necessary data for the field test which shall be collected to enable further confirmation of the offered design and/or trouble-shooting. Bidder shall recommend additional instrumentation that may be required for the purpose.

6)

a) Provision for life consumption/Equivalent Operating Hours (EOH) of critical components due to Creep & Fatigue shall be made available online (display in CCR) for Operating personnel. Also program/measures shall be made available online (display in CCR) to guide the operating personnel for maintenance planning.

b) Resulting Damage Factor due to Creep-Fatigue interaction shall be made available online (display in CCR) for Operating personnel.

3.09.00 Functions of HP/LP Bypass System

The HP/LP bypass system is intended for use in the following situations:

a) On hot starts to facilitate matching boiler steam to turbine metal temperatures prior to steam admission to the turbine, thus achieving a faster start up and reduced thermal stresses in the turbine.

b) During cold starts, for Boiler temperature control and condensate conservation.

c) On load rejection - or turbine trips, the bypass system will handle sufficient steam flow to avoid a boiler trip out thus allowing rapid reloading when fault condition clears.

d) The HP bypass system shall serve as pressure relief in case of transient main steam pressure excursion.

3.10.00 Noise Emissions

The plant will be designed and constructed to operate with the least practicable amount of noise.

Suitable acoustical treatment will be provided to ensure that when the plant is operating at any load, the sound noise level (to a reference of 0.0002 microbar) at a distance of 1 meter from the machine or enclosure outline and 1.5 meter above floor level, under any operating condition, does not exceed the more stringent of the following values and those on the Noise Rating curve ISO 85.

An exception will be made for the plant start-up operations or other big pressure reducing devices operating during emergency periods and to the safety valves.

The equivalent 'A' weighted sound pressure level measured at a height of 1.5 m above floor level in elevation and at a distance of one (1) metre horizontally from the nearest surface of any equipment / machine, furnished and installed under these specifications, expressed in decibels to a reference of 0.0002 microbar, shall not exceed 85 dBA except for equipment specifically listed under clause 4.03.01, Section X, Volume-II A of Technical Specification.

4.00.00 NAME PLATES/RATING PLATES/LABELS

4.01.00 Instruction plates, nameplates (rating plates) or labels shall be permanently attached to each main and auxiliary item of the Plant, including instruments, in a conspicuous position. These plates shall be of stainless steel and shall be engraved with the identifying name, type, identification number and manufacturer's serial number, together with the loading conditions under which the item of plant has been designed to operate.

4.02.00 Items such as valves, etc. which are subject to hand operation, shall be provided with nameplates so constructed as to remain clearly legible throughout the life of the plant giving due consideration to the difficult climatic conditions to be encountered. Nameplates shall be securely mounted where they will not be obscured in service by insulation, cladding, actuators or other equipment. Bidder shall pay specific attention to the nameplates/labels during painting, so that these are not painted over. Direction of flow is also to be engraved. All actuated valves shall be provided with labels, which shall include the valve and actuator reference number.

4.03.00 All nameplates and labels shall be in English language. All measurements shall be in S.I. units.

4.04.00 All segregated phases of conductors or bus ducts, indoor or outdoor, shall be provided with coloured phase plates to clearly identify the phase of the system.

4.05.00 Nameplates shall be 3 mm thick laminated white, black, white traffolyte for electrical and control panels and stamped stainless steel with lettering of a

minimum height 5 mm for other equipment of each unit. Warning labels and emergency equipment shall have red lettering in place of black. Danger labels shall have red lettering on a white background. Labels shall be of sufficient size to carry a full description of the Main Plant item and its complete KKS identifier. The size and location of nameplates shall be subject to Approval of the Owner. Lettering in all cases shall be machine-made and made to be legible after prolonged time in the range of ambient conditions prevailing at the Site.

4.06.00 Universal designation system utilizing six level breakdown KKS numbering system shall be followed for equipment identification. Each piece of equipment, motor, pump, valve, instrument, switchgear cabinet, junction box, control panel, panel board and associated apparatus shall be provided with tag plates indicating tag number and description. All major equipment (including the steam turbine, condenser, precipitator or fabric filter, main and auxiliary transformers, large pumps, and fans and motors) shall be provided with the data plates, indicating the name of the vendor, type, serial number, year of fabrication, main characteristics, and all further information necessary for a complete identification of the equipment.

4.07.00 All piping shall be painted and/or marked in accordance with the fluid contained according to a power plant color code to be proposed by Bidder and approved by Owner.

4.08.00 Tags shall be fitted by stainless steel self-tapping screws, stainless steel banding such that they are not readily lost or broken during routine operations and maintenance.

4.09.00 Surfaces of labels for cubicles and control equipment shall have a matte or satin finish to avoid dazzle. Colors shall be permanent and free from fading. Danger labels shall have red lettering on a white background. Labels shall be provided on front and rear access doors of all cubicles. Labels shall also be provided inside cubicles to assist the identification of apparatus and terminals.

4.10.00 All lifting beams, cranes, rails, jibs, hoists, slings, straps and other lifting equipment shall be properly tested and permanently marked with their lifting capacity.

5.00.00 SAFETY AND SECURITY

5.01.00 The design shall incorporate every reasonable precaution and provision for the safety of all personnel and for the safety and security of all persons and property. The design shall comply with all appropriate statutory regulations relating to safety. All structures and equipment shall be designed and constructed to withstand every foreseeable static and dynamic loading condition, including loading under earthquake conditions, with an adequate margin of safety.

5.02.00 Ready and safe access with clear headroom shall be provided to all parts of the plant for operation, inspection, cleaning and maintenance.

5.03.00 Escape routes and clear ways shall be provided to allow speedy evacuation of the plant in the event of fire hazard or explosion, and the plant layout shall allow for ease of access to all parts of the Works by rescue and fire fighting teams. The Plant layout shall be designed to localize and minimise the effects of any fire hazard or explosion. The recommendations of NFPA, OSHA, and TAC etc. as necessary shall be followed in all respects.

5.04.00 The use of corrosive, explosive, toxic or otherwise hazardous materials shall be kept to a minimum during construction and the design of the plant shall minimise the requirement for such materials during operation and maintenance. Where such materials must be used, all necessary precautions shall be taken in the design, manufacture and layout of equipment to minimise the resulting hazard, and all equipment necessary for the protection and first-aid treatment of personnel in the event of accidents shall be provided. Particular attention is drawn to avoid the use of materials containing asbestos in any form.

6.00.00 GUARDS

6.01.00 Effective guards and fences must be provided to prevent injury to operators through accident or malpractice.

6.02.00 Mesh guards which allow visual inspection of equipment with the guard in place are generally preferable. The guards shall be constructed of mesh attached to a rigid framework of mild steel rod, tube, or angle and the whole galvanised to prevent loss of strength by rusting or corrosion. The guards shall be designed to facilitate removal and replacement during maintenance.

6.03.00 All drive belts, couplings, gears, sharp metallic edges and chains must be safely guarded. Any lubricating nipple requiring attention during normal running must be positioned where they can be reached without moving the guards.

6.04.00 Guards for couplings and rotating shafts shall be in accordance with BS 5304-1975 or similar approved standard. All rotating shafts and parts of shafts must be covered.

6.05.00 Suitable fencing shall be provided to enclose all openings or doorways used for the hoisting and lowering of machinery etc. This fencing must be securely fixed but quickly detachable when required. A secure handhold must be provided on each side of the opening or doorway.

7.00.00 LOCATION AND LAYOUT REQUIREMENTS

The majority of plant and equipment shall all be of indoor installation. A broad list of buildings housing such equipment is given In Vol-II-G/1. Layout shall facilitate access for operation-maintenance and inspection of any one or more equipment/components at a time without disturbing the operation or installation of rest of the plant. Further, Bidder should comply with the criteria given under the various equipment and system specifications as well as those stipulated in Annexure-II attached to this section.

General Layout and other tender layout drawings enclosed in Volume-II-L [Tender Drawings] show the location of major installations and auxiliary buildings. The Bidder shall try to retain these locations as far as practicable. The layout of equipment within the power house as shown in the tender drawings is indicative. The Bidder may, subject to Owner's acceptance alter the same to suit the space requirement of the equipment offered.

While developing the layout of buildings the following criteria shall be given effect:

While preparing the detailed layout and deciding upon the transportation and construction/ erection strategy and functional requirements, the following aspects shall be ensured:

a) The spacing between various buildings and facilities shall be suitably decided so as to avoid interference between the foundations.

b) The area for construction/erection facilities like lay-down, pre-assembly, offices and stores will be accommodated within the areas available in General Layout Plan.

c) All statutory requirements including safe distances between various facilities as per applicable rules/acts/laws including local by-laws will be complied with.

Minimum clearances/ dimensions

i) Clear Head room within Main Plant Building for pipes, ducts, structures & cable trays etc. : 2.4 m (Minimum)

ii) Clear head room in passage bay between TG hall and first row of boiler column i.e. CD bay : 8 m

d) Deleted

e) Interconnecting walkways per unit:

Interconnecting platform	
Platform between main power house and Boiler	Two (2) nos. of interconnecting walkways (minimum 2.0m clear width) between TG building and boiler (on both side of boiler) at four elevations (minimum) preferably at ground, mezzanine, Operating and PRDS / De-aerator floor level shall be provided by Bidder for side mill/rear mill arrangement.. In case of front mill arrangement the mill bunker building shall be interconnected with 2.0m clear width platform with TG building at two levels (with one level

	necessarily connected with TG Hall operating floor and other interconnection level shall be decided during detailed engineering). The interconnection shall be on both sides of boiler center line for each elevation
Platform between boiler and Coal bunker building	Bunker Building shall be interconnected (1.5m clear width platform) with the respective steam generator at two elevations on either side of the steam generators (preferably at tripper floor leveland feeder floor level) and in each level, floors shall be interconnected to boiler in front as well as in rear sides and two nos.(One on left and one on right side) for front or rear mill arrangement.

f) All piping shall be routed at a clear height of 2500 mm (min.) from the nearest access level to clear man movement.

g) It is envisaged that Generator stator shall be handled by strand jack arrangement/suitable crane arrangement by Bidder during erection.

h). Cable/Pipe trestles height at rail/road crossings shall be 8 M (BOS)

i) A walkway of 750 mm (minimum width) with pipe hand rails & toe guards shall be provided all along length of the trestle for maintenance of cables & pipes. Ladders for approach to these platforms shall be provided near roads, passage ways and turning points.

j) Head room for man movement shall be minimum 2.5 m at ground floor in TG and boiler area and 2.1 m over all platforms. Height of trestles at approach roads to various buildings/facilities shall be 8M. In case building are located in off-site area and are adjacent to each other, then as a good engineering practice, the height of trestle shall be maintained all over as 8.0 M.

k) Each equipment room shall be provided with alternate exits in case of fire/accidents as per requirements of factory act and TAC.

l) Deleted

m) Rolling shutters shall be provided on `A'-row to facilitate the movement of Generator Transformers, Station & Unit transformers to the maintenance bay. Rolling shutter shall be provided for removal of Condenser tubes.

n) Deleted

o) The minimum width of clear access corridors around equipment shall be 1.2 meters.

p) Each building shall have an identified vacant space for equipment unloading and maintenance and preferably a separate bay altogether

in buildings housing heavy equipment. Provision for handling equipment by monorail hoist and/or overhead crane shall be made as specified.

q) The plinth level with respect to the existing grade level shall be as indicated elsewhere in this specification.

r) The minimum clear height available between two consecutive floor slabs shall not be less than 4.50 meters for Plant buildings and 3.50 meters for Non-Plant buildings, unless specifically mentioned. Adequate provision for natural ventilation and illumination shall be made as per good engineering practices.

s) There shall be at least two (2) nos. main access doors, one on either side of each building, of which one shall be minimum 3 meters wide with rolling shutters for equipment entry. For multistoried buildings(G+2 and above), at least two (2) nos. regular staircases diagonally opposite to each other shall be provided connecting all the floors and roof. These minimum requirements shall be augmented as required depending on the floor area, statutory requirements and TAC recommendations.

t) All buildings shall have provision for toilet (for gents, ladies and Physically challenged) or as specified elsewhere and associated sewage discharge system together with facility for drinking water. The criteria for ventilation, fire protection and illumination of building spaces specified elsewhere in this specification shall be complied with.

u) Top cover over underground pipes/cables shall be minimum one (1) meter. For CW/ACW Pipe, the top cover shall be minimum1.5 M.

v) Cubicle for operating personnel shall be located at safe place near the equipment.

w) Cable racks / pipe racks shall have hand railings in walkways on both sides at appropriate heights.

8.00.00 OPERATION AND MAINTENANCE CONSIDERATIONS

8.01.00 Space for ease of operation and maintenance including equipment removal, tube bundle/cartridge/rotor pulling etc. shall be provided. All valves, gates, dampers and other devices shall be located and oriented in such a way that they are accessible from operating floor levels. Where this cannot be adhered to, platforms and walkways with access ladders shall be provided to facilitate operation and maintenance.

8.02.00 Lifting devices i.e. hoists, chain pulleys, jacks, etc. shall be provided for handling of any equipment and/or part having weight in excess of 200 Kg during erection and maintenance activities. Suitable beams, hooks etc. for this

purpose shall be provided in the buildings and clear space provided below to a platform or floor which will allow normal risk free transport means to be used.

Lifting tackles, slings, etc. to be connected to hook of the hoist/crane shall also be provided by the Bidder for lifting the various equipment and accessories covered under this specification.

8.03.00 All similar parts of the equipment shall be made to gauge and shall be interchangeable with and shall be made of same material and workmanship as the corresponding parts of the equipment. Where feasible common components shall be employed in different pieces of equipment in order to optimize the spares inventory and utilization.

9.00.00 MATERIALS

9.01.00 In selecting materials of construction of equipment, the Bidder shall pay particular attention to the atmospheric conditions existing at the Site and the nature of material/fluid handled.

All materials shall be new and shall be of the quality most suited to the proposed application.

9.02.00 Materials used for various components shall be those which have already proven operating experience in similar type of applications.

9.03.00 All parts which could deteriorate or corrode under the influence of the atmospheric, meteorological or soil conditions at the Site, or under the influence of the working conditions shall be suitably and effectively protected so that such deterioration or corrosion is a minimum over the life of the plant.

9.04.00 Prohibited Materials

The use of the following materials is prohibited:

a) High alumina cement in structural elements

b) Wood wool slabs in permanent framework to concrete

c) Calcium chloride in mixtures for use in concrete works

d) Naturally occurring aggregate for use in reinforced concrete that does not comply with the applicable codes and standards.

e) Cast iron for any oil service

f) Carcinogenic material and suspected carcinogenic materials by World Health Organization.

g) Asbestos or any other fibrous form of hydrated magnesium silicate

h) Any other material generally known to be deleterious if used or incorporated in such project like the facility.

10.00.00 LUBRICATION

10.01.00 Provision shall be made for suitable efficient lubrication where necessary to ensure smooth operation free from undue wear.

10.02.00 Non ferrous capillary tubing shall be used throughout.

10.03.00 Gear boxes and oil baths shall be provided with filling and drain plugs, both of adequate size. An approved means of oil indication including level switches and temperature indication shall be provided.

10.04.00 All high speed gears shall be oil bath lubricated. Low speed gears shall be lubricated by means of soft grease. Removable and accessible drip pans shall be provided to collect lubricant, which may drop, from operating parts.

10.05.00 All lubrication points shall be conveniently situated for maintenance purposes. It must be possible to carry out lubrication from a gangway or landing and without the removal of guarding or having to insert the hand into it. Where accessibility to a bearing for oiling purposes would be difficult a method of remote lubrication shall be fitted.

10.06.00 The Bidder shall supply grease gun equipment suitable to service each type of nipple fitted.

11.00.00 LUBRICANTS, SERVO FLUIDS AND CHEMICALS

11.01.00 The Bidder shall provide a detailed and comprehensive specification for all lubricating oils, greases and control fluids required for the entire plant. A sufficient supply of these shall be provided by the Successful Bidder for initial commissioning, first fill and further topping till completion of trail operation. Contractor shall also supply a quantity not less than 10% of the full charge of each variety of lubricants, servo fluids, gases, chemicals etc. used which is expected to be utilized during the first year of operation. Further, higher quantities of lubricants, chemicals, consumables etc. as specified elsewhere in specifications shall also be supplied.

11.02.00 The Bidder shall supply a detailed schedule giving the lubricant testing, cleaning and replacement procedures. All equipment and facilities necessary for the testing, cleaning and changing of lubricants and control fluids shall be provided. The Successful Bidder shall endeavor to reduce the verities and grades of required lubricants and control fluids to a minimum, matching them where possible to those already in use in the generating station in order to simplify procurement and minimise storage requirements. All lubricants and control fluids shall be of internationally recognized standards and shall be easily obtainable from a large number of Indian suppliers. Bidder shall also indicate the equivalent Indian Standard for the above for easy procurement in future.

11.03.00 No lubricant or control fluid shall have toxic or other harmful effects on personnel or on the environment.

12.00.00 PLANT LIFE AND MODE OF OPERATION

The complete plant including all the equipment and systems individually and collectively shall be designed for continuous operation for an economic service life of twenty five (25) years under the prevailing site conditions and for the type of duty as specified in relevant sections of the specification.

The critical components of the Steam Generator, Turbine-Generator and Auxiliary equipment, the life of which is limited by time and temperature dependent mechanisms such as thermal stress, creep and low cycle fatigue, are to be designed considering expected (hot, warm and cold) start-up, shut-down and cyclic load variations. (Details are specified in the Volume-II B – Specification of Steam Generator and Auxiliaries and Volume-II C – Specification of Steam Turbine and Auxiliaries)

The units would be operated on base load with cyclic load variation. The load variation is expected to be as per schedule depending on power demand.

13.00.00 PACKAGING & MARKING

All the equipment shall be suitably protected, coated, covered or boxed and crated to prevent damage or deterioration during transit, handling and storage at site till the time of erection. While packing the materials, the limitations from the point of view of availability of railway wagon sizes in India should be taken account of. The details of various wagons normally available with Indian Railways for transportation of heavy equipment shall be considered by the Bidder. The Bidder shall be responsible for all loss or damage during transportation, handling and storage due to improper packing.

Bidder shall conduct his own route survey and transportation logistics for transportation of the equipment to project site by road/rail/sea and indicate the same in his proposal.

Each package shall have identification marking indicating the name and address of the consignee shall be clearly marked in indelible ink on two opposite sides and top of each of the packages. In addition the Bidder shall include in the marking gross and net weight, outer dimension and cubic measurement. Each package shall be accompanied by a packing note (in weather proof paper) quoting specifically the name of the Bidder, the number and date of contract and names of the office placing the contract, nomenclature of contents and Bill of Material.

14.00.00 PROTECTION

Equipment having antifriction or sleeve bearings shall be protected by weather-tight enclosures. Coated surfaces shall be protected against impact, abrasion, discoloration and other damages. Surfaces that are damaged shall be repainted.

Electrical equipment, controls and insulations shall be protected against moisture and water damages. All external gasket surfaces and flange faces,

couplings, rotating equipment shafts, bearings and like items shall be thoroughly cleaned and coated with rust preventive compound as specified above and protected with suitable wood, metal or other suitable covering to ensure their full protection. All exposed threaded parts shall be greased and protected with metallic or other suitable protectors.

All piping, tubing and conduit connections on equipment and other equipment openings shall be closed with rough usage covers or plugs shall be sealed and taped. Male threaded openings shall be closed with rough usage covers or plugs shall be sealed and taped. Female threaded openings shall be closed with forged steel plugs.

Returnable containers and special shipping devices shall be returned by the Bidder.

15.00.00 PAINTING

For Painting details, refer Section-XII of this Volume-IIA

16.00.00 COLOUR CO-ORDINATION & FINISH

16.01.00 Exterior surfaces throughout the plant shall be finished in colours and textures which will blend harmoniously together and with the surrounding landscape.

16.02.00 Interior surfaces throughout the plant shall be finished in colours and textures which will blend harmoniously together and which will be conducive to; the comfort, well-being and high productivity of the operators. Operating plant and services provided shall be colour coded for ease of identification.

16.03.00 All finishes shall be durable and as far as possible maintenance free. Finishes shall be easily cleaned.

16.04.00 Final colours and finishes shall be to the acceptance of the Owner.

17.00.00 ENVIRONMENT PROTECTION AND NOISE LEVEL REQUIREMENT

17.01.00 Environment Protection

The plant shall be designed for installation and operation in harmony with the surrounding environment and all measures of pollution control shall be ensured by the Bidder to restrict pollution from the liquid effluent and stack emission within the limits as given below with due consideration of Environment (Protection) Rules 1986 as amended till date.

The Plant shall be designed meeting the latest environmental requirement issued by MoEF&CC, GOI. In the event of Ministry of Environment & Forest stipulate any other conditions not specified hereunder, the Bidder shall comply with those requirements.

17.01.01 Liquid Effluent Discharge

a) Provision laid down in schedule-I for Thermal Power Plants and also in Schedule-VI. General Standards for discharge of Environmental pollutants Part-A: Effects of Environmental (protection) Rules 1986, as amended till date.

b) Any specific requirement(s) of State Pollution Authorities/Central Pollution Authorities over and above the above stipulation as per the latest norms/stipulations/guidelines issued.

17.01.02 Air Quality, Stack Emissions

a) Suspended Particulate Matter at chimney outlet - Maximum 30 mg/Nm^3 .(on 6% O2 dry basis)

b) Oxides of Nitrogen (NO_x)-100 mg/Nm^3 (Max)(on 6% O2 dry basis)

c) Sulphur di-Oxide(SO_2) -100 mg/Nm^3 (Max) .(on 6% O2 dry basis)

d) Mercury (Hg) - 0.03 mg/Nm^3 (Max)

e) The Efflux velocity from boiler stack(s) shall not be more than 18.3 m/sec.

f) Outlet dust emission level of bag filter installed in AHS and LHS shall be restricted to 18 mg/NM^3.

g) For The Coal Handling Plant, areas covered under Dry Fog Dust Suppression (DFDS)shall be designed to control the dust emission level in the working area measured at distance of 2m from the dust generation sources, over and above the atmosphere background dust level to shall be within 5 mg/NM^3

The Bidder shall include in his scope all necessary equipment and measuring instruments to comply with above requirements. Location and accessibility of the instruments shall be properly coordinated.

17.02.00 Noise Level Requirement

The plant shall be designed, constructed and provided with suitable acoustic measures to ensure the noise level criteria as per the following stipulations.

a) Maximum noise level shall not exceed 85 dB (A) when measured at 1.0M away from the noise emission source except for the equipment, as listed in clause no. 3.10.00 of this section.

b) Maximum noise level from its source within the premises shall not exceed 70 dB (A) as per Environment (Protection) Rules 1986, Schedule-III, `Ambient Air Quality Standards' in respect of noise.

c) Any statutory changes in stipulations regarding noise limitation that may occur in future according to State Pollution Control Board or Central pollution Control Board or Ministry of Environment & Forest regulation during tenure of the contract, the Successful Bidder shall comply with the requirement.

18.00.00 INSPECTION AND TESTING

18.01.00 Inspection and Tests during Manufacture

18.01.01 The method and techniques to be used by the Successful Bidder for the control of quality during manufacture of all plant and equipment shall be agreed with the Owner are set out elsewhere in this specification.

18.01.02 The Owner's general requirements with respect to quality control and the required shop tests are set out elsewhere in this specification.

18.01.03 Before any item of plant or equipment leaves its place of manufacture the Owner shall be given the option of witnessing inspections and tests for compliance with the specification and related standards.

18.01.04 Advance notice shall be given to the Owner as agreed in the Contract, prior to the stage of manufacture being reached, and the piece of plant must be held at this stage until the Owner has inspected the piece, or has advised in writing that inspection is waived. If having consulted the Owner and given reasonable notice in writing of the date on which the piece of plant will be available for inspection, the Owner does not attend the Successful Bidder may proceed with manufacture having forwarded to the Owner duly certified copies of his own inspection and test results.

The Successful Bidder shall forthwith forward to the Owner/Consultant duly certified copies of the Test Certificates in Three (3) copies for approval.

18.01.05 Under no circumstances any repair or welding of castings be carried out without the consent of the Owner/Consultant. Proof of the effectiveness of each repair by radiographic and/or other non-destructive testing technique, shall be provided to the Owner/Consultant.

18.01.06 All the individual and assembled rotating parts shall be statically and dynamically balanced in the works.

Where accurate alignment is necessary for component parts of machinery normally assembled on site, the Successful Bidder shall allow for trial assembly prior to dispatch from place of manufacture.

18.01.07 All materials used for the manufacture of equipment covered under this specification shall be of tested quality. Relevant test certificates shall be made available to the Owner. The certificates shall include tests for mechanical properties and chemical analysis of representative material.

18.01.08 All pressure parts connected to pumping main shall be subjected to hydraulic testing at a pressure of 150% of shut-off head for a period not less than one hour. Other parts shall be tested for one and half times the maximum operating pressure, for a period not less than one hour.

18.01.09 All necessary non-destructive examinations shall be performed to meet the applicable code requirements.

18.01.10 All welding procedures adopted for performing welding work shall be qualified in accordance with the requirements of Section-IX of ASME code or IBR as applicable. All welded joints for pressure parts shall be tested by liquid penetrant examination according to the method outlined in ASME Boiler and Pressure Vessel code. Radiography, magnetic particle examination and ultrasonic testing shall be employed wherever necessary/ recommended by the applicable code. At least 10% of all major butt welding joints shall be radiographed. Statutory payments in respect of IBR approvals including inspection shall be made by the Successful Bidder. Successful Bidder's scope and responsibility shall also include preparation of all necessary documents in the specific formats stipulated by the statutory bodies, coordination and follow up for above approvals.

18.02.00 **Performance Tests at Site**

18.02.01 The full requirements for testing the system shall be agreed between the Owner and the Bidder are set out elsewhere in this specification. The completely erected System shall be tested by the Successful Bidder on site under normal operating conditions. The Successful Bidder shall also ensure the correct performance of the System under abnormal conditions, i.e. the correct working of the various emergency and safety devices, interlocks, etc.

18.02.02 The Bidder shall provide complete details of his normal procedures for testing, for the quality of erection and for the performance of the erected plant. These tests shall include site pressure test on all erected pipe work to demonstrate the quality of the piping and the adequacy of joints made at site.

18.02.03 The Successful Bidder shall furnish the quality procedures to be adopted for assuring quality from the receipt of material at site, during storage, erection, pre-commissioning to tests on completion and commissioning of the complete system/equipment.

18.03.00 Special Testing requirements for Imported Items:

1). All equipment, components and parts imported for use in the Power Supply System and Network shall be tested within India to check for any kind of Embedded Malware/Trojans/Cyber threat and for adherence to Indian Standards.

2). All such testing shall be done in certified laboratories that will be designated by the Ministry of Power (MOP).

3). Any import of equipment/components/parts from "prior reference" countries as specified or by persons owned by, controlled by, or subject to the jurisdiction or the directions of these "prior reference" countries shall require prior permission from purchaser as per regulations stated by the Government of India.

4). Where the equipment/components/parts are imported from "prior reference" countries, with special permission, the protocol for testing in certified and designated laboratories shall be approved by the Ministry of Power (MOP).

The above mentioned shall apply to any item imported as a Stand Alone equipment or to be used as a component, or as a part in manufacturing, assembling of any equipment or to be used in power supply system or any activity directly or indirectly related to power supply system.

All the requirements mentioned by MOP, vide letter No. CEA/PLG /R&D/MII/2020, dated 03.07.2020 and other circulars as notified by the Government of India from time to time shall be complied.

18.04.00 For details of specific tests required on individual equipment refers to respective section of this specification.

19.00.00 TRAINING OF OWNER'S PERSONNEL

The Successful Bidder shall extend all possible assistance and co-operation to the Owner regarding the transfer of technology and developing expertise in the area of engineering operation and maintenance of the Plant.

Number of man-days of training as mentioned below shall be included in his Tender.

19.01.00 Training at Successful Bidder's Premises

The Successful Bidder shall conduct training of engineers of the Owner on engineering, operation and maintenance of the Plant at the Successful Bidder's or Associates or Sub Vendor's premises where adequate training facilities are available during the design and manufacturing stage of the successful Bidder.

The total man-months for training of engineers shall be maximum sixty (60), having following indicative break-up:

Discipline	No. of Man-month
Mechanical	40
Electrical	10
Control & Instrumentation	10

	60

However, the details of the training programme will be discussed and finalised with the successful Bidder.

The training may also be arranged by the Successful Bidder in any Plant where the equipment manufactured by the Successful Bidder or his Associates is under installation, operation or testing to enable the trainees to become familiar with the equipment being furnished by the Successful Bidder.

The training programme shall be adequate for the trainees to acquire the necessary expertise and competence in the area of engineering, operation and maintenance and as trainers for in-house technology transfer programme of the Owner.

The Successful Bidder shall be responsible for the development of the Training Module and Programme Schedule, which shall be submitted to the Owner for approval.

The components of the training modules shall include but not be limited to the training procedures/methodology, instructional materials such as audio visual materials, CDs and slides and manuals for each trainee.

Three (3) sets of the materials included in the training modules shall be handed over to the Owner upon completion of the training. An evaluation shall be jointly undertaken by the Successful Bidder and the Owner's representative on the adequacy, appropriateness and relevance of the training and the programme effectiveness after the training. The training material shall be in English language only.

The content of the training programme shall include but not be limited to :

1. Coal fired thermal plant principles in management and practice for operators, technicians and maintenance personnel.

2. Plant operation and systems training for operators as applicable.

3. Maintenance training programme covering electrical, mechanical and instrumentation and control.

Said training programme shall be submitted to the Owner for approval.

The timing of the training should be such that the participants will be conversant with sufficient know-how to participate in the pre-commissioning and commissioning tests of the Plant.

The Successful Bidder shall provide qualified English speaking instructors and training coordinator(s) during the tenure of the training programme.

19.02.00 Operation and Maintenance Training at Site

The Successful Bidder shall provide a comprehensive training programme related to design application, plant management, operation and maintenance, including trouble shooting, of the Successful Bidder's supplied system and equipment at the Site starting from Start of Commissioning and thereafter up to the Final hand over of the Unit. Adequate number of instructors shall be employed at site for this purpose for all the packages / sub systems.

19.03.00 On-the-Job Training

During the period of pre-commissioning, commissioning and trial operation, the Owner shall provide operation and maintenance personnel to assist the Successful Bidder in the operation and maintenance of his supply and work under the direction of the Successful Bidder for the purpose of on-the-job training.

The Owner shall have the right to send to the Site his employees later intended to operate and maintain the equipment supplied under this Contract. The successful Bidder shall, without additional cost, use his site staff to instruct these employees on the operation and maintenance of the equipment. All instructions shall be in the English language.

19.04.00 Training for 3D model review software

Training for Purchaser’s personnel for 60 man-days (for 10 employees in minimum 2 batches of 5 each) shall be provided at Purchaser’s office at Neyveli / Chennai, for the 3D Model Review Software(s) being offered under the package as stipulated elsewhere in the specification. This is in addition to the training man months detailed in clause 19.01.00 above.

ANNEXURE I

LIST OF STANDARDS FOR REFERENCE

a) International Standards Organisation (ISO).

b) International Electro-technical Commission (IEC).

c) American Society of Mechanical Engineers (ASME).

d) American National Standards Institute (ANSI).

e) American Society for Testing and Materials (ASTM).

f) American Institute of Steel Construction (AISC).

g) American Welding Society (AWS).

h) Architecture Institute of Japan (AIJ).

i) National Fire Protection Association (NFPA).

j) National Electrical Manufacturer's Association (NEMA).

k) Japanese Electro-technical Committee (JEC).

l) Institute of Electrical and Electronics Engineers (IEEE).

m) Federal Occupational Safety and Health Regulations (OSHA).

n) Instrument Society of America (ISA).

o) National Electric Code (NEC).

p) Heat Exchanger Institute (HEI).

q) Tubular Exchanger Manufacturer's Association (TEMA).

r) Hydraulic Institute (HIS).

s) International Electro-Technical Commission Publications.

t) Performance Test Code (PTC).

u) Applicable German Standards (DIN).

v) Applicable British Standards (BS).

w) Applicable Japanese Standards (JIS).

x) Electric Power Research Institute (EPRI).

ANNEXURE I

LIST OF STANDARDS FOR REFERENCE

y) Standards of Manufacturer's Standardization Society (MSS).

z) Bureau of Indian Standards Institution (BIS).

aa) Indian Electricity Rules.

bb) Indian Boiler Regulations (IBR).

cc) Indian Explosives Act.

dd) Indian Factories Act.

ee) Tariff Advisory Committee (TAC) rules.

ff) Emission regulation of Central Pollution Control Board (CPCB).

gg) Pollution Control regulations of Ministry of Environment & Forests, Govt. of India.

hh) Central Board of Irrigation and Power (CBIP) Publications.

ii) National Building Code (NBC).

jj) Indian Road Congress (IRC).

kk) Latest guidelines of Railway Authority.

ll) American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE)

mm) Sheet Metal and Air Conditioning Contractors Association (SMACNA)

nn) Indian Society of Heating, Refrigeration and Air Conditioning Engineers (ISHRAE)

ANNEXURE-II

CRITERIA FOR LAYOUT

The guidelines will be applied in general, unless otherwise stated in other technical Volumes. In addition to these guidelines, Bidder shall refer the attached Plot Plan, drawing no. 18A03-DWG-M-002A, for tentative arrangement of the various facilities under this package.

	ITEM	SPECIFICATION REQUIREMENT
A.	**Site conditions to be considered**	
1.	Prevalent wind direction during summer (for deciding Cooling Tower orientation)	. See wind-rose in plot plan.
2.	Prevalent wind direction(s) during dry seasons (for deciding the location of coal stock pile and ash dump/ unloading areas, minimising the pollution effect due to dust, ammonia handling and storage system minimising the hazard)	See wind-rose in plot plan.
3.	Location of:	
a)	Water intake point.	From West
b)	Water discharge point.	Not applicable
c)	Plant drainage outfall point(s).	Towards South East
d)	Railway entries & exits.	Not Applicable
e)	Road entries & exits.	From North/South
f)	Electrical power transmission grid system.	Towards South East
g)	Preferred/selected ash dump area.	Towards South
h)	Nearest residential area.	Towards North-East.
i)	Ammonia Handling System	Towards North

ANNEXURE-II

CRITERIA FOR LAYOUT

	ITEM	SPECIFICATION REQUIREMENT
B.	**Layout Requirements**	
1.	Maximum permissible slope in	
a)	Rail track	Not applicable
b)	Road	1 in 30
c)	Sides of unpaved embankment	1 in 2
2.	Required road width	
a)	Main Plant access road 10.0 Metres with 1.5 m wide shoulders on either side.	
b)	Primary roads with access for 500 T crane	10.0 Metres with 1.5 m wide shoulders on either side.
c)	Primary roads without access for 500 T crane	7.5 Metres with 1.5 m wide shoulders on either side
d)	Access ways	7.5 m/4.0 m with 1.5 m / 1.2 m wide shoulders on either side respectively as mentioned in civil spec..
e)	Road to the power house unloading bay :	
	• Only for entry to the unloading bay • To pass through the unloading bay	Yes. No.
3.	Required minimum horizontal distance between the nearest points of	
a)	Plant boundary and the boundary of residential area	(Local municipality/factory rule)
b)	Electrical transformer and any other building/facility	As per the Tariff Advisory Committee Rules.
c)	Fire water supply installation and any building/facility subject to fire risk.	As per the Tariff Advisory Committee Rules.
d)	Inflammable liquid (fuel oil,Ammonia etc.) storage & handling installation and their fencing and other buildings/facilities.	Rules of the Indian Explosive (Indian Expolsives Act) and Indian Petroleum Code.

ANNEXURE-II

CRITERIA FOR LAYOUT

	ITEM	SPECIFICATION REQUIREMENT
4.	Required minimum vertical clearance	
a)	Under pipes/cable racks at road crossings	8.0 Metres.
b)	Soil coverage over underground pipes for CW/ACW piping	1.0 Metre (minimum) 1.5 M
c)	Outdoor Pipe/Cable trench (if required)	150 mm above FGL
d)	Minimum height of equipment (switchgear, cabinet etc.) above floor for HT cable entry	500 mm
e)	Minimum height of equipment (switchgear, cabinet etc.) above floor for LT cable entry	300 mm
5.	Railway Wagon clearance	Not applicable
6.	Minimum Clearance between any road edge and building/structure/ any fixed installation.	Building edge = 6.0 Metres.& Other services = 3.0 meters
7.	Required level, above the local developed grade level, of	
a)	Top of all roads	250 mm.
b)	Temporary storage areas, workshops, offices, residence etc. required at the time of erection work.	Yes.

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BUILDING/ EQUIPMENT LAYOUT REQUIREMENTS

1.0 BROAD GUIDELINES FOR LAYOUT PLAN

General layout plan indicating the available spaces for proposed project is as shown in the tender drawing placed in Volume-L of the tender specification. It shall form the basis for further elaboration by the Bidder for the plant facilities, which are in his scope.

While preparing the detailed layout, planning the facilities in the Bidder's scope and deciding upon the transportation and construction/ erection strategy and functional requirements, the Bidder shall ensure the following aspects:

i) The spacing between various buildings and facilities shall be suitably decided so as to avoid interference between the foundations.

ii) The entire construction activity shall take into account the commissioning of the units.

iii) The area for construction/erection facilities like lay-down, pre-assembly, offices and stores is to be managed by the Bidder within the areas available in General Layout Plan.

iv) The finished floor level at ground level of the TG building shall be designated at EL. 0.0M and shall be 500mm above the finished ground level (FGL) of that area.

The finished floor level for various areas / facilities shall be as follows:-

FFL of Main Plant Building	-	El. 0.00M
Top of paving for Transformer Yard	-	El. (-) 0.10M
FFL of offsite building	-	500 mm above FGL of respective area

v) All the buildings and facilities shall be approachable by the fire tenders.

vi) All statutory requirements including safe distances between various facilities as per applicable rules/acts/laws including local bye-laws shall be met by the Bidder.

vii) DG Set Exhaust Pipes (Height & Orientation) shall be designed as per Environmental Regulations.

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1.1 Main Plant Control Room

Two (2) nos. Main Plant Control rooms (MPCR) - one control room for unit #1 & common facilities and other control room common for units #2 & #3, shall be provided by the Bidder.

Main Plant Control Rooms / Control Equipment Room/ RIO rooms for each unit shall be provided with air-conditioning by the Bidder.

2.0 MAIN PLANT LAYOUT REQUIREMENT

Introduction

The proposed location of main plant block is indicated in the Plot plan drawing enclosed in Volume-II L of the tender specification, however Bidder has to develop layout keeping the location/orientation of the main power block, power evacuation corridor, make-up water corridor, same as indicated in bid document. Bidder shall develop his own layout for the equipment offered and the same to be clearly brought out in the bid under the scope of Bidder. However, while developing the layout the Bidder must give due considerations for the following requirements:

The unit control equipment's room shall be located in the TG building towards boiler side at operating floor level.

The unit control equipment room shall be multi-level and shall essentially house but not be limited to the followings:

i) Unit control panels in control equipment rooms, operator's consoles etc. for all modules. MPCR shall not have any internal column inside the room. Large span roof beams for control room to be adopted and designed.

ii) Computer room with engineering work stations & associated workstations, PADO etc.

iii) Station In charge.

iv) Batteries shall be at mezzanine floor level.

v) Cabling and all other facilities associated with the above system.

vi) SWAS room in TG building.

The Control Rooms, unit control equipment room (CER), computer room with programmer station, PADO room, UPS room, SWAS (Dry Panel) room shall be provided with Air conditioned areas.

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Washroom/Toilet facilities for ladies & gents separately shall be provided. Further, no vertical bracings, pipes, cable shafts etc. shall be routed through control room or control equipment room area. Design of control room interior including lighting, roof, flooring and decoration will also be provided by the Bidder

2.1 Operating floor inside the main plant building shall match with top level of TG deck.

2.2 Adequate distance shall be maintained between the transformers. As basic guidelines following norms will be adhered to:

i) Unit and generator transformers, station transformers, and all Auxiliary transformers shall be separated from the adjacent building/structures and from each other by a minimum distance as defined below or by a fire wall of two hours of fire resisting of height at least 600 mm above bushing / pressure relief vent whichever is higher.

Oil capacity of individual transformer separating distance (in liters)	Clear (in Meters)
5,000 to 10,000	8.0
Above 10,000 to 20,000	10.0
Above 20,000 to 30,000	12.5
Over 30,000 or more	15.0

ii) In case of auxiliary transformers having an aggregate oil capacity in excess of 2300 liters or more but individual oil capacity of less than 5000 liters, the separating distance between transformers and surrounding building shall be at least 6M unless they are separated by fire separating walls or are protected by high velocity spray system.

3.0 **Layout requirements for Electrical MCC/switchgear rooms**

i) The following clearances shall be maintained for HV/MV Switchboard.

a. Front Clearance

1). For one Row of Swgr - 2.0 M (Min)

2). Between HV/ MV and LV SWGR (front to front). - 2.5 M (Min)

3). For two Rows of Swgr (Front to Front clearance) - 2.5 M (Min)

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b. Back Clearance - 1.0 M (Min.)

c. Side Clearance Min. 1000 mm,

ii) The following clearances shall be maintained for LT Switchboard.

a. Front Clearance

1). For one Row of Swgr - 2.0 M (Min)

2). For two Rows of Swgr (rear to front) - 2.0 M

3). For two Rows of Swgr (Front to Front clearance) - 2.0 M (min)

b. Back Clearance

1). For single/double front - 1.0 M (Min)

c. Side Clearance

Min. 1000 mm, however provision to be made for any additional panel in future at both ends. Therefore end clearance shall be 1000 mm + width of panel (2 nos. per bus section).

HT Switchboard clearances shall be followed wherever both LT & HT switch boards are in the same MCC room.

iii) Height of HV/ MV/LT Switchgear Room (bottom to roof beam)

a) With Bus Duct – 4.5 M (min)

b) Without Bus Duct – 4.0 M (min)

4.0 EQUIPMENT LAYOUT REQUIREMENT

4.1 A preliminary layout of the Main Plant along with other auxiliaries, accessories and facilities are enclosed with the Tender Specification. A preliminary cross sectional drawing of the Main Plant is also enclosed. The drawings have been enclosed for Bidder's reference. These drawings are shown after considering the following aspects.

i) AB bay width as 31 M (minimum) and BC bay width as 12 M.(minimum)

ii) Double LP Turbine.

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iii) Double Condenser

iv) Exhausting the steam from Drive Turbine to Main condenser

v) The locations of TDBFPs and MDBFP are in BC bay.

vi) Dual Pressure condenser

4.2 While developing the layouts the Bidder shall give consideration for inclusion of following major layout parameters.

A. Steam Generator Area

Sl.No	Area	Description
1)	Pitch (estimated)	152.0 Meters
2)	Minimum distance between C row of Power house and 1st row of Boiler column(i.e. 1st row of bunker building considering side bunker arrangement)	12.0 Meters
3)	Minimum clearance to be maintained between Adjacent boiler/bunker bay columns and Control Tower building of powerhouse	10.0 Meters.
4)	Minimum distance between last column of boiler and 1st column of ESP	30.0 Meters
5)	Estimated distance between D-row of Boiler Column and chimney centerline.	322.0 Meters.
6)	Minimum clear space required at all working and walking areas for operating & maintenance personnel	

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	i) Horizontal, in all directions	
	a) Adjacent to any electrical equipment, electrical cables, running (rotating/ reciprocating) equipment, safety valve or vent/drain pipe outlet, pipe/ equipment of surface temperature exceeding 60°C.	1500 mm.
	b) Adjacent to any other plant facilities (including walls /structures)	1000 mm.
	ii) Vertical (head-room clearance)	
	a) Under any pipe/equipment surface of temperature exceeding 60°C and any electrical cables or other electrical items.	2.2 Meters.
	b) Under any other plant facilities (including structures, pipes etc.)	2.5 Meters.
	iii) For all areas where any equipment. (including trucks, trolleys and other material handling equipment) will move or maneuver	Minimum 500 mm from the outer edges of the equipment.
	iv) Minimum clear hand space required for	
	a) The application of thermal insulation	100 mm
	b) Welding work	150 mm
	c) Bolt tightening	150 mm
7)	Floors, platforms, staircase, ladders, walls, doors & windows	
	Statutory Requirement	As per the regulations of OSHA, IBR,Tariff Advisory Committee, Indian National Building Code, Indian Factories Act, PESO, Local Municipal Rules, etc.as applicable.

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8)	Operation & Maintenance Requirement	
	i) Adequate floor space shall be kept to permit dismantling, temporary storing and in-situ maintenance of plant & equipment parts, satisfying the clear space requirements stated above. A separate unloading bay for such purpose is required.	Yes
	ii) Floors or fixed/portable platforms with stairs/ ladders shall be provided for easy approach to any plant item, including valves, instruments etc. to be operated, observed and/or to be frequently (more than once a month) maintained.	Yes
9)	Other Maintenance Requirement	
	i) Maintenance of the internals/impellers of All important equipment, like mills, all fans of the boiler draft plant, DMCW cooling water pumps, blowers, heat exchangers, fuel oil pumps, filters etc.	Shall be possible without disconnecting or dismantling any piping/ducting.
	ii) Overhauling and handling of the casings for the above items	Shall be possible without disturbing / dismantling any piping /ducting not directly connected to them.
	iii) Crane Approach Wherever required the unobstructed approach of the crane hook/other hoisting equipment hook to various plant & equipment shall be possible.	Yes

B. Steam Turbine Generator Area

All equipment of steam turbine generator units and ancillary plant shall be installed indoor except the CST:

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Sl. No.	Area	Description
1.	Total TG building length	452 M (minimum) (Total 43 columns with two numbers expansion joint at two places).
2.	No. of unloading bays	Two transverse bays at 0.0 m elevation shall be provided for unloading and maintenance at one end of main plant building. Two additional bay shall be provided between units 1 & 2 and between units 2 & 3 for maintenance at ground floor. Width of maintenance bay shall be 10.5 M (minimum). Further additional bays may be provided as per system/layout requirements.
3.	AB bay & BC bay width	31M (minimum) & 12M (minimum)
4.	CD bay width	In case of Side Bunker arrangement - 12 M (minimum) In case of Inline Bunker arrangement- 3.5 M (minimum)
5	Minimum Clear passage/Pipe cum cable rack width between boiler and turbine bay.	12 M (minimum)
6.	Arrangement of TG set	Longitudinal
7.	No. of minimum floor levels in AB bay. Elevations / Equipment locations shown are indicative.	i. 0.00 M - Finished floor level ii. 0.00 M – Cable Vault iii. 3.5 M – HT switchgear iv. 9M - Mezzanine floor v. 12.3 M LT switchgear vi. 18M - TG floor (Operating Floor)

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8.	No. of minimum floor levels in B-C Bay. Elevations / Equipment locations shown are indicative.	i) 0.00 M - Finished floor ii) 2.0 M BFP Drive Turbine iii) 9.0 M HP heaters 6A & 6B and LP heaters 2 & 3 iv) 9M – Cable Vault v) 12.3 M UPS & Battery Charger vi) 18M Common Control Room, HP heaters – 7A/7B & 8A/8B vii) 24.0 M or above as applicable to house Deaerator storage tank, Air washer room, Aux PRDS viii) 33.0 M –Deaerator tower, , SW/PW tanks, Note: Providing concrete floor to the entire length of main plant building at 33 M level in BC Bay is optional to Bidder. However, Bidder shall provide concrete floor wherever required.
9.	No. of minimum floor levels in C-F Bay. Elevations / Equipment locations shown are indicative.	i) 0.0 M – AC Plant , SWAS Room, Inert Gas room ii9.0 M – Battery Room iii) 14.0 M – Cable Spreader Room iv) 18.0M – Control Equipment Room v) 24.0 M – Cable Spreader Room vi) 27.0 M – Boiler MCC Room vii) 31.0 M- DMCW O/H tank, NaOH solution tank, Air handling units, cooling towers/ softening units for centralized AC system

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10.	Clear walk ways in AB & BC bay & Interconnection with Service Building	Minimum 1.5 m width walkway at all the levels in AB bay on the A row side & B row side. 3.0 m along B-row at operating floor level for interconnection with service building. The Inter-connection platform shall be of Covered type.
11.	Clear Head room in AB & in BC bay	Pipes, cables & equipment's shall be such that a clear head room of not less than 2.5 m above the walkways/ working area is available.
12.	Control Room in BC bay	i) Two (2) nos. Main Plant Control rooms (MPCR) - one control room for unit #1 and common facilities and other control room common for units #2 & #3 as shown in the layout drawing. ii) Location of Control room shall be in B-C bay at operating floor level. iii) Location of Control equipment room shall be on operating floor level in C to F bay as shown in the drawing..
13.	Location of Deaerator (indicative)	In B-C bay at 24.0 M
14.	Location of service water tanks, Potable water tanks (indicative)	In B-C bay at 33.0 M
15.	Location of Condensate Polishing unit(Service vessel)	Preferably in BC bay at 0.00 M
16.	Location of Condensate Polishing unit (Regeneration system)	Outside TG building as shown in General layout drawing
17.	Location of LP chemical Dosing unit (CWT, AVT & OT)	Preferably at 0.00 M.

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18.	Interconnecting platform between main plant building and boiler	As mentioned in Clause 7.00.00.(e) , Section V
19.	Lay down area for maintenance and overhauling.	The layout of the Steam Turbine Generator unit shall permit sufficient lay down area in the operating floor of the respective unit for all the parts/components to enable carrying out maintenance and overhauling operations without any restrictions and without any hindrance to the operating personnel of other units.
20.	Passenger cum goods Lift in TG hall (2000 kg)	2numbers shall be provided in TG building (as shown in plot plan).
21.	Passenger Lift in Service Building (8 persons)	One number shall be provided in the Service Building
22.	Service Building	Please refer Civil Volume II-G/1 & G/2
23.	DG Shed	DG sets with acoustic & weatherproof enclosure shall be installed outside on RCC foundation, with shed and sides open. 4 nos. of 2000 kVA (minimum) DG sets and shall have sufficient space for maintenance, operator & Panels. The tentative Location of DG sets shall be as shown in the plot plan.
24.	AC plant room	These shall be kept as per the tender drawing.
25.	CST (Condensate Storage Tank)	This shall be kept as per the tender drawing.
26.	Clear Head room in Main Plant Building for pipe, Structures & cable trays etc.	2.5 M

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27.	Basement, Pits & Trenches in Main Plant building	Not Acceptable. However in exceptional cases Bidder shall bring out such requirements in his bid and get the approval of the Owner.

4.3 The following clearances to be maintained for C&I DDCMIS/PLC cabinets:

i) Clearance from back - 1200 mm

ii) Clearance from front - 1200 mm

iii) Clearance from side wall - 1000 mm

The above clearances are minimum requirement and may increase with increase in door swing of the cabinets.

4.4 The cable vault space below the HT / LT switchgear room and Control Room shall have 800 mm wide and 2.1 m high movement passage all around the cable trays in the cable vault/ cable spreader room for easy laying/maintenance of cables.

i)	Minimum clear working space Around the equipment	1200mm
ii)	Minimum width of all staircase	1500 mm for all indoor stairs and 1200 mm for outdoor stairs.
iii)	Clear head room in Passage bay between TG hall And first row of boiler column i.e. CD bay	8m
iv)	No. of Fire Escape staircases	As per NBC Part-4-Travel Distance. However, the Fire escape staircases in the main plant with fire doors quantity shall meet the requirement of NBC Part-4. Adequate space and provision for handling/ removal of pumps, motors, heaters, heat-exchanger, fans, Switchgear Panels, Transformers during maintenance shall be provided.
v)	Independent floor drains with separate down comers shall be provided where fire protection system are provided.	

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vi)	In TG bay at crane rail level, chequered plate walkway of minimum 600 mm clear width from face of the column to the hand rail on crane side to be provided for entire A-row & B-row column sectional depth for full length of the building.
vii)	Layout of facilities and equipment shall allow removal of Generator Stator, Generator transformers, Station & Unit transformers without disturbing equipment's, piping, cabling, ducts routed in the area. Adequate space and provision for handling/removal of pumps, motors, heaters, heat- exchanger, fans, Switchgear Panels, Transformers during maintenance shall be provided.
viii)	Valves including actuators and instrument tapping's shall be located in accessible positions and operating/maintenance platform for the same shall be provided. All piping shall be routed at a clear height of 2500mm (min.) from the nearest access level to clear man movement.
ix)	Steam turbine and Generator and other equipment's located in the turbine hall shall be accessible by the EOT cranes for their handling during erection and maintenance. Wherever special handling procedures are to be followed such as for the handling generator stator, rotor withdrawal of Generator etc., during erection, the same shall be under the scope of Bidder and described in written out document and attached with the bid. In case auxiliaries such as BFP are not in the reach of TG hall EOT crane, then separate EOT crane with proper maintenance area shall be provided along with all tools required for removal, assembly & handling of BFPs.
x)	Routing of cable trays & piping including piping & ducting (a) Trestle height in outdoor area shall be 3.0M (BOS) (b) Cable/Pipe trestles height at rail/road crossings shall be 8M (BOS). (c) The pipes including fire water pipes shall be routed over ground either on pedestals or on trestle in plant area. No trenches for pipes shall be envisaged as far as possible. (d) Head room below cable/ pipe rack in transformer yard area for movement of GT shall be such that the same can be moved with bushing installed. A clear gap of 500mm between top of bushing and BOS of the trestle shall be ensured. (e) A walkway of 750 mm (minimum width) with hand rails & toe guards shall be provided all along length of the trestle

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	for maintenance of cables. Ladders/staircase for approach to these platforms shall be provided near roads, passage ways and turning points. (f) Clear Head room for man movement shall be minimum 2.5m at ground floor in TG building area and 2.1m over all platforms for other areas. (g) Height of trestles at approach roads to various buildings/facilities shall be 8 M. In case building are located in off-site area and are adjacent to each other, then as a good engineering practice, the height of trestle shall be maintained all over as 8.0M. (h) Separate cable tray for optical fiber cable / UTP cable shall be provided wherever applicable. (i) The layout shall be developed so as to meet the requirements of the Cabling philosophy indicated separately (Cabling, Earthing & Lightning Protection).
xi)	Each equipment room shall be provided with alternate exits in case of fire/accidents as per requirements of factory act and TAC.
xii)	All cranes including TG EOT cranes shall be provided with approach ladders at least at two places. For the approach to the walk way along B row of TG EOT crane 2 nos. staircase from 24m level (BC BAY) shall be provided, with door in the B Row wall. Where ever cranes can't be maintained in situ on the carriage, facility to draw them to maintenance platforms at girder level as well as provision of suitable platforms shall be considered by the Bidder.
xiii)	For Ventilation requirement from A-row side of TG building, Air Washer room for installation of Air washer units along with pumps shall be considered at suitable location as shown in the general layout drawing. Further, for the remaining Ventilation requirement, Air Washer room for installation of Air washer units along with pumps in BC bay at 24m level (tentatively) for each unit shall be considered. All fresh air ventilation louvers shall be approx 1000 mm from floor level and directed downward at an angle.
xiv)	From the common centralized AC plant separate AHUs (Air handling units) shall be provided for Main plant, & Service building as shown in the general layout drawing/elsewhere in the specification. For further details relevant section of Technical Specifications may be referred.
xv)	All equipment operating maintenance platform including supporting structures such as grating platform in the oil equipment room,

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	control fluid equipment room, valve room, Deaerator, Gland Steam Condenser, Flash tank and for other equipment supplied and erected by the Bidder.
xvi)	Suitable rolling shutters shall be considered in the equipment layout to be developed by the Bidder on `A'-row to facilitate the movement of Generator Transformers, Station & Unit transformers to the maintenance bay. Further rolling shutters at different location shall be provided in TG hall for the movement of material. Rolling shutters shall also be provided along "C" row in TG hall wherever required.
xvii)	All pipe lines shall be routed on pedestals except at road/rail crossings where pipe culverts shall be provided. CW and ACW piping shall be laid below ground as per general layout drawing.
xviii)	A suitable rail track and associated facilities like jacking pads, mooring posts etc. shall be provided to facilitate the movement of Generator Transformers, Station Transformer, Unit Transformers and Unit Auxiliary Transformers to the maintenance bay. These rail tracks shall be accessible from the equipment unloading area of TG bay by a rail track.

5.0 **Lay down area for maintenance and overhauling**.

i) The layout of the Steam Turbine Generator units shall permit sufficient lay down area for all the parts/components to enable carrying out maintenance and overhauling operations without any restrictions and without any hindrance to the operating personnel.

ii) In case any special arrangement for rotor maintenance is required, the same shall be provided by the Bidder.

iii) All handling arrangement including any special arrangements like trolley, drive, pedestals etc. for carrying out maintenance and overhauling for steam turbine generator and its auxiliaries shall be provided by the Bidder.

iv) The Bidder shall furnish general arrangement drawings indicating the equipment lay down area with details such as blocks indicating orientation of dismantled items, travel path etc.

v) The Bidder shall also furnish general arrangement drawings indicating the lay down arrangement of major unit assemblies (provided as spares) in the TG hall with access from EOT crane..

6.0 Local Pits/trenches in Main Plant building are to be avoided. However pits/sumps which are unavoidable such as CW (Circulating Water System)

pits etc. shall be provided with required dewatering arrangements by means of permanently installed drainage pumps and piping up to the ETP. Bidder shall provide required sump pumps/drainage pumps/submersible pumps & Piping etc.

7.0 Pump shall be permanently fixed in the pits/sumps. If the pit depth is shallow, vertical top mounted sump pumps shall be provided and in deep pits self-priming drainage pumps (horizontal type) at floor level or alternatively submersible type pumps may be provided.

8.0 Each pit/sump shall generally be provided with two numbers (2x100% Capacity) of respective type pumps so that the entire pit is evacuated within 15-20 minutes and the operation of the pumps shall be interlocked through level measurement devices to be installed in the pit/sump so that the pumps shall start automatically and empty the pit.

9.0 The general design and construction features of Vertical sump pumps and Submersible pumps are furnished elsewhere.

10.0 In addition to the above, suitable drainage arrangement of different floors of Main Plant building and Service building, DG set area, Air Conditioning & Ventilation buildings shall be provided. These drains shall be led to the station sumps on the A row and B/C row sides. Sump pumps shall be provided as per the stipulations in Volume II-K of the technical specification. Bidder shall also provide piping, fittings etc. for taking this drain/oily waste water to ETP.

11.0 Bidder to furnish the detailed erection strategy along with the bid for major equipment's located in TG hall.

12.0 Bidder's shall prepare the detailed layout of main power block area indicating the location of all major equipment. The layout shall be furnished along with the bid submitted by the Bidder.

13.0 Valves shall be located in accessible positions.

14.0 Provision of monorails with chain pulley blocks/HOT cranes along with hoist, as required shall be kept.

15.0 Approach for removal of equipment for maintenance shall be provided.

16.0 A/C and ventilation ducts, Bus ducts, and Critical Piping routes to be identified at conceptual stage.

17.0 No cable trenches, under-ground cable vaults and pipe trenches are acceptable in Main Plant as well as interplant cable routing unless otherwise approved by the Owner.

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18.0 All the pipes and cables within the Plant boundary shall be routed above ground except the Circulating Water Piping and ACW piping (part).

19.0 All other safety requirements as per the factories act shall be observed while developing the layout.

20.0 Battery rooms shall be properly ventilated to release gases produced. An easily accessible wash basin with eye washer shall be provided in the battery room.

21.0 Pipelines shall be routed in such a way to avoid interference with other pipes and their hangers and supports, structure, equipment, electrical conduits, cable trays, ventilation ducts etc. The pipe routing shall also take into account the availability of structural members for providing suitable supports and hangers. Hot and cold premises of the system shall be suitably isolated/ segregated from each other. Routing of oil lines over steam lines shall be avoided. Also the electrical premises shall be fully segregated from system piping.

22.0 Piping layout shall have adequate flexibility to absorb all thermal expansion without causing undue stress in the pipelines.

23.0 All piping shall be grouped where practicable and shall be routed to present a neat appearance.

24.0 The piping shall be arranged to provide clearance for removal of equipment requiring maintenance and for easy access to valves and other piping accessories required for operation and maintenance. Availability of access to valves and specialties shall be properly indicated on the layout drawing.

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SECTION-VI

PROJECT MANAGEMENT AND SITE SERVICES

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SECTION-VI

PROJECT MANAGEMENT AND SITE SERVICES

1.00.00 PROJECT MANAGEMENT SERVICES

1.01.00 Responsibility

The Bidder shall identify a separate and independent project management team headed by a Project Manager for the execution of this project. Responsibilities of this project Management team shall cover the areas listed below :

a) Planning and Monitoring

b) Project Engineering Management

c) Contracts Management

d) Quality Assurance, Inspection & Expediting

e) Construction Management

f) Spares Management

g) Commissioning Management

Detailed responsibilities in the above areas are discussed below :

1.02.00 **Organisation**

1.02.01 **Headquarters**

The headquarters of the project management team shall be headed by a senior level executive designated as the Project Manager who shall be responsible for the execution of this project. He should have adequate financial power and authority to give decision.

Separately, designated leaders shall be identified for each of the areas mentioned under 1.01.00, who, in turn, will report to the Project Manager for all matters related to this contract.

1.02.02 **Central Co-ordination Cell**

The central coordination/ cell shall be based in the Project site at Talabira and shall have sufficient technical personnel to coordinate technical matters and to quickly resolve day to day queries or references made by Owner / Consultant without having the need to refer to his headquarters each time.

.1.02.03 **Site Organisation**

The site should have a competent Construction/Project Manager for all site operations with adequate financial power and sufficient level of authority to take site decisions. The organisation chart for site should indicate the various levels of experts to be posted for supervision in the various fields in civil construction, erection, commissioning etc.

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1.02.04 **Organisation Chart**

The Bidder shall furnish a detailed organisation chart for the project management team, clearly identifying the key personnel in each of the areas mentioned at 1.01.00 above. The expected number of executives at different levels shall also be indicated, separately for headquarters, central coordination cell and site organisation.

1.03.00 **Implementation Schedule**

The schedule for the completion of Coal based NLC Talabira Thermal Power project consisting of three (3) supercritical units of 800 MW capacity each, near Kumbhari & Tareikela villages in Jharsuguda District, Odisha would be inline with Volume-IB:

To achieve the implementation schedule, the Bidder shall furnish to the Owner, various schedules as defined below:

1.03.01 **Design & Engineering Schedules**

These schedules shall cover various design submissions indicating different *Design &* Engineering activities to be performed. Such schedules shall be furnished by the Bidder for each and every plant/systems/ equipment/ item covered in the scope of this specification.

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1.03.02 **Manufacturing Schedule**

The Bidder shall submit to the Owner, his manufacturing and delivery schedules for all equipment within sixty (60) days from the date of issue of the Letter of Award (LOA). Such schedules shall be in line with the detailed network for all phases of the work of the Bidder. Such schedules shall be reviewed, updated and submitted to the Owner, once in every two months thereafter, by the Bidder. Schedules shall also include the materials and equipment purchased from sub-suppliers. In the dispatch programme, the Bidder shall indicate a schedule of estimated programme, tonnage's specifically identifying various oversize dimensioned consignments (ODC). All dispatch details and item lists shall be made available to both Owner & site immediately after shipping.

1.03.03 **Erection Schedules**

In order to achieve the overall completion schedule, the Bidder shall provide the Owner all the information covering erection sequence, testing and commissioning activities. These schedules may be based on the erection procedures as per the L1 PERT approved by the Owner/Consultant within one month from the date of LOA.

1.03.04 The successful Bidder shall have to provide all the above schedules (i.e. 1.03.01, 1.03.02 & 1.03.03) in a tabular form in addition to that in the form of L2 & L3 networks and these shall necessarily include information not limited to the earliest and latest dates for various activities/submissions and also any related constraints. However, the Bidder shall include in his proposal a Level-1 (L-1) network showing the major activities and various milestones to achieve the above mentioned completion schedule within one month from the date of LOA.

1.03.05 The Bidder shall provide the Owner the original disc/software for all such schedules along with requisite no. of copies (as required by the Owner) within an agreed time schedule. This time schedule will be agreed between Owner and Bidder after the award of Contract. The Bidder's project management software shall be compatible with that of the Owner and the input data shall be furnished to the Owner in a manner compatible with Owner's project management software, MS Projects. .

1.04.00 **Detailed Responsibilities**

1.04.01 **Planning & Monitoring**

a) **Planning**

The Bidder shall prepare a Master Network Schedule in the form of PERT network consisting of at least 500 activities.

The network shall be prepared on a Work Breakdown Structure for the project which sub-divides the project into a set of manageable systems/sub-systems. The master network will identify milestones of key events for each system/package in the areas of engineering, procurement, manufacture and despatch and erection and commissioning. The master network shall represent the Level-I plan and will form the basis for development of detailed second and third tier execution plans. The master network shall conform to the overall schedule prescribed by Owner.

The master network should be submitted along with the bid, which would be mutually discussed and finalised before the Award of Contract. This master network would clearly indicate the responsibility of the Bidder and project management team. The master network shall also identify a complete list of inputs to be furnished by the Owner which may be required for proper interfacing and tie-up. Scheduled dates for providing such inputs shall also be indicated, which will be mutually discussed and finalised.

. b) **Monitoring & Progress Reporting**

The progress reports would be emanated every month, one from the head office of the Bidder and another from the site office. The progress report emanating from the head office should necessarily include the following sections:

i) Report on key milestones.

ii) Management summary indicating critical areas with details of actions initiated and effect of any on the project.

iii) Action needing attention of the Owner/Consultant.

iv) Detailed package wise status of engineering submissions, quality plan submissions and approval, procurement manufacture and dispatch..

The monthly report generated from the site office should necessarily include:

i) Report on key milestones.

ii) Management summary indicating critical areas with details of actions initiated and effect if any on the project.

iii) Action needing attention of the Owner/Consultant.

iv) This report would also cover the areas pertaining to the receipt of the equipment at the port, port clearance, transport, receipt at site, erection and commissioning.

In addition to the above, as the project execution progresses, the Bidder shall also be responsible for generating more frequent reports in the form of fax/e-mail information on progress in critical areas so that actions can be expedited. The exact format of the progress report shall be finalised after award of Contract.

1.04.02 **Project Engineering Management**

Based on the master network for the project (L-1) the Bidder will prepare an exhaustive list of engineering activities for the equipment/systems covered in his scope and a detailed programme of accomplishing the same within the time frame specified in the master network. This schedule will form the Level-2 (L-2) network for engineering activities.

Based on (L-2) network, the Bidder shall further develop the Level-3 (L-3) network for engineering activities which will indicate schedule for data availability, drawing release date and document submission dates.

Detailed (L-2) and (L-3) networks would be submitted sequentially by the Bidder within three months from the date of issue of Letter of Award and finalised within one (1) month thereafter. The same shall be approved by the Owner.

All such networks shall be provided in MS Projects software.

The Engineering management team should also co-ordinate all interface engineering activity between the Bidder and the equipment sub-vendors so as to ensure the correctness and completeness of related engineering documentation before the same is submitted to the Owner.

1.04.03 **Contracts Management**

Based on the master network, the Bidder shall submit L-2 programmes of manufacture and despatch. In addition, the master network shall also include periods considered for site activities viz. erection, commissioning etc. These L-2 programmes would be submitted in 3 months time from the date of award of contract and finalised within one (1) month thereafter. The Bidder will also submit site mobilisation plan. This programme would be submitted at the time of finalisation of award of contract and agreed immediately thereafter so that immediate development of the various activities at site could take place.

. The Bidder should also submit L-3 programmes for the manufacturing, despatch of the various items. These networks shall also show the customer hold points (CHP) which have to be cleared by Owner or their authorised representative(s) before further manufacturing can take place. These L-3 programmes for the manufacture and despatch would clearly identify responsibilities of the Bidder, sub-Bidder and Owner. These networks shall be submitted within one (1) month of the date of finalisation of the various sub-contracts by the Bidder.

In case all the manufacture is being done by the Bidder then the L-2 programmes would be themselves amplified to cover details of the manufacture, inspection, clearance by Owner and despatch.

The Bidder shall also submit the programme for procurement of bought out items, detailed shipping schedule and cash flow statement for Owner's approval.

1.04.04 **Quality Assurance, Inspection and Expediting**

The Bidder shall submit the list of manufacturers/sub-vendors from whom the equipment are expected to be procured as per the stipulation made elsewhere in the specification and the quality assurance plans thereof for the manufacture shall be approved by the QA group of Owner/Consultant before the manufacturing is commenced. The list of major suppliers would be submitted along with the bid and this shall be mutually discussed and approval will be given by the Owner/Consultant during contract negotiation meeting prior to placement of Letter of Award. This approved list will be binding to the Bidder.

On the quality plans, the customer hold points will also be identified based on which Owner would give clearance for the manufacture to proceed further.

Quality assurance/Inspection group of Owner would issue a material despatch clearance certificate (MDCC) after the inspection clearance which will enable the Bidder to despatch the equipment and claim the payment. In the despatch programme, the Bidder shall indicate a schedule of estimated programme, tonnages specifically identifying various oversize dimensioned consignments (ODC). Further the Bidder will also be required to ensure at all stages of shipment that packing of all shipments despatched are suitable for ocean freight to India, handling at the port of entry, inland transportation and preservation at site up to erection. All despatch details & item lists shall be made available to both Owner & site immediately after shipping.

The Bidder shall also expedite all despatches from their own works/works of their sub-vendors, so as to match with the various activities mentioned at 1.04.03 above.

1.04.05 **Construction Management**

Based on the L-1 Network Programme, within three (3) months of the issue of Letter of Award, the Bidder shall submit a programme of construction /erection/commissioning, either in continuation with the manufacture and despatch or separately for the implementation in the form of L2-PERT. These programmes would be amplified showing when the civil drawings shall be released by him and construction of civil works shall be completed by him to facilitate start of erection and subsequent activities and shall form the basis for site execution and detailed monitoring. The three monthly rolling programme with the first month's programme being tentative based on the site conditions would be prepared based on these L-3 programmes. The Bidder shall also be involved along with the Owner to tie up detailed resource mobilisation plan over the period of time of the contract matching with the performance targets.

The L-3 programme would be jointly finalised by the site in-charge of the Bidder with the Owner's project coordinator as well as the site planning representative. The erection programme will also identify the sequential erectable tonnages that are required for various equipment which should be taken care of in the despatch programmes.

Erection and commissioning of the equipment shall also be done under the supervision of experts from the respective equipment/ system supplier.

1.04.06 **Spares Management**

Along with the proposal for the plant and equipment, the Bidder shall also submit proposals/schedule for Mandatory spares

List / quantity of mandatory spares will be finalised by the Owner /Consultant at the time of the award of contract. It is the responsibility of the Bidder to ensure availability of spares during the period of testing and commissioning and all spares to meet Bidder’s obligations under the Warranty Period.

1.05.00 **Project Progress Review Meetings**

Keeping in mind the overall responsibility of the Bidder it is intended that periodic progress reviews on the entire activities of execution in respect of Coal based 3x800 MW NLC Talabira Thermal Power Project (NTTPP) will be held initially at least once in two (2) months at Consultant office at Kolkata/NLCIL Talabira site/NLCIL Neyveli Corporate office /NLCIL office at Chennai or in the office of the Bidder depending on the circumstances and mutual agreement. During peak period it may be held once in a month These meetings will be attended by reasonably higher officials of the Bidder and their leading sub-Bidders and will be used as a forum for discussing all areas where progress needs to be speeded up. Actions will be placed on the concerned agencies and decisions will be taken to expedite/speed up the progress. Minutes of such meetings will be issued reflecting the major discussions and decisions taken and circulated to all concerned for reference and action. The Bidder shall be further responsible for ensuring that suitable steps are taken to meet various targets decided upon such meetings.

In addition to the above, and to streamline the construction and erection at site, a suitable frequency and forum of periodic meetings between the Bidder and the Owner will be decided upon as part of erection coordination procedure. Site co-ordination meeting may be held on weekly basis.

1.06.00 **Owner's Consultant**

The Owner would appoint a consultant to assist him in some of the areas mentioned at 1.01.00 above. The details of interaction and procedures for coordination between Owner/Consultant and Bidder/Bidder's project management team shall be finalised during contract negotiations.

1.07.00 **Commissioning Management**

1.07.01 For commissioning of the various equipment/system covered under the scope of contract, Owner will form an organisation structure which may consist of the following committees. The Bidder shall nominate his representative on one or more of the committee as decided by the Owner:

a) Commissioning Teams.

b) Testing Teams.

1.07.02 Commissioning documents shall be prepared by the Bidder in the following manner and submitted for Owner's approval :

a) **Paper of Principle**

This document shall be prepared for the various equipment/ systems under commissioning and shall have the following objectives to fulfill and shall be submitted for Owner's approval at least six (6) months before their actual commissioning :

i) Establish design data against which Plant Performance will be compared.

ii) Set-out the testing objectives and proposals.

iii) Define the documentation required.

b) **Testing/Commissioning Schedule**

These shall be prepared for the various equipment/systems under consideration and shall contain sections like detailed testing method, programme, safety, individual responsibility and results.

c) **Standard Check Lists**

Standard checklists are intended for use at the completion of erection to ensure correct erection, testing and to a limited extent operation for repetitive items.

1.07.03 **Test Reports**

After the completion of commissioning activity of equipment/ systems, the Bidder shall prepare the test reports which shall include all the relevant information related to various commissioning checks, tests carried out, any deviations/commissions noticed with respect to the intended design requirements, sequence of various commissioning activities as actually adopted vis-à-vis as recommended in the procedures, programme schedules achieved and any other such information as required. These test reports shall be submitted in requisite number of copies to the Owner and this should be duly signed jointly by the Owner/Consultant and the Bidder/Equipment supplier, who are involved during the commissioning activities.

2.00.00 SITE SERVICES

These services shall be rendered by the Bidder as part of the overall project management service. The services shall broadly include but not be limited to the following :

2.01.00 Arranging material despatch from the shop by rail/road and/or sea as applicable.

2.02.00 Monitoring movement of materials & follow-up as necessary with Railways, road transport, port clearance etc. from the time of despatch F.O.R. works/F.O.B. port of shipment by Bidder till receipt of the same at site.

2.03.00 Unloading of materials inside project area, transportation to site store, assessment of lost/damaged items in transit and arranging insurance claims and replacement of lost/damaged items. The Bidder shall submit to the Owner a report detailing all the receipts during the week.

2.04.00 Issuing materials from site store/open yard from time to time for erection as per the construction programme. The Bidder shall be the custodian of all the materials issued till the plant is officially taken over by the Owner after complete erection and successful trial run & commissioning.

2.05.00 Transportation of materials to their respective places of erection and erection of the complete plant & equipment as supplied under this specification.

2.06.00 Trial run and commissioning of individual equipment/sub-systems and the plant as a whole to the satisfaction of the Owner, including supply of temporary equipment & services for chemical cleaning, steam blowing as well as performance guarantee tests.

For Coal Handling Plant, satisfactory operation of the system, amongst others, shall consist of operation without spillage or choking anywhere even during monsoon.

Provision for preservation of individual equipment after trial run and commissioning e.g. Nitrogen blanketing etc. as necessary shall also be in the scope of the Bidder.

2.07.00 Supply and application of the final paint, sand, first fill lubricants on all the equipment to be erected under this specification. Supply of chemicals and lube oils etc. as mentioned elsewhere in the specification.

2.08.00 For the purpose of erection and commissioning the Bidder's scope of work shall include but not be limited to the following :

2.08.01 Deployment of all skilled and unskilled manpower required for erection, supervision of erection, watch & ward, commissioning and other services to be rendered under this specification.

2.08.02 Deployment of all erection tools & tackle, construction machinery, transportation vehicles and all other implements in adequate number and size, appropriate for the erection work to be handled under the scope of this specification. Supply of commissioning spares.

2.08.03 Supply of all chemicals and consumables, e.g. Regeneration chemicals, alum, lime, polyelectrolyte, resin, welding electrodes, cleaning agents, diesel oil, grease, lubricant etc. as well as materials required for temporary supports, scaffolding etc. as necessary for such erection commissioning work as specified elsewhere in the specification, except those listed under exclusion elsewhere in this specification.

2.08.04 Construction of all civil/structural/architectural works, including construction of foundation for all equipment supplied as required, grouting of equipment on foundation after alignment, and all other incidental civil activities as detailed elsewhere.

2.08.05 All structural steel fabrication and erection work as detailed elsewhere in the specification.

2.08.06 Providing support services for the Bidder's erection staff e.g. construction of site offices, temporary stores, residential accommodation and transport to work site for erection personnel, insurance cover, watch & ward for security and safety of the materials under the Bidder's custody etc. as required.

2.08.07 Maintaining proper documentation of all the site activities undertaken by the Bidder as per the proforma mutually agreed with the Owner; submitting monthly progress reports as also any such document as and when desired by the Owner; taking approval of all statutory authorities e.g. Boiler Inspector, Factory Inspector, Inspector of Explosives etc. for respective portions of work under the jurisdiction of such statutes or laws.

2.08.08 The Bidder shall provide `Industrial Relations' unit and `Medical' unit to take care of his erection staff and the Owner shall have no obligation in this regard.

2.09.00 **Site Organisation**

The Bidder shall maintain a site organisation of adequate strength in respect of manpower, construction machinery and other implements at all times for smooth execution of the contract. This organisation shall be reinforced from time to time, as required, to make up for slippages from the schedule without any commercial implication to the Owner. The site organisation shall be headed by a competent construction manager having sufficient authority to take decisions at site.

On award of contract, the Bidder shall submit to the Owner a site organisation chart indicating the various levels of experts to be deployed on the job. The Owner reserves the right to reject or approve the list of personnel proposed by the Bidder. The persons, whose bio-data have been approved by the Owner, will have to be posted at site and deviations in this regard will not generally be permitted.

The Bidder shall also submit to the Owner for approval a list of construction equipment, erection tools, tackle etc. prior to commencement of site activities. These tools & tackle shall not be removed from site without written permission of the Owner.

2.10.00 **General Guidelines for Field Activities**

2.10.01 The Bidder shall execute the works in a professional manner so as to achieve the target schedule without any sacrifice on quality and maintaining highest standards of safety and cleanliness.

2.10.02 The Bidder shall co-operate with the Owner ,if rescheduling of Bidder's work is requested by the Owner in the interest of overall site activities, the same shall be complied with by the Bidder. In all cases of controversy, the decision of the Owner shall be final and binding on the Bidder without any commercial implication.

2.10.03 The Owner shall hold weekly meetings with Bidder at Site. The Bidder shall attend such meetings and take notes of discussions during the meeting and the decisions of the Owner and shall strictly adhere to those decisions in performing his Work. In addition to the above weekly meeting, Owner may call for additional meetings with Bidder or Bidder along with Bidder's sub-contractor and in such a case bidder / bidder's sub-contractor shall also attend such meetings.

2.10.04 Time is the essence of the Contract and the Bidder shall be responsible for performance of his Work in accordance with the specified construction schedule. If at any time the Bidder is falling behind the schedule, he shall take necessary action to make good of such delays by increasing his work force or by working overtime or otherwise accelerate the progress of the work to comply with the schedule and shall communicate such action in writing to the Owner, satisfying that his action will compensate for the delay. The Bidder shall not be allowed any extra compensation for such action.

2.10.05 The Owner shall however not be responsible for provision of additional labour and or materials or supply or any other services to the Bidder.

2.10.06 The works under execution shall be open to inspection & supervision by the Owner at all times. The Bidder shall give reasonable notice to the Owner before covering up or otherwise placing beyond the reach of inspection any work in order that same may be verified, if so desired by the Owner.

2.10.07 Every effort shall be made to maintain the highest quality of workmanship by stringent supervision and inspection at every stage of execution. Manufacturer's instruction manual and guidelines on sequence of erection and precautions shall be strictly followed. Should any error or ambiguity be discovered in such documents, the same shall be brought to the notice of the Owner. Manufacturer's interpretation in such cases shall be binding on the Bidder.

2.10.08 The Bidder shall comply with all the rules and regulations of the local authorities, all statutory laws including Minimum Wages, Workmen Compensation etc. The Bidder shall engage maximum number of local unskilled and semi skilled labours for construction works. All registration and statutory inspection fees, if any, in respect of the work executed by the Bidder shall be to his account.

2.10.09 All the works such as cleaning, checking, leveling, blue matching, aligning, assembling, temporary erection for alignment, opening, dismantling of certain equipments for checking and cleaning, surface preparation, edge preparation, fabrication of tubes and pipes as per general engineering practice at site, cutting grinding, straightening, chamfering, filling, chipping, drilling, reaming, scrapping, shaping, fitting-up bolting/welding, etc., as may be applicable in such erection and are necessary to complete the work satisfactorily, are to be treated as incidental and the same shall be carried out by the Bidder as part of the work.

2.10.10 In case of any class of work for which there is no such specification as laid down in the contract such as, blue matching, welding of stainless steel parts, etc., the work shall be carried out in accordance with the instructions and requirements of the Owner.

2.10.11 It may sometimes be necessary to remove some of the erected structural members to facilitate erection of bigger/pre-assembled equipment. In such cases, the removal and re-erection of such members, which are essential, and if so agreed by the Owner, will have to be done by the Bidder.

2.10.12 Attachment welding of necessary instrumentation tapping points, thermocouple pads, root valves, condensing vessels, flow nozzles and control valves etc., both for regular measurement and performance testing to be provided on equipment, its auxiliaries or pipelines covered within the scope of this tender, will also be the responsibility of the Bidder and the same will be done as per the instructions of Owner. The erection and welding of all above items will be the Bidder's responsibility, even if :

a) Product groups under which these items are re-leased are not covered in the scope of this tender.

b) Items are supplied by an agency other than the Bidder.

2.10.13 Preservation of all materials/equipment under custody of the Bidder during storage, pre-assembly & erection, commissioning etc., shall be the responsibility of the Bidder. All necessary preservatives and consumables like paints, etc., shall be arranged by the Bidder. Necessary touch up painting, periodic application of preservatives/paints on pressure parts/other equipment even after erection until completion of work shall be carried out by the Bidder. The Bidder shall fabricate piping, install lub oil systems and carry out the acid cleaning of fabricated piping. The Bidder shall also service the lub. oil system, carryout the hydraulic test of oil coolers, etc.

2.10.14 It is responsibility of the Bidder to do the alignment etc. if necessary, repeatedly to satisfy Owner, with all the necessary tools & tackles, manpower, etc. The alignment will be complete only when jointly certified so, by the Bidder & Owner. Also the Bidder should ensure that the alignment is not disturbed afterwards.

2.10.15 Additional platforms for approaching different equipment as per site requirement, which may not be indicated in drawings, shall be fabricated and erected by the Bidder. The materials required for these works shall be supplied by the Bidder and he will have to fabricate them to suit the requirement.

2.10.16 Equipment and material, which are wrongly installed, shall be removed and reinstalled to comply with the design requirement at the Bidder's expense, to the satisfaction of the Owner/ Consultant.

2.10.17 Before erection of any equipment on a foundation, the Bidder shall check and undertake if necessary rectification of foundation bolts, reaming of holes, drilling of dowels, matching of bolts and nuts, making new dowel pin, etc.

2.10.18 Assistance for calibrating/testing the power cylinders, valves, gauges, instruments, etc., and setting of actuators coming under various groups shall be provided by Bidder.

2.10.19 It shall be the responsibility of the Bidder to provide ladders on columns for initial works till such time stairways are completed. For this, the ladder should not be welded on the column and should be prefabricated clamping type. No temporary welding on any structural member is permitted except under special circumstances with the approval of Owner.

2.10.20 Structural materials required for the supporting/operating platforms required for the valves at various levels for the safe operation of valves will be arranged by the Bidder.

2.10.21 For civil, structural and architectural works, Volume II-G/1 & II-G/2 may be referred. For Instrumentation and Electrical works, Volume. II-E and Volume. II-F/1 & F/2 may be referred.

2.11.00 **Safety**

2.11.01 Safety and overall cleanliness of work site shall be given top priority. The Bidder shall ensure the safety of all workmen, materials and equipment either belonging to him or to others working at site. He shall observe safety rules & codes applied by the Owner at site without exception.

2.11.02 The Bidder shall notify the Owner of his intention to bring to site any equipment or material which may create hazard. The Owner shall have the right to prescribe the conditions under which such equipment or material may be handled and the Bidder shall adhere to such instructions. The Owner may prohibit the use of any construction machinery, which according to him is unsafe. No claim for compensation due to such prohibition will be entertained by the Owner.

2.11.03 Storage of petroleum products & explosives for construction work shall be as per rules and regulation laid down in Petroleum Act, Explosive Act and Petroleum and Carbide of Calcium Manual. Approvals as necessary from Chief Inspector of Explosives or other statutory authorities shall be the responsibility of the Bidder.

2.11.04 The Bidder shall be responsible for safe storage of his and his sub-Bidder's radioactive sources.

2.11.05 All requisite tests & inspection of handling equipment, lifting tools & tackle shall be periodically done by the Bidder. Defective equipment shall be removed from service. Any equipment shall not be loaded in excess of its recommended safe working load.

2.11.06 All combustible waste and rubbish shall be collected and removed from the worksite at least once each day. Use of undercoated canvas paper, corrugated paper, fabricated carton, plastic or other flammable materials shall be restricted to the minimum and promptly removed.

2.11.07 The Bidder shall provide adequate number of fire protection equipment of the required types for his stores, office, temporary structures, labour colony etc. Personnel trained for fire-fighting shall be made available by the Bidder at site during the entire period of the Contract.

2.11.08 All electrical appliances used in the work shall be in good working condition and shall be properly earthed. No maintenance work shall be carried out on live equipment. The Bidder shall maintain adequate number of qualified electricians to maintain his temporary electrical installation.

2.11.09 All workmen of the Bidder working in construction site shall wear safety helmets, safety boots and safety belts. The Bidder shall take appropriate insurance cover against accidents for his workmen as well as third party.

2.11.10 All the worksites shall be provided with adequate lighting facilities e.g. flood lighting, hand lamps, area lighting etc. by the Bidder for proper working environment during night times.

2.11.11 Adequate number of temporary toilets/urinals (men & women separate) shall be provided at work places with soak pits. Adequate drinking water facilities and rest rooms shall be provided for workers to take food and rest.

2.11.12 All safety precautions shall be taken for welding and cutting operations as per IS-818.

2.11.13 All safety precautions shall be taken for foundation and other excavation marks as per IS-3764.

2.12.00 **Taking Delivery & Storage**

2.12.01 The Bidder shall arrange issue of all equipment and materials to be erected under the contract from the stores/open yard at site by signing on standard indent forms. After completion of work, detailed auditing of the materials so issued shall be submitted to the Owner.

2.12.02 The Bidder shall arrange for proper and safe storage of materials till the same are taken over by the Owner as per terms of the contract. Manufacturer's instructions for preservation shall be strictly followed.

2.12.03 All empty containers, packing materials, gunny bags, transport frames and also surplus and unused materials reconciliation prior to completion of contract shall be dealt as per clause 2.12.0 Section – 2 of Vol IB.

2.13.00 **Site Welding & Heat Treatment**

2.13.01 Welding shall be done in accordance with IS-813, IS-816, IS-9595 & other relevant IS/International standards and as per instructions of Bidder. Only those welders, who are qualified as per IS-817 for ordinary welds and as per IBR/ASME Section-IX for high pressure welds, shall be employed in the job.

2.13.02 All welders shall be tested and approved by Owner's Engineer before they are actually engaged on the work even though they may possess the requisite certificates. The Owner reserves the right to reject any welder without assigning any reason. The welder identification code as approved by the Owner's Engineer shall be stamped by the welder on each joint done by them. The Bidder will be responsible for the periodic renewal, re-testing of the welders as demanded by Owner.

2.13.03 The Owner's Engineer is entitled to stop Bidder's any welder from his work if his work is unsatisfactory for any technical reason or there is a high percentage of the rejection of joints welded by him, which in the opinion of Owner's Engineer will adversely affect the quality of welding even though the welder has earlier passed the tests. The welders having passed the tests do not relieve the Bidder from his contractual obligations, to check the performance of the welders.

2.13.04 All charges for testing of welders including destructive and non- destructive tests if conducted by Owner or by the inspection authority at site shall have to be borne by the Bidder. The necessary test materials and consumables will have to be arranged by the Bidder and all testing facility made available, as required.

2.13.05 All welded joints shall be subject to acceptance by Owner's Engineer. Inspection of welds shall be in accordance with IS-822 or equivalent code.

2.13.06 Preheating/post-heating and stress relieving after welding are part of fabrication and erection work and shall be performed by the Bidder in accordance with the instruction of Owner's Engineer. Bidder shall arrange to supply heating equipment with automatic recording devices. Also the Bidder shall have to arrange for the labour, heating elements, thermocouples, compensating cables, insulation materials like mineral wools, asbestos cloth, ceramic beads, asbestos rope, etc. required for the heat-treatment and stress relieving works. During pre- heat/stress relieving operations, the temperature shall be measured at one or more points as required by attaching thermocouples and recorded on a continuous printing type recorder. All the record graphs for the heat treatment works carried out shall be got signed by the Owner's Engineer prior to the commencement of each cycle and handed over to Owner's Engineer on completion. The graphs will be the property of Owner. The Bidder has to provide thermo-chalks temperature recorders, thermocouple attachments, units, graph sheets, etc. required for the job and maintain them in good condition.

2.13.07 All electrodes shall be baked and dried in the electric/electrode drying oven to the required temperature and for the period specified by the Owner's Engineer before they are used in erection work. The electrodes used shall be as per

IS-814, IS-815, IS-1442, IS-7280 and other codes as applicable, and shall be of approved reputed manufacture. The electrodes shall meet the requirement of the pipe material. No electrode manufactured more than 12 months ago and the type covered under certificate issued after conducting tests more than 6 months ago shall be used. All electrodes shall be preserved at works and at site as per manufacturer's recommendations.

2.13.08 Oxy-acetylene flame or Exothermic chemical heating for stress relieving is not permitted. Heating shall be by means, of electric induction coil or electric resistance coil.

2.13.09 It may become necessary to adopt inter layer radiography/MPT/UT depending upon the site/technical requirement necessitating interruptions in continuation of the work and making necessary arrangement for carrying out the above work.

2.13.10 Gas tungsten arc welding process (TIG) shall be adopted for all root pass welds except for structural works until 4.75 mm thickness is deposited. Subsequent welding after root pass can be carried out by manual metal arc welding with coated electrodes. For pipes of thickness less than 6 mm the entire welding has to be carried out by TIG welding.

Fillet weld shall be made by shielded metal arc process as per applicable codes.

However, the Owner’s Engineer will have the option of changing the method of welding as per site requirement. The method adopted for manual arc welding shall be weaving technique and the width of weaving shall not exceed 1.5 times of the dia. of the electrode.

In case of deviation from welding process and electrodes, the Bidder shall take approval of the Owner prior to adoption of same.

2.13.11 The root pass for butt joints shall be such as to achieve full penetration with complete fusion of root edges.

2.13.12 Each pass shall be cleared and freed of slag before the next pass is deposited.

2.13.13 On completion of each run, craters, weld irregularities, slag etc. shall be removed by grinding or chipping.

2.13.14 Each layer of welding shall have an even and smooth appearance.

2.13.15 Welding sequence shall be adjusted in such a way that distortion due to welding shrinkage is minimised. Further any movement, shock or vibration during welding shall be avoided to prevent weld cracks.

2.13.16 Proper protection of welders and the work shall be taken during periods of rain. No welding shall be carried out when surfaced to be welded are wet from any cause.

2.13.17 Following will be stages of inspection during welding:

a) Two pieces to be joined shall be individually checked for the weld edge preparation and profile dimensionally and to the template. Dye penetrant check shall be carried out on edge prepared surfaces at random. The percentage will depend upon on criticality as specified by Owner's Engineer.

b) Joint fit up will be a stage of inspection. Misalignment after fit up may vary from 0.3 mm to 1.6 mm depending on outside diameter and thickness.

c) All joints shall be offered for visual inspection after root run. Subsequent welding should be made only after the approval of root run.

2.13.18 All welded joints shall be painted with anti-corrosive paint immediately on completion of radiography and stress-relieving.

2.14.00 For further details on procedures of work at site on civil, architectural, electrical and instrumentation & control services, refer Volume-II -G/1 & G/2, II-F/1 & F/2 and II-E of this specification respectively.

3.00.00 PROTECTION AND CARE

3.01.00 All construction and erection activities for this project are to be carried out in the plant premises as per safety guidelines specified elsewhere in the specification

3.02.00 Generator Stator Lifting may be considered by as mentioned below :

With the help of separate lifting arrangement to be provided by the Bidder from outside the TG building A-row column before the construction of A-row building wall.

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ENGINEERING SERVICES

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SECTION-VII

ENGINEERING SERVICES

1.00.00 GENERAL

1.01.00 As part of the overall project management activity, the Successful Bidder shall be responsible for proper engineering and co-ordination of activities during various phases of execution of the contract. The Successful Bidder shall identify a person, designated as Project Manager, with whom the Owner/ Consultant shall interact on matters related to engineering as well as execution of the contract. The Project Manager shall be the single-point contact person on behalf of the Successful Bidder and shall be responsible for all engineering co-ordination. The Owner/Consultant shall interact with the Project Manager only on all matters of co-ordination between the Owner and the Successful Bidder or on matters involving the Successful Bidder, his manufacturing units and sub-vendors. For the purpose of expediting the Owner or his representative may sometimes interact with the manufacturing units or sub-vendors of the Successful Bidders. However such interaction will not, under any circumstance, dilute the responsibility of the Successful Bidder to provide a fully engineered and coordinated package under this Contract.

1.02.00 On finalization of the contract, a procedure for exchange of engineering information will be mutually agreed and finalized between the Owner and the Successful Bidder.

2.00.00 DESIGN/ENGINEERING COORDINATION MEETING

The Successful Bidder and his sub-vendors will be called upon to attend design/engineering co-ordination meetings with the Owner/Consultant during the period of execution of Contract. The Successful Bidder including his sub-vendors shall attend such meetings at their own cost at Owner's office in Talabira/ Neyveli /Chennai /Delhi or Consultant's office in Kolkata/ or at mutually agreed venue as and when required and fully cooperate with such persons and agencies involved during those discussions.

3.00.00 CO-OPERATION WITH OWNER /CONSULTANT

The Successful Bidder shall cooperate with Owner / Consultant and freely exchange technical information to obtain most efficient and economical design and to avoid unnecessary duplication of efforts. The Owner /Consultantshall be provided with copies of all correspondences addressed by the Successful Bidder to other Sub-Vendors and Owner /Consultant in respect of such exchange of technical information.

4.00.00 GUIDELINES FOR OWNER'S ENGINEERING SERVICES

4.01.00 Prior to commencement of the engineering work as part of design submissions, all aspects of design viz., criteria for selection and sizing of all equipment and systems, design margins etc. including that for structural steel and civil work(Design Basis Report) shall be outlined and these shall form the basis for the detailed engineering work.

4.02.00 Engineering work shall be performed on modern and proven concepts and internationally accepted good engineering practices but fully compatible with the Indian environments. Owner shall have the right to review and approve the Bidder's engineering work by their consultant and ask for any clarifications and changes/modifications to the work performed by Successful Bidder.

4.03.00 At any stage during the performance of assignment, the Successful Bidder may be required to make certain changes/modification/improvements in design/ drawing/other documents, which in the opinion of the Owner could result in better improved design, layout, operability, plant availability, maintainability, reliability or economy of Plant & auxiliaries area and its systems/sub-systems in view of revised and more accurate information/data available at a later date(s) or feedback(s) received during execution/operation of similar units and the Bidder shall comply to the above without any additional time and cost. Such changes/ modifications/improvements required could be identified by Owner and/or consultant and mutually discussed. Owner requires the Bidder to incorporate such action in the subject assignment appropriately without any additional cost liability and time implication to the Owner and same shall be within the responsibilities and Scope of the Successful Bidder.

4.04.00 During the course of review of detailed engineering stages, it may be essential in the opinion of Owner/Consultant to obtain certain classified data for review purposes only. In case Owner so desires, the Bidder shall submit such data to Owner/Consultant.

4.05.00 During the course of review of detailed engineering, it may be essential in Owner's opinion to obtain data and information on similar equipment and plants engineered by the Bidder. In case Owner so desires the Bidder shall submit such data and information to the Owner.

4.06.00 It is not the intent to give details of every single task covered in the total engineering work to be carried out by Successful Bidder, however, all engineering work required for the satisfactory completion of the Plant& auxiliaries units/systems as specified shall be carried out by the Successful Bidder. Broadly, the following are the minimum requirements in respect of scope of major items of work:

4.06.01 Preparation, updating and finalisation of scheme drawings, control and interlock diagrams, detailed and fully dimensioned layout drawings (Power Plant& auxiliaries area layout and equipment layout detailed plan, elevation and cross-sectional drawings at different elevations/ floor levels) covering all mechanical, electrical, C&I, civil and structural items, equipment, systems and facilities. Drawings and

Schedules prepared by the Successful Bidder from time to time, as detailed designs are developed, shall be submitted for Owner's/ Consultant's approval before the work is taken up. Revisions, corrections, additions to drawings and schedules shall not be considered to change the scope of work.

4.06.02 Preparation of detailed technical specifications including data sheets, tender drawings and bill of material for all bought out items, as also finalisation of corresponding sub-Vendors.

4.06.03 Review of sub-Vendor's data, drawings, design calculations, schedules, bill of materials, instruction manuals etc. for all equipment, before forwarding them to Owner/Consultant for approval.

4.06.04 Preparation of civil construction drawings for all equipment showing foundation details and full details regarding equipment loads, floor openings, details of embedments, cutouts, etc. required for preparation of civil construction drawings and also as referred at relevant sections of Scope & Exclusions. These documents shall be preceded by appropriate design calculations, static and dynamic analysis as necessary.

4.06.05 Preparation and finalisation of process piping and instrumentation diagrams and schematics, complete in all respects for all systems/sub-system of 3x880 MW units.

4.06.06 Preparation of consolidated schedules and bills of materials, including line numbers, tag numbers, source of supply, service conditions, specifications, materials, types and connections details, quantities for items for 3x800 MW units.

4.06.07 Sizing of all piping and equipment as per the stipulated design criteria; carrying out of flexibility analysis/dynamic analysis as necessary; hangers &support Owner’s Engineering.

4.06.08 Final revision of all documents including preparation and compilation of Instruction Manuals for installation, commissioning, operation and maintenance for all equipment and systems. Refer clause 5.00.00 for the specific requirement in this regard.

4.06.09 Certification and submission of final as-built drawings for all areas.

4.06.10 Preparation and compilation of all drawings, schedules and instructions which may be required at site, whether separately mentioned or not.

4.06.11 All erection and assembly drawings which may be required at site.

5.00.00 INSTRUCTION MANUALS

5.01.00 The Bidder shall provide all necessary instruction manuals for the Owner’s review, comment, and final acceptances required in the Contract. The instruction manual shall contain full details required for erection, commissioning, operation and maintenance of each equipment. The instruction

manual shall be submitted in the form of one (1) soft copy and six (6) hard copies.

5.02.00 **Erection Manuals**

5.02.01 The erection manuals shall be submitted at least three (3) months prior to commencement of erection activities of particular equipment/system. The manuals shall contain the following as a minimum:

a) Erection strategy.

b) Sequence of erection.

c) List of tools, tackles, heavy equipments like cranes, dozers etc. required for erection.

d) Bill of Materials.

e) Safety precautions to be followed during erection.

f) Erection instructions.

g) Critical checks and permissible deviation/tolerances.

h) Check-list for pre-commissioning activities

i) Check-list for commissioning of the system.

j) Procedure for initial checking, testing and acceptance norms.

5.03.00 **Operation & Maintenance Manuals**

5.03.01 The operating and maintenance instructions together with drawings of the equipment, as completed, shall be in sufficient detail to enable the Owner to operate, maintain, dismantle, reassemble, and adjust all parts of the equipment. They shall outline a step-by-step procedure for all operations likely to be carries out during the life of 3x800 MW units. Each manual shall include a complete set of drawings together with performance/ rating curves of the equipment and test certificates wherever applicable.

5.03.02 If after commissioning and initial operation of 3x800 MW units, the manuals require any modification/ additions in the view of the Owner or Bidder, the same shall be incorporated and the updated final manuals shall be submitted to the Owner.

5.03.03 The manuals shall include the following:

i) List of spare parts along with their drawing and catalogue and Pro-forma for ordering spares.

ii) Location and identification guide for bearings of various equipment and lubrication schedule including charts showing lubrication checking, testing and replacement procedure.

iii) Wherever applicable, fault location charts shall be included to facilitate fault detection.

iv) Detailed specification for all consumables (including lubricating oils, greases, chemicals etc.) required for each equipment.

6.00.00 PLANT HANDBOOK

The Bidder shall provide the plant handbook for 3x800 MW units to the Owner as per provision of the contract.

The Plant Handbook shall contain the following as a minimum:

a) Design and performance data for BMCR,TMCR,80% TMCR &60 TMCR.

b) Process & instrumentation diagrams

c) Single line diagrams

d) Sequence & Protection interlock schemes

e) Alarm and trip values

f) Performance curves

g) General layout plan and layout of Balance of Plant building and auxiliary buildings.

h) Important Do's and Don'ts.

7.00.00 TENDER STAGE DOCUMENT SUBMISSION

7.01.00 The Bidder shall submit along with his Bid all documents/drawings as specified in RFP and respective sections of the Technical Specifications in Volume-II and Volume-III. The documents shall include but not be limited to the following:

a) All Bid proposal sheets duly filled up.

b) Detailed experience list and financial resources of the Prime Bidder his collaborators/associates in this Bid as well as the sub-vendors proposed.

c) Scheme drawings indicating scope of supply and service as offered by the Bidder indicating clearly exclusions, if any.

d) List of terminal points of the package offered together with quality and quantity of various input (i.e. water, air, electricity etc.) as required from the Owner at such interfaces.

e) Equipment GA, Layout, Design Calculations, interlock and other write-up, catalogues/literature etc. as required for clear understanding of the Bid submitted.

f) High level project schedule network indicating target dates for intermediate milestones and final commissioning of plant systems; This network shall be supplemented by a detailed write-up on proposed sequence and method of execution for project implementation, deployment schedule for Key personnel with their bio-data, schedule of construction machinery etc.

g) Sub-vendor list for the Equipment, as mentioned in Annexure-I, for approval by Owner/Consultant.

8.00.00 CONTRACT STAGE DOCUMENT SUBMISSION AND APPROVAL PROCEDURE

8.01.00 Engineering schedule shall be submitted by the Bidder as indicated in the tender documents. Engineering schedule shall be developed in format as desired by the Owner/consultant.

The documents shall be divided into two categories: a) for approval and b) for information/further Engineering and co-ordination by the Consultant.

In preparing this schedule, the Bidder shall allow two (2) weeks from date of receipt for review and comments by the Owner /Consultant for each submission of a document.

This document submission schedule shall require acceptance by the Owner/Consultant.

Bidder shall also develop and submit a Master drawing list to the Owner/consultant.

Bidder shall submit Document / drawings in the Owner's Data Management System (CCMS) only. Successful Bidder shall be provided with Single login credential for the same.

8.02.00 All contract documents shall be marked with the name of the Owner, the Project, the specification title and number and the unit designation.

All dimensions shall be in SI / Metric units.
All notes, markings etc. shall be in English.

8.03.00 Documents/Drawings, submitted during tender stage, shall be revalidated or revised as required and submitted as certified contract document for approval/information of the Owner/Consultant.

8.04.00 Unless specified otherwise, the following categories of documents/drawings would require approval of the Owner/Consultant:

a) System scheme and Process & instrumentation Diagrams (P&IDs).

b) Design basis documents / memoranda / calculations justifying sizing and selection of equipments, vessels, tanks, piping, valves & specialities as well as the process parameters.

c) Equipment data sheets and general arrangement drawings.

d) Materials of construction.

e) General Arrangement and Layout drawings.

f) Typical control schemes, circuit diagrams, drive/ feeder-wise control scheme showing all external interfaces.

g) Control System Configuration

h) Shop Inspection and Testing Procedures, Test Set-up & Instrumentation, Acceptance Criteria and Codes / Standards followed, correction curves / charts, etc.

i) Performance Test Procedures, Instrumentation, Acceptance Criteria and Codes / Standards followed, correction curves / charts, etc.

j) Schedules covering equipment delivery schedules, erection, testing and commissioning schedules at L1, L2 and L3 levels.

8.05.00 Unless specified otherwise, the following categories of documents/ drawings would be treated for information. The Bidder shall, however, incorporate all additional information and clarifications in these documents/ drawings as and when desired by the Owner/Consultant.

a) Input document for Equipment foundation.

b) Equipment cross-section drawings, product literature etc. which are of proprietary nature.

c) Predicted performance curves of equipment.

d) Various bills of quantity, schedules etc.

e) Piping fabrication drawings, isometrics etc.

f) Panel wiring diagrams.

g) Instruction/Operation manuals.

h) Service manuals and trouble shooting guide for C & I system including field instruments.

i) Operation logic diagrams.

j) Cable schedule and interconnection chart.

In essence, the Bidder is solely responsible for corrections and adequacy of design &engineering for documents under this category.

8.06.00 Upon review, the Consultant shall put his remarks and one of the following action stamps on the drawing/document:

a) Approved.

b) Approved as noted, resubmission required.

c) Commented, resubmission required.

d) For information/reference only.

For action stamps in category (b) & (c), documents must be resubmitted for review by the Owner/Consultant.

Except for action stamp under category (c), the Bidder can proceed with manufacturing and other sequential activities for those areas of a drawing/document approved under (a), (b) and (d).

The Consultant may accord approval in category (b) or (c) in more than one submission of a document till he is satisfied that the intent of the specification has been fully complied with. The Bidder shall be responsible for delay in such cases and no extension of time shall ordinarily be allowed on such grounds.

The Bidder's work shall be in strict accordance with the finally approved drawings and no deviation shall be permitted without written approval of the Owner/Consultant.

All civil, architectural drawings, design documents, structural drawings and design documents shall be submitted by the Bidder under approval category only.

Bidder to note that the drawings given approval in cat (b) above shall be generally resubmitted by the Bidder for moving the same to cat (a) within 15 days.

8.07.00 3D Model

a) Submission of 3D Model for Purchaser's Review

All the plant layouts shall be made in computerised 3D modelling system. The Purchaser reserves the right to review the 3D model at different stages during the progress of engineering. The layout drawings submitted for Purchaser's review shall be fully dimensioned and extracted from 3D model after interference check.

Contractor shall prepare the model of all the facilities located within plant boundary covering facilities in Main Plant Block area and Balance of plant (BOP) area in an integrated & intelligent 3D software solution. Main Plant Block area shall include , Transformer Yard, TG building (including all facilities), Boiler area, ESP area, chimney area, FGD area and any other facility located in main plant block. BOP area shall include all facilities pertaining to AHP, Coal Handling Plant , Limestone / Gypsum Handling Plant , DM PT plant, pipe & cable racks and any other facility located within plant boundary.

Contractor shall prepare 3D design review model (network ready, which shall include visual interference check, walk-through animation, video simulation for major equipment placement and removal, visual effect, photo realism etc), which is extracted from intelligent 3D model, for Purchaser's review as & when desired by Purchaser. However, all piping layouts, equipment layouts, floor plans, ducting layout (Air/flue gas, A/C, Ventilation etc.) and structural arrangement drawings shall necessarily be extracted from the aforesaid 3D model and submitted for Purchaser's review along with the 3D review model to enable Purchaser to review and approve these drawings.

The Contractor shall prepare the 3D model indicating the control & instrumentation equipments, devices such as location of LIE,LIR, flow elements, instrument tappings, thermowell stubs, JBs , cable trays, Flame scanners, Flame viewing cameras, ASLD, Acoustic Pyrometer, Control valves & actuators, Coal bunker level instruments along with approach / maintenance platform, provided for all these equipment's/devices. The LIE & LIR shall be placed in such a way that the doors can be opened freely from front & back side for ease of maintenance. The cable tray layout shall be implemented in such a way that the fouling to the pipes, ducts and other structures can be avoided.

These above drawings are to be extracted from the said 3D model and submitted for Purchasers review and approval along with the 3D model. After the completion of engineering of respective area i.e. TG building/ Boiler/ ESP etc., the corresponding complete 3D review model shall be handed over to the Purchaser for its reference.

b) Supply & Comissioning of Software , Hardware for 3D Model Review

Commercially available software for **3-D model design review (with 2 nos. licences)** (network ready, which shall include interference check, walk-through animation, simulation for equipment placement and removal, visual effect, construction sequencing etc) shall also be provided by the Bidder and loaded on a server with 2 work stations OR in 2 Laptops (latest configuration for server & workstation / Laptop , compatible for using the software) with one A-3 size coloured laser printer. The software shall include facility for obtaining hard copies of all the drawings/documents on standard plotter / printer.

All software provided shall necessarily include the cost for license(s) for use on all the machines for **5 years** including an Annual Maintenance Contract (AMC) which shall include software upgrades as & when released by the software agency for the same period.

The requisite hardware and software shall be supplied and commissioned by the Bidder at Purchaser's Office within 3 months of LOA.

c) **Training of Purchaser's personnel**

Further, training for Purchaser's personnel for **60 man-days (for 10 employees in minimum 2 batches of 5 each)** shall be provided at Purchaser's office at Neyveli / Chennai, for the software's being offered under the package.

8.08.00 Except key plan/general yard plan, any layout drawing requiring scrutiny shall not be drawn to a scale less than 1:50.

8.09.00 For review by the Owner &Consultant, the Bidder shall furnish six (6) prints of each drawing (2 for Consultant and 4 for Owner) (only for first submission). There upon all transaction of drawings including reviewed comments and stamping shall be done in soft. All transaction of drawings shall be accompanied by a reference letter mentioning the date, revision no. and document status. Only on receiving the Approval Stamping, Bidder shall distribute 6 sets of drawings (2 at NLCIL corporate office and 4 sets at NLCIL site office).

The Bidder shall furnish three (3) Soft Copies, three (3) sets of hard copies of "As Built "drawings for Owner at site. In case of "No change" in Approved drawings till commissioning , then final approved drawings shall be submitted with no. of soft copies and hard copies as indicated above, as "As –Built" drawing / document.

Autocad drawings for final plot plan, key & Main SLDs, all layouts, P&IDs etc., shall also be furnished.

8.10.00 In case of contradiction between the stipulations above and those stated elsewhere in the specification, the more stringent stipulations shall prevail.

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QUALITY ASSURANCE REQUIREMENTS

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SECTION-VIII

QUALITY ASSURANCE REQUIREMENTS

1.00.00 QUALITY ASSURANCE PROGRAMME

1.01.00 To ensure that the equipment and services under the scope of Contract whether manufactured or performed within the Successful Bidder's works or at his Sub-Vendor's premises or at the Owner's site or at any other place or work are in accordance with the specifications, the Successful Bidder shall adopt suitable quality assurance programme to control such activities at all points, as necessary. Such programmes shall be outlined by the Successful Bidder and shall be finally accepted by the Owner/ Authorised representative after discussions before the award of contract. A quality assurance programme of the Successful Bidder shall generally cover the following:

a) His organisation structure for the management and implementation of the proposed quality assurance programme.

b) Documentation control system.

c) Qualification data for Bidder's key personnel.

d) The procedure for purchase of materials, parts, components and selection of Sub-Vendor's services including vendor analysis, source inspection, incoming raw-material inspection, verification of materials purchased etc.

e) System for shop manufacturing and site erection control including process controls and fabrication and assembly controls.

f) Control of non-conforming items and system for corrective actions.

g) Inspection and test procedure both for manufacture and all site related works.

h) Control of calibration and testing of measuring and testing equipments.

i) System for quality audit.

j) System for indication and appraisal of inspection status.

k) System for authorising release of manufactured product to the Owner.

l) System for handling storage and delivery.

m) System for maintenance of records.

n) Furnishing of quality plans for manufacturing and field activities detailing out the specific quality control procedure adopted for controlling the quality characteristics relevant to each item of equipment/component as per format enclosed at Annexure-I to this section.

2.00.00 GENERAL REQUIREMENTS - QUALITY ASSURANCE

2.01.00 All materials, components and equipment covered under this specification shall be procured, manufactured and tested at all the stages, as well as Services provided for erection, commissioning and testing shall be as per a comprehensive Quality Assurance Programme. An indicative programme of inspection/tests to be carried out by the Bidder for some of the major items is given in the respective technical specification. This is however, not intended to form a comprehensive programme as it is the Bidder's responsibility to draw up and implement such programme and reviewed by by the Owner/Consultant. The detailed Quality Plans for manufacturing and field activities should be drawn up by the Bidder, separately in the format attached at Annexure-I and will be submitted to Owner/Owner's representative for review. Schedule of finalisation of such quality plans will be finalised before award.

2.02.00 Manufacturing Quality Plan will detail out for all the components and equipment, various tests/inspection, to be carried out as per the requirements of this specification and standards mentioned therein and quality practices and procedures followed by Bidder's Quality Control organisation, the relevant reference documents and standards, acceptance norms, inspection documents raised etc., during all stages of materials procurement, manufacture, assembly and final testing/performance testing.

2.03.00 Field Quality Plans will detail out for all the equipment, the quality practices and procedures etc. to be followed by the Bidder's site Quality Control organisation, during various stages of site activities from receipt of materials/equipment at site.

After pipe lines have been laid and joined, the same shall be tested hydrostatically as specified in this section.

For Welded Joints, Non- Destructive Test (NDT) shall be performed as per relevant codes or mentioned elsewhere in the specification, whichever is stringent.

All the longitudinal and circumferential welded seams shall be subjected to chalk and kerosene test prior to hydraulic testing. This shall be done at the presence of the Owner. In addition to this, test coupons shall have to be provided for each longitudinal seams for mechanical tests (tensile and bend), if considered necessary by the Owner. The test coupons are to be broken in presence of the Owner. Bidder shall satisfy the Owner that work is being carried out in accordance with the specification drawings and other conditions. Owner shall have full access to the Bidder's working area.

Bidder's scope of supply for fabrication, erection, cleaning, testing and commissioning of the piping systems installed by him shall include the following:-

All welding consumables like welding electrodes, filler rods and wires; gases like oxygen, acetylenes, argon, carbon-dioxide, propane, backing rings etc.

Films for radiographic examination of welds.

X-ray and Gamma -ray equipment including isotopes, dye penetrants, and other required non-destructive testing materials and equipment (all to be taken back by the Bidder after completion of work).

All heating and stress relieving equipment, thermocouples asbestos blankets, cables, temperature recorders, charts heat sensitive chalks and crayons etc. (All to be taken back by Bidder after completion of work).

All machinery, equipment tools and tackles as required for transportation handling, fabrication and erection (All to be taken back by Bidder after completion of work).

All equipment/ materials as required for cleaning, flushing, blowing out and hydro testing of the piping systems; these shall include but not be limited to pumps and compressors with prime movers, instruments, pipe work with supports, valves, strainers and other specialties, blanks, plugs, spool pieces, dummy plates, electrical accessories, etc. (All to be taken back by Bidder after completion of work).

All scaffolding materials and false work (To be taken back by Bidder after completion of work).

2.04.00 The Bidder shall also furnish copies of the reference documents/plant standards/acceptance norms/tests and inspection procedure etc., as referred in Quality Plans along with Quality Plans. These Quality plans and reference documents/standards etc. will be subject to Owner/Consultant approval without which manufacture shall not proceed. In these approved quality plans, Owner/ Consultant shall identify Customer Hold Points (CHP), test/checks which shall be carried out in presence of the Owner/Consultant and beyond which the work will not proceed without consent of Owner/ Consultant in writing.

All deviations to this specification, approved quality plans and applicable standards must be documented and referred to Owner/Consultant for acceptance and dispositioning.

2.05.00 The Bidder shall provide adequate notice to the Owner for inspection before the material is dispatched as per the provisions of the Contract. No material shall be despatched from the manufacturer's works before the same is accepted subsequent to pre-despatch final inspection including verification of records of all previous tests/inspections by Owner/Consultant and duly authorised for despatch issuance of Material Despatch Clearance Certificate (MDCC).

2.06.00 All materials used or supplied shall be accompanied by valid and approved materials certificates and tests and inspection report. These certificates and reports shall indicate the sheet numbers or other such acceptable identification numbers of the material. The material certified shall also have the identification details stamped on it.

2.07.00 All the individual and assembled rotating parts shall be statically and dynamically balanced in the works.

Where accurate alignment is necessary for component parts of machinery normally assembled on site, the Bidder shall allow for trial assembly prior to despatch from place of manufacture.

2.08.00 Castings and forgings used for construction shall be of tested quality. Details of results of chemical analysis, heat treatment record, mechanical property test results shall be furnished.

2.09.00 All welding and brazing shall be carried out as per procedure drawn and qualified in accordance with requirements of ASME Section-IX/BS-4870 or other International equivalent standard acceptable to the Owner.

All brazers, welders etc. employed on any part of the contract at Bidder's/Sub-Vendor's works or at site shall be qualified as per ASME Section-IX or BS-4871 or equivalent international standard approved by the Owner. Such qualification tests shall be conducted in presence of Owner/his authorised representative.

For welding of pressure parts and high pressure piping the requirements of IBR shall also be complied with.

Under no circumstances any repair or welding of castings be carried out without the consent of the Owner. Proof of the effectiveness of each repair by radiographic and/or other non-destructive testing technique, shall be provided to the Owner.

All pressure parts shall be subjected to hydraulic testing as per the requirements of IBR. Other parts shall be tested for one and half times the maximum operating pressure, for a period not less than thirty (30) minutes.

2.10.00 All non-destructive examination (NDT) shall be carried out in accordance with approved international standard. The NDT operator shall be qualified as per SNT-TC-IA (of American Society of non- destructive examination). Results of NDT shall be properly recorded and submitted for acceptance.

All welding procedures adopted for performing welding work shall be qualified in accordance with the requirements of Section-IX of ASME code or IBR as applicable. All welded joints for pressure parts shall be tested by liquid penetrant examination according to the method outlined in ASME Boiler and Pressure Vessel code. Radiography, magnetic particle examination and ultrasonic testing shall be employed wherever necessary/ recommended by the applicable code. At least 10% of all major butt welding joints shall be

radiographed or as specified elsewhere whichever is stringent. Statutory payments in respect of IBR approvals including inspection shall be made by Bidder. Bidder's scope and responsibility shall also include preparation and submission of all necessary documents in the specific formats and manner stipulated by the statutory bodies, coordination and follow up for above approvals.

2.11.00 All the Sub-Vendors proposed by the Bidder for procurement of major bought out items including castings, forgings, semi-finished and finished components/equipment list of which shall be drawn up as per the stipulation laid elsewhere in the specification. Quality Plans of the successful Sub-Vendors shall be discussed, finalised and accepted by the Owner/Consultant and form part of the Purchase Order between the Bidder and the Sub-Vendor.

2.12.00 All the purchase specifications for the major bought-out items, list of which shall be drawn as per the stipulation laid elsewhere in the specification..

Owner reserves the right to carry out quality audit and quality surveillance of the systems and procedures of the Bidder's or their Sub-Vendor's quality management and control activities. The Bidder shall provide all necessary assistance to enable the Owner carry out such audit and surveillance.

Quality audit/acceptance of the results of tests and inspection will not prejudice the right of the Owner to reject equipment not giving the desired performance after erection and shall not in no way limit the liabilities and responsibilities of the Bidder in earning satisfactory performance of equipment as per specification.

2.13.00 Quality requirements for main equipment shall equally apply for spares and replacement items.

2.14.00 Repair/rectification procedures to be adopted to make any job acceptable shall be subject to the acceptance of the Owner.

2.15.00 For quality assurance of all civil works refer to the specifications for civil works.

3.00.00 QUALITY ASSURANCE DOCUMENTS

3.01.00 The Bidder shall be required to submit two (2) copies and two (2) sets of microfilms of the following Quality Assurance documents within three (3) weeks after despatch of the equipment:

a) Material mill test reports on components as specified by the specification.

b) The inspection plan with verification, inspection plan check points, verification sketches, if used and methods used to verify that the inspection and testing points in the inspection plan were performed satisfactorily.

c) Non-destructive examination results /reports including radiography interpretation reports.

d) Factory tests results for testing required as per applicable codes and standards referred in the specification.

e) Welder identification list listing welder's and welding operator's qualification procedure and welding identification symbols.

f) Sketches and drawings used for indicating the method of traceability of the radiographs to the location on the equipment.

g) Stress relief time temperature charts.

h) Inspection reports duly signed by QA personnel of the Owner and Bidder for the agreed inspection hold points. During the course of inspection, the following will also be recorded :

   i) When some important repair work is involved to make the job acceptable.

   ii) The repair work remains part of the accepted product quality.

i) Letter of conformity certifying that the requirement is in compliance with finalised specification requirements.

4.00.00 INSPECTION, TESTING AND INSPECTION CERTIFICATES

4.01.00 The Successful Bidder shall give the Owner fifteen (15) days written notice of any material being ready for testing for Indian supply and 1 month for FOB. Such tests shall be to the Successful Bidder's account except for the expenses of the Inspector. The Owner’s Inspector, unless the witnessing of the tests is virtually waived, will attend such tests within fifteen (15) days for Indian supply and 1 month for FOB of the date on which the equipment is notified as being ready for test/inspection failing which the Successful Bidder may proceed with test which shall be deemed to have been made in the Inspector's presence and shall forthwith forward to the Inspector duly certified copies of test reports in six (6) copies.

4.02.00 The Owner’s Engineer or Inspector shall within fifteen (15) days from the date of Inspection as defined herein give notice in writing to the Successful Bidder, or any objection to any drawings and all or any equipment and workmanship which is in his opinion not in accordance with the contract. The Successful Bidder shall give due consideration to such objections and shall either make modifications that may be necessary to meet the said objections or shall confirm in writing to the Owner’s Engineer/Inspector giving reasons therein, that no modifications are necessary to comply with the contract.

4.03.00 When the factory tests have been completed at the Bidder's or sub-Vendor's works, the Owner/Inspector shall issue a certificate to this effect fifteen (15) days after completion of tests but if the tests are not witnessed by the Owner/ Inspectors, the certificate shall be issued within fifteen (15) days of the receipt of the Bidder's test certificate by the Owner/Inspector. Failure of the Owner/Inspector to issue such a certificate shall not prevent the Bidder from proceeding with the works. The completion of these tests, or the issue of the certificates shall not bind the Owner to accept the equipment should it, on further tests after erection be found not to comply with the contract.

4.04.00 The Bidder shall furnish quarterly inspection programme indicating schedule dates of inspection at customer hold point and final inspection stages. Updated quarterly inspection plans will be made for each three consecutive months and shall be furnished before beginning of each calendar month.

ANNEXURE-I : FORMAT OF QUALITY ASSURANCE PROGRAMME

Name of Company/ Successful Bidder	NAME OF CONTRACT PACKAGE			QUALITY PLAN FOR						
	Package No. : _____ Bidder : _____			QP No. : _____ Date _____ Rev.No.: _____ Date _____						
Sl. No.	Component & Operation	Characteristics	Class	Type of Check	Quantum of Check	Reference Document	Acceptance Norm	Format of Record	Agency	Remarks

ANNEXURE-II: FORMAT OF MANUFACTURING QUALITY PLAN

MFGR.'s LOGO	MANUFACTURER'S NAME AND ADDRESS	MANUFACTURING QUALITY PLAN	PROJECT : PACKAGE : CONTRACT NO. : MAIN-SUPPLIER :
		ITEM : SUB-SYSTEM:	QP NO.: REV. NO.: DATE: PAGE: …. OF….

SL. NO	COMPONENT & OPERATIONS	CHARACTERISTICS	CLASS	TYPE OF CHECK	QUANTUM OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORMS	FORMAT OF RECORD		AGENCY			REMARKS
										M	C	L	
1.	2.	3.	4.	5.	6.	7.	8.	9.	D*	10.			11.

LEGEND: * RECORDS, INDENTIFIED WITH "TICK" (√) WILL BE ESSENTIALLY INCLUDED BY SUPPLIER IN QA DOCUMENTATION.
** **M:** MANUFACTURER/SUB-SUPPLIER
C: SUPPLIER/NOMINATED INSPECTION AGENCY, L: OWNER
P: PERFORM **W**: WITNESS AND **V:** VERIFICATION. AS APPROPRIATE,

CHP: OWNER WILL IDENTIFIED IN COLUM "N"

DOC. NO.: REV……
CAT…..

MANUFACTURER/ SUB-SUPPLIER	MAIN-SUPPLIER	FOR OWNER USE			
SIGNATURE			REVIEWED BY	APPROVED BY	APPROVAL SEAL

MFGR.'s LOGO	SUPPLIER'S NAME AND ADDRESS	ANNEXURE – III: FORMAT OF FIELD QUALITY PLAN	PROJECT : PACKAGE : CONTRACT NO. : MAIN-SUPPLIER:
		ITEM : SUB-SYSTEM :	QP NO.: REV.NO.: DATE: PAGE: …. OF….

SL. NO	ACTIVITY AND OPERATION	CHARACTERISTICS / INSTRUMENTS	CLASS# OF CHECK	TYPE OF CHECK	QUANTUM OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORMS	FORMAT OF RECORD	D*	REMARKS
1.	2.	3.	4.	5.	6.	7.	8.	9.		10.

MANUFACTURER/ SUB-SUPPLIER	MAIN-SUPPLIER	LEGEND: * RECORDS, INDENTIFIED WITH "TICK" (√) WILL BE ESSENTIALLY INCLUDED BY SUPPLIER IN QA DOCUMENTATION. **LEGEND TO BE USED: CLASS # : A = CRITICAL, B=MAJOR, C=MINOR; 'A'** WILL BE WITNESSED BY OWNER FQA, **'B'** WILL BE WITNESSED BY OWNER ERECTION / CONSTRUCTION DEPTT. AND **'C'** WILL BE WITNESSED BY BIDDER (A & B CHECK WILL BE OWNER CHP STAGE)	FOR OWNER USE	DOC. NO.: REV……		
SIGNATURE				REVIEWED BY	APPROVED BY	APPROVAL SEAL

FORMAT NO.:	1/1	Engg. Div. / QA&I

ANNEXURE-IV : FORMAT OF FIELD WELDING SCHEDULE

PROJECT	:	FWS NO	:
BIDDER	:	REV NO.	:
PACKAGE	:	FIELD WELDING CODE	:
SYSTEM	:	PAGE NO.	:

Sl No.	Drawing No. for Weld Locations & Identification mark	Description of parts to be welded	Material specification	Dimensions	Process of Welding	Type of Weld	Electrode Filler Specification	WPS No.	Minimum Preheat Temperature	Heat Treatment Temperature [Holding Time in secs]	NDT Method Quantum	NDT Specification Number	Accep-tance Norm Ref.	Remarks

The Field Welding Schedule should be submitted for :

- Pressure Parts
- Tanks/Vessels
- Piping
- Heavy/Important Structural Steel
- Heat Exchangers
- Bus Ducts

ANNEXURE-V : FORMAT OF INSPECTION REQUEST FORM

From :

To :

Attn :

Dear Sirs,

Items detailed below are ready for inspection. Please arrange inspection and confirm the date of inspection.

1.	Purchaser	:	
2.	Project	:	
3.	Purchaser's order reference	:	
4.	Consultant's reference	:	
5.	Sub-order reference	:	
6.	Sub-contractor's name and full address	:	
7.	Place of Inspection (full address)	:	
8.	Contact person, telephone no., Mobile No. and email ID.	:	
9.	Description of item and quantity	:	
10.	Nature of inspection required	:	
11.	Proposed date(s)	:	
12.	Weekly holiday	:	

We confirm that the items have been fully inspected/tested by us at all stages, of inspection as per quality plan, and all material test certificates, QC records, test Reports, calibration records of measuring/testing instruments with tractability to national level are available with us.

Thanking you and awaiting your confirmation.
Yours faithfully, Cc: Sub-contractor
Note : 1. Clear notice period (date of receipt to date of inspection of ..... days) 2. Weekly holidays for Purchaser: Sunday. 3. General Holidays : As per NLC IL / Odisha state government holidays towards local inspection.

VOLUME: II-G/1

TECHNICAL SPECIFICATIONS
FOR
CIVIL, STRUCTURAL & ARCHITECTURAL WORKS

CONTENTS

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SECTION - I

GENERAL

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VOLUME: II-G/1

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.

3.00.00 SCOPE OF CIVIL WORKS

The scope of civil work comprises all necessary investigations, survey, foundations, building, superstructures and infrastructure required for the successful completion and operation of the Thermal Power Plant to be constructed as Phase-I (3x800 MW). The FGD system shall be provided to treat the flue gases so produced in the furnace in order to keep the SOX value within the prescribed norms as per the MoEF&CC Gazette Notification S.O.3305(E) dated 07-12-2015 in respect of revised SO2 emission norms.

The work under this Section consists of all Civil & Structural and Architectural works but not limited to items mentioned below.

- Topographical Survey in Plant Area including Raw water reservoir Ash Dyke, Bridges across Bhedhan river and Raw water intake pipe Corridor (for the full length and a width of 20 m approximately) and all other area which are in EPC scope.

- All area grading works & Micro grading, leveling & dressing are in Bidders scope. (finished grade levels shall be as mentioned elsewhere)

- Geo-Technical investigation

- Demolition of existing structures / facilities, if any encountered within the plant premises and all other area which are in EPC scope, and site clearance (The bidder may visit the site to access before quoting)

- Plant Roads as shown in the Plot Plan and RCC Box Culverts as per system requirement. Inspection road for Raw water reservoir Ash Dyke, and Raw water intake pipe Corridor are in EPC scope. Only RCC box culverts shall be provided for drainage and for all the underground conduits at road crossings.

- Boundary walls/Fencing in buildings, if required from statutory point of view (switchyard, transformers area, stores, etc)

- Storm water Drainage network for the entire plant area.

- Water supply, drainage and sewerage works for the entire plant area.

- Blasting shall not be permitted for excavation of foundation irrespective of the soil strata encountered.

Plant buildings and Structures / Facilities under the scope of work of EPC bidder:

All Civil & Structural works for the following buildings/structures are to be completed: Also refer Section 3.00.00 of Volume II / G-1 Section-IV.

Boiler and its related Auxiliaries

- Mill and Bunker Building
- Boiler foundation ,Fan, Mills etc
- Foundation for PA, SA & ID Fans etc shall be provided with VIS.
- Boiler Maintenance Building
- Bottom ash Hopper
- ESP Foundations & Equipment foundations
- ESP Control Building.
- Fuel Oil Unloading-Cum- Pressurizing Pump House
- Fuel Oil Dyke
- Foam Pump House Building (RCC)
- BA Overflow sump
- Compressor Shed in Ammonia Storage Area
- SG area paving including necessary drains.
- Auxiliary Boiler MCC and Control Building.
- MCC/Operator room for SCR (common for all the three units)
- RIO-cum-VFD Panel Room
- Auxiliary Boiler Foundations.
- Blowdown Tank
- Plant IA/SA Compressor House
- All foundations for other technological requirements
- All civil and structural works related to Ammonia storage area as per system/process requirements

Turbine and its related Auxiliaries

- Turbine Building Substructure and Superstructure with EOT Crane.
- TG foundation including column & deck slab
- Service Building
- CPU Regeneration Building
- ACW Pump house for each unit
- Air Washer Room for each unit on roof of each unit ACW Pump House
- A/c Plant Building and inert gas room

- Civil and structural works for transformers and yard civil works including transformer foundation, paving, burnt oil pits and fencing etc.
- CST Pump Shed
- DG Plant Shed with foundation for supporting skid mounted DG Sets
- Condensate Storage Tank Foundation
- Cycle / Scooter Stand Car Parking near service building.
- Equipment Foundation
- All pipe and cable racks including foundations, pipe & cable trenches, duct bank etc.
- Rails and rail road.

Coal Handling System and its related Auxiliaries

- Receiving Tower
- Crusher House
- Drive House
- Junction Towers
- Conveyor gallery and Trestles
- CHP Control room cum Switchgear room
- Pump cum compressor house for DSS/DFDS
- Structural Steel Shed for Dozers
- Coal Handling system maintenance Building
- Coal Pile Run Off Pond
- Equipment Foundations
- Civil works related to Dust Extraction System and Bunker Ventilation System.
- Civil Works related to StockPile Wind Barriors.
- Civil Works related to Dust Suppression System
- RCC paving for Coal Stockpile, Foundations for Stacker and Re-claimers, Coal stock pile run off drains, fencing, roads, security tower, along with associated items etc.

Ash Handling System and its related Auxiliaries

- Compressor House and Main control room
- Ash Handling System Switchgear Room and RIO Room

- Ash water transfer pump house including sump,
- Silo utility building cum HCSD Pump House including sump including switch gear and control room. Dust Conditioner Sump.
- Structural Steel Water Impounded Bottom Ash Hoppers
- Structural Steel BA overflow tanks in Bottom ash Hopper area
- Structural steel tank for collection of Duct & APH ash hoppers
- Ash water Pump House Including sump
- RCC Fly Ash Silo Six (6) Nos. for 3 units.
- Structural Steel dewatering Bins
- Structural Steel Common Sedimentation tank and common surge tank
- Structural Steel Buffer Hopper Tower (Dry ash Collection Tower) for Fly Ash
- Structural steel Agitator Retention Tank (ART)
- Conveyor belt gallery for transferring moist bottom & coarse ash from dewatering bin to Agitator Retention Tank through clinker crusher
- Construction of Ash Dyke for HCSD Slurry Disposal including nearby Nallah bund strengthening
- RCC Pedestals for HCSD slurry disposal including garlanding in proposed ash dyke
- All Civil and Structural Works related to Pipe racks for Ash Pipe Lines, Air Pipe Lines, Water Pipe Lines, Misc. drain Sump, Cable racks, Cable Trenches and supporting structures, bridge across Bhedan River on the ash dyke side for HCSD slurry pipes, Road Transport and Raw water intake pipes, bridge across Bhedan River on the Mines side for HCSD slurry pipes and Road transport along with approach road, electrical transmission line / cable etc.
- Equipment Foundations.
- Construction of drain sumps in BAH Area, Silo Area and Vaccum Pump Area.
- Weighbridge

Raw Water Intake & Transfer System

- Raw Water Intake pump house with Control & Switchgear Room (near Hirakud Reservoir)
- Forebay Channel and other associated works like dredging etc as per system requirement.
- Inspection BT Road including culverts etc..along pipe corridor from intake pump house near Hirakud to plant except water body crossings.
- 33 KV tower civil and structural works as per Electrical requirement.

- Raw Water Transfer pump house & Switchgear Room
- Raw Water Reservoir (two compartments) Storage capacity as mentioned in Mechanical volume.
- All Civil and Structural Works related to laying of raw water intake pipe lines from Hirakud intake pump house up to plant raw water reservoir and then up to Raw water pre-treatment plant
- Bridges for Pipes crossing water body (RCC foundation & Pier with Steel gantry and walk way)
- Equipment Foundations

Water Pre-treatment & DM Water System

- Stilling chamber, Clarifiers, inlet channels etc. along with associated facilities for Pre-Treatment Plant and DM Plant
- Filter Water Storage Tank
- Chemical House with Treatment Plant/ Lab
- Degasser Tower, Degassed water storage tank & pump house
- DM plant building with switchgear room, control room
- DM Water Storage Tanks
- Acid / Alkali Storage Tanks
- Clarified Water Reservoirs (two compartments) and pump houses with SWGR/MCC Room for PT and DM Plant
- Equipment Foundations
- Sludge Pit & Neutralization Pit as per system requirement
- Rain water harvesting Pond
- Pump House for Rain Water Harvesting Pond.
- PW Chlorination plant building
- UF Permeate storage tank & pump house

Circulating Water System

- CW pump house With Switchgear Room and RIO room
- CW Treatment cum Chlorination plant building
- Equipment Foundations
- All related Civil and Structural Works for valve chambers, Sump, Forebay, Channels from Cooling Tower

Induced Draught Cooling Tower

- All Civil and structural works for RCC Induced Draft Cooling Tower

- Cold water Basin and associated civil works.
  Other auxiliaries, stairs etc
- Unitized Switchgear Room

Effluent Treatment Plant

- ETP building including pump house and control & Switchgear room
- ETP CTBD / RO plant building with effluent disposal system
- Central Monitoring Basin
- Clear water tank (and Degassed storage tanks)
- TPI Overflow Sump
- Slop Oil Tanks
- Acid/alkali dosing tanks
- Degasser Tower
- Sumps for respective pumps
- ETP reject treatment plant building
- Equipment Foundations

Sewage Treatment Plant ~~(2 Nos.)~~

- STP building ~~(2 Nos.)~~
- All Civil Works related to Sewage Conveying and disposal System including Cast in situ RCC Manholes / Inspection / collection chambers / Ventilating shaft with chambers all of RCC / NP3 RCC Hume pipe laying

HVAC SYSTEM:

- All civil works for air conditioning system

Single-Flue RCC Chimney

- All Civil and structural works for three (3) nos. RCC Chimney one for each 800 MW units with internally lined (borosilicate) steel flue enclosed by RCC Wind Shield to suit MOEF norms.
- Other Auxiliaries, Internal Steel Platforms, External RCC Platforms, ladders, elevator etc.
- Structural steel staircase upto the top most internal platform and from there to roof of the chimney is cage ladder.
- Three (3) nos. Rack &Pinion Elevator. one No. for each chimney

Fire Protection & Detection System

- Fire Water Pump House
- Fire Water Booster Pump House
- All related civil works for Fire detection and protection for laying fire hydrant lines within the entire plant zone including BTG Area, transformer yard area etc.

  Equipment Foundations

Switch Yard

- GIS Control Room
- GIS Building as per Electrical Requirement
- Transformers Foundation & Reactors Foundations
- Equipment Foundation
- Tower foundations
- GIB
- Storm Water Drainage System
- Burnt oil pits
- Rail Road

Hydrogen Generation plant

- Hydrogen Generation building with cylinder storage facility

Roof Top Solar System

- Civil works for roof top solar system for the RCC Roof buildings inside the entire power station including Thermal Project site office as per the electrical requirement.

General Plant Illumination

- All Civil and Structural Works related to General Plant Illumination System.

Non Plant buildings under this scope of work:

- Canteen
- Fire Station
- Weigh-bridge (three numbers)

- ~~Workshop~~
- ~~First Aid Centre~~
- ~~Permanent Stores~~
- ~~Construction Store~~
- Two nos. of RCC Bridges (Bridge-1 & Bridge-2) across Bhedan River
- ~~One no. Toilet Block for CHS area and One no. for Boiler area~~
- ~~Cycle / Scooter stand and Car Parking Shed near Service Building~~

FGD and its related Auxiliaries

Limestone based process shall be adopted for FGD system. The buildings / structures envisaged are listed below.

Limestone Based System

- Limestone Storage Building/Covered structural steel shed
- Limestone Crusher House
- Limestone Grinding Building
- Absorber Pump & Oxidation air blower House
- Electrical Switchgear & Control Building (FGD main building)
- Gypsum De-watering House
- Gypsum Storage Building/shed
- Junction Tower (If applicable)

All Civil & Structural works for the followings are also to be provided:

- Foundation for FGD Absorber System
- Limestone Handling System and Gypsum Handling System.
- Buildings, silos, equipment foundations, sumps, tanks etc.
- Conveyor gallery, trestle as necessary to provide to meet the functional requirements
- Junction towers
- Foundations of all technological structures and equipment like Ball Mill foundation, Miscellaneous Tank and Pump foundations.
- Pipe racks, Cable racks and related supporting structures (as

applicable)

- Exhaust flue gas duct structure support foundation.
- Waste water treatment system and related equipment foundations.
- Crusher foundation and fan foundation and shall be provided with VIS with springs.
- Transformer foundations including fencing, paving etc.

Above list of Plant & Non Plant Buildings is not exhaustive. Buildings necessary for the smooth operation of the Power Plant and as per system requirement shall be within this scope of work of the bidder. All related approach roads and roads within the system requirement along with RCC drains and sewage network.

Rain water harvesting for the entire Power plant:

All the rain water from road drains/buildings shall be conveyed and let into Rain harvesting pond located at suitable location which is also in the scope of the successful bidder. In case, if the initial construction water pond is converted into rainwater harvesting pond at a later stage, all the requirements as mentioned below for rainwater harvesting pond shall be ensured.

Inside and bottom surface of rain water harvesting pond shall be lined with impermeable LDPE lining of thickness 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 fine sand. The liner shall be protected by M30 precast concrete tiles placed over it. Dimensions of precast concrete tiles laid over LDPE sheet will be 300 x 300 x 50 mm – laid over 25 mm thick 1:4 cement mortar. The jointing between tiles should be done with 1:3 cement mortar.

Water from rain water harvesting pond shall be recycled to raw water reservoir. Water from the RWHP will be 100% recycled in the raw water reservoir in dry season. The pond will be located at the lowest contour of the plant as far as feasible so that it can effectively collect all the rain water by gravity.

From the outlet of rain water harvesting pond, water will be pumped out to raw water system for use as supplement to raw water.

Trapezoidal section shall be provided for pond with minimum holding capacity of 40,000 m^3 of water. All necessary system installation for conveying water from RWHP to RWR is within the scope of Bidder.

Suitable over flow arrangement shall be provided for the pond with RCC Drain connecting up to the Bhedan river. Invert level of Overflow drain in the Pond shall be 100mm below the Invert level of Inlet drain. The road crossing of the drains shall be in RCC Culvert.

Scheme for the rain water harvesting as above shall be submitted by the successful bidder for approval by the Owner/consultant

Bridge across Bhedan River:

There shall be 2 Nos. Bridges across Bhedan River.

The bridges across Bedhan river shall be of RCC and shall be designed as per IRC 112 and all relevant IRC/Indian standards (latest revisions). All other associated civil & structural works are under the scope of Bidder.

The bridge-1(west side) connecting mines shall have four lanes of road with walkways. In addition to this necessary provision/ extra width for carrying Ash pipe line shall also be considered suitably as per system requirement. The bridge shall also be used for routing of HCSD pipelines in future for dumping of combined ash in the mine voids created over a period of time.

The bridge-2(eastside) connecting Township and Power plant shall have four lanes of roads with walkways. In addition to this necessary provision/ extra width for carrying Ash pipe, any other water line and Makeup water Intake pipe lines shall also be considered suitably as per system requirement.

The total width of bridges shall be as per functional requirements. Necessary head room shall be provided for free movement of Boat / Ferry taking High flood level (HFL) into account.

Any statutory approvals (including payment of necessary fee, levy and all other related misc. expenditure from the State/Central Govt. authority for obtaining statutory approval) required shall also be under the scope of the successful bidder. Owner shall support by way of giving letters etc. for obtaining approvals for the above.

Other Civil Works.

All civil and Structural Works related to Pipe racks, Cable racks, Cable Trenches, Duct banks etc. and supporting structures as applicable for the entire plant area shall be within this scope of work.

All civil and Structural Works related to Roads, drains and Pavements as applicable for the entire plant area shall be within this scope of work.

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. Wherever plant road meets the plant main road, RCC box culvert shall be provided by successful bidder. All the storm water drains inside the power plant shall be RCC.

All plumbing and water supply fittings & fixtures, rainwater drainage of plants of any building / premises / open area in the scope of this package. All the

sewerage shall be collected from plant area and the same shall be interconnected to the Main Plant Sewer System as per detailed layout requirement which is also under bidder's scope. All drainage and sewage manholes and chambers shall be of RCC of grade M30.

Criteria for Chimney have been mentioned in different sections.

TG, Crushers for both Coal and Limestone, MILL, ID & FD fans, TDBFP and MDBFP foundations shall be provided with VIS.

4.00.00 MAJOR PLANT STRUCTURES / UTILITIES /COMPONENTS

The descriptions of some of the major structures / utilities / components covered under the Package are given below:

The Building dimensions mentioned elsewhere in the Specifications / Tender drawings are minimum requirements only. Dimension of the building shall be decided by the successful bidder to suit the equipment size to be supplied for functional requirements duly taking into account for maintenance requirements also. Layout shall be prepared by the bidder such that no horizontal overlapping of foundations (at different levels) is encountered to the extent possible. Moreover, combining foundations for different buildings / structures / facilities are to be avoided to the extent possible.

4.01.00 Bunker Building

The entire coal bunker structure complete with motor operated shut off gate at bunker outlet, bunker extraction feeders, coal pulverizes, Coal pipes, pulverized fuel burners and associated auxiliaries. The bunker bay arrangements shall be as per system requirements as specified in the relevant Mechanical Volume.

The entire assembly of the feeder parts, the bearings, driving and driven sprockets etc. shall be housed on heavy duty structural frame with arrangement for mounting the same on RCC foundation.

Walkways, platforms and staircases for the buildings and structures under civil scope shall be provided in accordance with following clear width requirements:

i) Maintenance access walk-ways: 1500mm.

ii) Other walk ways: 1000mm.

iii) Ladders: 600mm. & Staircase: 1500mm for indoor and 1200mm for outdoor stairs (for both steel and RCC)

Handrails shall be provided on all sides of Feeder floor and openings.

Bunker building shall be designed considering load from connecting conveyor gallery and other CHP facilities. The framing shall be of structural steel. This shall be designed as a moment connected framing in the transverse direction and braced in the longitudinal direction.

6m minimum clear height to be considered above bunker top to accommodate coal feeding arrangement. Also, loading due to dust extract equipment and conveyor to be considered while designing bunker building.

The associated civil and structural works required for the conveyor system as per technological requirement shall be carried out by successful EPC bidder. In bunker bays, Monorails with Hoists shall be supplied by bidder. The erection and fixing of the same shall also be by successful EPC bidder.

Supply and erection of all gratings, insert plates etc. shall be under the scope of EPC Bidder. Bidder shall also furnish the required size of insert plate. Bidder shall consider in design and provide necessary embedded plates, inserts, opening etc. in Bunker building bay for installation of bunker conveyor, dust extraction equipment associated accessories.

Connecting conveyor gallery and other CHP facilities at bunker building shall be considered for design of steel superstructure and substructure as required.

Provision of foundations for the interconnecting stretch of conveyor gallery structure between the bunker buildings shall be considered in line with layout and arrangements.

Necessary Expansion gaps as per the design requirement shall be provided at all elevations including roof as required. RCC pedestals for steel columns at this location shall have expansion gap with common foundation.

In addition to the above, framing arrangement for structural steel platform at various levels around the bunker shall be provided with proper access ladder, for poking, striking and attending to air canons, if required.

Roof shall be given access through boiler staircase and elevators. Two nos. of staircase shall provide access to all floor/platforms extending upto the roof level. The bunker building shall be isolated from Power house building and Requisite nos. of all weather corridor as per operational requirements shall be provided to access steam generator building from bunker building. The all weather corridor shall have fixed at one end and sliding supports at other end.

Necessary AI doors, AI windows, Aluminium louvers facing above bunker level etc. (as per HVAC requirements) shall be provided as required. All windows shall be provided with wired glass as per the requirement.

DI Rain water down-comers for plant buildings and UPVC down comers for non-plant buildings shall be provided as per the requirement.

Erection openings as required shall be provided complete with removable

hand railings, hatch covers etc.

Roof water proofing shall be as per technical specification mentioned elsewhere in this contract.

Building roof shall be of Cast-in-situ R.C.C. over galvanized MS metal decking (colour coated on exposed surfaces) of approved profile supported on steel beams/girders and the sides shall be cladded with permanent colour coated metal cladding system with double skin with insulation. The cladding shall be from Bunker feeding floor to roof. The remaining portion of the building below Bunker feeding floor up to ground floor shall generally be uncladded. However, brick cladding shall have to be provided, if required, as per TAC and any other statutory requirements. All the cladding and roofing sheets shall be of Zincalume.

The Bunker building Columns and auxiliary columns, etc shall be designed/spaced accordingly and also for convenient operation/maintenance of Mills and other equipments.

4.02.00 **ESP Control Building**

ESP Control Building shall be one number per unit. This unitized building is located adjacent to ESP for respective unit. All electrical Switchgear & Control panels for ESP operation are located in different floors of this four-storied building, having one floor allocated for accommodating Switchgear, one for Auxiliary control panels(ACP) and HVAC equipment and balance two for cable spreader below switchgear and ACPs.

i) Lift shall be provided besides other facilities.

ii) RCC foundations shall be provided for the building structures.

iii) Necessary glazing shall be provided on the wall of the control room to have a good view of the operating areas. False ceiling shall be provided for control room.

iv) All trenches, pits, channels etc. shall be constructed of water tight reinforced concrete.

v) RCC roof slab shall be rendered water proof & shall have DI rainwater down comers as required.

vi) Ground floor slab shall be RCC floor with subgrade as per Technical Rule.

vii) False ceiling, Partition etc. shall be as per architectural/technical rule.

viii) RCC staircase with hand railing shall be provided as per architectural/Technical rule.

ix) Necessary arrangement shall be provided for lifting the panels.

x) Doors, windows, ventilators etc. shall be provided to suit requirements as per Architectural/Technical Rule.

xi) Inserts and cut outs shall be provided to suit requirement.

xii) Finishes, fittings and fixtures shall be provided as per architectural/Technical Rule.

xiii) PCC apron shall be provided in slope all-round the building with side drains.

xiv) Chain link fencing around the transformers and gate as required shall be provided.

xv) Suitable access road shall be provided to the building.

4.03.00 Auxiliary Boiler MCC & Control Building

Auxiliary Boiler MCC & Control Building will be a RCC framed building with RCC roof. It shall have two rooms, one for accommodating the electrical MCC & Panels for Auxiliary boiler while the other shall be meant for accommodating DDCIMS remote I/O cabinets and operator stations. Auxiliary boiler shall be covered with rain canopy made of steel frames, supports, steel sheeting, etc. complete.

4.04.00 Fuel Oil Unloading cum Pressurizing Pump house

The Fuel Oil Unloading-Cum- Pressurizing Pump House shall be RCC building and is common for all the units. This building is located near Common Fuel oil dyke area (The number of pumps shall be finalized as per the technological requirement)

Sumps/collection pits shall be provided with drainage facilities for underground channels/pits etc.

Inserts and cutouts shall be provided to suit requirement.

RCC roof slab shall be rendered waterproof with adequate waterproofing treatment and shall be provided with DI down comers.

Doors, windows, rolling shutters, ventilators etc. shall be provided as per requirement.

Necessary glazing shall be provided on the wall of control room to have a good view of the operating area.

PCC apron shall be provided in slope all-round the building with side drain.

Suitable access road shall be provided to the building.

Civil works to facilitate erection of monorail.

Switchgear & Control room

Fuel Oil Storage Tanks

i) Suitable foundations for required number of tanks shall be provided.

ii) RCC bund wall / dyke of required height shall be provided all-round in the tanks area to contain oil spills and any leakage and in accordance with Government Acts & regulations on oil pollution prevention.

iii) RCC paving shall be provided in the tank area outside tank foundation with slope towards RCC peripheral drain. RCC crossovers shall be provided at appropriate locations for entry of personnel to the tank farm.

iv) Pits, trenches etc. shall be of RCC construction with adequate water proofing treatment.

v) RCC foundation for all auxiliary equipment, all pipe line supporting trestles, pumps etc. shall be provided as per requirement.

vi) Chain Link fencing shall be provided all-round the area with provision of steel gates and access road as per LPA norms.

4.05.00 **Not Used**

4.06.00 **Compressor Shed in Ammonia Storage Area**

The Compressor Shed in Ammonia Storage Area shall be located as per plot plan.

The shed is of structural steel construction with sheet roofing and the sides are open.

i) Reinforced concrete foundation shall be provided for building columns.

ii) Reinforced concrete foundations will be provided for all equipment at ground floor.

iii) The ground floor slab shall be of RCC as per architectural / technical rule.

iv) Finishes, fittings and fixtures shall be provided as per requirements.

v) Suitable access road shall be provided to the building.

4.07.00 **Electrical Room for SCR System**

The number and location of Electrical Room for SCR System shall be as per electrical requirement. It will be a RCC framed building with RCC roof.

4.08.00 **RIO-cum-VFD Panel Room**

3 (Three) numbers (1 for each unit) RIO-cum-VFD Panel room to be provided near boiler area. This building to be single storied Steel-framed building with RCC foundation. To be cladded by Fly ash brick walls. Roof shall be of RCC on metal deck. The room shall be air conditioned with false ceiling. RCC Grade slab to be as per Technical Specification. All related civil works are under scope of bidder.

4.08.01 **Boiler Maintenance Building**

The Boiler Maintenance Building is common for all the three units. The building is to be sized and designed to meet all functional requirements (minimum size 30m x 60m).

This building shall be single storey steel structure of framed / braced design. Roof shall be RCC over metal deck on structural steel beam. Crane Supporting Structures shall be provided including Supply and Erection of EOT Crane of capacity as per the Technological Requirement. Side Cladding shall be of Fly ash brick.

RCC ground floor slab shall be provided as per architectural/technical rule.

PCC apron will be provided in slope all around the building with side drains.

Steel door and aluminium glazed windows with steel grill protection, and rolling shutter (electrically operated with gears), shall be provided.

Door, Window and other finishes shall comply with Architectural specification.

Toilets are to be provided in the building as per the technical rule. 150mm dia DI Rain-water-down-comers to be provided. Plinth protection, garland drains and approach road are to be provided

4.09.00 **Power House Building**

i) Turbine Building

The turbine building is an enclosed insulated, weather-tight steel framed structure which houses the turbine generator, condenser and related equipment including the feed water heaters. 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.

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Access shall be provided to the unloading and maintenance bay for unloading TG components and auxiliary components. The superstructure shall be of structural steel framing with RCC floor slabs on permanent color coated metal deck sheeting. Fly Ash Brick work side cladding upto 3.0m from FFL and above that double skinned insulated zincalume metal sheet cladding upto roof level to be considered for 'A' row and gable ends. At B row fly ash brick cladding shall be upto deaerator floor and above deaerator floor double skin metal cladding insulated zincalume upto roof level.

On C Row, it shall generally be double skin metal cladding above 3m high brick wall above FFL upto roof level of B-C bay. Above 3m level, where brick work is technically required in certain areas like – electrical room etc, single skin metal cladding shall be placed externally covering the fly ash brick wall as continuation of metal clad façade.

Polycarbonate sheets shall be fixed along with metal cladding in approved pattern/as shown in the Tender Drawing for adequate lighting purpose for the Power House Building.

The roof of the TG bay shall be permanent metal decking with in-situ concreting and screed on top and supported on steel truss. The structure is braced in the direction of the crane travel but provided with rigid joints at roof level and framing at other floor levels with the electrical and mill bays in the transverse direction. The roof of the TG Bldg shall have Electro mechanical roof extractor.

Service and maintenance bays shall not have any intermediate floors, however a 1500 mm wide observation gallery with handrails shall be given along the wall at the operating floor level to observe the TG erection operation.

The access to the roof of the TG building will be provided with staircase. Adequate number of Windows shall be provided to ensure natural light.

Doors on external walls shall be provided as per the functional requirement as well as considering emergency escape provisions. For equipment entry into the service bay specially designed steel electrically operated rolling shutters shall be provided with appropriate operating mechanism. Electrically operated rolling shutter shall also be provided in front of condenser to facilitate tube removal.

Rain water from the roof shall be taken into DI rainwater pipes at suitable intervals as per architectural / technical rule. DI pipe sleeves for draining out rainwater from chajja and canopy shall be provided at suitable locations.

Wherever openings are provided in the floor for handling of equipment using EOT cranes such openings shall be covered with gratings provided over removable steel beams.

AC Plant shall be located in the ground floor of common control building.

Separate pipe rack between C-D row shall be provided, so that the power house columns can be designed independent of the pipe loads on this rack.

TG hall EOT crane capacity shall be as per mechanical requirement.. For rigging and positioning of the condensers, building frame shall not be of any hindrance and temporary openings in the building walls and wall supporting structures shall be maintained till completion of the rigging and positioning of the condensers.

Within the building, the concrete foundation for supporting the turbine generator shall be completely isolated from the building floors for vibration control. The foundation for Turbo-generator shall rest on suitable vibration isolation system consisting of springs and visco dampers (supplied by owner approved vendor).

The Boiler Feed Pumps / motors are erected either on elevated floor or on ground floor, foundations for the same shall have suitable vibration isolation system consisting of springs.

The fundamental frequency of the foundation shall be at least ± 30% away from operating frequency. Resonance at other possible frequencies (half and twice operating speed) shall also be checked.

RCC plinth beams shall be provided connecting the RCC columns/pedestals along A, B, C rows and Gable ends.

The concrete operating floor shall be designed for construction and maintenance loadings of TG. Hatchways with removable chequered plates or grating floor covers shall provide access to equipment on lower floor and shall be within turbine hall crane access. The intermediate floors shall be of concrete with hatchways as necessary.

The fasteners to be used for these factory made panels shall be of adequate sizes, self-drilling and self-tapping type, compatible with galvalume steel sheets.

Windows, doors, exterior walls, internal finish and external finish shall be as laid down in Vol: II-G/1, section-IV of this specification.

The roof shall be flat with a gentle slope of about 1 in 100 towards the transformer yard. The roofing shall be done by cast-in- situ RCC slab over metal decking supported by steel purlins which are spanning between two adjacent roof trusses. The roof shall be insulated by providing 75 mm thick foam concrete. The roof shall be provided with membrane water proofing as per architectural specification for making the roof waterproofed. Roof finishes shall be as per architectural specification mentioned Vol:II-G/1,section-IV of this specification.

Lighting, ventilation shall be provided as described in other sections of this specification.

i. Electrical and Deaerator Bay

This bay is continuous with the turbine building on the boiler side. This bay houses the electrical switchgears, deaerator heaters, control panels and provides space for major pipe lines and electrical cables.

All floors with hatchways as required & roof shall be of cast-in- situ concrete and the sides shall be cladded with 230 mm thick fly ash brick masonry. Deaerator floor shall be properly sloped for draining water to nearby catch pits or drains.

Stairs and platforms shall be provided as required for maximum utility and safety.

All floors and roofs of Turbine Hall shall be cast-in-situ RCC slab over metal deck as mentioned above.

RCC slab-on-grade on ground floor shall be laid as per architectural / technical rule Ground floor slab shall have drainage trenches covered with steel grating.

Stairs and platforms shall be provided as required for maximum utility and safety. Stairs shall have to be provided as per TAC / LPA regulations and any other statutory requirements.

Expansion gap of 50 mm shall be provided at all elevations between RCC floors and roofs of two adjacent units. At the roof it shall be suitably covered so as to make it leak proof and the floor gaps shall be properly covered so that the smooth access, from one side to other is not prevented. Steel columns of adjacent units at this location shall be 1500 mm apart and shall have common foundation.

The building framing shall be structural steel with moment connection in the transverse direction and bracing in longitudinal direction located by the side of turbine building. It shall be ensured that in front of control room no cross bracing is provided.

A minimum headroom of 2200 mm shall be given in the cable vaults. In control room false ceiling level shall be kept 3500 mm above floor level.

All floors shall be of in-situ RCC slab provided over structural steel beams with Metal deck sheeting. Minimum thickness of structural concrete shall be with an additional 50 mm provided for finish as per architectural/technical rule. No openings shall be permitted on the roof of control room excepting possible opening for A/C duct to exercise proper control on air conditioning. Any such AC Duct shall be within the AHU room only and no part of it shall be exposed.

No openings shall be permitted on the roof also, as this shall interfere with effective water proofing.

Windows, doors, exterior walls, internal finish and external finish shall be as laid down in Vol: II-G/1, section-IV of this specification.

Walls shall normally be supported on wall/floor beams. If wall beams cannot be avoided they shall preferably be given at the level of floor beams and shall be encased in concrete. No portion of the structural steel column shall be visible inside the room. All such columns shall be encased upto the next roof level with fly ash brick masonry.

Cable vaults shall be provided with minimum 2 doors for each floor. The doors shall be 2-hour rated fire-check doors. No windows shall be provided on the turbine bay side.

Switchgear room shall be provided with minimum two 2-hour rated fire-check doors to satisfy statutory requirement. In addition a two leaf sliding doors of slush welded steel construction may be provided if required to move the switchgears into the room making use of equipment lifting hatch provided in turbine building.

For Control room & Annex rooms, refer to Vol: II-G/1, section-IV of this specification.

Floor above control room, where steam / water pipes are routed, shall be provided with proper drains to prevent any accumulation of water. This is very important to prevent seepage of water into the control room.

All openings in floor for switchgear and other panels shall be sealed with fireproof material after cables are connected.

PCC apron shall be provided in slope all-round the building with side drains. Architectural finishes shall be as per specification described elsewhere. Suitable access road shall be provided for the building.

4.11.00 ACW Pump House

This building is located near A Row of Power House Building. Three (3) nos ACW Pump house, one for each 800 MW unit, have been envisaged for this project. Necessary hoisting facilities shall be provided as per the mechanical requirement.

This shall be a double storied (G+1) steel framed building. Roof shall be of RCC supported on colour coated trough shaped permanent decking supported on steel beams. Side cladding shall be by fly ash brick upto 1.0 m height from FFL supported on plinth beams. Above 1 m high fly ash bricks Double skin sheet insulated Zincalume metal cladding shall be provided Air washer Room is provided in 1st floor. Water tank and RCC supporting

structures for louvers, filter and foundation for equipment such as fans and pumps are also included in the scope. Proper drainage of the floor has to be provided for.

4.12.00 **CST Pump Shed**

This is located in front of A Row of Power house building. One no CST Pump shed has been envisaged for three 800 MW units and the same is located near Unit no I.

This shall be a single storeyed steel framed shed structure with Zicalume roof sheeting and Side Sheeting. RCC Grade slab as per Technical Specification.

4.13.00 **Condensate Storage Tank**

Three (3) nos Condensate Steel Storage Tank each having capacity as per Mechanical requirement shall be installed near power house. Diameter of Tank shall be around 12 M. All civil works including foundation, paving, drains etc. are under the scope of the bidder.

4.14.00 **CPU Regeneration Building**

This building is located near Boiler Unit no I. This building is common for three 800 MW units.

This shall be a Three storied (G+2) steel framed building. Roof shall be of RCC supported on colour coated trough shaped permanent decking supported on steel beams. Side cladding shall be by fly ash brick. Proper drainage of the floor has to be provided for. Necessary hoisting facilities shall be provided as per technological requirement.

4.15.00 **DG Plant Shed**

DG Plant shed is located in Transformer Yard. Four (4) nos DG sets (one for each 800 MW Unit and one common standby for three 800 MW Units) shall be housed in this shed.

This shall be a steel framed shed structure with roof sheeting and Sides are open. RCC Grade slab as per Technical Specification. All related civil works are under scope of bidder.

4.16.00 **Plant IA/SA Compressor House**

IA/SA Compressor House is a single storeyed Steel-framed building with RCC Roof. It is located near SG area. Compressor House is cladded by Fly ash brick walls. RCC Grade slab as per Technical Specification. All related civil works with facilities are under scope of bidder. Necessary hoisting facilities shall be provided as per the technological requirement.

4.17.00 **Service Building**

This is a five storeyed (G+4) RCC framed structure fully cladded with fly ash brickwork. Mainly office zones to be provided with necessary toilets. Floors in the power house shall have access to the Service Building Floor. Two numbers of staircases and Elevators are to be provided inside the building. For detail descriptions, Vol-II-G1-Sec IV (Architectural part) may be referred. The total floor area of the building shall be minimum 7000 sqm.

4.18.00 **Transformer Yard**

Transformer Yard shall comprise of foundations for transformers mainly GT, ST, UT, and UAT. There shall also have foundations for bus ducts, lightning arrestor etc. In transformer yard area cable shall run in RCC trenches. Foundation for rail track, Jack pad with mooring point shall be provided in yard area. Cable pull pit, Duct bank, Fire walls, Oil collection pit, chain link fencing with gates etc. shall be part of Transformer yard.

Civil works for the equipment foundations, facilities and miscellaneous civil works to be provided for the project shall include but not be limited to the following:

- All Transformers and its foundation including ST, GT, UT, and UAT with soak pit and common oil pit.
- Fire separation/protection walls in RCC (as per LPA norms) for transformers.
- The RCC Paved area for the Transformer yard shall extend from A row columns to Road R39 and Road R16 to R5 covering the entire Transformer yard. The entire transformer yard area shall be provided with chain-link fencing with necessary gates
- Cable trenches in the transformer yard for facilitating laying of cables .
- Cable, pipe trenches and duct banks within the power plant.
- All civil works related to laying of Fire Hydrant lines like trenches/pedestals etc., are in the scope of EPC Bidder.
- Permanent road and its connection to the plant main road and pavements for the various facilities including providing culverts, drains etc, Rail track within the Transformer yard and up to the maintenance bay for movements of Transformers.
- Surface drains are to be connected to nearest storm water drainage system of the plant, which is connected to the plant network.
- For contaminated water / oil drainage, arrangement shall be made to drain the same including effluents from UTs/UATs/STs to sump pits by gravity flow. Also refer Electrical volume Vol-II-F1 in this regard

- Supporting structures and platforms with access for utility pipelines.
- The transformer yard paving shall be 100 mm below the plant 0.00 (i.e.) Power House Bldg Finished ground floor level. However, all the rail roads shall be kept at 0.00 M level. Wherever, the paving approaches the rail road shall be provided with a mild slope to make easy movement of vehicular movement.

4.19.00 Pipe/Cable Trestles and Foundations

All cables & pipes in outdoor area shall run above ground over steel trestles or other supporting structures wherever erection of trestles is not possible for easy inspection & maintenance within plant area. All the pipe/cable racks falling in the plant area shall be suitably constructed as per the piping / electrical requirements. In some localized area, Pipe/Cable can run in R.C.C. trenches. In case over ground routing is not feasible due to site constraints, the pipe/cable to be routed through duct-banks, subject to the approval of the Owner.

A minimum clearance (clear head room) of 8.0m shall be kept for all over ground pipe/cable trestles for all road/rail crossings. In other areas the clear height shall be 4.0m (minimum) from finished grade level. All cable racks shall be provided with continuous walkway of minimum 750mm width with handrail and toe-guards all along the length of the trestle along with approach ladders near roads, passageways etc. All pipe racks shall be provided with walkway as per the mechanical requirement. Walkway shall be provided with GI Grating. The racks can be multi-tiered. Cable shall normally be laid above the pipes. For actual width of the pipe rack, no. of pipes/cables etc. shall be as per Mechanical specification and drawings may be referred.

Before and after the rail/road crossing, a barrier of suitable height shall be constructed so as to prevent the approach of cranes (having height more than 8.0m) etc. up to the pipe/cable rack trestles.

Pipe thrust shall be considered as per layout and design requirements.

Trestles (framed twin columns) & foundations are to be provided for supporting the pipe/cables at suitable intervals. Four legged trestles are to be provided mainly at intercepting location of branch (maximum distance shall be 100m) Crossover, operating platform & necessary trussed resisting arrangement at pipe bend shall be provided as required. Necessary expansion joints in the structure shall be provided as per IS: 800 (Latest Revision). The trestles shall generally be provided using rolled sections only.

4.20.00 Criteria for Facilities / Structures

All the Buildings / Structures to be constructed as per the process requirements. Different functional requirements like Mechanical, Electrical, C&I, HVAC etc. to be fulfilled while designing the building / facilities sizes and

other details. All Codal stipulations shall be maintained.

Architectural requirements shall be as per Vol-IIG1/ Sec-IV.

All non-plant buildings which are parts of EPC package are described in detail in Vol-IIG1/ Sec-IV.

Other buildings / facilities not specifically mentioned in this section or in Vol: II-G/1, Section-IV, but required for the operation of the plant shall be constructed by the bidder.

The EPC bidder may add extra facilities/buildings as may be required for operation of plant without additional cost to the owner subject to prior approval of Owner/Consultant.

Above list of Buildings mentioned in cl 3.00.00/4.00.00 is minimum and not exhaustive. Buildings necessary for the smooth operation of the plant shall be within this scope of work.

4.21.00 Design of infrastructural facilities

4.21.01 Roads

All roads shall be RCC roads except approach roads to Raw Water Reservoir Ash dyke, some of the patrol road along compound wall inside plant boundary as per Plot plan and inspection road to Raw water Intake Pump house which are BT roads.

The sub base over the well compacted subgrade of all plant service roads within plant area shall initially be made with hard shoulder on either side of carriage width as per architectural/technical rule. After major construction activities are completed the road shall be surfaced with RC concrete slab as per proper design requirement. For RCC roads the construction layers (cross section) as per cl 2.07.00/Vol II-G2/Part A/Section X shall be followed.

All power 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.

All roads around the plant to FOPHS, boiler area, Turbine area, transformer yard area and where there is heavy vehicle movement shall also be of RC concrete roads with hard RC shoulder.

All the roads in the entire plant area within the EPC package scope shall 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.

The additional roads and access to individual buildings/structures/facilities within scope of this specification which are not specifically shown in layout but required from functional requirement is also included in the scope of EPC Bidder. Moreover, bidder to note that all these roads shall be RCC only.

All the roads within the plant shall be under the scope of the EPC package bidder including formation of sub-grade, sub-base and laying of DLC, PCC and RCC.

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 stone boulder / laterite sub-base of 230 mm consolidated thickness with 63 mm downgraded aggregate size.

Minimum RCC carriageway and shoulder width shall be as per approved drawing.

The 'Type' of RCC roads to be decided based on the approved plant and road layouts based on Tender Drawing

Finished top (crest) of roads shall be 250 mm above the surrounding grade level.

Access within the plant site as well as to building / structures shall be provided as a system of roadwork.

4.21.02 **Surface Treatment**

F.G.L. of Boiler Area shall be 202.500 M.

F.G.L. of Power House Area shall be 202.500 M

Plant 0.00 shall correspond to 203.00 M which is FFL of Powerhouse building. All reference shall be taken from plant 0.00 only.

The Finished Paving Level (FPL) of the Entire Boiler Area shall be 200 mm below the FFL of the Power House Building.

The Finished Paving Level (FPL) of the Entire Transformer Yard Area shall be 100 mm below the FFL of the Power House Building.

The entire Switchyard area shall be provided with chain-link fencing. Switchyard area shall be filled with 150 mm thick layer of 20 mm to 40 mm size BG metal.

The entire boiler area shall be provided with RCC Paving.

The entire boiler area and Transformer yard area shall be paved with

reinforced cement concrete with 200 mm thickness minimum and sloped to drains.

The RCC paving applicable in the EPC package, Shall be 200 mm thick and sloped to drains. Paving shall be M30 except road portions with double layer of reinforcement min 10 mm tor 200 c/c both ways (top & bottom) over 100mm thick lean CC M10 on 230 mm thick compacted stone boulder / laterite soling interstices filled with gravel over well-compacted (Minimum 90% Proctor density)Sub-grade.

Maintenance access roads of minimum 7.5m wide shall be provided to all major equipment e.g. ID Fan, FD Fan, ESP etc. All drain / trench covers in these areas shall be designed to withstand truck loading of class IRC.

Roadways shall be clearly identified with kerbs and painting. All drain / trench covers in these areas shall be designed to withstand truck loading as mentioned in Vol II G1/section II.

The drainage of the entire plant area shall be properly planned. Network of RCC drains having RCC cover along with slotted holes and Galvanised MS grills at a spacing of 4m shall be provided covering the entire Boiler, Transformer and Switch yard areas which shall lead the storm as well as process leakage water to the peripheral drains, which in turn shall lead to network of plant RCC storm water drain system with rain water harvesting pond . Other areas (except Boiler, Transformer yard and Switch yard areas) the RCC drains are rectangular Open drains. All structural steel columns in the area shall be provided with encasing to a height of minimum 200 mm above paving level and in addition the bases also need encasing if base plates are below paving level.

4.21.03 Area Grading

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 shall be carried out by - Bidder. Also, final micro leveling is to be done by the successful Bidder as the area may get disturbed due to construction and monsoon activities.

Work shall have to be carried out as per grading layout plan approved by the Owner. All existing drains/channels in the plant and other areas associated with the plant shall be suitably diverted before taking up any construction. These diversions shall be so designed as to ensure effective disposal of water without any accumulation or flooding in adjoining areas.

4.21.04 Storm water & Drainage System

RCC rectangular Drains shall be designed as a network covering the entire plant area are under EPC bidder's scope. Plant main storm network is under

EPC package. Carrying the storm water of the entire plant to the Rain water harvesting pond and from the pond outfall point upto Bhedan River is within the scope of EPC package bidder. It shall be noted by the successful bidder that buildings area under owner's scope shall also be considered and joined in the main plant storm water system & main plant drainage network. Hence, the bidder shall design their storm water RCC drain & Sewerage network to take the additional load accordingly.

Sewerage from various facilities of the EPC package shall be considered. Overall sewerage system shall be designed accordingly.

All the drains including the Plinth protection drains shall be of RCC within the plant area. All the buildings shall have plinth protection of 1000 mm wide (excluding drain width) towards the peripheral drains.

Auxiliary/Branch drains shall cover individual grades to terrains; collect storm water and other non-contaminated discharge from plant buildings and then to be connected to storm water drainage system.

The invert level of the in-plant peripheral drains shall be kept such that water can be discharged by gravity to the drain under all condition. RCC box culverts shall carry drainage under intercepting roads and railway tracks. Suitably designed underground storm water RCC box culverts on the basis of design loads specified elsewhere in this specification shall be limited to required areas where surface drainage ways are not desirable or practicable from other functional point of view. The drains shall generally be of open type (except Boiler, Transformer and switch yard areas) RCC rectangular construction with 600mm minimum clear width except for building plinth drains which shall be 300mm minimum clear width. All plinth drains shall be covered with Precast slab.

All drains along the periphery of buildings, boiler, transformer and switchyard areas and all plinth drains shall have perforated R.C.C. pre-cast cover slab of minimum 50 mm thickness with provision of openable galvanized steel grating covers at every 4.0 m intervals. Design of such drain covers shall be done considering loading as specified elsewhere. In areas where operational requirements are there and vehicular loads shall come, pre-cast RCC covers/box culverts of suitable thickness without perforations and designed for the vehicular loads (as mentioned in Vol II G1/section II) shall be provided.

The drainage system shall be designed for precipitation intensity of 100 mm per hour (maximum hourly intensity of rainfall). Run-off coefficient for open ground area (unpaved) shall be minimum 0.90 and for paved area and other covered surface including roads the same shall be considered as 1.0. Minimum free board of 150mm shall be kept while designing drains.

Surface drains shall normally have a slope of not less than 1 in 1000 along longitudinal direction and RCC structures shall be provided at drops/falls to prevent scouring. Drops/falls shall be provided on both sides of box culverts. Minimum self-cleansing velocity shall be adopted as 0.7m/sec but the velocity

of flow shall not be more than 2.4 m/sec for concrete drain, however, it is recommended to maintain the maximum velocity within 1.2 m/sec.

4.21.05 **Construction Facilities for early works**

The Bidder shall develop and construct all necessary facilities like Batching plant, Construction store, Fabrication yard and Raw material storage area and Canteen for site personnel at no extra cost to the Owner. The associated roads and drains connecting these facilities shall also be constructed by the Bidder. The Bidder shall visit the site and locate suitable areas for these facilities.

4.21.06 **Not Used**

4.21.07 **Waste water Drainage system**

The Boiler area, turbine area and Transformer yard area service water waste shall be collected in a RCC underground oily waste retention pit. Pump supporting floor/maintenance area shall be provided. The bidder shall provide the necessary pumping mechanism and the pipeline upto the Oil Water Separator (Oil Water Separator is also included in the scope) for disposal of the same.

4.22.00 **Coal Handling Plant**

Structures in CHP are discussed below. For detailed specifications of Coal Handling System, Volume II-H2 of this specification shall be referred to. Coal handling areas shall have suitable surface drainage facilities.

4.22.01 **Coal Stock Yard**

Entire area as per mechanical requirement shall be excavated to suitable depth and given slope of 1 in 100 in suitable directions as approved. Entire excavated area shall be watered and rammed and compacted with 10 tonne roller. 100mm thick river sand cushion layer shall be placed over compacted sub-grade and consolidated by flooding. 230 mm thick boulder soling shall be laid over sand cushion with joints filled with river sand. Over boulder soling, 100 mm thick lean concrete (1:4:8) shall be spread. Final layer shall be minimum 200mm thick RCC slab of grade M30 having double layer reinforcement of 10 dia 200 c/c both ways. Slope is to be maintained through all layers.

The coal stack area shall be graded with suitable slope for draining the surface by longitudinal drains shall be of RCC trenches with graded gravel packets at about 1.5m intervals on the sides to trap coal dust. Weep holes shall be provided in the trench walls at the locations of filter pockets for collecting surface water in the longitudinal drains for discharging into the main

surface drain to be provided by the successful bidder by the side of the road. RCC retaining wall of 1.0 m height above FFL (Paving) shall be provided around the crushed coal pile to prevent coal spillage into the drain. Necessary control joints in the grade slab shall be considered to avoid temperature and shrinkage cracks in the slab. The design of coal stack area shall take care of loads arising due to dozer movement and shall be designed to sustain coal-water pressure.

RCC drains with removable pre-cast RCC slotted cover shall be provided on either side of the coal stock yard and all-round the stock piles. These drains shall be designed to carry the drainage of water during rain from the coal yard and leading to runoff pit. The header drain shall be provided with a bifurcation at the discharge end i.e. at the inlet to the common collecting/settling pond so that it gets divided in to two individual branch drains. Each individual branch drain shall be provided with a gate suitable for operation in coal slurry at the inlet to individual section to the common collecting/settling pond. The slope of the drains shall be so designed for easy run-off.

Coal yard run off pit / settling tank shall be of RCC construction with baffle walls to facilitate settlement of coal particles in the pit. The tank shall be in two compartments separated by a partition. A sump shall be provided at the end of the pit to pump out the decanted water. The clear water from the tank shall overflow into an adjoining settled water tank compartment and the clear water shall be pumped to the clarifier. Necessary platforms shall be provided for Pumps. The coal Pile run off system shall be designed in line with guidelines given in mechanical Volume II-H2.

RCC approach road to the coal stock yard shall be provided by the successful bidder Approach Road to nearest road and other roads inside stock yard with RCC drains and RCC box culverts shall be suitably provided. Roads shall be 7.5m wide with berm of 1.5m wide on both side and shall be of RCC.

Stacker cum Reclaimer foundation shall be in RCC and shall be designed as a Frame / continuous wall supporting the rail and the wall shall be resting on rigid type RCC continuous strip foundation. Lateral tie beams between two rail supporting elements shall be provided at a regular interval of approx. 3.0m center. The conveyor shall be supported on lateral tie beams connecting the rail supporting structures. Expansion joint for the beams supporting the rails preferably at 30m is to be provided. No expansion joint is permitted in foundation. The foundation shall be designed for the most critical combination of loads as furnished by the equipment supplier. The portion between the two rails and between rail & retaining wall on both sides shall be paved in concrete as per specification.

Water supply points shall be provided at suitable intervals along the stacker and reclaimer rail track as per mechanical requirement. Beyond stock pile area and up to the junction Towers, foundations for trestles, short supports shall be given. The top of pedestals shall be 500mm above FGL.

RCC supports for Dust Suppression System in stock yard shall be provided by the successful bidder. The RCC structures shall be designed in accordance with design criteria.

All civil and structural works for Wind shield in the stock pile area shall be provided as per mechanical requirement.

Refer to Vol-IIH for detailed mechanical and process requirements.

4.22.02 **Junction Towers (JTs)**

Over ground JTs shall have RCC foundations and pedestals at (+) 500 mm above ground level. The super structure for JTs shall be of steel framed structure with adequate bracing arrangement. The ground floor shall be of RCC and shall be finished with cement concrete flooring with metallic hardener having proper slopes for drainage. All intermediate floors shall be of RCC over metal deck. The roofs shall be of metal deck with RCC slab with water proof treatment and drainage slope. The side cladding shall be of single skin, zincalume metal cladding.

JTs shall be provided with independent steel staircase with steps of Galvanised MS grating from ground to Roof level. Elevator shall be provided as per mechanical requirement. The elevators shall be provided with elevator pit at the ground level and MCC room at the top. The clear width of the stair , tread and rise shall be as per architectural / technical requirement. However the codal regulations shall also be complied with. Continuous galvanized MS handrails shall be provided for the staircases.

Drive units shall be directly supported on floor beams from suitable structural steel stools and not on concrete floors. All Junction Towers shall be provided with adequate number of windows and doors. The window area shall not be less than 10 percent of total wall area. Maintenance platform inside /outside of Junction Towers may have chequered plate floors with horizontal floor bracing.

Minimum clearance of 1.5m shall always be provided around any equipment / structure / pedestal inside the building.

Junction Towers with metal sheeting as cladding shall have 1.0 m high 230 mm Fly ash brick enclosure from finished ground floor. Around the building. Fly Ash Brick wall shall be inside face of sheeting with a lapping of 150 mm.

Adequate floor washing arrangement shall be made for all JTs. Provision of floor dust collection and removal by chute shall be made. Deflection of JTs at conveyor entry level shall be within height/1000 across the conveyor & height/500 along the conveyor. While designing JTs necessary provision shall be made in loading for future conveyor to house inside JTs (JT8). Minimum height between the floors in junction towers shall be 4m. Sliding door shall be provided at the monorail openings. Removable Handrails shall also be provided at these locations. Monorail projection outside the building shall be

as per system requirements. RCC paving 5m width upto Road shall be provided at the unloading area (GL).

Door, Window and other finishes shall comply with Architectural specification. Rain-water-down-comers to be provided. Plinth protection, garland drains and approach road are to be provided.

4.22.03 **Conveyor gallery and Trestles**

On grade and over ground galleries shall be of enclosed type for adequate weather protection. The walkways for on-grade galleries shall be raised and they shall be made of concrete with skid proof finish. Overhead conveyor galleries shall be structural steel consisting of two girders braced at top and bottom and supported on trestles.

Walkway portion of over ground conveyor galleries shall be of chequered plate of 8mm thick with antiskid bar or expanded metal grating. Minimum clear width of central walkways shall be as 1100mm and side walkways shall be 1000 mm with 3.0m clear height. For Single Conveyor gallery, both side Walkways shall have 1000mm minimum clear width. The maximum span of standard gallery shall be 24 m unless higher span is necessitated due to site constraints which shall be subjected to the approval of Owner/Consultant. The galleries for double stream conveyors shall have one central walkway and two side walkways and single stream conveyors shall have two side walkways.

Galvanised MS Hand railings shall be provided as required. For Entire conveyor Gallery seal plate of minimum 4 mm thickness shall be provided so that a complete leak proof bottom will be formed. The over ground conveyor galleries shall be designed for adequate ventilation and natural lighting.

Conveyor gallery having slopes greater than 8 degree, stepped walkways of chequered plates with nosing and toe guard shall be provided all along the conveyor. 10mm dia Tor anti-skid steel bars shall be provided @ 500 mm c/c for inclined walkways below 8 degrees.

Suitable floor washing arrangement shall be made in the conveyor gallery with down comers.

In between Junction Towers / buildings four legged trestles shall be placed at a maximum interval of 100 m. The arrangement shall be such as to ensure that force in the longitudinal direction of conveyor gallery of length not more than 100 m shall be transferred to four legged trestle. Cross overs shall be placed for conveyors at approximately every 100m of route length and minimum 1 per conveyor. For conveyors more than 40 m length automatic counter weight gravity type Automatic take up with HGTU or VGTU (complete system) shall be provided.

Two legged trestles at regular interval may be placed between four legged trestles. The end supports resting on the four legged trestles can have one

hinged and the other on slide type. Slide type support shall be with PTFE bearing to allow both rotation and movement.

End of conveyor gallery which shall be supported over Junction Towers, shall be so detailed that only vertical reaction is transferred from gallery and no horizontal force in longitudinal direction is transferred from gallery to Junction Towers and vice–versa by providing sliding supports.

All RCC trestle pedestals shall be raised to minimum (+) 0.500 m above FGL. Trestles shall be of structural steel braced adequately and provided at suitable locations. Location of trestles shall be decided carefully so that there is no interference with underground and over ground structures, tunnels, trenches, drains, etc. The minimum clearance over road and railway crossing shall be 8.0 meters.

Overhead conveyors shall be located in a suitably enclosed gallery of structural steel. The overhead gallery shall consist of two vertical latticed girders having rigid jointed portal frame at both ends. Cross beams at floor level supporting conveyor stringer beams shall be made of single rolled steel beam or single channel section (ISMB or ISMC) or plate girder. Horizontal bracings are to be provided at top & bottom plan of the gallery (latticed girder shall be braced together in plan at the top and bottom). Common end portal frame shall not be used for adjacent conveyor spans.

Roof truss shall be provided at upper node points of latticed girders to form an enclosure. The gallery should as far as possible be erected as a box section keeping all the vertical and horizontal bracing tied in proper position.

The ground conveyors shall be located in suitably enclosed gallery of structural steel consisting of rigid portal frames spaced at regular intervals and suitably braced. Plinth protection along with drains shall be routed along the ground conveyors.

Conveyor gallery shall have permanently colour coated Zincalume sheet covers on roof and both sides. However in roof, a panel of minimum 1.5mx1.5m area at about 6.0m c/c shall be provided with 4mm thick translucent sheets of polycarbonate material for natural lighting. A continuous slit opening of 500 mm shall be provided on both sides just below the roof sheeting. The bottom level of edge of roof sheeting shall match with bottom of slit level to prevent rain water entry. Adequate provision of openable aluminum windows shall be kept on both sides of conveyor gallery with MS safety grills inside.

Crossover with chequered plate platform and ladder for crossing over the conveyors shall be provided at approximately every 100 m intervals of conveyor. Crossover shall preferably be located over four-legged rigid trestle location.

Conveyor gallery structure shall be designed considering both conveyors operating simultaneously.

Allowable vertical deflection of gallery girder shall be restricted to span/400. Vertical deflection of beam supporting conveyor short supports is to be restricted to span/450. Horizontal deflection of end portal is to be restricted to height/325. For trestles and junction towers, it shall be restricted to height / 1000 across the conveyor direction and height / 500 along the conveyor direction.

Conveyor Gallery connecting JT and bunker bay shall be resting on the bunker bay structure at bunker end. Necessary loading details of conveyor gallery shall be considered to design the bunker bay columns supporting the beam and gallery. Necessary Supporting Beam for conveyor gallery and Brackets required at the bunker bay end shall also be provided.

While casting the bunker floor, necessary insert plates for fixing the rail shall be provided.

Foundation design for Junction Towers and Trestles in the Power House region shall take care of the foundations of nearby main plant facilities within the available space.

4.22.04 **Crusher House**

Crusher house shall be of steel structure of framed / braced design. Intermediate Floors and roofs shall be RCC over metal deck sheet on structural steel beam. Side cladding shall be Fly ash brickwork up to 3.0m height from FFL Above that metal cladding as per architectural specification. Roof shall be given adequate slope for drainage. Roof shall be given with proper water proofing, as per description mentioned elsewhere in this specification. Proper arrangement shall be provided to convey the rain water through gutter of matching colour and DI down comers as specified elsewhere. Roof shall be provided with RCC Parapet .

Adequate number of aluminium glazed windows shall be provided as specified elsewhere. Wherever monorails are projecting outside (projection shall be as per technological requirement) for lifting of equipment, hollow metal sliding flush doors shall be provided. Main entrance doors shall have electrically operated rolling shutter adequately sized to carry equipment inside. Other doors shall be of hollow metal flush doors. Ramps shall be provided in front of main door. Grade slab as well as intermediate floors shall be of RCC. Intermediate floor shall be RCC over metal deck supported on steel beams. Handrail shall be provided around all openings with RCC kerb.

Minimum clearance of 1.5m shall always be provided around any equipment / structure / pedestal inside the building.

Two staircases shall be provided upto the roof one inside and one outside, both of structural steel. Elevator shall be provided. Machine room of elevator floor and roof shall be of RCC over metal deck sheet. Elevator pit shall be provided as per the system requirement. Side cladding of M/C room shall be

of colour coated sandwiched cladding system. An RCC kerb wall of 300 mm shall be given around the floor and 100mm kerb around openings. M/C room shall be given adequate slope for drainage purposes with 150mm dia DI down comers. Roof shall be given with proper water proofing, as per description mentioned elsewhere in this specification. . Main door to M/C room shall be of hollow metal flush door. Adequate ventilation shall be given using aluminium glazed window. Toilet shall be provided in the Crusher house. Elevator pit shall be kept at least 500 mm above general grade level to prevent flooding. A sump shall be provided inside the pit to collect and pump out water. Sump shall be given with access ladder.

Foundation of the building columns shall be of RCC. Foundation design criteria are given elsewhere. All the foundations shall be connected together by tie / plinth beams. Top of the pedestals for the columns shall be above finished ground floor level as specified elsewhere.

Side cladding shall be with permanently colour coated profiled zincalume steel sheets double skin with insulation inside. However, panels of suitable size to suit the architectural treatment and made of translucent sheets of polycarbonate material shall also be provided on the side cladding for natural lighting. The lower portion of side cladding for a height of minimum 3.0m height above finished ground floor level shall be of 230mm thick fly ash brick wall plastered on both faces. Grade slab shall be of RCC. Permanent metal decking shall be used for support of floor slabs. Within this building cubicles are to be provided for resting room of operators and these shall be constructed with one brick thick fly ash brickwork having both sides plastered and RCC roof slab. Vertical bracings shall be provided only on four sides along the periphery. No vertical bracings between columns shall be allowed inside the floor

Plinth protection, garland drains and approach road are to be provided.

Necessary provision of hoisting and handling arrangements shall be as per technological requirement.

Below the monorail projection, RCC paving in M30 (5 m wide upto road) shall be laid at the grade level for loading unloading.

The entire crusher house shall be designed as per approved mechanical drawing.

Crusher Foundation

The crusher shall be supported on M35 grade RCC deck slab mounted on vibration isolation system comprising springs and viscous dampers, which in turn shall be supported independently on ground-supported RCC frame structure. The crusher foundation and columns shall be made isolated from crusher building & this shall suit to process requirements. Crusher foundations shall be kept isolated by providing 75 to 100 mm gap all around at crusher floor level as per process requirements. The vibration isolation shall be done

by providing inertia block with anti vibration pads. These pads shall be suitably procured with respect to crusher manufacturer's specifications.

Detailed dynamic analysis shall be done for top deck of coal crusher together with springs & dampers and natural frequencies & amplitudes of vibration shall be determined. A mathematical model of top deck shall be formulated with three dimensional beams, plate, and finite elements for the purpose of analysis with the spring idealized with vertical and horizontal stiffness. The mass of the machine together with that of the top deck shall be considered for the analysis. Natural frequencies up to at least 10% above the operating speed shall be determined and three frequencies shall be checked against the design criteria. Forced response dynamic analysis shall be carried out for the unbalance forces generated during operating condition using a sinusoidal forcing function. Unbalanced forces as given by the manufacturer shall be used for this purpose.

Ultrasonic pulse velocity (UPV) test shall be carried out for crusher foundation to ascertain the homogeneity and integrity of concrete. Testing shall be done as per IS: 1331 (Part-1). The defects shall be rectified by using cement / epoxy grout etc.

Isolation Efficiency

The vibration isolation system shall be designed for about 90% isolation efficiency.

De-coupling

A ratio of the least 10 (ten) shall be ensured between the stiffness of the supporting structure and the stiffness of the spring system in the vertical direction of achieve de-coupling between the two (the stiffness of the spring system being lower). This ensures that dynamic analysis of the supporting structure need not be carried out.

Frequency Criteria

The frequency criterion has already been laid down implicitly foundation isolation efficiency criteria and de-coupling required.

The bending mode frequency of the top deck shall be at least 20% above the operating speed.

Unbalance Forces

i. Unbalance forces arising out of all the following cases shall be considered for checking the design and amplitudes.

ii. Balance quality grade Q40 as per VDI 2060-1966.

Amplitude Criteria

The calculated amplitudes (mean to peak values) shall not exceed following limits under the specified conditions:

Operating speed of 750 RPM:

i) 150 microns for an unbalance force arising out of balance quality grade Q40 as per VDI 2060.

ii) 300 microns in case of a one hammer broken condition.

iii) Amplitudes need not be checked for a three hammer broken condition.

Operating speed of 450 RPM:

i) 200 microns for an imbalance force arising out of balance quality grade Q-40 as per VDI-2060.

ii) 300 microns in case of a one hammer broken condition.

iii) Amplitudes need not be checked for three hammer broken condition.

For intermediate operating speed between 450 to 750 RPM, the amplitude limits can be linearly interpolated.

The amplitude limits mentioned above are in both vertical and horizontal directions. The amplitude shall be calculated at critical points on the top surface of the RCC deck. The amplitudes shall be checked for the most unfavourable superposition of modes in any direction. However, phase difference between the maximum amplitude occurring in different directions due to the rotating vector may be considered while superimposing the modes.

Transient Resonance

Transient resonance, which may occur during the start-up or coasting down condition of the crusher, shall be checked and the amplitudes in such a condition shall not exceed one – and half times those at operating speed for each design condition.

Strength Criteria

The following criteria shall apply for the design of top deck:

i) Dead loads, live loads, seismic loads and dynamic loads shall be considered for the design. The most unfavourable combination shall be considered for design.

ii) Seismic loads shall be assumed to act together with dynamic loads for a one millimeter eccentricity in the crusher.

iii) Fatigue shall be considered while designing for dynamic forces. A

fatigue factor of 2.0 shall be used on all dynamic forces to arrive at the equivalent static force for the purpose of design.

iv) Working stress method shall be used for the design of RCC deck. In survival condition, 10% overstressing may be permitted.

v) The RCC top deck shall be at least of M35 grade of concrete as per IS:456.

vi) For calculating unbalance forces, the heaviest hammer (plain or toothed) shall not exceed the value specified by the manufacturer.

vii) Loss of contact of foundations at founding level shall not be allowed for any combination of loads.

Door, Window and other finishes shall comply with Architectural specification.

DI Rain-water-down-comers to be provided. Plinth protection, garland drains and approach road are to be provided. Toilets are to be provided in the building as per the technical rule.

4.22.05 Coal Handling System Maintenance Building

This building shall be single storey steel structure of framed / braced design. Roof shall be RCC over metal deck on structural steel beam. Crane Supporting Structures shall be provided including Supply and Erection of EOT Crane of capacity as per the Technological Requirement. Side Cladding shall be of Fly ash brick.

RCC ground floor slab shall be provided as per architectural/technical rule.

Steel door and aluminum glazed windows with steel grill protection, and rolling shutter (electrically operated with gears), shall be provided.

Door, Window and other finishes shall comply with Architectural specification.

Toilets are to be provided in the building as per the technical rule. 150mm dia DI Rain-water-down-comers to be provided. Plinth protection, garland drains and approach road are to be provided. Stair case shall be provided upto Roof and with parapet.

4.22.06 Control Room-Cum-Switchgear Room

This building shall be two storeyed RCC framed structure. Floor and Roof shall be RCC and Side Cladding shall be of Fly Ash Bricks.

All air-conditioned areas, shall be provided with the suspended aluminium false ceiling system (details specified elsewhere) with under deck insulation.

Adequate aluminium doors and windows shall be provided for natural lighting, ventilation and view. All windows in air conditioned rooms shall have hermetically sealed double glazing.

False ceiling, AC & ventilation ducts, cable galleries, inserts, concealed/conduit wiring as per technological requirements are to be provided. RCC stair case shall be provided from GF to Roof. Roof shall be provided with RCC Parapet of 125mm thick and 1000mm height.

HT Transformers shall be placed outside the building with fencing, gate, soling & paving, drainage system are to be provided. LT Transformers shall be accommodated within switchgear room.

Door, Window and other finishes shall comply with Architectural specification.

150mm dia DI Rain-water-down-comers to be provided. Plinth protection, garland drains and approach road are to be provided. Toilets are to be provided in the building as per the technical rule.

4.22.07 **DFDS/Misc. Pump and Compressor House**

This building shall be single storey RCC framed building. Roof shall be of RCC. Side Cladding shall be of Fly Ash Brick. Pumps, Compressor and other associated equipment shall be placed on Ground Floor. Monorail of suitable capacity shall be provided for necessary equipment Handling. All civil works including one RCC storage tank required for DFDS/DE/Ventilation system are under this scope.

Door, Window and other finishes shall comply with Architectural specification.

150mm dia DI Rain-water-down-comers to be provided. Plinth protection, garland drains and approach road are to be provided. Toilets are to be provided in the building as per the technical rule.

RCC Stair case shall be provided upto Roof and with parapet.

Drive House

This building shall be Steel framed building. Roof shall be of RCC over metal deck. Side Cladding shall be of single skin metal sheet. Monorail of suitable capacity shall be provided for necessary equipment Handling. All process and mechanical requirement shall be fulfilled.

Door, Window and other finishes shall comply with Architectural specification.

150mm dia DI Rain-water-down-comers to be provided. Plinth protection, garland drains and approach road are to be provided.

HGTU/VGTU

VGTU or HGTU shall be provided as per the mechanical requirements. Provision for monorail with hoists shall be provided as per mechanical requirements. In take up tower chequered plate platform shall be provided at every 3m height. All openings shall be provided with hand rails. Provision of Structural steel staircase shall be kept from GL to topmost platform.

4.22.08 **Different Equipment Foundations for Coal Handling System**

Foundations shall be designed, detailed and provided for the equipment for Coal handling system and auxiliaries as described below. This list is indicative only. Foundations for any other equipment / components as required for completeness of the system are also in the Bidder's scope.

A) Foundations required for the equipments as listed in mechanical specification inside crusher House , Junction Tower, Coal Bunker Unit-1 , Unit-2 & Unit-3

B) DFDS Pump & Compressor, Air receiver foundations, PVC water tank foundations on top of all buildings, Crusher House & Junction Towers, Different electrical equipment foundation like Transformer, Electrical Panel etc

4.22.09 Receiving Tower

This building shall be Steel framed building. Roof shall be of RCC over metal deck. Side Cladding shall be of single skin metal sheet. Monorail of suitable capacity shall be provided for necessary equipment Handling. All process and mechanical requirement shall be fulfilled. All other facilities shall be similar to Junction towers.

Door, Window and other finishes shall comply with Architectural specification.

150mm dia DI Rain-water-down-comers to be provided. Plinth protection, garland drains and approach road are to be provided.

Stair access upto roof shall be provided.

4.23.00 Ash Handling System

Major Structures in AHS are discussed below. For detailed specifications of Ash Handling System, Volume II-H1 of this specification shall be referred to. Ash handling areas shall have suitable surface drainage facilities

4.23.01 **Compressor House Including Switchgear Room and Main Control Room**

Compressor House equipment room shall be single storied and Switchgear

Room and Main Control Room Shall be Two storeyed RCC framed structure with RCC Floors and RCC roof and fly ash brick wall cladding. Both Compressor house equipment room and switchgear shall be located side by side. Crane Girder /monorail shall be provided for handling of Compressor and other associated equipment as per mechanical requirement. Necessary corbels with embedment plates shall be provided in the RCC columns for erecting crane girder, if required. Stair access to roof shall be provided.

All air-conditioned areas, shall be provided with the suspended aluminium false ceiling system (details specified elsewhere) with under deck insulation.

Adequate aluminium doors and windows shall be provided for natural lighting, ventilation and view. All windows in air conditioned rooms shall have hermetically sealed double glazing.

False ceiling, AC & ventilation ducts, cable trenches, inserts, concealed/conduit wiring as per technological requirements are to be provided.

For Transformers outside control room, fencing, gate, soling & paving, drainage system are to be provided.

Door, Window and other finishes shall comply with Architectural specification. Main entrance shall be provided with electrically operated Rolling Shutter with RCC Ramp.

Rain water down comers to be provided. Plinth protection, garland drains and approach road are to be provided. Toilets are to be provided in the building as per the technical rule.

4.23.02 **Ash water Pump House including sump, Sealing Water Pump House including sump and Switchgear & RIO Room**

Ash water Pump House and Sealing water Pump House shall be single storeyed Steel framed structure with RCC Floors and RCC roof supported on Metal deck Sheeting. Side Cladding shall be of Fly ash Bricks. Sump shall be of RCC Construction. Ash water pumps, Sealing Water Pumps and their associated equipment shall be supported on Ground Floor. Provision shall be kept for crane/monorails for handling of equipment. Stair access to roof shall be provided. Ash water tank & sealing water tank shall be of RCC located above the ground level. The tanks shall be designed as a water retaining structure as per IS: 3370. RCC sumps for Ash Slurry Pump house shall be designed as per IS: 3370 duly considering water table as well as additional surcharge pressure. RCC staircase shall be provided for access to bottom of all the sumps. All basements shall be provided with handrails all-round.

Door, Window and other finishes shall comply with Architectural specification.

Rain water down comers to be provided. Plinth protection, garland drains and approach road are to be provided. Toilets are to be provided in the building as

per the technical rule.

Sump shall be designed as un-cracked section in accordance with IS: 3370 (Latest Revision) by working stress method.

4.23.03 **Silo Utility Building cum HCSD Pump House including Switchgear RIO Room**

Silo Utility Building Including Switchgear Room shall be Single storeyed RCC framed structure with RCC Floors and RCC roof. Control room shall be of RCC construction with RCC roof. Side Cladding shall be of Fly ash Bricks. Provision shall be kept for crane and monorail for handling of equipment as per Mechanical specification.

All air-conditioned areas, shall be provided with the suspended aluminium false ceiling system (details specified elsewhere) with under deck insulation.

Adequate aluminium doors and windows shall be provided for natural lighting, ventilation and view. All windows in air conditioned rooms shall have hermetically sealed double glazing.

False ceiling, AC & ventilation ducts, cable trenches, inserts, concealed/conduit wiring as per technological requirements are to be provided.

For Transformers outside control room, fencing, gate, soling & paving, drainage system are to be provided.

Door, Window and other finishes shall comply with Architectural specification.

Rain water down comers to be provided. Plinth protection, garland drains and approach road are to be provided. Toilets are to be provided in the building as per the technical rule.

Stair access upto roof shall be provided

4.23.04 **RCC Fly Ash Silo**

i) Fly ash silo shall be of circular cross section and shall be of RCC construction. The capacity of the silo shall be as per process requirement.

ii) The silo shall be designed as per the requirement of IS: 4995. The minimum thickness of the silo wall, hopper, roof slab shall be 200 mm.

The following additional checks shall be done while designing the silo wall :

a) Actual Stresses in Concrete and steel shall be checked with

the permissible stresses as per relevant IS codes.

b) Crack width (0.2mm allowable) shall also be checked for combined tension with bending as per the relevant design standards.

iii) The silo shall be designed for the following conditions:

a) The silo is full with ash upto its full height / capacity

b) The silo is partially empty with top surface of ash, at an angle of repose less than 30 degrees.

The following loads are to be considered for design:

i) Density of fly ash to be considered for volume calculation shall be 750 kg/cum.

ii) Density of fly ash to be considered for load calculation shall be 1600 kg/cum.

iii) Density of dry fly ash to be considered for the design of supporting structures for dry fly ash conveying pipes, shall be taken as 1000 kg/cum. The pipe shall be considered full with dry fly ash

iv) The static pressure calculated at rest shall be multiplied by an over pressure factor of 1.35 for the top 1/3 rd portion and by a factor of 1.75 for the bottom 2/3rd portion. Special attention shall be given in assessing the effect of hot temperature of ash on the concrete wall. Temperature of ash shall be taken as 150^{o} C.

v) Roof over silo shall be RCC slab supported on structural steel beams. Operating floor and silo bottom floor shall be RCC slab supported on RCC beams. One Airtight RCC manhole shall be provided in the roof of each Silo.

vi) External surface of Silo shall be painted with Sandtex matt, two coats over one coat of primer.

Other requirements are as follows:

i) Structural steel staircase with intermediate platforms and inter-connecting the silos at operating and at roof levels shall be provided. Monorails shall be provided as per process requirement. Suitable formwork shall be provided to achieve smooth surface finish inside the silo.

ii) Independent supporting structure shall be provided for each silo.

iii) The minimum clearance between Silo operating floor Beam / any item

and the top of the ground floor paving of the silo area shall be 7.0m minimum.

iv) There are Six (6) nos. of Silos, two (2) nos. (Interconnected) for each unit. Total three (3) nos. structural Staircase with GI gratings shall be provided one at each end. Inside the silo at the hopper portion, there shall not be any flat surfaces.

v) Top level platform and operating platform for all silos shall be interconnected. All platforms shall be of GI gratings.

vi) The silo supporting structure shall also support all the equipment, instruments, fittings and attachments associated with silos, such as aeration system, dust separators, hoists, ventilation filter, all valves including the valves below silos, rotary feeders with measuring arrangement, hydromix conditioners along with associated water piping and valves, dry fly ash unloaders. Necessary inserts / embedment may be provided wherever required.

vii) The silos shall be supported at top and at bottom of cylindrical portion. The silo outlets provided at the bottom of silos shall have adequate lateral restraint to prevent vibrations.

viii) The framing arrangement shall be provided in such a way that the trucks and closed tankers can have a clear passage with min 7.0m high to approach the underside of the silos for unloading dry ash from the silos.

ix) Independent access for trucks shall be provided below each silo. The trucks / tankers shall be able to leave in forward direction without reversing. There shall be two passageways for truck / tanker movement under each Silo. The Silo orientation shall be such that, at a time two ash tankers shall be parked, below each Silo.

x) The columns of supporting structure shall have ties in longitudinal as well as transverse directions.

xi) The entire area below Silos and enclosed by road shall be RCC paved with RCC Garland drains connected to the plant main drains.

All drains in AHS area shall be provided with RCC Drain Sumps with minimum 5m^3 capacity and the overflow water only shall be led to the plant main drains.

4.23.05 **All Civil Structural Works related to pipe racks for Ash pipe lines, Air Pipe Lines, Water Pipe Lines, Misc. drain sump, Cable Rack, Cable Trenches and supporting structures**

Pipe support works shall include, ash slurry pipe supports from ash slurry pump house to ash dyke including garlanding, bridge across Bhedan river,,

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.

RCC fore bay / Intake Channel along with dredging shall be considered. Approval for intake system shall be obtained from DoW / statutory authorities as per Mechanical volume II IB/1. 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 intake system is in the scope of the Bidder. Owner shall support by way of giving letters etc. for obtaining approvals for the above.

4.24.01 **Raw water intake pump house with control & Switchgear Room**

Intake Water Pump House Building shall be RCC framed structure complete with fly ash brickwork cladding, steel doors, steel windows, rolling shutters, RCC roofing, flooring, staircase upto roof , painting, approach road etc. and all other items necessary for satisfactory performance of the building. Gents Toilets shall be provided in the buildings as per the technical rule with septic tank and soak pit. Switchgear & control room shall be annexed to this pump house as per write-up given in cl-4.24.04.

4.24.02 **Raw Water Pipe line**

Civil and structural works related to conveying of Raw water from Raw water intake pump house through pipe lines for its storage to the Raw Water Reservoir inside the plant boundary, is within the scope of EPC package bidder. Laying of this pipeline shall be as per mechanical specification. Thrust block shall be provided as per the layout and the design requirements. All civil and structural works related to raw water Pipe line works shall be in scope of bidder as per system/process requirements.

If any road crossing encountered it shall be through RCC box culvert. RCC apron protection along the outer slope of the embankment shall be provided where the water pipe line comes into the Raw water reservoir. The pipe shall be properly erected over the outer apron cum pedestals. The pipe shall cross the embankment from outside to inside through concrete encasing.

At the inner side of the embankment where the water dissipates, necessary Stepped RCC Apron of minimum 2000mm width shall be provided and shall extend to the bed level of the Raw water reservoir with RCC sump at the bottom. The sump shall be minimum 1000mm depth below bed level and three side walls to a minimum height of 1500mm above bed level. Apron shall have RCC wall along the apron edge on both sides having the height equal to the top level of culvert.

The RCC Apron on both outer and inner slope of the embankment shall have RCC footing founded inside the embankment at regular spacing based on the design requirement. The grade of concrete shall be M30.

Necessary civil and structural works (Bridge/RCC foundation, Piers and Steel girders with walk way) for supporting the pipe line for crossing the river / any

other water body also in the scope of the successful bidder. For the Bhedan river crossing, bridge to be provided for ash pipe line may be used with necessary spacing and supports

Necessary above ground piping on pedestal supports with all valves and pipe fittings. Information about recirculation line flow capacity and common pipe header flow capacity to be included

RCC box culvert shall be provided for each road/rail crossing for buried pipes. During laying of pipe necessary sand bedding (150 mm thick) shall be provided.

Selected earth shall be used for back-filling.

For underground piping, necessary earth cover over the top of pipe (Minimum 1.5 M) shall be provided.

4.24.03 Patrol Road & 33 kv transmission tower

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.The road shall serve for patrolling, inspection and maintenance of pipelines and electric transmission line. The road shall have 1.0m wide 150 mm thick WBM shoulder over sub base on either side having sufficient load bearing capacity to support loaded trucks. All along the road earthen drain shall be provided on one side.

Foundation and structural works for 33 kv transmission line / tower shall be provided as per electrical requirement.

4.24.04 Switchgear and MCC Room

All air-conditioned areas, shall be provided with the suspended aluminium false ceiling system (details specified elsewhere) with under deck insulation.

Adequate aluminium doors and windows shall be provided for natural lighting, ventilation and view. All windows in air conditioned rooms shall have hermetically sealed double glazing.

False ceiling, AC & ventilation ducts, cable galleries, inserts, concealed/conduit wiring as per technological requirements are to be provided. RCC stair case shall be provided from GF to Roof. Roof shall be provided with RCC Parapet of 125mm thick and 1000mm height.

HT Transformers shall be placed outside the building with fencing, gate, soling & paving, drainage system are to be provided. LT Transformers shall be accommodated within switchgear room.

Door, Window and other finishes shall comply with Architectural specification.

150mm dia DI Rain-water-down-comers to be provided. Plinth protection, garland drains and approach road are to be provided. Toilets are to be provided in the building as per the technical rule

4.25.00 **Raw Water Makeup System**

4.25.01 **Raw water transfer Pump House & Switchgear Room**

Raw water Pump House shall be single storeyed RCC framed structure with RCC Roof and side cladding shall be of Fly ash Bricks. All necessary provisions to be made to support pumps, gates, screens and other misc. equipment. The operating floor shall be framed RCC Floor supported on RCC Sump Walls. RCC raft with Sump shall be provided with individual suction pit for each pump. The highest water level in a sump shall be such as to ensure a minimum clearance of 500 mm below the lowest concreted portion of the floor in the pump house. The superstructure shall have gantry girder for EOT crane of capacity as specified in technical specification. Electrically operated MS rolling Shutter to be provided towards approach road side. Doors, windows and toilets shall be as per architectural specifications. Necessary storage water tank shall be provided on roof. Approach to roof through staircase shall be provided. Substructure shall be designed as un-cracked section.

Separate Electrical Room with all necessary electrical systems like panels, switchgear and air conditioned control room shall be provided. Roof extractors shall be provided.

Door, Window and other finishes shall comply with Architectural specification.

Rain water down comers to be provided. Plinth protection, garland drains and approach road are to be provided. Toilets are to be provided in the buildings as per the technical rule.

Sump shall be designed as un-cracked section in accordance with IS: 3370 (Latest Revision) by working stress method.

If there is an intake fore-bay at the entry of the pump house, the angle of inclination of the side walls of the fore bay with the direction of water flow shall not exceed ten (10) degrees under any circumstances. PRV is not permitted.

4.25.02 **Raw Water Reservoir**

Raw water reservoir shall be designed to store the total plant water requirements including service water. Reservoir shall be constructed by optimized cutting/filling required to build up raw water storage capacity as indicated in Mechanical volume.

The reservoir shall be formed with optimum cutting and filling of the earth (without compromising the safety of power plant) subject to the property of the excavated soil fit for embankment construction. The top of bund shall be at

same level throughout the length of the Raw water reservoir. Minimum height of top of bund shall be 1.5m above peripheral road level. The slope between vertical and horizontal of the reservoir shall be 1:2.5. 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 spreaded 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.

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.

The top of embankment (of reservoir) shall be minimum 1.5m (free board) above the maximum water level of the reservoir. The area all around the reservoir shall be graded to RL 201.50M for construction of peripheral road. The construction of embankment shall be done by excavating soil from the reservoir area and after establishing that the soil is fit for embankment formation by conducting suitable soil tests and after getting approval from the Engineer-in-charge for the soil test. 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. During detail engineering the successful bidder shall develop reservoir by excavation/filling as per the topographical details/contour drawing such that the required capacity of reservoir can be achieved by way of optimized cutting and filling.

The stability of internal and external slope of the dyke shall be designed to ensure with a FOS of minimum 1.25 due to surcharge load of 1.0 t/m^2 at the top of dyke. Top width of the bund for Reservoir shall be 5 M including road.

Top of the bund shall be provided with minimum 4m wide WBM (two layers of 75mm compacted thick over 230mm consolidated thick stone boulder / laterite soling as per specification) road with slope at one side from inner to outer edge.

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

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.

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

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.

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 arrangement shall be designed suitably

The founding level of the embankment / bund formation shall be at least 600 mm below the NGL. The layers of bund formation shall not exceed 150 mm per layer.

Toe drain made of RCC of minimum 300 mm depth & 450 mm wide all-round the Reservoir is to be provided and shall be connected to the nearby Nallah.

The foundation shall be prepared by removal of weak and organic materials, compaction by rolling, filling the voids and controlling the moisture on land surface. The dykes shall be designed and constructed in layers compacted with rollers appropriate to the soil used to achieve dry density of at least 95% of standard Proctor density at OMC.

Provision of cut-off trench filled with impervious soils below dyke section shall be made to increase the length of seepage water flow in the foundation, thereby controlling the exit gradient, which safeguards the erosion.

As per IS, Filter media with alternative layers of sand and pebbles shall be provided in the bund as per the design requirement at desired locations in the bund. The filter media shall be 1500 mm below the top of the bund and led to the rock toe. Sand Chimney, Rock toe and any other codal requirements for the Successful formation of embankment shall be in Bidder`s scope.

Necessary slope stability of the embankment with capacity calculations along

with design document shall be submitted in line with the IS requirements.

4.25.03 **Equipment Foundations**

Different Equipment Foundations for Raw water Makeup System

Foundations shall be designed, detailed and provided for the equipment for Raw Water Makeup system and auxiliaries as described below. This list is indicative only. Foundations for any other equipment / components as required by mechanical specification for completeness of the system are also in the successful Bidder's scope.

All Civil & Structural Works for Raw Water Pump House and Raw water Transfer Pumps are in the scope of the Bidder.

4.26.00 Water Treatment System

4.26.01 **Chemical House/Lab**

Chemical house shall be a two storied concrete RCC framed building housing various chemical solution tanks, chemicals, pumps, MCC and control room. Provisions shall be made for Chemical storage room, coal sample preparation room, coal and Oil analysis room and AC rooms such as Office room, Environmental testing room, Water analysis room, Special testing room, etc.

Air conditioned area shall be provided with split air conditioners with false ceiling. All other area shall be provided with mechanical exhaust with 20 air changes per hour and ceiling fans.

The covered finish floor area space for all the laboratories including laboratory, chemical & glassware storage room and office area shall not be less than 600 sq. meters. The laboratory is two story building with each floor area of minimum 300 sqm. The laboratory premises shall be provided with concealed pipework for compressed air, de-mineralised water, potable / service water with valves and sufficient nos of the power points for laboratory equipments all along the lab at specific locations. RCC Platforms of minimum 1 m width and at a level of 0.9m from FFL shall be provided with Porcelain sink as per the mechanical requirement. The platforms shall be finished with Glazed ceramic tiles with dadoing above upto lintel level.

Adjoining the chemical house there shall be chlorine ton container storage room and chlorinator room. The chemical house shall have sufficient unloading space, wide corridors, office space, etc. Clear height of 5.5m (minimum) shall be provided in each floor. The building shall be complete with RCC roof, Fly ash Brick wall as side cladding, plastering, doors, windows, rolling shutters, flooring, plaster, painting, roofing, etc. and all other items necessary for satisfactory performance of the building. The building shall have toilets and the scope shall include supply and fixing W.C.'s urinals, showers, eyewash facilities and all plumbing sanitary and other work required for

satisfactory completion of the above building. The tanks and parts of floor slabs shall be lined with Acid/Alkali proof tile lining. Monorails of adequate capacities shall be provided as per functional requirements.

Walkways, platforms with hand rails shall be provided to have clear access from Chemical House to different units like Stilling Chambers, Parshall flumes, Distribution Chambers, Clarifiers etc. and also various sub-systems/units of Water Pretreatment Plant. Walkways shall be provided with concrete interlocking blocks as per architectural specification.

Door, Window and other finishes shall comply with Architectural specification.

RCC Clarified water tank of capacity mentioned in the mechanical volume shall be provided..

DI Rain water down comers to be provided. Plinth protection, garland drains and approach road are to be provided. Toilets are to be provided in each floor of the building as per the architectural / technical rule. RCC stairs up to the roof shall be provided. Parapet as per architectural requirement shall be provided.

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4.26.02 **PW Chlorination Plant Building**

The Chlorination Plant Building shall be a single storied RCC framed building with RCC roof housing the chlorination plant. Hoists with monorail shall be provided for normal plant operation and for handling of equipment during erection/maintenance. The side cladding shall be with Fly ash Brick Work. The building shall be complete with plastering, doors, windows, rolling shutters, flooring, and painting, roofing, etc. and all other items necessary for safety and satisfactory performance. Access to roof through RCC Stair shall be provided. Parapet as per architectural requirement shall be provided.

Door, Window and other finishes shall comply with Architectural specification.

DI Rain water down comers to be provided. Plinth protection, garland drains and approach road are to be provided. Toilets are to be provided in the building as per the architectural / technical rule

4.26.03 **UF Permeate Storage Tank and Pump house, Degassed water storage tank & pump house**

Tank and pump house shall be single storied steel framed structure. Roof shall be of sloped structural steel construction with single skin zincalume sheet and sides shall be open. There shall be hoist and monorail of required capacity for handling of pumps. The Storage tank shall be as per system requirement and of RCC construction.

Door, Window and other finishes shall comply with Architectural specification.

DI Rain water down comers to be provided. Plinth protection, garland drains and approach road are to be provided. Toilets are to be provided in the building as per the technical rule.

4.26.04 DM Plant Building with switchgear room, control room, MCC Room

DM Plant Building with switchgear room, control room shall be of single storied RCC framed structure with RCC Floor and flat RCC roof. Side cladding shall be of Fly ash Bricks. MCC room, Control room and maintenance bay shall be part of DM plant building. Underslung Crane to be provided in DM plant building for handling equipment.

Separate Central Chemical Laboratory shall be provided as per specification. Equipment foundations & trenches in ground floor slab shall be of reinforced concrete. Ground floor shall be provided with ironite flooring except at locations, which may come in contact with acid/alkali where acid/alkali resistant tile lining with epoxy mortar shall be provided. Effluent drain trenches shall also have acid proof lining at inside surfaces of drain as well as soffit of pre-cast removable covers.

Door, Window and other finishes shall comply with Architectural specification. Access to roof through RCC Stair shall be provided. Parapet as per architectural requirement shall be provided.

DI Rain water down comers to be provided. Plinth protection, garland drains and approach road are to be provided. Toilets are to be provided in the building as per the technical rule.

4.26.05 Foundation for DM Water Storage Tanks

The DM storage tanks shall rest on a flexible foundation and shall consists of hydraulically compacted clear river sand, in layer of 200 mm thickness to achieve a relative density of 75%, using suitable compaction equipment, topped with 150 mm thick PCC. The PCC layer shall be topped with 50 mm thick anti-corrosive asphalt layer, which in-turn shall be topped with a 50 mm thk layer of premix carpet. The entire sand fill along with toppings shall be confined within a RCC ring wall of appropriate design. The foundation system shall be designed as per IS: 803.
Minimum 2.5m wide RCC pavements shall be provided around each outdoor equipment. Drain arrangement shall be made as per the requirement.

4.26.06 Acid/Alkali storage tank

Acid / Alkali storage tanks shall be resting on RCC saddles on elevated RCC platform. The platform shall be supported on RCC beams, columns with RCC foundations. The saddles along with platforms shall be lined with acid/alkali proof tiles.

Acid/alkali storage and handling area shall also be lined with acid / alkali resistant 3mm thick PPG lining. Thickness of tiles shall be as per specification.

4.26.07 **Clarified Water Reservoirs and Pump Houses with SWGR/MCC Room for PT Plant and DM plant**

The Pump House shall be RCC Frame structure with RCC roof. Side Cladding shall be Fly ash Brick wall except for the portion of the building wall/cladding adjacent to Transformer. Clarified water tank shall be of water tight RCC construction having two compartments covered with RCC roof. It may be fully underground or partly underground with partly over-ground. Vent pipes shall be provided at roof. Clarified water tank including RCC roof shall be designed as un-cracked structure as per IS: 3370.

The clarified water pump house shall be complete with plastering, doors, windows, rolling shutters, flooring, painting and all other items necessary for satisfactory performance of the building. Cast-in-situ RCC crane girder or steel girders shall be provided as per specification. MCC room shall also have to be provided. Suitable windows, doors, access to roof through RCC Stair and parapet shall be provided in accordance with Architectural specification.

Minimum grade of concrete for clarified water tank shall be M30. All water tight structures shall have provision of contraction, expansion and construction joints. The structures shall have smooth finish and shall be given cement wash for decent appearance. The structure shall be designed as un-cracked section in accordance with IS: 3370 (Latest Revision) by working stress method.

Door, Window and other finishes shall comply with Architectural specification.

DI Rain water down comers to be provided. Plinth protection, garland drains and approach road are to be provided. Toilets are to be provided in the building as per the architectural / technical rule.

The pump house building shall accommodate necessary pumps as specified in concerned Mechanical volume and associated transformer (with RCC fire wall), switch gear room, control room and all electrical equipment.
.The portion of the building wall/cladding adjacent to Transformer shall be of RCC wall.

Fire Pumps and other associated equipment shall be placed on Ground Floor of Clarified water. Monorail/Crane shall be provided for necessary equipment Handling.

All air-conditioned areas, shall be provided with the suspended aluminium false ceiling system (details specified elsewhere) with under deck insulation.

False ceiling, AC & ventilation ducts, cable trenches, inserts, concealed/conduit wiring as per technological requirements are to be provided.

Fire water tank to be provided as per concerned Mechanical volume..

4.26.08 **Sludge Sump and Neutralization-pit as per system requirement**

The sludge sump shall be an underground RCC sump; part of the sump shall be covered with RCC slab for supporting the sludge pumps. MS steel shed with zinc galvalume sheeting shall be provided for the Sludge disposal pumps. Gravity flow of sludge to Sludge sump from tube settler, clarifiers, stilling chambers, Distribution Chambers, etc. shall be ensured.

Neutralizing pit shall be designed as a water retaining structure with external damp proofing. Floor and internal surface of walls of the pit shall be given PPG (Plastic Polypropylene Glass) lining as per Technological specification.

4.26.09 **Tanks and Equipment Foundations**

Different Tanks and Equipment Foundations for Water Treatment System

Foundations shall be designed, detailed and provided for the tanks and equipment for Water treatment system and auxiliaries as described below. This list is indicative only. Foundations for any other equipment / components as required for completeness of the system are also in the Bidder's scope.

Clarified Water Pump House -– FGD Makeup pumps, APH wash Pumps, CT Makeup Pumps, Service water Pumps. Foundation for Pressure Sand Filter shall also be provided

Concrete channel shall be provided with proper design and detailing as per design criteria. Shall be designed as un-cracked section as per IS:3370

4.26.10 All Civil and Structural works related to Stilling chamber, Flash Mixer, Clarifiers, inlet channels, Sludge Thickener, RCC Sludge Sump, Centrifuge etc. along with associated facilities for Pre-Treatment Plant shall be done as per functional requirement and as per technical criteria. Also foundation for Various Dosing Tanks, Pumps and Motors etc. as per System requirement shall be under bidder's scope.

Stilling chamber, (2nos)

Stilling chamber shall be of RCC construction with a minimum capacity as mentioned in mechanical volume. Suitable draining arrangement shall be provided from stilling chamber to nearest sludge well/sludge pit for final disposal to Sludge Sump.

Flash Mixer (4nos)

Flash Mixers are RCC construction with minimum retention time as mentioned in mechanical volume.

Clarifier (HRSCC type) (4nos)

It shall be partly above ground and partly below ground upto a maximum underground depth of 1.5m. However foundation shall be placed 1.00m below NGL. It shall be designed with required overloading margin as mentioned in mechanical volume. The retention time shall be as per mechanical volume. The clarifier unit shall be circular, central feed type with concentric recirculation zone (rapid mixing), reaction zone (slow mixing) and clarification zone in RCC construction The bottom of clarifier shall be sloped towards the center and mechanically driven sludge scraper and collector shall be used to remove the settled sludge down the sloping bottom to the central sludge area. Rubber squeezer pads shall be provided on sludge scraper and skimmer. Sludge removal system design shall consist of central sludge area with rotating pickets and back flush arrangement for proper control of sludge accumulation at the bottom. Suitable scum collecting arrangement shall be provided in the clarifying section for removal of floating debris, foam, etc. Clarifier shall be provided with a gate at the outlet for isolation of any of the clarifier for maintenance. Draining arrangement shall be made from clarifier to Sludge Sump for the disposal of sludge.

Inlet channels

Four RCC inlet channel shall be constructed for connecting stilling chamber to four flash mixers. Necessary fixing arrangements shall be made in the channels for Parshall Flume, flow indicators, etc. as per the mechanical requirement.

Sludge Thickener

Two numbers of Lime slaking tanks, two numbers of Lime solution Preparation tanks and two numbers of $FeCl_3$ solution preparation tanks in RCC shall be constructed with PPG lining inside as per the mechanical requirement.

Foundations shall be designed, detailed and provided for the major equipment for DM Plant and auxiliaries as described below. This list is indicative only. Any other equipment / components as required for completeness of the system; foundations of the same are also in the Bidder's scope.

- Foundation for Various Dosing Tanks, Pumps, Motors etc. as per System requirement
- Foundation for various Transfer Pumps, Motors etc. for DM System (i.e. Degassed Water Transfer Pumps, MB Feed Pumps, Ultrafiltration Feed Pumps, DM Water Transfer Pumps etc.) as per process requirement.

- Foundation for various Backwash Pumps, Blowers, Motors etc. for DM System (i.e. PSF Backwash Pumps, Air Blowers for PSF, UF Backwash, Blower for MB Exchanger etc.) as per process requirement.
- Equipment Foundations for Pressure Sand Filters, Ultra Filtration Skids, Cation Exchanger, Anion Exchanger, Mixed Bed Exchanger, Degasser Tower, Degasser Blower etc.

Required Foundations for Chlorine Tonners, Chlorinators, Gas Filters, Injectors, Caustic Solution tanks, Blowers etc. shall be under Bidders scope under RW & PW Chlorination System.

All RCC water / liquid retaining and conveying structures shall be designed as un-cracked sections. Water proofing admixtures shall be added in the concrete. PVC water stoppers shall be provided in construction / contraction / expansion joints and the joints shall be properly sealed as per the architectural specifications. Plinth protection with garland drains shall be provided around all the structures / facilities.

4.27.00 Circulating Water System

4.27.01 CW Pump House with Switchgear Room

Circulating water pump house along with Electrical Annex building Switchgear room shall be single storied steel frame building. CWPH roof shall be RCC supported on Metal deck Sheet and RCC roof for annex building. Adequate Roof Extractors shall be provided. Side cladding shall be of Fly ash Brick wall for annex building and single sheet Zincalume cladding over 1.0m high Fly ash brick wall from FFL for main Pump house. The electrical annex building (switch gear room) shall be 800mm above FGL.

Separate unloading and maintenance bay to be provided for CW pump house.

Separate bays shall be provided for each pump by providing intermediate dividing piers of RCC between the pumps. The building shall be provided with lifting & handling crane facility of the capacity as per mechanical specification.

CW pump house shall be designed for Concrete Volute type pumps.

For concrete volute type, the suction draft tube and pump volute casing shall be of cast-in-situ concrete construction. Inner lining/finishing shall be done as per mechanical specification.

Reinforcement shall be Fe500 CRS (IS1786) and concrete grade shall be M30. Sulphate Resistant cement as per IS12330 shall be used. Minimum wall thickness shall be 200mm. Cover to concrete is 50mm mimimum on all faces.

Thrust blocks shall be provided in CW Pump house at the change of direction

in the Suction pipe as per the design requirements.

All the CW pump sumps shall be provided with required number of MS stop log gates as indicated in specification for the respective pump bay along with electrically operated semi-gantry crane. Steel embedment required for stop logs shall be provided for all the bays. Overhead EOT crane with necessary hoists shall be provided inside the Pump House as per the mechanical requirement.

All bays of pump sump shall be provided with a removable coarse screen including electrically operated semi-gantry crane. Steel embedment required for trash racks shall be provided for all the bays. MS Ladder/rungs shall be provided in each sump and finished as indicated in mechanical volume.

The sub-structure of pump houses including their fore-bays shall be RCC with M30 grade of concrete conforming to IS: 456.

CW pump house shall be structurally separated from fore-bay by providing an expansion joint. The pump house shall be provided with separate unloading and maintenance bay.

The RCC Sump of the pump houses shall be designed as Un-cracked section as per IS: 3370 (Latest Revision) by working stress method.

The pump house sub-structure & fore-bay shall be analyzed and designed for overturning, sliding & uplift.

Door, Window and other finishes shall comply with Architectural specification.

Rain water down comers to be provided. Plinth protection, garland drains and approach road are to be provided. Toilets are to be provided in the building as per the technical rule. Suitable access to the roof through RCC stair shall be provided ..

Thrust block shall be provided for CW piping as per layout and design requirements. For road crossings of CW pipelines, RCC box culverts shall be provided.

Cooling Water Channels

RCC cooling water channel shall be of rectangular shape and designed as a water retaining structure as un-cracked section. Depth of channel and width of channel shall match with the width and depth of the cooling water channel from cooling tower. These branch channels shall join together and form common channel to the fore-bay to the pump house. Dimension of the channel shall be decided on the basis of the quantity of water to be carried by the channel and shall be in line with approved SUMP MODEL STUDY & CFD analysis. Floor of the channel shall be given a mild slope to ensure necessary velocity of flow. The top of the channel shall be kept at least 500 mm above

finished ground level with suitable galvanised MS pipe hand railing on either side. Expansion joint shall be given at a spacing of about 30 m. Pedestrian crossovers (at least in two locations) shall be provided across each channel as per good engineering practices. The channel shall smoothly diverge and form the fore-bay in front of the pump house. It is suggested that the bottom of the fore-bay shall be kept flat and the difference in level between the channel and C. W pump sump shall be made up in the channel stretch before joining the fore-bay, using a slope as per Hydraulic Institute Standards (HIS).

Fore-bay

Invert level of fore-bay shall generally match with the C. W. sump level with proper slope, which shall be decided based on submergence requirement of the C.W. pumps at the lowest water level in the sump. Fore bay dimension shall be in line with approved SUMP MODEL STUDY & CFD analysis. Fore-bay shall be provided with cage ladder constructed of galvanised steel at four corners. Top of the fore-bay wall shall be kept at least 500 mm above grade level and handrail of galvanised M.S. pipes shall be given for the entire length. Water level indicator (float type) shall be provided in the fore-bay close to the pump sump on either side to observe the depth of water. Pressure relief valve shall not be considered for the design of fore-bay. It shall be designed as Un-cracked section as per IS: 3370 (Latest Revision). If sandwiched slab is provided for forebay, the minimum thickness of the top slab, bottom slab and divider shall be 300mm. Factor of safety against uplift pressure shall be 1.2.

GI chain link fencing equal to the height of the hand railing shall be fixed over the Handrails for the entire length of the fore-bay and channels.

4.27.02 **CW Treatment cum Chlorination Plant Building**

CW Treatment cum Chlorination Plant Building shall be single storeyed RCC Framed structure with RCC roof. Side cladding shall be of Fly ash Brick wall. Chlorination plant building shall house chlorine toner and or chlorine / chemical dosing pump and auxiliaries. Necessary provisions for ventilation and erecting monorails, hoists etc. shall be considered.

Door, Window and other finishes shall comply with Architectural specification. At the main entrance electrically operated Rolling shutter shall be provided with RCC ramp. Additional doors shall be provided as per the functional requirement.

Access to roof shall be provided through RCC Staircase.

Rain water down comers to be provided. Plinth protection, garland drains and approach road are to be provided. Toilets are to be provided in the building as per the technical rule.

4.27.03 **Equipment foundations**

Different Equipment Foundations for Circulating Water System

Foundations shall be designed, detailed and provided for the equipment for Circulating Water system and auxiliaries as described below. This list is indicative only. Foundations for any other equipment / components as required for completeness of the system are also in the successful Bidder's scope.

CW Pump House ---- CW pumps, Seal Water pumps (In case of concrete volute type CW pumps)

Required Foundations for Chlorine Tonners, Chlorinators, Gas Filters, Injectors, Caustic Solution tanks, Blowers etc. shall be under successful Bidder's scope for CW Chlorination System.

Required Foundation for Unloading / Storage Tanks, Dosing Tanks, Pumps, Motors etc. shall be under successful Bidder's scope for CW Treatment System.

Fore-bay, Concrete Channel shall be provided with proper design and detailing as per design criteria.

4.27.04 All related Civil and Structural Works related to Sump, Fore-bay, Channels from Cooling Tower shall be done as per functional requirement and as per technical criteria. Physical sump model study & CFD analysis for CW pump house along with fore bay and CFD analysis for CW Channel from CW pump house to cooling tower shall be done by the Bidder as per the requirement of Mechanical specification.

Each individual sump in the CW Pump house shall be designed in accordance with the recommendations specified in Hydraulic Institute / British Hydraulic Research Association/equivalent international standard and its dimensions shall be finally selected after conducting necessary sump model tests and CFD analysis.

The highest level of water in the CW pump house shall be such as to ensure minimum 300 mm clearance between below the soffit of the lowest floor of the pump house and maximum water level.

4.28.00 Sewage treatment Plant 2 Nos.

4.28.01 **STP Building 2 Nos**

STP Building shall be single storied RCC framed building with RCC Roof. Side cladding shall be of Fly ash Bricks. Roof shall be provided with roof treatment and RCC parapet. Access to roof through RCC Staircase shall be provided.

STP Building shall Include Control Room, MCC and Switchgear Room.

All air-conditioned areas, shall be provided with the suspended aluminium false ceiling system (details specified elsewhere) with under deck insulation.

Adequate aluminium doors and windows shall be provided for natural lighting, ventilation and view. All windows in air conditioned rooms shall have hermetically sealed double glazing.

False ceiling, AC & ventilation ducts, cable trenches, inserts, concealed/conduit wiring as per technological requirements are to be provided.

Door, Window and other finishes shall comply with Architectural specification.

Rain water down comers to be provided. Plinth protection, garland drains and approach road are to be provided. Toilets are to be provided in the building as per the technical rule.

4.28.02 **All Civil Works related to Sewage Conveying and Disposal system**

Sewer system shall be provided for the disposal of sewages from the toilets of different buildings / facilities. RCC pipe of class NP3 conforming to IS: 458 shall be used for the sewerage network which shall have manhole at an interval of maximum 30m, at changes in gradient, and at changes of direction or in straight stretches. At the road crossings the sewer line shall be encased with concrete of grade M20 (150mm thick) with skin reinforcement. The sewage shall be conveyed to Sewage Treatment Plant at suitable location through gravity. Sewerage system shall be provided with adequate ventilation for the pipe work as well as manhole.

The sewage network from the various toilet blocks of the entire area under EPC package and all Buildings like Thermal project site office. Building inside the Plant shall be properly planned. In addition, the sewage shall be inter-connected to the Main Plant Sewage network system which is in the scope of EPC package. The entire sewage generated from the entire power plant shall be finally let into the any one STP at two different locations.

The sanitary waste of all the toilets from different buildings of the plant shall be collected by gravity into the respective collection chambers and shall lead to common collection sump (Minimum 15m^3 capacity each STP with 1m free board) under gravity flow only.

The Sewerage treatment plant shall be modular type based on FAB/MBBR technology followed by disinfection by Hypo and necessary tertiary treatment prior to reuse in horticultural purpose. The Plant shall be complete with all fittings and fixtures and shall include all ancillary works such as laying of sewage pipes, installation of Manhole and inspection chambers, Common Collection Sump, Bar screen & Oil & Grease chamber, equalizing Tank, Fab Tank, tube settler, Filter Feed Tank, pump house, treated water tanks, Sludge Pit etc. as per the system requirement.

The finally treated sewage shall meet the norms of environment protection rules 1986 and its amendments and the rules of CPCB / MOEF / State Pollution Control Board. The treated waste water from STP shall be used for gardening purposes in the power plant. Necessary pipeline, pumping etc. shall be in the scope of EPC package bidder.

All the sewer lines shall be designed such that the self-cleaning velocity is maintained to facilitate the maintenance of sewer lines. Sewer lines shall be designed considering peak factor as per guidelines of CPHEEO manual and shall run at 0.5 full at ultimate peak flow.

4.28.03 Different Equipment Foundations for Sewage Treatment System

Foundations shall be designed, detailed and provided for the major equipment for Sewage Treatment Plant and auxiliaries as described below. This list is indicative only. Foundations for any other equipment / components as required for completeness of the system are also in the Bidder's scope.

- Required foundation of TPI Separator along with its auxiliaries
- Required foundation for API along with its auxiliaries
- Foundation for Various Tanks, Pumps, Motors etc. as per System requirement
- Foundation for various Transfer Pumps, Motors etc. for STP System (i.e. Filter Feed Pump, Treated Water Disposal Pumps, Sludge Pumps etc.) as per process requirement.
- Equipment Foundations for Duel Media Filters, Activated Carbon Filters, Air Blowers etc.

4.29.00 Effluent treatment Plant

Waste water generated from the 3 x 800 MW plant shall be treated in a full scale effluent treatment system.

The oily / process waste water shall be transferred through pumping and waste water transportation system to Central Monitoring Basin for further treatment. The pipes shall be adequately sloped for drainage and shall carry flow to neutralization pit/Effluent Collection Sump /Oil water separator etc. as required. Plant effluent shall be discharged into the central monitoring basin, which has been outlined in the Technical Specification of Effluent Treatment System Vol-II-IB/4.

After necessary dosing, waste water shall be transferred to Clear Water Sump through effluent collection reservoir and clarifier. This clear Water shall be treated by filtration, ultrafiltration and reverse osmosis and finally sent to clarified water reservoir. Necessary UF Water Storage Tank, Degassed Water Storage Tank etc. shall be under scope of EPC package bidder. All pumps

under this system shall be accommodated inside the building or dedicated pump house / room as required.

4.29.01 **ETP Building Including pump house and control & Switchgear room**

ETP Building Including pump house, dosing system, Electrical Room (if required) and control room shall be single storeyed RCC framed building with RCC Roof. Side cladding shall be of Fly ash Bricks. Access to Roof through RCC Staircase shall be provided.

Pumps and other associated equipment shall be placed on operating Floor. Monorail/Crane shall be provided for necessary equipment Handling.

All air-conditioned areas, shall be provided with the suspended aluminium false ceiling system (details specified elsewhere) with under deck insulation.

Adequate aluminium doors and windows shall be provided for natural lighting, ventilation and view. All windows in air conditioned rooms shall have hermetically sealed double glazing.

False ceiling, AC & ventilation ducts, cable trenches, inserts, concealed/conduit wiring as per technological requirements are to be provided.

Door, Window and other finishes shall comply with Architectural specification.

Rain water down comers to be provided. Plinth protection, garland drains and approach road are to be provided. Toilets are to be provided in the building as per the technical rule.

4.29.02 **ETP CTBD/RO building with effluent disposal system**

ETP CTBD/RO building shall be of single storied RCC framed structure with RCC Floor and flat RCC roof. Side cladding shall be of Fly ash Bricks.. Equipment foundations & trenches in ground floor slab shall be of reinforced concrete. Underslung Crane is to be provided in the building for handling equipment. This building shall have switchgear room, control room and Chemical / Consumable Storage Area. Approach to Roof through RCC Staircase shall be provided

.False ceiling, AC & ventilation ducts, cable trenches, inserts, concealed/conduit wiring as per architectural requirements are to be provided

Door, Window and other finishes shall comply with Architectural specification.

Rain water down comers to be provided. Plinth protection, garland drains and approach road are to be provided. Toilets are to be provided in the building as per the technical rule.

4.29.03 **Central Monitoring basin**

Effluent Water from various sources shall be led to central monitoring basin for further treatment. The waste water from various sources shall be collected at CMB with the help of pumping system. These Pipes shall be laid on Pipe rack, Pipe sleeper or underground as per the layout requirement. Central Monitoring Basin shall have two compartment arrangements. The basin shall be of RCC Construction with sufficient capacity excluding free board (300mm minimum). Inlet and Outlet structures, accessories, overflow collection sump shall be of RCC Construction. Acid/alkali dosing tanks/pumps are provided for neutralizing the collected effluent. The Acid / alkali dosing and handling area shall be properly dyked and lined with acid / alkali proof bricks From the CMB the neutralized water shall be pumped to Effluent Collection Sump (CTBD Treatment plant). This CMB shall have common pre-settling compartment. CMB shall be underground type. The CMB shall be designed for minimum detention period as mentioned in mechanical volume.

Minimum grade of concrete for Central monitoring basin shall be M30. Water proofing admixtures shall be added in concrete. PVC water stoppers shall be used in joints. All water tight structures shall have provision of contraction, expansion and construction joints. The structures shall have smooth finish and shall be given cement wash for decent appearance. The structure shall be designed as un-cracked section in accordance with IS: 3370 (Latest Revision) by working stress method.

4.29.04 **Different Buildings/Equipment Foundations for Effluent Treatment System**

Foundations shall be designed, detailed and provided for the major equipment for Effluent Treatment Plant and auxiliaries as described below. This list is indicative only. Foundations for any other equipment / components as required for completeness of the system are also in the Bidder's scope.

- Necessary Pump and Motor Foundations of Waste water Transfer Pumps at various effluent collections Pit.
- Required foundation of TPI Separator along with its auxiliaries
- Required foundation for API along with its auxiliaries
- Foundation for Various Tanks, Pumps, Motors etc. as per System requirement
- Foundation for various Transfer Pumps, Motors etc. for ETP/CTBD/RO System (i.e. CMB Overflow Pumps, Clarifier Feed Pump, DMF Feed Pumps, BA Overflow Seal Water Pumps, RO Feed Pumps, RO High Pressure Pumps, RO Permeate transfer pump, Parshall flume, Flash mixer, etc.) as per process requirement.
- Equipment Foundations for Duel Media Filters, Basket Filters, Ultra

Filtration Skids, Micron Cartridge Filter RO Module, Degasser Tower, Degasser Blower etc.

- One (1) Backwash Water Storage Tank of RCC construction having effective capacity as mentioned in mechanical volume.
- One (1) RCC RO Reject Water sump of adequate capacity shall be constructed.
- One ETP reject treatment plant building to be provided as per G1-Sec-IV.

Clarifier

The clarifier unit shall be of RCC construction, circular, central feed type with concentric recirculation zone (rapid mixing), reaction zone (slow mixing) and clarification zone. It shall be designed with minimum retention time as per mechanical volume.

Chemical House

Feed Chamber of R.C.C. construction shall be provided. Feed Chamber shall provide a minimum residence time as per mechanical volume.

Clear Water Reservoir shall be of RCC construction with holding capacity as per mechanical volume.

Over-Head clarified water storage tank of RCC construction with minimum capacity as per mechanical volume.

ETP sludge sump of RCC construction with holding capacity as per mechanical volume.

Tilted Plate Interceptor Overflow Sump of RCC construction with minimum capacity as per mechanical volume.

API type oil water separator overflow sump of RCC construction of minimum capacity as per mechanical volume.

CT Blowdown reservoir of RCC construction with holding capacity as per mechanical volume.

pH correction chamber of RCC construction.

UF filter water tank of RCC construction with PPG anticorrosive lining of 3.5mm overall thickness.

Degassed water storage tank of RCC construction with inner FRP lining and holding capacity as per mechanical volume. External painting as per mechanical specification.

Ferric Chloride Solution preparation tank of RCC construction with inside PPG lining of 3.5mm overall thickness.

Lime Solution preparation tank of RCC construction with inside PPG lining of 3.5mm overall thickness

4.30.00 Fire Protection and detection system

4.30.01 **All civil works for laying of fire water lines**

For Fire protection & detection system, civil & structural works shall be as per the specific technical requirement. Fire Water pipes shall be taken on grade slab over RCC pedestals / in underground RCC trenches with removable RCC cover slabs as per the site requirements. In all areas, like Boiler, Power House building outside periphery, ESP, Switch Yard, Chimney, etc. pipes shall be placed inside the RCC trench with removable RCC cover for the paved areas and Fire water pipes in rest of the areas for the entire plants shall be on the RCC pedestals in general. The RCC pedestal shall be laid at intervals as stipulated in TAC. All civil works including the construction of Pedestals, RCC trenches with removable RCC covers shall be under the scope of bidder. Complete civil works of fire protection and detection work are covered in bidder's scope..

4.30.02 **Fire water tank foundation**

.Separate tanks for Fire Water storage are required (as per Cl-1.00.00, Sec-II of Vol-II-J). Tank shall have all provisions as per the process requirement.
The foundation for Fire water tank shall be provided as per design requirements

4.30.03 **Equipment Foundations**

Different Equipment Foundations for Fire Protection and Detection System

Foundations shall be designed, detailed and provided for the following equipment for Fire Protection and detection system and auxiliaries as described below. This list is indicative only. Foundations for any other equipment / components as required for completeness of the system are also in the Bidder's scope.

i. Hydrant pumps (motor driven)

ii. Hydrant pumps (diesel engine driven)

iii. Spray pumps (motor driven)

iv. Spray pumps (diesel engine driven)

v. Jockey pumps

vi. Deluge valve House

vii. Hose House

viii. Booster Pumps

ix. Foam Tanks

x. Hydrant Stand Post

4.30.04 FIRE WATER PUMP HOUSE

i. Fire water pump house shall be RCC framed structured building with RCC roof and fly ash brick masonry.

ii. The pump house building shall accommodate fire water pumps and any other facilities as per system requirement. Safety norms shall be followed as applicable. RCC stairs up to the roof shall be provided.

4.30.05 FIRE WATER BOOSTER PUMP HOUSE

i. Fire water Booster pump house shall be RCC framed structured building with RCC roof and brick masonry.

ii. The pump house building shall accommodate fire water Booster pumps and any other facilities as per system requirement. Safety norms shall be followed as applicable. Access to roof shall be provided.

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4.31.00 SWITCHYARD CIVIL WORKS

4.31.01 **Switchyard Control Room**

Switchyard Control Room Shall be Two (2) storeyed RCC framed structure with RCC grade slab and Floors and RCC roof. Side claddings shall be of Fly ash Bricks.

Control room, offices, MCC & switchgear room, cable vault, Stores, Battery rooms, Pantry room, etc. shall be accommodated within this building maintaining all functional and / or operational requirements.

Rolling shutter, Door, Window, False Ceiling with under deck insulation, roof treatment and other finishes shall comply with Architectural specification. There shall be continuous hermitically sealed double glazing aluminium window for the control room on switchyard side.

Rain water down comers to be provided. Plinth protection, garland drains and approach road are to be provided. Toilets are to be provided in the building as per the technical rule. RCC stairs up to the roof shall be provided.

4.31.02 **GIS Building in Switch Yard (**Number shall be as per Electrical requirement)

GIS Building Shall be One (1) storeyed RCC framed structure with RCC ground Floor and RCC roof on metal deck. Roof beams shall be of structural steel. Side claddings shall be of Fly ash brick wall. Provision shall be kept for crane for handling of equipment. The building shall be provided for natural ventilation.

The FFL of GIS buildings shall be as per Electrical requirement Foundation for GIS equipment shall be provided. Cable trenches shall be designed and provided as per requirement.

Door, Window and other finishes shall comply with Architectural specification. Rain water down comers to be provided. Plinth protection, garland drains and approach road are to be provided. Toilets are to be provided in the building as per the technical rule. Access to roof through RCC stair shall be provided.

The GIS Building shall be provided as per the technological requirement. The Building shall be provided with Epoxy Floor Finishing as specified below:

FLOOR FINISHING SYSTEM:

2.2 mm Self Levelling Epoxy – Polyurethane (EPU) system

The specification of the flooring system shall be as below:

SURFACE CLEANING/REPAIR/LEVELLING:

Cleaning of surface free from dust, dirt, moisture & all foreign material from the floor. All damaged and deteriorated concrete shall be repaired with polymer concrete materials to restore sound condition. Concrete surface is checked for cracks, joints and pot holes. Control joints shall be filled in with suitable flexible polymer materials as per manufacturer's recommendation.

PRIMER: Providing and applying two component, high viscous, solvent free epoxy primer, having a volumetric mixing ratio of resin and hardener 1:1, to provide a DFT of around 200 microns.

SCREED: Providing and applying low viscous, high strength, epoxy based self levelling screed, to the desired thickness of 1000 microns. The layer is de aerated by spike roller to dislodge air pockets. Finished screed has compressive strength of 120-125MPa.

SELF LEVELLING TOP COAT: Providing and applying EPU based self

levelling top coat, to yield a thickness of 1000 microns. The volumetric mixing ratio shall be 2:1.

The top coat shall have the following properties –

- Compressive strength - 60-70MPa
- Tensile strength -15–20MPa
- Elongation - 45-50%
- Flexural strength - 40–45MPa

CURING & PROTECTION: Allow flooring system to cure undisturbed for atleast 24 hours after application of final coat. All polymers require 7 days at room temperature to reach optimum design strength. Lower temperature extends curing times.

- Flexural strength - 40–45MPa

CURING & PROTECTION: Allow flooring system to cure undisturbed for at least 24 hours after application of final coat. All polymers require 7 days at room temperature to reach optimum design strength. Lower temperature extends curing times.

The materials shall be procured from standard manufacturers and got it approved by the purchaser before use.

4.31.03 **Civil Works for Switchyard includes:**

i) Towers, girders, lightning masts and equipment supporting structures including proto type assembly etc.

ii) Foundations and supporting pedestals for towers, lightning masts, equipment supporting structures etc.

iii) Foundations and superstructures for Switchyard control room building and GIS building.

iv) Earthing mat, single lane rigid pavement roads and RCC drains in switchyard area including road / drain / trench crossings etc.

v) All necessary embedments, inserts, supporting structures & supporting members as required etc.

vi) Cable trenches in switchyard and inside GIS Building, control room building including civil works for panel /equipment fixing etc.

vii) Stone filling to be considered for entire switch yard area. PCC layer below stone filling shall be properly sloped to drain the water to the

drains surrounding the switchyard limits. Approach roads, drains and cable trenches shall be of RCC

viii) On all sides, 150 mm thick PCC Paving of grade M-20 over 230 mm thick Stone Boulder soling shall be provided from the switchyard fencing to nearest drains for draining the storm water

ix) Switchyard shall be enclosed with chain link fencing with intermediate steel post & steel gates as per Electrical requirement.

x) Not used.

xi) Necessary civil works including RCC foundations for BR (Bus Reactor), LR (Line Reactor), ICT (Interconnecting Transformer) and Interbus Transformer (IBT) within the switch yard area shall be provided. RCC rail road shall be provided from the above transformers/Reactors to the Rail road. Smooth gradient in the rail road shall be maintained between the level differences as per the design requirements. Anchor blocks shall be provided at suitable locations.

xii) Construction of RCC Oil Pit within the switchyard area as per the electrical requirement.

Design Criteria

Gantry structure, which consists of open web towers connected by girders, shall be made of structural steel conforming to Grade IS: 2062 and duly galvanized conforming to IS: 2629 and IS: 4759. All joints shall be bolted connections. All bolts for connections shall be of 16 mm dia conforming to IS: 12427 and of property class 5.6 as per IS: 1367 (Part 3). Nuts shall conform to IS: 1363 (Part 3) of property class 5. Foundation bolts shall conform to IS: 5624 and property class shall be 4.6 as per IS: 1367 (Part 3). Butt splice shall be used for splicing the main members and splice shall be located away from the node point. IS: 802 “Code of practice for use of structural steel in overhead transmission line towers” shall be followed for design of structures. Height & type of towers shall be established based on electrical requirements. A provision of $\pm$ 30 degree angle of deviation of line in horizontal plane and $\pm$ 20 degree deviation in vertical plane is considered and the resulting worst combination of forces shall be considered for design. For all outgoing and incoming feeders, the conductor span shall be taken as 200 m for design purpose.

Switchyard structures shall be designed for the worst combination following loads:

i) Dead loads (load of wires/conductors, insulator, electrical equipment and structural members).

ii) Live loads

iii) Wind loads

a) Switchyard gantries, towers, equipment supporting structures and lightning mast shall be designed as per IS: 802. The wind load calculations shall be made as per IS: 802 except the parameters basic wind speed (Vb) and terrain category as stipulated elsewhere in this specification.

b) All other structures shall be designed as per IS: 456 / IS: 800. The wind load calculations to be made as per IS: 875 shall be with the parameters as stipulated elsewhere in this specification.

iv) Seismic loads

v) Temperature load

vi) Loads due to deviation of conductor (gantries shall be checked for ± 30 deg deviation in horizontal plane and ± 20 degree deviation in vertical plane).

vii) Loads due to unbalanced tension in conductor / wire.

viii) Torsional load due to unbalanced vertical and horizontal forces.

ix) Erection loads

x) Short circuit forces including snap in case of bundled conductors etc.

Note:

i) The occurrence of earthquake and maximum wind pressure is unlikely to take place at the same time. The structure shall be designed for either of the two. However, temperature stresses can be ignored, as these towers are freestanding structure in open space.

ii) Short Circuit forces and Wind pressure shall be considered to act together for design of switchyard structures.

iii) Direction of wind shall be assumed such as to produce maximum stresses in any member for the combination of wind load with conductor tensions. The wind acting perpendicular and parallel to bus conductor and shield wire shall be considered separately.

iv) The conductor tension shall be assumed as acting on only one side of the gantry for the analysis and design of switchyard gantries.

v) The distance between terminal and dead end gantry shall be taken as 200 meters.

Factor of Safety

Foundation shall be designed for a factor of safety of 2.2 for normal and broken wire condition and 1.65 for combined short circuit and broken wire condition. For the design of towers, stipulations of latest version of IS 802 (Part 1 / Sec 1 & 2) shall be applicable.

Design consideration for Switchyard Equipment Support

i) The supporting structure for BPI, LA & tariff metering CVT shall be comprised of grade YST:210 or of higher grade conforming to IS:1161 & shall be designed as per IS:806 “Code of Practice for use of steel tubes in general building construction”.

vi) Minimum diameter of the Pipe-type support for 400 kV structure shall be 250 NB.

vii) The supporting structure for tariff metering CT & Wave Trap equipment shall be comprised of lattice structural steel conforming to IS:2026 and shall be designed as per IS:802.

Special Design Consideration for Lightning Mast

Diagonal wind condition shall be considered for lightning masts. Diagonal wind shall be taken as 1.4 times the wind calculated on longitudinal/ transverse side. Lightning mast shall be provided with minimum two nos. of platforms as per requirement and a cage ladder for climbing purpose shall be provided up to platform at top level. Top of platform shall have grating, railing and toe guard plates. The minimum width of platform shall be 900 mm. Live load of 300 kg/m^2 above platforms shall be considered for design of Lighting Mast.

Additional Design Criteria for Structures

i) The design of RCC structures shall generally be carried out using limit state method of design as per IS: 456. The minimum grade of concrete shall be of RCC M30 as per IS: 456.

The fabrication and erection of the switchyard works shall be carried out generally in accordance with IS: 802 and IS: 800. All materials shall be completely shop fabricated and galvanized.

All structural steel members including stub members, bolts, nuts, spring washers, etc. shall be hot dip galvanized after fabrication. Minimum section thickness shall be as per technical rule . Weight of zinc coating shall be at least 0.610 kg/m^2 and foundation bolts shall have heavier zinc coating at least 0.80 kg/m^2.

Cable Trenches

Cable trenches shall be provided for routing of cables as required and shall be of adequate size. The trenches located within switchyard shall project at least 150 mm above the finished paving level so that no storm water shall enter into the trench. The bottom of trench shall be provided with a longitudinal slope of 1:500. The downstream end of cable trenches shall be connected to sump pits where provision shall be made for pumping. The precast covers shall not be more than 300 mm in width and shall not be more than 65 kg. Lifting hooks shall be provided in the precast covers. Trenches shall be given a slope of 1:250 in the direction perpendicular to the run of the trenches. Angle of size 50x50x6 mm (minimum) with lugs shall be provided in the edges of RCC cable trenches and any other place where breakage of comers of concrete is expected. All cable trenches shall be provided with suitable insert plates for fixing support angles of cable trays. All internal cable trenches shall have minimum 8 mm thick (o/p) chequered plate covers while external cable trenches shall have pre-cast RCC covers. However, the portion of the cable trench behind and sides of control panel shall be provided with suitable chequered plate covers as directed by the Engineer. Cable trenches inside switchyard, having depth more than 500 mm, shall have wall thickness of minimum 150 mm with two layer reinforcement.

Stone Filling

Stone filling with 40mm downgraded BG metal shall be provided in entire switchyard area with thickness as per the electrical specification requirement. Below that 150mm thick PCC of Grade M20 with 230mm (consolidated thick) layer of Stone boulders soling shall be provided. Stone filling shall be compacted by using ½ tons roller with 4-5 passes and suitable water sprinkling. Before laying the Stone boulders soling, the top layer of the soil shall be treated for anti-weed considering the types of weeds found in the vicinity. The anti-weed / soil sterilization chemical shall be procured from reputed manufacturer. The Bidder shall submit necessary details pertaining to the types of weeds found in the vicinity, anti-weed/soil sterilization such as manufacturer's name, their specification, test certificate etc. for Employer's approval. Any modification, if required in the proposed anti-weed treatment chemicals, shall have to be done by the Bidder at no extra cost to the Employer. The Bidder shall be required to furnish a performance guarantee of three years for the anti-weed treatment. This guarantee shall commence from the date of completion of work or date of handling over, whichever is later.

4.32.00 General Plant Illumination

4.32.01 Civil / structural works related to General Plant Illumination

The System description is detailed in Section VII of Volume II F2. All Civil and Structural Works related to General Plant Illumination System including Equipment foundations, panel foundations and all other related civil works are under the scope of EPC package Bidder.

All necessary Civil and Structural Works including excavation, backfilling,

design, fabrication, erection, painting, cleaning up, inspection and testing etc. as per technical specification as required also under the scope of package bidder.

Design, detailing and execution of foundations, Trenches etc. as necessary for the system including the design of Street light poles, flood lighting towers/poles/high mast considering all possible loads (DL, wind etc.) under the scope of package bidder.

Any other equipment / components as required for completeness of the system; foundations of the same are also in the Bidder's scope.

4.33.00 Plant Buildings / Structures for FGD

Structures in FGD are discussed below. For detailed specifications, of FGD System, Mechanical Volume shall be referred to. FGD areas shall have suitable surface drainage facilities.

4.33.01 **Junction Towers (JTs)**

Over ground JTs shall have RCC foundations and pedestals at (+) 500 mm above ground level. The super structure for JTs shall be of steel framed structure with adequate bracing arrangement. The ground floor and all intermediate floors shall be of RCC of Grade M30 and intermediate floors shall be over metal deck sheets and shall be finished with IPS (Indian Patent Stone) with metallic hardener having proper slopes for drainage. The roofs shall be of RCC covered with metal deck with water proof treatment and drainage slope. Parapet wall shall be provided as per the architectural specification. The side cladding shall be of 230mm fly ash brick upto 1m height and single skin, zincalum metal cladding over the brick work. Brick wall shall be inside face of sheeting with a lapping of 150 mm

JTs shall be provided with independent steel staircase with steps of Galvanised MS grating from ground to Roof. The clear width of the stair shall be minimum 1.2m. The tread shall be at least 275 mm and riser shall be uniform throughout the height and shall not exceed 150mm. However the codal regulations shall also be complied with. Continuous galvanized MS handrails vertical and horizontal shall be provided for the staircases with toe guard (150x6) for entire staircase and landing area

Drive units shall be directly supported on floor beams from suitable structural steel stools and not on concrete floors. All Junction Towers shall be provided with adequate number of windows and doors. The window area shall not be less than 10 percent of total wall area. Maintenance platform inside /outside of Junction Towers may have chequered plate floors with horizontal floor bracing.

Minimum clearance of 1.5m shall always be provided around any equipment / structure / pedestal inside the building.

Adequate floor washing arrangement shall be made for all JTs. Provision of floor dust collection and removal by chute shall be made. Deflection of JTs at conveyor entry level shall be within height/1000 across the conveyor & height/500 along the conveyor. While designing JTs necessary provision shall be made in loading for future conveyor to be housed inside JTs, as applicable.

Door, Window and other finishes shall comply with Architectural specification. DI Rain-water-down-comers of 150mm thick to be provided. Plinth protection, garland drains and approach road are to be provided.

4.33.02 **Conveyor gallery and Trestles**

On grade and over ground galleries shall be of enclosed type for adequate weather protection. The walkways for on-grade galleries shall be raised and they shall be made of concrete with skid proof finish. Overhead conveyor galleries shall be structural steel consisting of two girders braced at top and bottom and supported on trestles.

Walkway portion of over ground conveyor galleries shall be of chequered plate of 8mm thick with antiskid bar or expanded metal grating. clear width of central and side walkways shall be as per Mechanical requirement with 3.0m clear height. For Single Conveyor gallery, both side Walkways shall be as per Mechanical requirement. The maximum span of standard gallery shall be 24 m unless higher span is necessitated due to site constraints which shall be subjected to the approval of Owner/Consultant. The galleries for double stream conveyors shall have one central walkway and two side walkways and single stream conveyors shall have two side walkways.

Galvanised MS Hand railings shall be provided as required. For Entire conveyor Gallery seal plate of minimum 4 mm thickness shall be provided so that a complete leak proof bottom shall be formed. The over ground conveyor galleries shall be designed for adequate ventilation and natural lighting.

Conveyor gallery having slopes greater than 8 degree, stepped walkways of chequered plates with nosing and toe guard shall be provided all along the conveyor. 10mm dia Tor anti-skid steel bars shall be provided @ 500 mm for inclined walkways below 8 degrees.

Suitable floor washing arrangement shall be made in the conveyor gallery with down comers.

In between Junction Towers / buildings four legged trestles shall be placed at a maximum interval of 100 m. The arrangement shall be such as to ensure that force in the longitudinal direction of conveyor gallery of length not more than 100 m shall be transferred to four legged trestle.

Two legged trestles at regular interval may be placed between four legged trestles. The end supports resting on the four legged trestles can have one hinged and the other on slide type. Slide type support shall be with PTFE

bearing to allow both rotation and movement.

End of conveyor gallery which shall be supported over Junction Towers, shall be so detailed that only vertical reaction is transferred from gallery and no horizontal force in longitudinal direction is transferred from gallery to Junction Towers and vice–versa by providing sliding supports.

All RC trestle pedestals shall be raised to minimum (+) 0.500 m above FGL. Trestles shall be of structural steel braced adequately and provided at suitable locations. Location of trestles shall be decided carefully so that there is no interference with underground and over ground structures, tunnels, trenches, drains, etc. The minimum clearance over road and railway crossing shall be 8.0 meters.

Overhead conveyors shall be located in a suitably enclosed gallery of structural steel. The overhead gallery shall consist of two vertical latticed girders having rigid jointed portal frame at both ends. Cross beams at floor level supporting conveyor stringer beams shall be made of single rolled steel beam or single channel section (ISMB or ISMC) or plate girder. Horizontal bracings are to be provided at top & bottom plan of the gallery (latticed girder shall be braced together in plan at the top and bottom). Common end portal frame shall not be used for adjacent conveyor spans.

Roof truss shall be provided at upper node points of latticed girders to form an enclosure. The gallery shall as far as possible be erected as a box section keeping all the vertical and horizontal bracing tied in proper position.

The ground conveyors shall be located in suitably enclosed gallery of structural steel consisting of rigid portal frames spaced at regular intervals and suitably braced. Plinth protection along with drains shall be routed along the ground conveyors.

Conveyor gallery shall have permanently colour coated Zincalume sheet covers on roof and both sides. However in roof, a panel of minimum 1.5mx1.5m area at about 6.0m c/c shall be provided with 4mm thick translucent sheets of polycarbonate material for natural lighting with MS grill support.. A continuous slit opening of 500 mm shall be provided on both sides just below the roof sheeting. The bottom level of edge of roof sheeting shall match with bottom of slit level to prevent rain water entry. Adequate provision of openable aluminum windows shall be kept on both sides of conveyor gallery shall be provided with MS safety grills inside. Separate walk way with roof outside the gallery for Cable rack shall be provided to suit the requirements of approved Mechanical GA of conveyer gallery.

Crossover with chequered plate platform and ladder for crossing over the conveyors shall be provided at approximately every 100 m intervals of conveyor. Crossover shall preferably be located over four-legged rigid trestle location.

Conveyor gallery structure shall be designed considering both conveyors

operating simultaneously.

Conveyor gallery and supporting trestles located between transfer houses / buildings shall be arranged in any one of the following ways. Allowable vertical deflection of gallery shall be restricted to span/450. For trestles and junction towers, it shall be restricted to height / 1000 across the conveyor direction and height / 500 along the conveyor direction.

4.33.03 **Lime stone Crusher House**

Crusher house shall be of steel structure of framed / braced design. Floors and roofs shall be RCC over metal deck sheet on structural steel beam. Side cladding shall be Fly ash brickwork up to 3.0m height from FFL above that metal cladding as per architectural specification. Roof shall be given adequate slope for drainage. Roof shall be given with proper water proofing, for description mentioned elsewhere in this specification. Proper arrangement shall be provided to convey the rain water through gutter of matching colour and down comers as specified elsewhere.

Adequate number of aluminium glazed windows shall be provided as specified elsewhere. Wherever monorails are projecting outside for lifting of equipment, hollow metal sliding flush doors shall be provided. Main entrance doors shall be electrically operated rolling shutter adequately sized to carry equipment inside. Other doors shall be of hollow metal flush doors. Ramps shall be provided in front of main door. Grade slab as well as intermediate floors shall be of RCC. Intermediate floor shall be RCC over metal deck supported on steel beams. Handrail shall be provided around all openings with kerb plates/concrete. Minimum clearance of 1.5m shall always be provided around any equipment / structure / pedestal inside the building.

Two steel staircases shall be provided one inside and one outside, both of structural steel. Rack and pinion elevator shall be provided. Machine room of elevator floor and roof shall be of RCC. Side cladding of M/C room shall be of colour coated sandwiched cladding system. An RCC kerb wall of 300 mm shall be given around the floor and 100mm kerb around openings. M/C room shall be given adequate slope for drainage purposes. Roof shall be given with proper water proofing, for description mentioned elsewhere in this specification with 150mm dia DI down comers. . Main door to M/C room shall be of hollow metal flush door. Adequate ventilation shall be given using aluminium glazed window. Toilet shall be provided in the Crusher house. Elevator pit shall be kept at least 500 mm above general grade level to prevent flooding. A sump shall be provided inside the pit to collect and pump out water. Sump shall be given with access ladder.

Foundation of the building columns shall be of RCC. Foundation design criteria are given elsewhere. All the foundations shall be connected together by tie / plinth beams. Top of the pedestals for the columns shall be above finished ground floor level as specified elsewhere.

Side cladding shall be with permanently colour coated profiled double skin

zincalume steel sheets with insulation . However, panels of suitable size to suit the architectural treatment and made of translucent sheets of polycarbonate material shall also be provided on the side cladding for natural lighting. The lower portion of side cladding for a height of minimum 3m height above finished floor level shall be of 230mm thick fly ash brick wall plastered on both faces. Grade slab shall be of RCC. Permanent metal decking shall be used for support of RCC floor slabs. Within this building cubicles are to be provided for resting room of operators and these shall be constructed with one brick thick fly ash brickwork having both sides plastered and RCC roof slab. Vertical bracings shall be provided only on four sides along the periphery. No vertical bracings between columns shall be allowed inside the floor.

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Plinth protection, garland drains and approach road are to be provided.

Necessary provision of hoisting and handling arrangements shall be as per technological requirement.

Below the monorail projection, RCC paving in M30 5m wide upto road shall be laid at the grade level for loading unloading.

The entire crusher house shall be designed as per approved mechanical drawing.

Crusher Foundation

The crusher shall be supported on M35 grade RCC deck slab mounted on vibration isolation system comprising springs and viscous dampers, which in turn shall be supported independently on ground-supported RCC frame structure. The crusher foundation shall be made isolated from crusher building & this shall suit to process requirements. Crusher foundations shall be kept isolated by providing 75 to 100 mm gap all around at crusher floor level as per process requirements. The vibration isolation shall be done by providing inertia block with anti-vibration pads. These pads shall be suitably procured with respect to crusher manufacturer's specifications.

Detailed dynamic analysis shall be done for top deck of limestone crusher together with springs & dampers and natural frequencies & amplitudes of vibration shall be determined. A mathematical model of top deck shall be formulated with three dimensional beams, plate, and finite elements for the purpose of analysis with the spring idealized with vertical and horizontal stiffness. The mass of the machine together with that of the top deck shall be considered for the analysis. Natural frequencies up to at least 10% above the operating speed shall be determined and three frequencies shall be checked against the design criteria. Forced response dynamic analysis shall be carried out for the unbalance forces generated during operating condition using a sinusoidal forcing function. Unbalanced forces as given by the manufacturer shall be used for this purpose.

Ultrasonic pulse velocity (UPV) test shall be carried out for crusher foundation to ascertain the homogeneity and integrity of concrete. Testing shall be done as per IS: 1331 (Part-1). The defects shall be rectified by using cement / epoxy grout etc.

Isolation Efficiency

The vibration isolation system shall be designed for about 90% isolation efficiency.

De-coupling

A ratio of the least 10 (ten) shall be ensured between the stiffness of the supporting structure and the stiffness of the spring system in the vertical direction of achieve de-coupling between the two (the stiffness of the spring system being lower). This ensures that dynamic analysis of the supporting structure need not be carried out.

Frequency Criteria

The frequency criterion has already been laid down implicitly foundation isolation efficiency criteria and de-coupling required.

The bending mode frequency of the top deck shall be atleast 20% above the operating speed.

Unbalance Forces

i) Unbalance forces arising out of all the following cases shall be considered for checking the design and amplitudes.

ii) Balance quality grade Q40 as per VDI 2060-1966.

iii) One hammer broken condition. The missing hammer shall be assumed to be closest to the crusher non-drive end of the crusher.

iv) Three hammers broken condition. All the three hammers broken shall be assumed to be from the same suspension bar and located at the non-drive end of the crusher.

Amplitude Criteria

The calculated amplitudes (mean to peak values) shall not exceed following limits under the specified conditions:

Operating speed of 750 RPM:

i) 150 microns for an unbalance force arising out of balance quality grade Q40 as per VDI 2060.

ii) 300 microns in case of a one hammer broken condition.

iii) Amplitudes need not be checked for a three hammer broken condition.

Operating speed of 450 RPM:

i) 200 microns for an imbalance force arising out of balance quality grade Q-40 as per VDI-2060.

ii) 300 microns in case of a one hammer broken condition.

iii) Amplitudes need not be checked for three hammer broken condition.

For intermediate operating speed between 450 to 750 RPM, the amplitude limits can be linearly interpolated.

The amplitude limits mentioned above are in both vertical and horizontal directions. The amplitude shall be calculated at critical points on the top surface of the RCC deck. The amplitudes shall be checked for the most unfavourable superposition of modes in any direction. However, phase difference between the maximum amplitude occurring in different directions due to the rotating vector may be considered while superimposing the modes.

Transient Resonance

Transient resonance, which may occur during the start-up or coasting down condition of the crusher, shall be checked and the amplitudes in such a condition shall not exceed one – and half times those at operating speed for each design condition.

Strength Criteria

The following criteria shall apply for the design of top deck:

i. Dead loads, live loads, seismic loads and dynamic loads shall be considered for the design. The most unfavourable combination shall be considered for design.

ii. Seismic loads shall be assumed to act together with dynamic loads for a one millimeter eccentricity in the crusher. However, seismic loads and dynamic loads arising out of hammer breakage need not be considered together.

iii. Fatigue shall be considered while designing for dynamic forces. A fatigue factor of 2.0 shall be used on all dynamic forces to arrive at the equivalent static force for the purpose of design.

iv. Working stress method shall be used for the design of RCC deck. In survival condition, 10% overstressing may be permitted.

v. The RCC top deck shall be atleast of M35 grade of concrete as per IS:456.

vi. Fatigue need not be considered for the three hammer broken condition.

vii. For calculating unbalance forces, the heaviest hammer (plain or toothed) shall not exceed the value specified by the manufacturer.

viii. Loss of contact of foundations at founding level shall not be allowed for any combination of loads.

Door, Window and other finishes shall comply with Architectural specification.

DI Rain-water-down-comers to be provided. Plinth protection, garland drains and approach road are to be provided. Toilets are to be provided in the building as per the technical rule.

4.33.04 **Limestone Storage Building/Shed**

This building shall be single storey steel structure of framed / braced design. Roof shall be colour coated zincalume metal slopped roof truss. Crane Supporting Structures shall be provided including Supply and Erection of EOT Crane of capacity as per the Technological Requirement. Side Cladding shall be of Fly ash brick wall upto 3.0m and colour coated single skin zincalum sheet metal cladding above brick wall.

RCC ground floor slab shall be provided as per Architectural /technical rule..

Steel door and Al glazed windows with Al grill protection, and rolling shutter (electrically operated with gears), shall be provided.

Door, Window and other finishes shall comply with Architectural specification.

Plinth protection, garland drains, DI down comers with gutters and approach road are to be provided.

RCC paving shall be provided both inside and outside the storage building as per the technological requirement. Inside the building the floor shall be finished with 50mm thick metallic hardener floor finishing.

4.33.05 **NOT USED**

4.33.06 **Limestone Grinding Building**

This building shall be single storey steel structure of framed / braced design. Roof shall be RCC on metal deck sheet. Crane Supporting Structures shall be provided including Supply and Erection of Crane of capacity as per the Technological Requirement in the slurry preparation area. Monorail of required capacity as per technological requirement shall be provided. Side

Cladding shall be of Fly ash brick wall upto 3.0m and single skin colour coated zincalum sheet metal cladding above brick wall. Access to roof through stair shall be provided. Roof shall be provided with RCC Parapet of 125mm thick and 1.0m height.

RCC ground floor slab shall be as per Architectural /technical rule.

Steel door and Al glazed windows with Al grill protection, and rolling shutter (electrically operated with gears), shall be provided.

Door, Window and other finishes shall comply with Architectural specification.

150mm dia DI Rain-water-down-comers to be provided. Plinth protection, garland drains and approach road are to be provided. Toilets are to be provided in the building as per the technical rule. Floor finishing shall be of 50mm thick minimum with metallic hardener. RCC paving shall be provided both inside and outside the storage building as per the technological requirement.

4.33.07 **NOT USED**

4.33.08 **Absorber Pump & Oxidation air blower House**

These buildings shall be single storey steel structure of framed / braced design. Roof shall be RCC on metal deck sheet. Crane Supporting Structures shall be provided including Supply and Erection of Crane of capacity as per the Technological Requirement. Side Cladding shall be of 230mm Fly ash brick wall. Access to roof through stair shall be provided. Roof shall be provided with RCC Parapet of 125mm thick and 1000mm height.

RCC ground floor slab shall be provided as per Architectural /technical rule.

Steel door and Al glazed windows with Al grill protection, and rolling shutter (electrically operated with gears), shall be provided.

Door, Window and other finishes shall comply with Architectural specification.

150mm dia DI Rain-water-down-comers to be provided. Plinth protection, garland drains and approach road are to be provided. Toilets are to be provided in the building as per the technical rule. Floor finishing shall be of 50mm thick with metallic hardener.

4.33.09 **Electrical Switchgear & Control Building / FGD Main Building**

This building shall be two storeyed RCC framed structure. Floor and Roof shall be RCC. Side Cladding shall be of 230mm Fly Ash Bricks. Access to roof through RCC staircase shall be provided. Roof shall be provided with RCC Parapet of 125mm thick and 1000mm height.

The layout of FGD Electrical & Control Building with hoisting facilities shall be

as per technological requirement.

All air-conditioned areas, shall be provided with the suspended aluminium false ceiling system (details specified elsewhere) with under deck insulation.

Adequate aluminium doors and windows shall be provided for natural lighting, ventilation and view. All windows in air conditioned rooms shall have hermetically sealed double glazing.

Aluminium glazed partitions for control room are to be provided.

False ceiling, AC & ventilation ducts, cable galleries, inserts, concealed/conduit wiring as per technological requirements are to be provided. RCC stair case shall be provided from GF to Roof. Roof shall be provided with RCC Parapet of 125mm thick and 1000mm height.

Door, Window and other finishes shall comply with Architectural specification.

150mm dia DI Rain-water-down-comers to be provided. Plinth protection, garland drains and approach road are to be provided. Toilets are to be provided in the building as per the technical rule. Ground floor of the building shall be of RCC as per Architectural /technical rule.

For Transformers outside control room, fencing, gate, soling & paving, drainage system are to be provided.

4.33.10 Gypsum De-watering House

This building shall be a three storeied (G+2) steel structure of framed / braced design. Intermediate floors shall be RCC. Roof shall be colour coated zincalume metal slopped roof truss. Layout and provisions shall be as per the technological requirement. Dry gypsum from this building shall be transported to gypsum dumping shed through belt conveyors. Crane Supporting Structures shall be provided including Supply and Erection of Crane of capacity as per the Technological Requirement. Side Cladding shall be of 230mm Fly ash brick wall upto 3.0m and single skin colour coated zincalume sheet metal cladding above brick wall.

RCC ground floor slab shall be provided as per Architectural /technical rule..

Steel door and Al glazed windows with Al grill protection, and rolling shutter (electrically operated with gears), shall be provided.

Door, Window and other finishes shall comply with Architectural specification.

150mm dia DI Rain-water-down-comers with gutters to be provided. Plinth protection, garland drains and approach road are to be provided. Toilets are to be provided in the building as per the technical rule. Floor finishing shall be of 50mm thick with metallic hardener.

4.33.11 **Gypsum Storage Building/shed**

This building shall be single storey steel structure of framed / braced design. Roof shall be colour coated zincalume metal slopped roof truss. Crane Supporting Structures shall be provided including Supply and Erection of EOT Crane of capacity as per the Technological Requirement. Side Cladding shall be of 230mm Fly ash brick wall upto 3.0m and single skin colour coated zincalum sheet metal cladding above brick wall.

RCC ground floor slab shall be provided as per Architectural /technical rule..

Steel door and Al glazed windows with Al grill protection, and rolling shutter (electrically operated with gears), shall be provided.

Door, Window and other finishes shall comply with Architectural specification.

150mm dia DI Rain-water-down-comers with gutters to be provided. Plinth protection, garland drains and approach road are to be provided. Toilets are to be provided in the building as per the technical rule. Floor finishing shall be of 50mm thick with metallic hardener.

4.33.12 **Miscellaneous Items**

The RCC Sumps / Liquid retaining Tanks shall be designed as Un-cracked section as per IS: 3370 (Latest Revision) by working stress method.

Design, detailing and execution of equipment foundations, Trenches etc. as necessary for the system are under the scope of EPC package bidder.

Any other equipment / components as required for completeness of the system; foundations of the same are also in the Bidder's scope.

4.34.00 **Brief Design Consideration for Some Special Structures**

Induced Draught Cooling Tower

The civil works for cooling tower (both main and auxiliary) are related mainly to following areas, but not limited to:

1. Cooling tower

a) Cooling Tower Basin, Sump and Duct

The basin of the cooling tower for collection of cold water shall be made of Reinforced Cement Concrete (RCC M35 grade as per IS;456). The floor of the basin shall be sloped to minimum 1 in 80 towards outlet. The required slope shall be achieved by either screed concrete of 1:2:4 having minimum thickness at edge as 25mm or by suitably adjusting base/floor raft.

Galvanized handrail 1000mm high shall be provided all round the cooling tower basin and sludge sump pit.

The bottom 500 mm of this railing shall also have galvanized 3 mm thick wire mesh with opening size of 50mm grid to avoid ingress of leaves vegetation and debris into the basin.. The basin shall be tasted for water tightness as per IS:3370.

Basin floor slab shall be designed to rest on raft/mat/pile foundation including support structures. The stiffness of the subsoil shall be taken into account. The founding level of the raft/mat shall be either on virgin ground level or shall be placed at higher level only after scooping out filled up soil up to virgin ground and then filling back with well compacted sand (95% of relative density) up to the founding level of the raft/mat. The bidder shall ascertain the safe bearing capacity of the stratum/pile capacity at the founding level and may adopt the same subject to Owner/Consultant approval

Bottom of the lowest level beam shall be at least at free board level. In case, the beams are provided into the water, the same shall be designed for uncracked section.

The end of the outlet channel shall be provided with 230 mm wide and 6 mm thick PVC water stop all round the cross section of channel at the terminal point of Bidder to enable further extension by the Employer. The outlet channel shall be covered on top with removable precast concrete slabs with G.I. handrail on both sides of the channel.

Hot water duct around cooling tower shall be below ground.

b) Super Structure of Cooling Tower

Beams and other structures like tie beams, slabs etc. shall be of reinforced cement concrete of grade M30 (minimum) as per IS: 456. Uniform concrete grade shall be used for the entire cast-in-situ reinforced concrete superstructure.

The fan deck slab shall be properly sloped so that rain water does not accumulate over the deck slab. The slope shall be 1:120(min). The slope shall be provided with screed concrete (1:2:4). Deck slab and all other over ground platforms shall be provided with galvanized GI hand rails (vertical post as well as horizontal pipes) and with galvanized toe guard all around. Suitable arrangement for drainage of rain water to be provided..

c) Cells, Distribution System and Stack

Cooling tower cells shall consist of RCC columns, beams and walls. Hot water distribution channel shall also be of RCC. Cell division partition walls may be of Cast-in-Situ RCC or precast concrete blocks.

Hot water channel shall be covered with suitably designed precast/ cast-in-situ concrete slab. Wherever flow control valves are located over hot water basin, there shall be placed over precast concrete covers/concrete slab and designed for specified load. The minimum thickness of RCC fan stack shall be 150mm. The fan stack shall have two layers of reinforcement on either faces in both directions with minimum dia of reinforcement bars as 8mm and maximum spacing as 150mm c/c. External surfaces of cooling tower peripheral cladding walls and fan stack shall be painted with two or more coating of waterproof cement paint of approved shade, make and colour.

d) Staircase

Two (2) numbers RCC staircase for approach to fan deck for each cooling tower shall be provided.

e) Steel Structures

All mild steel parts of structures used in cooling towers shall be hot double dip galvanized for a very long period of maintenance of more than 20 years. The minimum coating shall be 610gm/sq.m and shall comply with relevant IS codes. Galvanizing shall be checked and tested in accordance with IS:2629. All welding shall be done before galvanizing. Any site joints required to be carried out after galvanizing shall be either flanged or screwed joints, Nails, nuts, bolts and all components coming in direct contact with water shall be of stainless steel of AISI 304 or SS 316 or equivalent as approved by OWNER. For painting of steel members in overhead cable trestle refer elsewhere in this specification.

f) Grade of concrete

All RCC work to be done under this specification, unless specified otherwise, shall be design mix (controlled) concrete of grade M30 of IS: 456. Water-cement ratio shall not exceed 0.45.

i) All other civil works required to make installation of cooling tower complete, including the connection of hot water duct at terminal point.

ii) Dedicated Switchgear building (Two Storied RCC) shall be provided for each IDCT near the IDCT as per system requirement

2. Design Criteria

R.C.C Structures

The design of all RCC structures under induced draught cooling water system shall be carried out using Working Stress Method of design as outlined in IS: 456 & IS 3370 (Part I to IV). Minimum clear cover to all RCC structures under induced draught cooling water system shall be 50mm. Design of structures such as staircase etc. which are not in contact with water/ water spray/ moist air shall be carried out adopting material stresses as given in IS: 456. However, design of structures such as columns, beams, fins, walkways, slabs, etc. shall be carried out as per IS:3370. In addition, a crack width check on sections designed as above shall be carried out. The crack width (calculated as per provisions of IS 456/IS:3370) shall not exceed 0.1mm. The design of liquid structures like C.W. basin, sump, outlet channel, hot water distribution channel shall be as given herein below..

(a) Design of CW Basin wall, sump, column foundations, outlet channel, duct, sludge pit, Hot water distribution basin/ Hot water Channel shall be designed as Uncracked section as per IS : 3370 (Part I to IV). Both water face and soil face of above liquid retaining structures shall be designed as uncracked section. The allowable stresses for concrete and steel shall be as per IS: 3370 (Part-I to IV). The C. W basin, ducts, sludge pit, etc. shall be designed for the following conditions:

(1) Water filled inside up to the designed level and no earth outside.

(2) Earth pressure plus 2.5 T/m2 surcharge (Vertical direction) plus ground water table at Finished Graded ground Level (FGL) outside and no water inside.

Wherever the foundation raft is same as the CW basin slab, the foundation shall be designed as uncracked section (both water face and soil face). However, if the foundation slabs are provided at different level requirements, the CW basin slab shall be designed as uncracked section (both water face and soil face). The structures below CW basin slab i.e. Foundation slab/raft, basin supporting columns/walls shall be designed as per working stress method.

(b) For uplift due to ground water table, the basin slab shall be checked against uplift for basin empty condition with ground

water table at FGL. Stability against uplift shall be ensured both for all construction phases & operating stage with no water inside. The provision of flap valve/ pressure relief valves is not permitted. The factor of safety against uplift shall be as per IS: 3370.

(c) Fan deck shall be designed for rolling loads due to movement of equipment during Installation/ maintenance operation.

(d) All RCC structures shall comply with durability requirements for severe exposure conditions as per IS: 456.

Individual Outlet Channel leading to CW Channel

RCC cooling water channels shall be of rectangular shape and designed as a water retaining structure as un-cracked section. Depth of channels and width of channels shall be in-line with CW Channel. These branch channels shall join together and form common channel to the fore-bay to the pump house. Dimension of the channels shall be decided on the basis of the quantity of water to be carried by the channel and shall be in line with approved SUMP MODEL STUDY & CFD analysis. Floor of the channel shall be given a mild slope to ensure necessary velocity of flow. The top of the channel shall be kept at least 500 mm above finished ground level with suitable galvanised MS pipe hand railing on either side.

3. Steel Structures

1. All welds shall be subject to 100% visual examination.
2. Dye penetration test on welds shall be carried out.
3. Welding shall be done as per approved procedures and by qualified welders.

Galvanizing shall be checked/ tested for all tests as per IS: 2629. For all steel structures outside cooling towers, painting shall be as per details specified elsewhere in this specification.

4. Loading

For consideration of loads on structures and load combinations IS: 875 (Part 1 to 5) –Code of Practice for design loads other than Earthquake) for Buildings and Structures shall be followed..

Live Loads

The following live loads (minimum) shall be adopted for the design of buildings, structures:

a Roof / Fan deck 500 Kg/Sqm

b	RCC Floors	500 Kg/Sqm
c	Stair, landings	500 Kg/Sqm
d	Chequered & Grating floor	400 Kg/Sqm
e	Culverts and its allied structure	Class `AA' loading (wheeled and tracked both) and to be checked for Class `A' loading as per IRC standards.
f	Basin, sump	Earth pressure in submerged condition water pressure as applicable and additional surcharge load of 2.50 T/Sqm
g	Covers for H.W. channel/ H.W. distribution basin	500 Kg/Sqm
h	Walkways inside cooling towers	500 Kg/Sqm
i	Underground pipes and ducts	Earth pressure and surcharge load of 2.50 T/Sqm
j	Cover of cable / pipe trenches	500 Kg/Sqm or as per (e) above as the case may be.

4.35.00 HYDROGEN GENERATION PLANT

Hydrogen generation building (with cylinder storage facility) shall be RCC/Steel frame with fly ash brick masonry with jally. This building falls under hazardous building category. The entire building campus shall be properly fenced to prevent unauthorized ingress or egress. Safety norms shall be followed as applicable. Facilities for the staff shall be provided as applicable.

Construction of the Hydrogen generation plant building in compliance with Indian Explosive Act and other statutory regulations governing the building.

All equipment foundations associated civil/structural works and technological structures to fulfill the technological requirement are in the scope of 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 Hydrogen generation plant inside the Power Plant is in the scope of the Bidder. Owner shall support by way of giving letters etc. for obtaining approvals for the above.

5.00.00 DOCUMENT SUBMISSION

Design and Construction documents pertaining to all Civil, Structural and Architectural works that shall be required to be submitted to Owner for their approval have been brought out under following clauses. Approval of these

documents by the Owner/Consultant shall not relieve the successful bidder of his responsibility for any errors and fulfillment of Contract requirements.

5.01.00 **Design Document**

Design Document shall comprise Mechanical/Electrical input Drawings, design data, design assumptions & references, detailed structural analysis (including computer output, if any) & design calculations and design drawings.

Design calculations and drawings shall be submitted and reviewed only after approval of corresponding Mechanical/Electrical/System general arrangement drawings. The Bidder shall submit approved GA drawings along with design documents, design drawings for comments/approval of the Owner/Consultants. On final approval of the drawing and design, Bidder shall submit the drawing with soft copy in CD each to the Owner and consultant for distribution. For number of design documents, design drawings & GA drawing to be submitted, bidder shall refer to section VI of Vol.-IIA.

5.02.00 **Construction Document**

Based on approved design drawing, detailed drawings for construction shall be prepared by the successful bidder. For reinforced concrete structures and foundations detailed bar bending schedules with approximate quantity involved (both reinforcement and concrete in grade wise) in approved format shall accompany each detailed drawing. For structural steel work the detailed drawing shall have schedule of structural members with approximate quantity of steel involved. The successful bidder shall prepare detailed fabrication drawing along with bill of materials.

All detailed drawings/ fabrication drawings as decided by Engineer for all structures along with bar bending schedule/bill of materials need be furnished to Owner/Consultants at construction site for their review and approval.

Upon approval, each drawing along with soft copy in CD shall be submitted to the Owner and Consultant for their distribution. Procedures for submission and approval of Construction Documents other than stated above have been mentioned elsewhere in this specification. For number of construction drawings/Fabrication drawings to be submitted, bidder shall refer to section VI of Vol.-IIA.

5.03.00 **As Built Drawings**

"As-built" drawings shall be prepared by the Bidder after completion of construction / erection incorporating all the changes, if any, done on Engineer's instruction/approval. In case of any discrepancy in the number of prints and CD to be submitted for Design, Construction documents and As-Built drawings mentioned elsewhere in the specification, stipulations made here shall prevail.

6.00.00 LAYOUT

Before starting the work, the successful bidder shall carry out the setting out of foundation and structures and provide levels, with reference to general existing grid and benchmark. If the successful bidder uses the grid, benchmark and reference pillar made by other agencies, he shall coordinate with that Agency. and shall satisfy himself of the accuracy of the reference marks. If he is required to set out the foundation afresh, he shall do so independently with reference to the one existing grid and benchmark, which has been followed by other agency at the instruction of the Engineer. In case any discrepancy is found, it shall be immediately brought to the notice of the Engineer for any rectification / modification necessary. No complaint shall be entertained at a later stage. The successful bidder shall accurately set out the position for holding down bolts and inserts.

If required, in the option of the Engineer, he shall construct and maintain pillars for grid, references and benchmarks and maintain them till the completion of the construction. He shall also help the Engineer with instruments, materials and labour for checking the detailed layouts and levels. The successful bidder shall be solely responsible for the correctness of the layout and levels, and Engineer's approval shall not be deemed to imply any warranty in carrying out the works correctly. The bidders shall take into account the cost of these in quoting their price.

7.00.00 WORKSMANSHIP

Workmanship shall be of the best possible quality and all work shall be carried out by skilled workmen except for those, which normally require unskilled persons. Welding shall be done by experienced and certified welders in proper sequence using necessary jigs and fixtures. Fabrication shall be done in shops having proper equipment for accurate edge lining and milling of column shaft ends, base plate surfaces etc., and shaping and dimensioning of anchor bolt assembly, inserts and other misc. items. Necessary inserts / embedment in buildings/structures shall be provided as per the technological requirements. In addition to the requirement specified above, if the bye- laws of the local Govt., Municipal or other authorities require the employment of licensed or registered workmen for various trades, the successful bidder shall arrange to have the work done by such registered or licensed personnel. In case of manufactured materials, the successful bidder shall have, with no additional cost to the Owner, the services of the supervisors of the manufacturers to ensure that the work is being done according to the manufacturer’s specifications.

8.00.00 TEMPORARY WORK

All scaffoldings, staging, temporary bracing and other necessary temporary work required for proper execution of the Contract shall be provided by the successful bidder at his own cost and inclusive of all materials, labour,

supervision and other facilities.

The layout and details of such temporary work shall have the prior approval of the Engineer, but the successful bidder shall be responsible for proper strength and safety of the same. All temporary work shall be so constructed as not to interfere with any permanent work or with the work by other agencies. If it is necessary to remove any of the temporary work at any time to facilitate execution of the work or with the work of other agencies, such removal and re-erection, if required, shall be carried out by the successful bidder at the direction of the Engineer without any delay and any extra cost on this account shall be borne by the successful bidder.

9.00.00 INTERFACE WITH STRUCTURES UNDER OTHER'S SCOPE

Modification in layout of foundation/structure during detail engineering stage may be necessary to avoid fouling with other structures. Necessary changes on this account shall be made by the bidder without any extra cost to Owner.

10.00.00 SEQUENCE OF WORK AND PROGRESS REPORT

The sequence in which the works are to be carried out shall be as approved by the Engineer in accordance with the construction method accepted by the Engineer and to be followed by the successful bidder. A programme of work is to be submitted for the Engineer's review and approval and this has to be periodically updated and modified as per actual progress to enable timely completion.

The successful bidder shall regularly submit to the Engineer progress reports for periods of working as specified by the Engineer showing up to date progress on all-important items of work.

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 - II

SPECIFIC DESIGN REQUIREMENTS [CIVIL]

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SECTION-II

SPECIFIC DESIGN REQUIREMENTS [CIVIL]

1.00.00 INTRODUCTION

This section outlines the followings:

a) A brief description of Soil Characteristics.

b) Design considerations for Reinforced Concrete Structures.

c) Design considerations for Foundations.

d) Roads.

2.00.00 GEO-TECHNICAL SYSTEM

Detail soil investigation, as required, to be carried out for foundation design of various facilities.

Soil characteristics and parameters to be adopted in final design, the successful bidder is required to do detail geotechnical investigation work as part of the contract to verify/generate data so required. The successful bidder shall conduct all the Field and Laboratory tests as mentioned in Vol-II-G2A – Section: II

It should be noted that nothing extra (both time & cost) whatsoever on account of variation between soil data annexed in this specification and that found by detailed geotechnical investigation to be carried out by bidder shall be payable.

The bidder shall use Geotechnical recommendations available in the tender document for various locations, depths and widths for reference for estimation purpose. Moreover, bidder is at liberty to carryout suitable number of borehole tests at site to assess the Net Safe Bearing Capacity values / Pile capacity for design of foundation prior to quote. After contract award, the successful bidder shall conduct detailed Geo-technical investigation. After completion of detailed Geo-technical investigation, the draft Geo-technical investigation report shall be submitted to owner/consultant for review/Approval. During the review/Approval, The recommendations furnished by successful bidder will be compared to the recommendations available in the tender document for various locations and depths. During the review, owner/consultant will offer their suggestions/remarks on the successful bidder`s draft Geotechnical investigation report, If any. The design, type, size, depth of the foundation / pile, Net safe bearing capacity / Pile capacity values shall be based on the approved soil investigation report of the successful Bidder/Owner's soil recommendations(Available in the Tender

document) whichever is conservative.

The design of foundation open/ pile shall be carried out by Limit State or working stress method as per the provisions of IS-456 / IS-2911 & other applicable IS codes.

.

Contour plan details & approximate grade levels will be supplied with tender drawing along with plant +- 0.0m & UTM co-ordinate.

Technical specification for Geotechnical Investigation presented in Vol-II-G2A – Section: II to be referred.

3.00.00 LOADS

All structures and portions thereof shall conform to the latest revision of relevant Indian Standard specifications and also to the various other technical requirements.

Before proceeding with the submission of civil & structural design of structures for approval, the bidder shall get the approval for the loads not pertaining to Civil & Structural (such as technological structures, mechanical equipment & supports, electrical equipment& supports, C&I equipment& supports, other miscellaneous equipment& Supports, etc.) from respective mechanical / electrical and C&I divisions. Civil & structural design & subsequent Civil/Structural drawings shall be reviewed by the Client/Consultant only after the approval of loads/load data as mentioned above.

Any structure, which carries Indian Railway Loading or is situated in vicinity of Railway lines, the design has to conform to the Indian Railway Standard Specifications and approval must be obtained from Railway Authority including the clearance etc.

All structures shall be designed to sustain within the stress limitation as specified in the Code, all dead loads plus assigned live, equipment, wind, seismic or other design loads.

a) Dead Loads

Dead load shall include the weight of all structural components and architectural appurtenances incorporated in the structures plus hung loads and any other permanent, externally applied load. This should also include equipment dead load. The content of tanks, Ash storage bins shall be measured at full capacity for this purpose. The piping loads, Cable tray loads, Hung loads and the contents of tanks, silos, hoppers and bins shall be listed separately so that they can be excluded from dead load when dead loads are acting as stabilizing loads for uplift..

The following unit weight of material shall be considered for computation of loads. Loads given in IS:875 (part-I) shall be made use

of for material not listed below.

Materials		Unit weight
Plain cement concrete	:	24.0 kN /cum
Reinforced cement concrete	:	25.0 kN /cum
Structural steel	:	78.5 kN /cum
Brick work	:	19.0 kN /cum
Cement plaster	:	21.0 kN /cum
Floor Finish	:	24.0 kN /cum
Coal	:	12.0 kN /cum
Fly Ash	:	16.0 kN /cum
Bottom Ash	:	16.0 kN /cum

For R.C.C roof wherever Solar panels are placed: DL of Solar panel shall be considered as per Manufacturer recommendation. In addition to other DL specified above

b) Live Loads

Live loads in different areas shall include dust loads, minor equipment loads, cable trays, small pipe racks/hangers, operation/maintenance loads etc. The loads considered shall not be less than those specified in IS: 875 (Part II).

The loads listed hereunder are minimum loads for the areas involved. If actual expected load is more than the specified minimum load, then actual load is to be considered. Special use areas shall be investigated and loading revised upward as necessary.

Hung loads shall be based on minimum loading equivalents of 1.0 kN/sq.m for piping and 0.5 kN/sq.m for electrical, ventilation and air conditioning. Loadings resulting from concentrations of facilities in specific areas shall be substituted where listed base loading is excluded.

Sl No	Building/Structure	Live Load
i)	**All Buildings**	
	a). Roofs	
	Inaccessible roof (Flat)	1.5 kN/sq.m + hung loads, if any + 0.5 kN/sq.m (dust load).
	Accessible roof where equipment are placed	5 kN/sq.m + hung loads, if any+ 0.5 kN/sq.m (dust load).
	Accessible roof	1.5 kN/sq.m + hung loads, if any +

	Accessible roof Without equipment , and roofs with solar panel without any equipment	0.5 kN/sq.m (dust load).
	Inclined roof	As per IS: 875 (Part 2)
Sl No	**Building/Structure**	**Live Load**
	b) Stairs, Balconies& Platforms	5.0 kN/sq.m
	c) Corridors	5.0 kN/sq.m
	d) Removable gratings, chequered plates, walkways etc	5.0 kN/sq.m
	e) Office, Laboratory, Conference rooms :and other non-plant areas etc.	5.0 kN/sq.m
Note: Dust load values mentioned above shall be considered along with dead load while calculating lump mass for seismic load combinations		
ii)	**Bunker Building**	
	a) Ground Floor	25.0 kN/sq.m
	b) Bunker Feeding Floor	15 kN/sq.m + hung loads + 0.5 kN/sq.m (dust load).
iii)	**Power House Building**	
	a) Ground Floor Unloading Bay	50 kN/sq.m
	Other areas	25 kN/sq.m
	b) Mezzanine Floor	15 kN/sq.m plus hung loads
	c) Operating Floor Equipment Lay-down Area	35 kN/sq.m plus hung loads or actual load furnished by equipment supplier whichever is higher
	Rotor Removal Area	50 kN/sq.m plus hung loads or actual load furnished by

		equipment supplier whichever is higher. Rotor removal area beams shall also be checked for half the rotor load at the center of the beam
	Other Areas in Turbine Hall	25 kN/sq.m plus hung loads
Sl No	**Building/Structure**	**Live Load**
	All other Areas in Operating Floor except Turbine Hall	15 kN/sq.m plus hung loads
	d) Cable Spreader Floor	7.5 kN/sq.m plus hung loads
	e) All other floors	10 kN/sq.m plus hung loads
	f) Due to anchoring of conductors on any "A" row column	2 x 20 = 40 kN (Twin ACSR Moose Conductor) and 10 kN (Shielding Wires) or actual load furnished by equipment supplier.
iv)	**Auxiliary Buildings**	
	a) Ground Floor	10 kN/sq.m
	b) Cable Spreader Floor	7.5 kN/sq.m
	c) Pump House Operating Floor	15 kN/sq.m / As supplied by Pump manufacturer, whichever is higher
	d) Office Floor	5 kN/sq.m
	e) Switchgear room	15 kN/sq.m
	f) All other Floors	10 kN/sq.m
v)	**Non-Plant Buildings**	
	a) Floors with equipment	10 kN/sq.m
	b) All other floors	5 kN/sq.m
vi)	**Coal Handling**	

	structures	
	a) Flat accessible roofs	1.5 kN/sq.m + 1 kN/sq.m dust load.
	b) Flat inaccessible roofs	0.75 kN/sq.m + 1 kN/sq.m dust load
Sl No	**Building/Structure**	**Live Load**
	c) Inclined roof	In accordance with IS 875 For live load + 0.25kN/sq.m For dust load.
	d) All TPS and Crusher house floors	7.5 kN/sq.m
	e) Switch gear and MCC floor	15 kN/sq.m
	f) Walkways of Gallery	3 kN/sq.m or a concentrated load of 2 kN at center + dust load of 1 kN/sq.m

Note: Dust load values mentioned above shall be considered along with dead load while calculating lump mass for seismic load combinations.

vii) Underground Structures/Trenches/pits

Minimum surcharge shall be 20 kN/sq.m. For structures in vicinity of roads and heavy vehicular movement surcharge shall be considered as applicable as per loading specified elsewhere in this specification. Trenches/pits inside building shall be designed for a surcharge equal to Live Load intensity of Ground Floor or 15 kN/sq.m whichever is greater. In Boiler area, Power House area and other outdoor areas in BTG area, the minimum surcharge shall be 20 kN/sq.m.

viii) Covers for Trenches / Channels

At road crossings and entrance of the buildings wherever vehicle/crane movement expected, the covers shall be designed for vehicular movements as per IRC standards.

Trench cover at entry to building and road crossings shall be designed for live load of 100 kN at centre. Trench cover at other location shall be designed with a surcharge of 15 kN/m^2 or a concentrated load of 500kg at centre which is worst.

ix) **Roads**

Design of roads shall be in accordance with Indian Road Congress

standard.

x) **Road Culverts and its allied structures including Road Crossing of Trenches.**

At all road crossings RCC box culverts along with manholes on both sides shall be used. Such road culverts and its allied structures & Road Crossing of Trenches shall be designed for Class `AA' loading (wheeled and tracked both) and to be checked for Class `A' loading as per IRC standards.

xi) **Railway Supporting Structures, Rail Culverts**

Railway supporting structures and rail culverts shall be designed as per Railway Bridge Rules.

Reduction in Live load as per provision of IS:875 shall not be permitted.

The areas covered with equipment shall be designed on the basis of weight of equipment (flooded/operating) in addition to an uniform live load of 5.0 kN/sq.m or specifically defined live load whichever is greater.

Foundations and fixing arrangements for items of equipment, which generates vibration, if any shall be designed to prevent transfer of such vibrations to the adjoining structures. For loads caused by moving equipment over the floor for installation, consideration shall be given to the shoring of beams and floor, from floors below.

For loads caused by moving equipment over the floor for installation, consideration shall be given to the shoring of beams and floor, from floors below.

c) Equipment Loads

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.

ii) All equipment, tank and piping design loadings shall include Hydraulic Testing loads.

iii) Air and gas duct loadings shall include weight of insulation, duct attachments, dust accumulation loads, seismic, wind and other loads as applicable.

iv) Crane girders and supporting columns shall be designed for vertical and horizontal forces (including impact forces) as developed from the crane weights and wheel loads.

Unless otherwise specified, the vertical and horizontal loadings shall conform to the applicable sections of the IS specifications.

v) Weight of equipment, ducts, tanks, pipes, conduits etc. supported by structure shall include maximum possible loading conditions i.e. flooded material contents and associated impacts, test loadings, anchorage and constraint effects.

vi) All structural components shall be designed to accommodate anticipated concentrated loads which shall or may be applied during the life of the plant.

Where both concentrated and uniform loads cannot act simultaneously, the structure or component shall be analyzed for both conditions of loading and shall be designed for most critical condition.

vii) Jet forces resulting from guillotine type pipe ruptures shall be considered in the design, if it is of high magnitude. Jet force to be considered shall be equal to the product of the pipe cross section and the internal design pressure applied on an area equal to the pipe cross section.

vii) Lay down areas in the Turbine Hall shall be investigated for concentrated loads resulting from equipment components to be stored during erection and maintenance operation. Where live load allowance is inadequate to permit storing of such equipment components, the design live load shall be increased to permit such use or the area shall be restricted by identifying lay down areas for specific components, each area to be identified by permanent marking.

d) Wind Loading

Wind loading shall be in accordance with Indian Standard Code IS:875 (Part 3) (Latest Revision) for a basic wind speed of 44 m/sec. upto a height of 10 metres above mean ground level. Terrain Category-2 shall be considered for all structures.

Risk coefficient (k1) shall be considered as 1.07 for all structures. The k2, k3, k4 factors shall be considered as per IS: 875(part 3 latest revision).

e) Seismic Loading

The lateral forces shall be established in accordance with the recommendations of IS:1893 (Latest Version only). The site falls in Zone-III as identified in the map in IS:1893 and hence seismic forces would be considered accordingly for the structures and buildings. Importance factor shall be taken as 1.75.

Seismic Load shall be considered in all three directions for analysis and design of all the buildings & Structures even if it is not warranted as per IS-1893.
For all the buildings & structures, Response Spectrum Method shall be used for the calculation of seismic forces. Material damping factor and number of modes to be considered for the analysis shall be as per recommendation in the code referred above. The number of modes to be considered in the analysis shall be such that at least 95% of the modal mass is excited.

f) Temperature Loads

The structures shall be designed to withstand stresses due to fifty (50) percent of the total temperature variation. The total temperature variation for temperature loading should be taken as two thirds (2/3) of the average annual variation in temperature. The average maximum annual variation for this purpose shall be taken as the difference between the mean daily minimum temperature during the coldest month of the year and mean daily maximum temperature during the hottest month of the year.

Mean Daily minimum ambient temperature during coldest month of the year = 7.6°C

Mean Daily maximum ambient temperature during hottest month of the year = 47.5°C

Expansion and contraction due to changes of temperature of materials of a structure shall be considered and adequate provision shall be made for the effects produced as per provision in the relevant IS codes.

g) Steam Piping Load

Minimum intensity of steam piping load shall be 6.0 kN/sq.m for the areas at different levels through which steam piping is routed. However, the loading shall be checked as per static/dynamic analysis for steam piping or load data supplied by piping vendor and the worst loading shall be considered in design. Horizontal anchor loads, if any, shall also have to be considered in design.

h) Earth Pressure Load

Earth pressure for all underground structures shall be calculated using coefficients of earth pressure at rest, coefficient of active or passive earth pressure (whichever is applicable).

However, for the design of sub-structure of pump house and underground liquid storage tanks earth pressure at rest shall be considered with coefficient of earth pressure at rest shall not be less than 0.50.

In addition to earth pressure and ground water pressure, etc., surcharge load shall also be considered for the design of all underground structures including channels, sumps, cable & pipe trenches, etc., to take into account the vehicular traffic in the vicinity of the structure. Intensity of Surcharge Load for all underground structures and foundations shall be considered as 2.0t/sq.m in general unless mentioned otherwise.

i) Crane, Monorail & Elevator Loads

Crane girders and supporting columns shall be designed for vertical and horizontal forces (including impact forces) as per crane vendor's data. All lifting beams and monorails shall have their design loads increased for impact factor as mentioned hereinafter. For frame analysis, the lateral crane surge shall be applied on one side of the frame at a time and in either direction.

Impact Factor

Loads for cranes, hoists and elevators shall be taken as per IS:875 / IS:807 (Latest Revision). The minimum impact factor to be used in design shall be as follows:

Crane loads

a) For vertical force, an impact factor of 25% of the maximum crane wheel load for crane girder 10% for column and foundation.

b) A lateral crane surge of 10% of the weight of the trolley plus lifted load applied at the top of each rail.

c) A horizontal surge of 5% of the maximum static wheel loads of the crane applied at the top of the rail in longitudinal direction.

Monorail loads

a) Impact factor of 10% of lifted load of hoist for monorail and support design.

b) Impact factor of 25% of the lifted load for electrical pulley and support design

Elevator

A 100% of the lifted load including elevator live load plus the cab weight for the elevator support beams.

j) Construction Loads

The integrity of the structures shall be maintained without use of temporary framing struts or ties and bracing as far as possible. However, construction or crane access considerations may dictate the use of temporary structural systems. Special studies shall be made and documented to ensure stability and integrity of the structures during any periods involving use of temporary bracing systems.

k) Other Loads

Stresses imparted to structures due to differential settlements, variation of water table, erection and maintenance load, creep and shrinkage shall also be considered in design of all structures.

All Power House Columns adjacent to first row of Boiler columns shall be designed for an additional load of 500 kN to account for piping/cable rack loads. However, after finalization of all the Pipe/Cable racks adjacent to first row of Boiler columns, the Main power house shall be analyzed and designed again for the actual loads. If warranted, any design changes shall be incorporated by the bidder during the course of the engineering without any cost implication to the Owner.

All Power House Columns along the transformer yard, shall be designed for an additional load of 50KN/m for horizontal pipe / cable rack in addition to conductor pull load from substation. However, after finalization of all the Pipe/Cable racks the transformer yard, the Main power house shall be analyzed and designed again for the actual loads. If warranted, any design changes shall be incorporated by the bidder during the course of the engineering without any cost implication to the Owner.

All structures situated in the vicinity of railway lines shall be designed conforming to the Indian Railway Standard Specification.

l) Thrust Load

Thrust blocks shall be designed against the thrust load from pipe lines considering the test pressure in the pipe lines and as per the relevant IS Code with adequate factor of safety.

3.01.00 **Stability of Structures**

Design shall be checked against buoyancy due to the ground water (Ground water table shall be considered at Plant Finished Grade Level) during construction and maintenance stages for structures like underground tanks, pits trenches, basements, etc. Minimum factor of safety of 1.2 against buoyancy shall be ensured considering empty condition inside and ignoring the superimposed loading and surcharge. For purpose of calculating downward load due to any overburden, only the mass located vertically above the projected area shall be taken into consideration.

All building sub-structures including pump houses shall be checked for sliding and overturning stability during both construction and operating conditions for various combination of loads. Factor of safety for these cases shall be taken as mentioned in IS:456 and other relevant IS codes. However, following minimum factor of safety shall be followed.

a) Factor of safety against overturning due to wind, seismic or other lateral load shall be 1.5 minimum.

b) Factor of safety against sliding shall be 1.5 minimum.

c) Factor of safety against uplift due to hydrostatic forces shall be 1.2 and due to any other loads shall be 1.5.

Stability of the structure shall also be investigated for loading conditions during construction, repair or other temporary measures. Lower factor of safety may be used for such loading conditions as per relevant IS codes.

In case where dead load provides the restoring force, only 0.90 times characteristic dead load shall be considered. Imposed loads shall not be considered as restoring force.

Ground water table shall be considered at Plant Finished Grade Level for design of foundations and all underground structures.

3.02.00 **Load Combinations**

Buildings and structures shall be designed to resist the load stated in the previous section acting in the following 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$\pm$ CS $\pm$ TL

iv) DL + LL + PL + Equip + Cb + CtLB$\pm$ CS $\pm$ TL

v) 0.9DL $\pm$ EL (for DL only) $\pm$ TL

vi) 0.9DL $\pm$ WL1 $\pm$ TL

vii) 0.9DL $\pm$ WL2 $\pm$ TL

viii) DL + *LL + PL + Equip + Cb + Ct $\pm$ EL $\pm$ 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

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 the combinations as stated above to assess worst effect on whole structure as well as its components.

Seismic Load shall be considered in all three directions for analysis and design of all buildings &Structures even if it is not warranted as per IS-1893.

The above mentioned load combinations are for general guidance. However, applicable load factors & load combinations (for both serviceability & strength)

shall be as per IS:875 (Part 5),IS-456, IS-13920 & IS-1893 all parts (Latest Revisions).

Appropriate allowable increase in permissible stresses as per IS codes, may be taken only under normal loads along with wind and seismic conditions. However, members which are designed primarily to resist wind, no increase in permissible stresses shall be permitted.

Load Combinations for Underground Structures

Following loading conditions shall be considered in addition to the loading from super structure for the design of sub-structure of pump house, channels, sumps, tanks, reservoirs, trenches and other under-ground structures.

Only liquid pressure from inside and no earth pressure and ground water pressure, and surcharge pressure from outside (applicable only to the structures which are liable to be filled with water or any other liquid).

Earth pressure, surcharge pressure and ground water pressure from outside and no water pressure from inside.

Base slab & intermediate piers of the pump house shall be designed for the condition of different combination of pump sumps being empty during maintenance stages with maximum ground water table. Intermediate dividing piers of pump sumps and partition walls in channel shall be designed considering water on one side only and the other side being empty for maintenance.

Design shall also be checked against buoyancy due to ground water (Ground water table shall be considered at Plant Finished Grade Level) during construction and operation stage. Minimum factor of safety of 1.2 against buoyancy shall be ensured considering empty condition inside and ignoring the superimposed loading and surcharge. For purpose of calculating downward load due to any overburden, only the mass located vertically above the projected area shall be taken into consideration.

3.03.00 Design Concepts

Wind and seismic forces shall not be considered to act simultaneously.

For the design of main plant structures during seismic condition, the tank shall be considered full up to operating level. For other load combinations, tank in flooded condition shall be considered.

`Lifted Load' of crane shall not be considered during seismic condition.

For analysis &design of all underground structures/foundations, ground water table shall be considered at the Finished Ground Level.

If R.C.C. floors and roofs except those cast over metal decking are assumed to act as diaphragm transmitting lateral loads to braced bays then main

beams/girders shall be provided with shear connectors. However, whenever large/more number of cutouts is provided in the floor slab, horizontal floor bracings shall be provided below slab to transfer horizontal force to columns without considering diaphragm action from slab. Shear connectors shall also be provided over beams having R.C.C. slab on one side and opening /chequered plate / grating on other side.

For R.C.C. roofs cast over metal decking, horizontal bracings must be provided below slab to transfer horizontal force to columns.

Roof decking sheets shall be designed as per IS:801 to carry the self-load, dead load due to RCC slab and finishes and imposed load. The deflection of metal deck shall be limited as per BS:5950. Suitable shear studs shall be provided as per BS:5950 on the top of roof beam.

In Turbine Bay, horizontal wind girders between A-row and B-row columns must be provided below Mezzanine and Operating floor at gable ends to transmit wind load from gable columns.

PTFE (Poly tetra Fluoroethylene) bearing shall be provided where horizontal loads not to be transferred.

For calculation of seismic load, equipment load shall be considered as Dead Load.

Ultrasonic pulse velocity tests shall be carried out for the top decks of all machine foundations viz. FD Fan, Mill foundations, TG deck along with substructure, Boiler Feed Pump foundations, etc., to ascertain the homogeneity & integrity of concrete.

Whenever any structure under this contract shall carry or receive additional load from the work of any other contract, the structures under this contract shall be provided with sufficient margin to carry the above load, details of which shall be finalized during detail engineering.

Gratings / chequered plates shall not be considered as restraining members for compression flange of beams/girders. Diaphragm action shall also be not considered in design. Adequate horizontal bracings to be provided.

4.00.00 DESIGN OF REINFORCED CONCRETE STRUCTURES

a) Reinforced Concrete Structures shall be designed in accordance with the requirements of IS-456 (Latest Revision), IS-13920, IS-1893 (Latest revision)& IS-875 (Latest Revision) or as specified in this specification for all possible combination of loads, e.g. dead load, live load, crane loads, wind or seismic loads, soil loads and surcharge loads etc. Ductile Detailing as per IS-13920 and IS:4326 shall be adopted. Curtailment in reinforcement shall not be allowed for RCC slabs.

The following grades of concrete as per IS-456 shall generally be used.

Sl. No.	Class	Grade of conc.	Min. cement content Kg/cum	Max. free water cement ratio
1.	i) Plain cement concrete used for screeds and fill between two foundations one above other at different levels	M15	240	0.6
	ii) Lean concrete below all foundations, plinth beams, drains, pits, etc.	M10	-	-
2.	i) Plinth protection.	M20	300	0.55
	ii) Grade slab, RCC drains and trenches, Paving, RCC Manholes and Chambers	M30	330	0.55
	iii) Precast cover slab	M25	-330	-45
3.	i) Reinforced concrete for super structure and foundation	M30	330	0.45
	ii) Reinforced concrete for water retaining structure	M30	330	0.45
	iii) RCC roads (Main road & approach road)	M30	330	0.5
4.	Pre-cast concrete	M30	300	0.5
5.	Reinforced concrete for deck & substructure of all heavy & vibrating equipment such as TG foundation, TG Top Deck, Crusher, ID, FD fan, STG, BFP, Mill & Fan Foundations, Cooling tower basin	M35	340	0.45
6.	TG Top Deck	M35	340	0.45
7.	Piles	M30	400	0.5
8.	For Chimney refer the respective section.			

b) Reinforcing bars shall be TMT CRS (corrosion resistant steel) bars of minimum grade Fe 500 conforming to IS-1786 (Latest Revision) and Mild Steel bars conforming to IS: 432 (Grade I) (Latest Revision) of vendor approved by Owner/consultant. Fe 500D / Fe 550 or higher grade reinforcement bars may be used for construction but for design of primary reinforcement, the grade shall be restricted to Fe 500 only& for design of secondary reinforcement (stirrups & ties), the grade shall be restricted to

Fe 415 only. Test certificate for reinforcement steel shall be obtained from recognized agency, before using by the successful bidder. If the steel is purchased by the bidder, Engineer may desire to check the testing of the same & the successful bidder shall arrange it in approved laboratory at his own cost.

c) Ordinary Portland cement namely Grade 43 conforming to IS: 8112 (Latest Revision) shall be used for construction of all RCC structures and foundations. Higher grade 53 may be used in the work but the design restricted to Grade43 only.

d) The design of R.C.C - Structures shall be carried out by limit state or working stress method as per the provisions of IS-456 (Latest Revision).

e) All Concrete tanks/liquid retaining structures/liquid conveying structures shall be designed in accordance with the recommendation of IS-3370 (Latest Revision) as un-cracked section.

f) Grouting material:

Grouting shall be done with Conbextra GP-2 or equivalent for Equipment foundations and Conbextra GP-1 or equivalent for all structural column bases. For pipe-supports grouting shall be done with 1:1:2 cement-sand - 6mm down stone chips. Grouting thickness shall be as per manufacturer's recommendation subject to a minimum of 25mm for equipment foundations Grouting thickness shall be 50mm minimum for all structural columns.

g) For reinforcement detailing IS:5525 (Latest Revision), IS: 13920 (latest revision) and SP:34 shall be followed.

h) The walls shall be provided with reinforcement on both faces for sections 150 mm or more, even if not required from design consideration.

i) Liquid Retaining Structures

All RCC liquid retaining/conveying structures shall be leak proof and designed as un-cracked section in accordance with IS:3370 (Latest Revision).

All water retaining / storage structures shall be designed assuming liquid up to the height of wall irrespective of provision of any over flow arrangement.

All underground structures and water retaining structure etc. shall be provided with integral water proofing admixture and non-shrink polymeric water proof grouting compound by injection from inside/outside along with application of two coats of acrylic polymer modified cementitious compound for water proofing coating as per approved manufacturer's specifications on outside surface.

Internal surface of all water retaining structures shall have 20 mm thick

plaster (1:3) admixture with approved quality water proofing compound. 10 mm thick plaster (1:3) to be provided below roof slab of water retaining structure.
Foundations below ground level coming on direct contact with soil shall be treated with two (2) coats of hot bitumen (85/25) over a coat of primer except for foundations requiring water proofing / hydro-insulation for ingress of sub-soil water.

Storm water drains shall not be provided with bituminous paint and weep holes also shall not be provided in storm water drains.

5.00.00 FOUNDATION DESIGN

The design of foundation open / pile shall be carried out by Limit State or working stress method as per the provisions of IS-456(latest revision).

The foundation shall be placed on firm and incompressible virgin strata with adequate bearing capacity. For open foundation depth of footing shall be not less than 1.0m below virgin soil. However, Open foundations in filled-up soil may also be considered for the foundations of very small structures having net SBC requirement of 5 T/sq.m and below at the discretion of Owner / consultant with the minimum depth of foundation as 1.5M from FGL & with a permissible total settlement of 25mm.The successful bidder shall carry out confirmatory SBC report and submit for approval before submitting design and drawings in filled up soil. However maximum SBC allowed in filled up soil is 5T/m2 only.

For analysis & design of all foundations, ground water table shall be considered at the Finished Ground Level.

Foundation shall be checked for safety against overturning, sliding and uplift considering ground water table at the Finished Ground Level. Loss of contact for foundations is not permitted.

Crusher to be supported on springs (VIS).

RCC deck of any vibrating equipment may be supported on vibration isolation system consisting of steel helical spring units and viscous dampers which in turn will be supported on RCC foundation system.

ID & FD fans and Mill foundations are to be provided with VIS.

The concrete foundation for supporting the turbine generator will be completely isolated from the building floors for vibration control. The foundation for Turbo-generator shall rest on suitable vibration isolation system consisting of springs and visco dampers (supplied by owner approved vendor).

The foundation for Boiler Feed Pumps / motors shall rest either on suitable vibration isolation system consisting of springs or on solid concrete foundation if the pumps / motors are placed on ground floor. In case, the Boiler Feed Pumps / motors are erected on elevated floor (above ground floor), foundations shall

rest only on suitable vibration isolation system consisting of springs.

For booster fans, the supports shall be on VIS.

Pile foundation, if adopted, shall be designed in accordance with IS:2911(Part-I / Sec-I, II and III) (Latest Revision).

The type, size, depth of the foundation / pile shall be based on the approved soil investigation report of Bidder/Owner's soil investigation report whichever is conservative

5.01.00 **Foundations**

Top of RCC columns/ pedestals for the steel columns (Boiler, Power House Columns, Bunker columns, ESP columns, etc.) shall generally be kept at a lower level so that the column base plates together with gussets and stiffeners remain below the finished floor level. Foundation levels of some columns shall have to be suitably lowered to accommodate underground services, pits, trenches, etc.

Common foundation should be provided for columns both side of the expansion joint and shall be designed for loading on both columns.

Foundations for Buildings and structures shall be designed to resist forces and moments, caused by vertical loads and by wind or seismic loads, based on static and dynamic analysis done for those structures. The foundation sections shall be sized and reinforced adequately for moments and shear stresses.

5.02.00 **Heavy and rotating Equipment Foundations**

Loadings (both static and dynamic) of major equipment such as Turbine Generator, Boiler feed pump, Mill, FD & ID fans, Crusher, etc. shall be obtained from the manufacturer's certified drawings of the specified equipment. RCC decks of FD, ID , PA fan, Turbine Generator, Boiler Feed Pump / motors & Crushers, shall be supported on vibration isolation system consisting of steel helical spring units and viscous dampers shall be completely isolated from the building floors which in turn will be supported on RCC foundation system. The foundations for Turbine Generator to rest on suitable vibration isolation system consisting of springs and damper.

The concrete foundation for supporting the turbine generator will be completely isolated from the building floors for vibration control. The foundation for Turbo-generator shall rest on suitable vibration isolation system consisting of springs and visco dampers (supplied by owner approved vendor).

The foundation for Boiler Feed Pumps / motors shall rest on vibration isolation system consisting of springs.

For static and dynamic analysis of machine foundation following data shall be furnished by the equipment manufacturer.

a) Loading diagram showing static and dynamic loads and points of application of loads.

b) Operating speed of m/c; Critical speed of m/c.

c) Weight of rotating parts; maximum eccentricity of rotating mass from the geometric axis of rotation.

d) Location of C.G. of machines in all three axes.

e) Mass Moment of Inertia.

f) Allowable amplitude/velocity of vibration at machine bearing points.

g) Temperatures in various areas during operation.

Design of foundations for major equipment shall be done in accordance with relevant parts of IS-2974 (Latest Revision). Unbalanced loads for normal operating condition as given by machine manufacturer and/or VDI 2060 whichever is more shall be used for calculating dynamic response. The dynamic analysis shall consist of free vibration analysis and forced vibration analysis. While designing following aspects shall also be taken care of.

i) Foundations shall be isolated from adjacent structures for vibration control and it shall be designed to meet the manufacturer's deflection criteria and other manufacturer’s recommendations..

ii) The turbine generator pedestals shall be designed to meet the manufacturer's deflection criteria and other recommendations.

ii) Natural frequencies of structures and components shall be away from the running speed of equipment by at least 20% generally but for important ones it shall be away by at least 30%. However, frequency separation criteria and amplitude criteria as laid down in IS:2974(Latest Revision) and/or DIN 4024 and/or VDI 2056 and/or as required by the machine manufacturer, whichever is more stringent shall also be satisfied. A fatigue factor of 2.0 shall be considered for dynamic forces / due to normal unbalance. For design of foundation of large fans, heavy & rotating fan foundations etc. provision shall be kept in the foundation for addition of mass/area for retuning of the foundations, if required at a later date.

All block foundations resting on soil shall be designed using the elastic half space theory or Barkan’s theory. The mass of the RCC block shall not be less than three times mass of the machine and the CG of the combined mass of foundation and equipment should pass through the CG of the base area with tolerance not more than 5%.

For the foundations supporting minor equipment weighing less than one ton or if the mass of the rotating parts is less than one hundredth of the mass of the foundation, no dynamic analysis is necessary. However, if such minor

equipment is to be supported on building structures, floors, etc. suitable vibration isolation shall be provided by means of springs, neoprene pads, etc. and such vibration isolation system (VIS) shall be designed suitably.

Wherever RCC top deck is designed with VIS for machine foundations, the design of the RCC top deck shall be designed and vetted by the reputed VIS manufacturer like GERB. However the overall responsibility of the overall structure including foundation lies with the EPC contractor.
Analysis and design of the Steam Turbine-Generator (STG) foundation, FD & ID fans, Boiler Feed Pumps & Crushers foundations shall be carried out in accordance with relevant codes IS: 2974 Part-3 (Latest Revision) and IS: 456 (Latest Revision) and/or manufacturer's requirements. The loads to be considered for static analysis and design shall consist of dead weight of the machine and foundation, machine power torque, condenser loads under normal operating condition, Equivalent static load due to machine unbalance, thermal elongation forces, forces due to one sided operation of the condenser, forces due to condensate pump failure, vacuum loads, forces due to piping, frictional forces at machine sole plate level for turbine, generator and condenser, temperature distribution under operating condition, failure loads of turbine (blade unbalance/loss of blade/bowed rotor), failure loads of generator (short circuit loads), seismic loads due to generator, turbine and condenser and erection loads.

In case of machines supported on VIS with springs and viscous dampers it shall be ensured that not more than 5% of the dynamic loads are transmitted to the substructure. Necessary provisions of DIN 4024 shall be adhered to while designing the substructure. Substructure shall be designed for static loads. The vibration isolation system shall consist of helical spring units and viscous dampers supporting the RCC inertia block which support the machine. The spring units shall conform to DIN 2089 and DIN 2096.

For all equipment foundations supported on VIS system, the stiffness of the supporting substructure shall be at least ten (10) times that of spring elements as per DIN 4024.

While performing dynamic analysis of fan, TG & BFP foundation, effect of soil contributing to dynamic properties shall be considered.

Wherever VIS is provided for equipment inside the Power Plant – The Civil Design document / drawings for the RCC Top deck above the VIS supporting the equipment shall be vetted / designed by the VIS spring manufacturer and the same shall be submitted to NLC / Consultant by the successful bidder for approval during detailed engineering. However the overall responsibility for the structural safety, rigidity & soundness of the entire structure lies with the successful bidder.

5.03.00 **Open Foundations**

In case open foundations are adopted, the following shall be adhered to:

a) Minimum width of foundation shall be 1.0 m.

b) Minimum depth of foundation shall be 1.0 m below NGL.

c) It shall be ensured that all foundations of a particular structure/ buildings/facility shall rest on one bearing stratum, i.e. either overburden or rock.

d) Wherever the intended bearing structure is weathered rock but the actual stratum encountered during foundation excavation consists of both overburden soil and weathered rock at founding level, under such cases either the foundation shall be lowered completely into the weathered rock or the overburden soil upto the weathered rock level shall be removed and built up through PCC up to designed foundation level.

e) The net allowable bearing pressure values to be adopted for design upon Owner's approval shall correspond to total permissible settlement as mentioned under para "permissible settlement of foundations" or the permissible settlement from functional requirement, whichever is more stringent.

Permissible settlement of foundations:

Maximum allowable total settlement for all foundations of any structure/ facility should be restricted to 25 mm except as listed below.

For all non-plant buildings as mentioned in the following list, Maximum allowable total settlement should be restricted to 25 mm for all foundations.

- Canteen
- Fire Station
- Weigh-bridge
- Time office and Security Complex including Gate-I
- Watch Tower
- Workshop
- First Aid Centre
- Permanent Stores
- Construction Store
- Hydrogen and Carbon-di-oxide Cylinder Storage Building
- Cycle/ Scooter/car stand at the main gate

5.04.00 Pile Foundations

In case piles are adopted, following shall be adhered to:

a) The pile foundation shall be of RCC, Cast-in-situ bored, precast/cast-in-situ driven pile as per IS: 2911 (Latest Revision). Bored piles shall be installed by using rotary hydraulic rig. Three-stage flushing of pile bore shall be ensured, by airlift technique or any other internationally accepted method duly approved by the Owner.

b) The minimum diameter of pile shall be 450mm for cast-in-situ and 300mm for precast piles. The uplift and lateral load capacity shall be established by field test.

c) Only straight shaft piles shall be used. Minimum cast length of pile above cut-off level shall be 1.0 m.

d) The bidder shall furnish design of piles (in terms of rated capacity, length, diameter, termination criteria to locate the founding level for construction of pile in terms of measurable parameter like (SPT &SCPT value, set criteria etc.), reinforcement for job as well as test piles, etc.) for Owner's approval.

e) The piling work shall be carried out in accordance with IS: 2911 (Relevant part) (Latest Revision) and accepted construction methodology. The construction methodology shall be submitted by the Bidder for Owner's approval.

f) Number of initial load tests to be performed for each diameter and rated capacity of pile shall be as under:

Vertical
Lateral
Uplift } Minimum of 2 Nos. in each mode.

For large size projects (for piles more than 1 000 numbers), a minimum of two tests for first 1 000 piles and additional one test for every additional 1 000 piles and part thereof

The initial pile load test shall be conducted with test load upto three times the estimated pile capacity. In case of compression test the method of loading shall be cyclic as per IS: 2911 (relevant part) (Latest Revision).

g) Number of routine pile load tests to be performed for each diameter/allowable capacity of pile shall be as under:

i) Vertical -2.0 % of the total number of piles provided.
ii) Lateral -2.0 % of the total number of piles provided.

The routine tests on piles shall be conducted up to test load of one and half times the allowable pile capacity. The Owner shall approve piles for routine load tests. Routine load tests may be done by conventional method as per IS: 2911 (Part-4) (Latest Revision).

In case, routine pile load test shows that the pile has not achieved the desired capacity or pile(s) have been rejected due to any other reason, then the Bidder shall install additional pile(s) as required and the pile cap design shall accordingly be reviewed and modified, if required, without additional cost to the Owner.

h) Testing of piles and interpretation of pile load test results shall be carried out as per IS: 2911 (Part-4) (Latest Revision). Bidder shall ensure that all the measuring equipment and instruments are properly calibrated at a reputed laboratory/ institute prior to their use. Additional measurement for pile movement shall also be done.

i) Low Strain Pile Integrity test shall be conducted on all test piles and job piles. This test shall be used to identify the piles for routine load test and not intended to replace the use of static load testing.

5.05.00 **Other Requirements**

i) In case of high ground water table, for excavations comprehensive dewatering arrangement shall be required. Scheme for dewatering and design with all computations and back-up data of dewatering and sheet pilling shall be submitted for Owner's information.

ii) The founding level for trenches/channels shall be decided as per functional requirement. The bottom of excavation shall be properly compacted prior to casting of bottom slab of trenches/channels.

iii) Excavation for open foundations shall be covered with PCC immediately after reaching the founding level. In case of any local loosening of soil at founding level during excavation, the same shall be removed and compensated by PCC of Grade M 10. The foundation pits shall be maintained dry during the complete construction period by means of suitable dewatering systems.

iv) Backfilling, around foundations and bottom of pipes, thrust blocks, etc. shall be carried out with approved material 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. Where ever necessary Sand filling shall be used for back filling.

v) Excess/surplus excavated material (debris and other unusable materials as decided by owner) shall be disposed of by the Bidder as per the instructions of the Owner upto a lead of about 5 km 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.

vi) CBR tests for rigid / concrete pavement design shall be carried out by Bidder after earth filling has been completed, if applicable.

vii) The storage tanks shall rest on flexible tank pad resting on an open foundation / pile foundation. The tank pad shall be made of two layers. The first layer shall be thoroughly compacted fill of gravel, coarse sand or other suitable material topped with minimum 75mm thick compacted crushed stone, screenings, fine gravel, clean sand or similar material mixed in hot asphalt (80 / 100 bitumen or equivalent 8 to 10% by volume), rolled and compacted. The second layer shall be with minimum 25 thick premix carpet with 12 mm and down broken stone chips and 80/100 grade hot bitumen. The tank pad shall be laid by an expert agency approved by owner/consultant having wide experience in execution of similar works. The tank pad shall be made up from founding level to the required level by controlled compaction in layers of 200 mm to achieve a relative density of 85% using suitable compaction equipment approved by the Owner. In addition to the above, in case of an open/shallow foundation, a ring wall shall be provided adjacent to the tank wall for retaining the fill below tank. The foundation system shall be designed as per the provisions of IS: 803. The tank shall have a flexible bottom plate, which shall establish complete bearing with the foundation fill.

6.00.00 GENERAL REQUIREMENTS

6.01.00 Minimum Thickness of Structural Elements

The following minimum thickness shall be followed:

Pile caps	1.5 times the diameter of pile
Suspended floor / slab / walkways / canopy slabs, etc. (Thickness of roof slab and intermediate floors shall be measured excluding trough depth of metal deck sheet)	150 mm
Ground floor slab/Grade slab (non-suspended)	200 mm
Water Retaining slabs / walls	200 mm
Walls of Cable / pipe trenches / underground pits / Launder walls and base slab	150 mm
Drain walls and base slab upto 500mm depth	125 mm
Drain walls and base slab more than 500mm depth	150 mm
All footings (including raft foundations)	300 mm
Parapets	125 mm
Sunshades at edge	75 mm
Pre-cast louvers / fins	50 mm

Pre-cast trench cover slabs / floor slabs / louvers	100 mm
Paving (except for RCC Roads)	200 mm
Basement walls and base slab	250 mm
Silo / bin walls	200 mm
Underground reservoir	
Below ground (Walls and base)	250 mm
Above ground (Walls)	200 mm
RCC Roads	250 mm

The above are minimum requirement only unless otherwise mentioned elsewhere in the specification.

From fire resistance point of view minimum thickness of reinforced concrete members shall be as per Fig 1 or Table 16a of IS 456 (Latest Revision) or specified above, whichever is higher.

6.02.00 **Minimum Heights for Pedestals/Encasements of Steel Columns**

Pedestals to Steel Columns for building structures:

In case the top of pedestal is kept at a lower level so that the column base plate together with gussets and stiffeners remain below finished floor level (FFL) the column bases as well as the column sections shall be encased in concrete above FFL as per following unless otherwise specified.

a)	Open area	:	300 mm above paved level
b)	Covered area	:	300 mm above FFL

Stair and ladder pedestal shall be kept 200 mm above the finished floor level.

Pedestals to Steel Columns for Equipment structure:

a)	Equipment in open area	:	as required (300mm min)
b)	Equipment in covered area	:	as required (150 mm min)
c)	Structures and equipment supplied by vendor	:	as per vendor's data subject to minimum as specified above

6.03.00 **Ground floor slab-on-grade**

Ground floor slab-on-grade shall be minimum M-30grade RCC construction laid

over minimum 100mm thick lean concrete of Grade M10. Minimum consolidated 230mm thick graded BG stone or laterite (63mm down size) soling with interstices filled with sand/gravel and compacted mechanically, shall be provided as sub-base below lean concrete. The sub-base shall be laid over rammed and hydraulically compacted sand fill of minimum 300 mm thick over well compacted (Min. 90% Proctor density) sub-grade.

The ground floor slab shall be of minimum 200mm thick with double layer reinforcement (top & bottom)of 10mm (minimum)dia at the rate of 200 (maximum) c/c both ways with 50 mm thk IPS floor finish

For Toilet Floor shall be 100 thick PCC (M25) with 50 thick floor finish as per system requirement .

6.04.00 **Stairs, Platforms, Handrails**

All internal stairs, platforms and walkways shall either be of RCC or Structural Steel with minimum 8mm thick chequered plate construction. All outdoor stairs, platforms and walkways shall either be of RCC or Structural Steel with GI grating made of minimum 40 x 6 mm Flats. S.S handrails shall be provided for TG building and service building

All handrails (For steel structures and RCC structures)made of MS Galvanized hand railings with 40 mm NB (medium) main posts and 40 mm NB (medium) as horizontal rails as per IS:1161(Latest Revision) with GI toe guard min 6 mm thick & min 150 mm wide shall be provided including throughout staircase and landing.

7.00.00 ROADS

Geometric design of road shall be done in accordance with Indian Road Congress Standard. The ruling gradient for roads in longitudinal direction shall be 1 in 30. Normally roads shall have much flatter gradient. Transverse camber of 1 in 40 shall be provided.

A detailed CBR test, shall be carried out as per the procedure outlined in IS-2720 (Part-XVI)(Latest Revision). CBR test shall be carried out in remoulded soil samples under soaked condition.

All roads shall have hard shoulder on either side of carriageway. Shoulders shall have sufficient load bearing capacity to support loaded trucks. A flatter slope of 1 in 30 shall be provided on shoulders. A Table is provided in Vol-II G 1 / Section-I showing Carriageways, shoulder widths etc.

Only RCC box culverts shall be provided for drainage and for all the underground conduits at road crossings. Level crossings shall be provided where a Railway siding line crosses the road. All culverts shall be designed for IRC class "AA" loading and checked for class A loading.

At all road crossings RCC box culverts along with manholes (if required) on both sides shall be used. Such road culverts and its allied structures including R.C.C. Road Crossing of Trenches shall be designed for Class `AA' loading (wheeled and tracked both) and to be checked for Class `A' loading as per IRC standards.

For RCC roads the cross section as per cl 2.07.00/Vol II-G2/Part A/Section X shall be followed.

8.00.00 DRAINAGE

Open RCC rectangular drains shall be provided for storm water. However, perforated RCC cover slabs (minimum 50mm thick or as per design, whichever is higher) with GI gratings at 4m interval shall be provided for drains in Boiler, Transformer and Switch yard areas. The thickness of sides & bottom of drains shall be minimum 125 mm or as per design considerations whichever is higher. Drains shall have minimum 600mm base width. RCC box culverts shall be provided for road and rail crossing. Drains shall be provided on both sides of the roads. For depth more than 500mm drain, minimum 150mm wall thickness with double layer reinforcement shall be provided.

Inside surface of the drain will have smooth neat cement finish over with 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 minimum slope of the drain shall be 1:1000 longitudinally to take care of the silting problems. It is recommended to maintain the maximum velocity within 1.2 m/sec.

9.00.00 TRANSFORMER TRACK & JACKING PAD

Lay out of transformer track and jacking pads shall be as shown in appropriate drawing.

Transformer track shall be designed as beam on elastic foundation. For this, appropriate soil investigation / test shall be carried out to establish design parameters. Grade of concrete, reinforcement etc. shall be as specified earlier.

10.00.00 MISCELLANEOUS DESIGN / CONSTRUCTION CRITERIA

1) All RCC/Steel buildings shall be provided with RCC Plinth beams

connected to RCC Columns/Pedestals. All masonry walls from ground floor shall be placed on reinforced concrete plinth beams connected to RCC Columns/Pedestals. However, light internal partitions may be placed on ground floor slab. The plinth beam shall be partially above FGL and partially below FGL. Minimum embedment of the plinth beam below Finished Ground level (FGL) shall be 300 mm. All RCC/Steel buildings shall be provided with Wall/Tie beams at every 2.5 metre height of brick wall.

2) The steel column base plate along with stiffening gusset plates shall not be protruded above floor level for main plant area. The column base assemblies shall be encased with concrete M20 upto floor level.

3) For exposed areas the columns shall have a minimum encasing of 300 mm above paved level in main plant area.

4) Ramps for building entrance shall be cast in situ RCC slab and the slope of ramps shall not be more than 1 (vertical) to 8(horizontal).

5) Minimum 100 mm thick lean concrete M10 shall be provided below all underground structure, trenches etc., to provide a base for construction.

6) All buildings shall have RCC/steel framed super structure. All walls shall be non-load bearing infilled panel walls.

7) Duct banks consisting of PVC/GI conduits for cables shall be provided with reinforced concrete encasing of M25grade. The minimum depth of top of duct bank from grade level shall be 500mm.

8) Angles 50 x 50 x 6 mm (min.) with lugs shall be provided for edge protection all round of cut-outs/opening in floors, edge of drains supporting grating covers, edges of RCC cable/pipe trenches, manholes supporting covers, supporting edges of pre-cast covers. RCC stairs/ steps and any other places where breakage of corners of concrete is expected.

9) Trenches located outside building shall project at least 100mm above the finished formation level so that no storm water shall enter into the trench. Trenches and drains shall not be clubbed together by providing a common wall. The bottom of the trench shall be sloped suitably for draining out the collected water into the sump pit. The pre-cast covers shall be of minimum M-25grade and shall not weight more than 65 kg. Lifting hooks shall be provided in the pre-cast covers. The minimum drainage slope along line shall be 1 in 1000.

10) All underground concrete structure such as basement, sumps water-retaining structure shall be designed for water tightness.

11) The concrete surface of foundations in contact with earth shall be provided with two coats of hot bituminous painting (85/25) conforming to IS:702 @ 1.2kg/sq.m in each coat) over a coat of bitumen primer except where special water proofing is specified for specific structures mentioned

elsewhere.

12) All joints, including construction and expansion joints for the water retaining structure and others below subsoil water level shall be made water tight by using PVC ribbed water stops with central bulb. The minimum thickness of PVC water stops shall be 6 mm and minimum width shall be 230mm.

13) All mild steel parts used in the water retaining structures shall have anticorrosive epoxy based paint or equivalent.

14) Anti-termite chemical treatment shall be given to column pits, wall trenches, foundations of buildings, filling below the floors, switchyard area etc., as per IS-6313 (Latest Revision) and other relevant standards.

15) Concrete hume pipes for underground service (sewage line) shall of class NP3 as per IS-458 (Latest Revision).

16) For all buildings suitable arrangements for draining out of water collected from equipment, blowdowns, leakages, floor washing, fire-fighting etc., shall be provided for each floor.

17) All RCC walls and slabs shall have two layers of reinforcement for section having thickness 150 mm and above.

18) All gratings shall be made of 40x6 thick GI flat unless noted elsewhere in the specification. Stairs treads made of grating shall be provided with non-skid abrasive nosing.

19) NOT USED.

20) Unless stated elsewhere specifically in this specification, the finished floor level of any building shall be at least 500 MM above the finished grade level and 800mm above FGL for electrical buildings. The finished paving level shall be at least 300mm above FGL for Boiler Area and switchyard area.

21) For RCC buildings of more than 15M shorter span steel roof truss/girders maybe provided to support the concrete roof on permanently colour coated (on exposed face) galvanized M.S. troughed metal decking over concrete columns. Gable and side cladding will be constructed with fly ash brick masonry.

22) Sealing of joints shall be done by two part polysulphide sealant and shall be from approved manufacturer conforming to IS: 12118 (Latest Revision). Material shall consist of polysulphide polymer and a curing agent. Clear cover to reinforcement shall be as per IS:456 for moderate exposure condition. However, for concrete in contact with soil and water it shall not be less than 50 mm.

23) Generally foundation for buildings & equipment shall not be structurally

connected to ground floor slab.

24) Allowable differential settlement between two foundations shall be as per IS:1904 (latest). Foundations for structures and equipment shall be proportioned to resist the worst conditions of loadings and shall be generally designed as per the provisions of IS:1904.

25) For equipment foundations, the total and differential settlements that are likely to occur shall be assessed. Design of such foundations will restrict expected settlements to within limits required for proper operation of the plant.

26) Machine foundations shall be separated from adjacent building column foundations by a minimum gap of 25 mm to avoid propagation of vibrations into the buildings.

27) For all settlement sensitive equipment and structures, due care shall be taken during designing of structures and foundations to limit the settlement as required for efficient functioning.

28) In general, for fixing of gates/screens with the RCC wall/slab, anchor fasteners or any other anchors shall not be used. The fixing shall be done with cast-in situ bolts/pockets/inserts in RCC.

29) If any similar design criteria mentioned elsewhere in this specification contradict the above, the stringent of the criteria shall be adopted for design.

ANNEXURE - I

VIBRATION ISOLATION SPRING FOUNDATIONS

1.0 General Requirement

Steel helical springs and viscous dampers shall be provided for equipment requiring foundations with vibration isolation system by the supplier with requisite experience and proven track record of similar installation in power plants of Unit capacity not less than 800 MW.

Complete Vibration Isolation System with Steel Helical Springs and Viscous Dampers shall be provided for the foundations of Crushers.

Complete Vibration Isolation System with Steel Helical Springs and Viscous Dampers shall be provided for the foundations of Turbo-generator. For Boiler Feed Pump and any other vibrating/rotating equipment resting on intermediate floors, springs to be provided if recommended.

2.0 Material (Design & Supply)

2.1 Steel helical springs and viscous dampers shall consist of

i) Steel helical spring units and viscous dampers along with viscous liquid including associated auxiliaries for installation of the spring units and dampers like steel shims, adhesive pads etc.

ii) Frames for pre-stressing of spring elements.

iii) Suitable hydraulic jack system including electric pumps, high-pressure tubes etc. required for the erection, alignment etc. of the spring units. One set of extra hydraulic jacks and hand operated pumps shall also be provided.

iv) Any other items which may be required for the pre-stressing, erection, release of pre-stress, alignment and commissioning of the steel helical springs.

2.2. The objective of designing the supporting arrangement for any rotating equipment shall be so that the vibration level is maintained as minimum as possible under all operating conditions. Accordingly, respective rotating equipment shall be supported on RCC deck slab which in turn shall rest on vibration isolation unit consisting of steel helical springs and viscous dampers, which in turn shall be supported on RCC supporting structure. The above design shall form part of this specification.

2.3. The spring units shall have definite stiffness in both vertical and horizontal directions with the horizontal stiffness not less than 30% of vertical stiffness. The stiffness shall be such that the vertical natural frequency of any spring unit at its rated load carrying capacity is not more than 3 to 5 Hz.

2.4. The damper units or spring-cum-damper units shall be of viscous type offering velocity proportional damping. The damper units shall be suitable for temperatures ranging from 0 to 50˚C. The damping resistance of individual damper units shall be such that the designed damping is provided using reasonable number of units. Damper shall have damping resistance ranging from 40 kN sec/m to 750 kN sec/m.

2.5. The sizes of the spring units, damper units and spring-cum-damper units shall be such that groups of such units can be accommodated on column heads in case of elevated foundations and on pedestals/walls in case of foundations at ground level.

2.6. The steel helical springs and viscous dampers shall be designed for ensuring “fit and forget” guarantee.

3.0. Manufacturing & Testing

3.1. Complete manufacturing and testing of the steel helical springs and viscous dampers shall be done at the manufacturing shop of the approved sub-vendor/supplier. For this purpose, the successful bidder/sub vendor shall submit the detail program for approval of engineer and take up the manufacturing/testing after approval of such program. The program shall include:

i) Manufacturing schedule and quality check exercised during manufacturing.

ii) Detail of test to be carried out at the manufacturing shop with their schedule.

iii) Special requirements, if any, regarding concreting of top deck.

iv) Complete step-by-step procedure covering the installation and commissioning of the spring system.

v) Manuals for erection, commissioning, testing and maintenance of the steel helical springs and viscous dampers.

vi) A checklist for confirming the readiness of the civil fronts for erection of steel helical springs and viscous dampers.

vii) Checklist for equipment required at each stage of erection.

viii) Bill of materials (data sheet) of various elements such as spring units, viscous dampers, with their rating, stiffness etc. included in the supply.

ix) Bill of materials (data sheet) for frames for pre stressing, hydraulic jack including electric pump, high pressure tubes, hand operated pump etc. with their rating and numbers.

x) Any other details which may be necessary to facilitate design and construction of the foundations/structures.

3.2 The springs shall conform to codes DIN 2089 and DIN 2096. The quality assurance and inspection procedures shall be finalized on the basis of the above codes and the quality plans be drawn accordingly.

4.0 Erection, Commissioning and Supervision

4.1 Complete erection and commissioning of the steel helical springs and viscous dampers including pre-stressing of elements, placing of elements in position, checking clearances on the shuttering of the RCC top deck, releasing of pre stress in spring elements, making final adjustments and alignments etc. all shall be done a specialist supervisor of supplier/sub vendor trained for this purpose.

4.2 The scope of work shall be deemed to include all activities, which may not have been explicitly mentioned but are reasonably implied for the successful commissioning of steel helical springs and viscous dampers.

4.3. The successful bidder shall guarantee the performance of the steel helical springs and viscous dampers for 24 months from the date of commissioning of each machine which shall be termed as “Guarantee Period”.

5.0. Realignment of Spring System

If any realignment of the steel helical springs and viscous dampers is required to be done for aligning the shaft or for any other reasons during the first one year of operation from the date of Commercial Operation of the machine, the same shall be done by the successful bidder as and when asked for at no extra cost of the Owner.

6.0. Acceptance Criteria

Stiffness values shall be checked. The permissible deviations shall be as per DIN 2096. Following acceptance criteria shall be followed:

i) General workmanship is being good and as recommended by the manufacturer is approved by the Engineer.

ii) Tolerances are within the specified limit

iii) Material test certificate (MTC) is in compliance with the applicable codes/standards.

iv) Bought out material is from the approved manufacturer/vendor

v) Bought out material is matching with the approved sample

ANNEXURE - I

7.0. Codes and Standards

Latest revision of following codes shall be used for the design of the spring supported foundations :

IS: 456	Code of practice for plain and reinforced concrete.
IS: 2974	Code of practice for design and construction of machine foundations.
IS: 1893	Criteria for earthquake resistant design of structures
DIN: 4024	Machine foundations; Flexible supporting structures for machine with rotating masses
DIN: 2089	Helical compression springs out of round wire and rod : calculation & design
DIN: 2096	Helical compression springs out of round wire and rod : quality requirements for hot formed compression springs.
VDI: 2056	Criteria for assessing mechanical vibrations of machine.
VDI: 2060	Criteria for assessing the state of balance of rotating rigid bodies.

ANNEXURE - II

Special Conditions for Construction of TG Foundation

1.0 Scope

i) The work to be performed under this contract consists of providing all materials except those supplied by the Purchaser, shuttering, staging, inserts, construction equipment, labour and all incidental items not shown or specified but reasonably implied or necessary for the proper completion of the work, all in the strict accordance with the drawings, schedules and specifications and including revisions and amendments thereto and such detailed drawings as may be provided by the Consultant, during the execution of the work.

ii) It is not the intent to specify completely herein all the details of designs and construction of the structure. However, the structure shall conform in all respects to high standards of Engineering, design and workmanship and be capable of performing in continuous commercial operation upto contractors guarantee in the manner acceptable to the Purchaser / Consultant who will interpret the meaning of drawings and specifications and shall have the power to reject any work or materials which in his judgment are not in full accordance therewith.

2.0 Form Work

i) All forms shall be abundantly wetted on both sides before concrete is poured. The date of removing forms for each individual stage of construction shall be fixed by the Purchaser / Consultant.

ii) The minimum period for striking of formwork shall be as follows:-

a)	Vertical sides of beams and pedestals	-	7 days
b)	Bottom of beams / slabs	-	28 days

However, the vertical faces shall be loosened after 24 hours of completion of concreting the supports.

iii) Concrete surface shall not normally be patched or otherwise treated after the removal of forms. Where the surfaces exposed on stripping is not of a satisfactory nature, owing to the contractors failure to take necessary precaution before, during of after the concrete placing, such surfaces shall be worked and finished in accordance with the instructions of the Purchaser / Consultant at the cost of the contractor. The pores shall be filled in with a neat solution of cement and water applied by brush and when dry the surface shall be rubbed down with carborundum stone. The cost of the above treatment shall be deemed to be included in the unit rate entered by Contractor. The top surface of the T.G. deck shall be float-finished, unless otherwise specified to the required levels. There must be no surface grouting are treating which might draw the 'fines' to the top. All shuttered surfaces shall be left as they strip without removing boards or panel markings. Any

serious honey combing will render the concrete work liable to rejection and cutting out and re-concreting wholly or partly as the Engineer in Charge directs. All costs involved in repairing defect shall be borne by the Contractor.

iv) The arrangement and method for movement of workers during TG construction to various levels of the TG foundations shall be submitted well in the advance to the Engineer- in – Charge for his approval for taking up the work.

v) In addition to the above paras the contractor shall also satisfy all other requirements for formwork.

3.0 Staging

i) The entire staging for supporting the formwork, walkways and platforms for placing concreting equipment such as vibrators, etc., shall be of structural steel. The staging shall be designed for the worst combination of loading as specified hereinafter.

ii) The Contractor shall submit 6 copies of design calculations and staging drawing to prove adequacy of the staging for approval of the consultant. On receipt of final approval, the contractor shall supply 20 copies of approved drawings for distribution.

iii) The staging shall be so designed that no load from platforms are passed on to the formwork at the top.

iv) All platforms, walkways etc., shall be clear of the formwork and at least 200mm above it. The width of platforms and walkways shall be at least 1.2 metres for easy movement of labour both ways.

v) The platforms shall be planks or bamboo mats (clamped with steel strips suitably stiffened to avoid springing).

vi) The form work and staging shall be designed for a live load of 1000 $Kg/m^{2.}$

vii) Unit weight of green concrete shall be considered as $2500kg/m^3$ for design of form work and staging.

viii) The staging shall be braced in both the directions.

ix) The staging shall be supported on rigid surfaces at ground level.

x) The staging shall be sufficiently rigid to prevent any distortion in the form work.

4.0 Special Precautions

i) The contractor shall take all precautions to ensure concreting of TG Raft, columns and TG Deck in one pour each. Concreting shall be continuous and no break in concreting shall be permitted.

ii) The Contractor shall prepare a scheme for concreting giving details of number of mixers, labour, vibrators, pouring schedule and obtain prior approval of the same from the Engineer-in-Charge before starting of concreting.

iii) The Contractor shall ensure that at no time the temperature of the green concrete exceeds 38 degree C by taking proper precautions. If required, ice shall be added to control the temperature at no additional cost to the Purchaser.

iv) Approved "Retarders" shall be used by the contractor in the proportions specified by the manufacturer for total concreting work of the TG foundation. The cost of the admixture shall be included in unit rates quoted by the Contractors.

5.0 Test for Soundness of Concrete

i) After completion of the construction of TG foundations, the contractor shall get the Deck and column tested for soundness of concrete by "ultrasonic wave – non – destructive test method" from reputed research institution like IIT /SERC etc. at no extra cost to the Purchaser.

ii) If the test report calls for any rectification in the concrete works by way of pressure grouting or otherwise, the same shall be carried out by the contractor at no additional cost to the Purchaser to the satisfaction of the Purchaser / Consultant.

iii) If require, any additional test to establish the adequacy of the rectification works carried out shall be done by the contractor at no extra cost to the Purchaser.

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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.

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SECTION-IV

SPECIFIC DESIGN REQUIREMENTS [ARCHITECTURAL]

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SECTION - IV

SPECIFIC DESIGN REQUIREMENTS [ARCHITECTURAL]

1.00.00 SCOPE

The architectural services shall cover finishing work of power house, Bunker building and all auxiliary buildings, Non-plant buildings included under the specification starting from brick work, partition walls, roof protection, finishing of walls, floors and ceilings, false ceiling, cladding, as required potable water system, service water, Plumbing and sanitation etc. as required for functional requirement. Chimney are covered separately in their relevant sections.

The bidder offer shall cover the complete requirements as per the best prevailing practices keeping in view the statutory and functional requirements of plants & facilities and providing enough space & access for operation, use & maintenance and to complete satisfaction of the owner.

Buildings under scope of work (also refer section 3.00.00 of Volume II/ G-1 Section I):

Plant buildings:

Turbine and its related Auxiliaries

- Turbine Building / Power house building
- CPU Regeneration Building
- ACW Pump house for each unit
- Air Washer Room for each unit on roof of each unit ACW Pump House
- A/c Plant Building and inert gas room
- CST Pump Shed
- DG Plant Shed

Boiler and its related Auxiliaries

- Mill and Bunker Building
- Boiler Maintenance Building
- ESP Control Building.
- Fuel Oil Unloading-Cum- Pressurizing Pump House
- Compressor Shed in Ammonia Storage Area
- Auxiliary Boiler MCC and Control Building.

- MCC / Operator Room for SCR System(Common for all three units)
- RIO-cum-VFD Panel Room
- Plant IA/SA Compressor House

Coal Handling System and its related Auxiliaries

- Receiving Tower
- Crusher House
- Drive House
- Junction Towers
- Conveyor gallery
- CHP Control room cum Switchgear room
- Pump cum compressor house for DSS/DFDS
- Coal Handling system maintenance Building

Ash Handling System and its related Auxiliaries

- Compressor House and Main control room
- Ash water pump house including switchgear room and control room
- Silo utility building cum HCSD Pump House
- Ash water Transfer pump house including switchgear and control room

Raw Water Intake & Transfer System

- Raw Water Intake pump house near Hirakud Reservoir with Control & Switchgear Room
- Raw Water Transfer pump house & switchgear room

Water Pre-treatment & DM Water System

- Chemical House with Treatment Plant/ Lab
- Degassed water storage tank & pump house
- DM plant building with switchgear room, control room
- Clarified Water pump houses with SWGR/MCC Room for PT plant & DM plant
- Pump house for Rain water harvesting Pond.
- PW Chlorination plant building
- UF Permeate storage tank & pump house

Circulating Water System

- CW pump house With Switchgear Room and RIO room
- CW Treatment cum Chlorination plant building

Effluent Treatment Plant

- ETP building including pump house and control & switchgear room
- ETP CTBD / RO plant building with effluent disposal system
- ETP reject treatment plant building

Sewage Treatment Plant(2 nos.)

- STP building (2 nos.)

Fire Protection & Detection System

- Fire Water Pump House
- Fire Water Booster Pump House

Switchyard

- GIS Control Room
- GIS Building as per electrical requirement

Hydrogen Generation plant

- Hydrogen Generation building with cylinder storage facility.

FGD and its related Auxiliaries

Limestone based process will be adopted for FGD system. The buildings / structures envisaged are listed below.

Limestone Based System

- Limestone Storage Building/Covered structural steel shed
- Limestone Crusher House
- Limestone Grinding Building
- Absorber Pump & Oxidation air blower House

- Electrical Switchgear & Control Building (FGD main building)
- Gypsum De-watering House
- Gypsum Storage Building /shed
- Junction Tower (If applicable)

Non-Plant buildings:

- Service Building
- Canteen
- Fire Station
- Weigh-bridge (three numbers)
- Workshop
- First Aid Centre
- Permanent Stores
- Construction Store
- Toilet Blocks -one number for CHS area and one number for Boiler area (Separate Building)
- Cycle/Scooter stand and Car Parking shed near Service Building

Above list of Plant & Non Plant Buildings is not exhaustive. Buildings necessary for the smooth operation of the Power Plant shall be within this scope of work of the bidder.

Building Description

Sl. No.	List of Structures / Buildings	No. Reqd.	No. of Storey	Types of Building structure				
				Frame / Structure	Floors	Roof	Side Cladding	Remarks
Turbine and its related Auxiliaries								
1.	Turbine Building	1	As per layout	Steel	Metal deck with R.C.C	Metal deck with R.C.C	230mm fly ash Brick work side cladding upto 3.0m from FFL and above that double skinned insulated zincalume metal sheet cladding upto roof level to be considered for 'A' row and gable ends. At B row brick cladding will be upto deaerator floor and above deaerator floor double skin zincalume metal cladding upto roof level. On C Row, it will generally be double skin metal cladding above 3m high brick wall above FFL upto roof level of B-C bay. Above 3m level, where brick work is technically required in certain areas like – electrical room etc., single skin zincalume metal cladding will be placed externally covering the brick wall as continuation of metal clad façade.	

Sl. No.	List of Structures / Buildings	No. Reqd.	No. of Storey	Types of Building structure				
				Frame / Structure	Floors	Roof	Side Cladding	Remarks
2.	CPU regeneration building	1	G+2	Steel	Metal deck with R.C.C	Metal deck with R.C.C	Fly Ash Brick wall cladding	
3.	ACW pump house with Air washer room at roof	3	G+1	Steel	R.C.C. over metal deck	Metal deck with R.C.C	Side cladding shall be by fly ash brick upto 1.0 m height from FFL and remaining part shall be Double skin sheet insulated Zincalume metal cladding	
4.	A/C plant building and inert gas room	1	G	R.C.C.	R.C.C.	R.C.C.	Fly Ash Brick wall cladding	
5.	CST Pump Shed	1	G	Steel	R.C.C.	Sheeting	Single skin, Zincalume metal cladding	
6.	DG Plant Shed	1	G	Steel	R.C.C.	Sheeting	Open	
7.	Plant IA/SA Compressor House near SG	1	G	Steel	R.C.C.	Metal deck with R.C.C	Fly Ash Brick wall cladding.	
Boiler and its related Auxiliaries								
1	Mill &Bunker Building	6		Steel	R.C.C.	R.C.C. on metal deck sheet.	Double skin with insulation Colour coated Zincalume sheet metal cladding	
2	Boiler maintenance building	1	G	Steel	R.C.C.	R.C.C. on metal deck sheet.	Fly Ash Brick wall cladding	
3	ESP control building	3	G+3	R.C.C.	R.C.C.	R.C.C.	Fly Ash Brick wall cladding	

Sl. No.	List of Structures / Buildings	No. Reqd.	No. of Storey	Types of Building structure				
				Frame / Structure	Floors	Roof	Side Cladding	Remarks
4	Fuel oil unloading cum pressurizing pump house	1	G	RCC	R.C.C.	RCC	Fly Ash Brick wall cladding	
5	Auxiliary boiler MCC & control room	1	G	RCC	R.C.C.	RCC	Fly Ash Brick wall cladding	
6	Compressor Shed in Ammonia Storage Area	1	G	Steel	R.C.C.	sheet roofing	Open.	
7	Electrical Room for SCR System	1	G	RCC	R.C.C.	R.C.C.	Fly Ash Brick wall cladding	
8	RIO-cum-VFD Panel Room	3	G	Steel	R.C.C.	R.C.C. on metal deck sheet.	Fly Ash Brick wall cladding	
Coal Handling System and its related Auxiliaries								
1	Receiving Tower	1	G	Steel	RCC over metal deck	Metal deck with RCC	Single skin, Zincalume metal cladding fly ash brick upto 1m height with sheet overlap 150mm	
2	Drive House	1	G	Steel	-	Metal deck with RCC	Single skin, Zincalume metal cladding above fly ash brick upto 1m height with sheet overlap 150mm	
3	Crusher House	1	Multi-storied	Steel	RCC over metal deck	Metal deck with RCC	Double skin, Zincalume metal cladding with insulation above 3.0m high fly ash brick wall	

Sl. No.	List of Structures / Buildings	No. Reqd.	No. of Storey	Types of Building structure				
				Frame / Structure	Floors	Roof	Side Cladding	Remarks
4	Junction towers	6		Steel	RCC over metal deck	Metal deck with RCC	Single skin, Zincalume metal cladding above fly ash brick upto 1m height with sheet overlap 150mm	
5	Conveyor gallery	As per layout	NA	Steel	Chequered plate floor with minimum 8 mm thickness	Single skin, Zincalume metal roofing	Single skin, Zincalume metal cladding	
6	CHP Control room cum switchgear room	1	G+1	RCC	RCC	RCC	Fly Ash Brick Wall	
7	Pump cum compressor house for DSS/DFDS	1	G	RCC	-	RCC	Fly Ash Brick Wall	
8.	Coal Handling System Maintenance Building	1	G	Steel	-	Metal deck with RCC	Fly Ash Brick Wall	
Ash Handling System and its related Auxiliaries								
1	Compressor House including switchgear and Main control room	1	Only G for Compressor House	RCC	-	RCC	Fly Ash Brick Wall	

Sl. No.	List of Structures / Buildings	No. Reqd.	No. of Storey	Types of Building structure				
				Frame / Structure	Floors	Roof	Side Cladding	Remarks
			and G+1 for Switch gear room					
2	Ash water pump house including switchgear room and control room	1	G	Steel	-	RCC over metal deck	Fly Ash Brick Wall	
3	Ash water Transfer pump house including switchgear room and control room	1	G	Steel	-	RCC over metal deck	Fly Ash Brick Wall	
4	Silo utility building cum HCSD pump house	1	G	RCC	-	RCC	Fly Ash Brick Wall	
Raw Water Intake & Transfer system								
1	Raw Water Intake Pump House with Control & Switchgear Room	1	G	RCC	-	RCC	Fly Ash Brick Wall	

Sl. No.	List of Structures / Buildings	No. Reqd.	No. of Storey	Types of Building structure				
				Frame / Structure	Floors	Roof	Side Cladding	Remarks
2	Raw Water Transfer Pump House & switchgear room	1	G	RCC	-	RCC	Fly Ash Brick Wall	
Water Pre-treatment & DM water System								
1	Chemical House with Treatment plant/ Lab	1	G+1	RCC	RCC	RCC	Fly Ash Brick Wall	
2	PW Chlorination plant building	1	G	RCC	-	RCC	Fly Ash Brick Wall	
3	UF Permeate storage tank &pump house	1	G	Steel	-	Shed with single skin zincalume sheet	Open	
4	DM plant building with switchgear room, control room	1	G	RCC	-	RCC	Fly Ash Brick Wall	
5	Clarified Water pump house with switchgear/MCC room for PT Plant	1	As per functional requirement	RCC	-	RCC	Fly Ash Brick Wall	
6	Clarified Water pump house with	As per function	As per function	RCC	-	RCC	Fly Ash Brick Wall	

Sl. No.	List of Structures / Buildings	No. Reqd.	No. of Storey	Types of Building structure				
				Frame / Structure	Floors	Roof	Side Cladding	Remarks
	switchgear/MCC room for DM Plant	al require ment	al require ment					
7	Degassed water storage tank & pump house	1	G	RCC	-	RCC	Fly Ash Brick Wall	
8	Pump house for Rain water harvesting pond	1	G	RCC	-	RCC	Fly Ash Brick Wall	
Fire Protection & Detection System								
1	Fire water Booster PH	As per function al require ment	As per function al require ment	RCC	-	RCC	Fly Ash Brick Wall	
2	Fire water PH	As per function al require ment	As per function al require ment	RCC	-	RCC	Fly Ash Brick Wall	
Circulating Water System								
1	CW pump house	1	G	Steel	-	RCC on	Single sheet Zincalume cladding	

Sl. No.	List of Structures / Buildings	No. Reqd.	No. of Storey	Types of Building structure				
				Frame / Structure	Floors	Roof	Side Cladding	Remarks
	with Switchgear Room and RIO room					Metal Deck (annex Building roof will be RCC)	over 1.0m high Fly ash brick wall from FFL and Fly Ash Brick Wall for annex Building	
2	CW treatment cum Chlorination plant building	1	G	RCC	-	RCC	Fly Ash Brick Wall	
Effluent Treatment Plant								
1	ETP building including pump house and control room	1	G	RCC	-	RCC	Fly Ash Brick Wall	
2	ETP CTBD / RO building with effluent disposal system	1	G	RCC	-	RCC	Fly Ash Brick Wall	
3	ETP reject treatment plant building	1	G	RCC	-	RCC	Fly Ash Brick Wall	
Sewage Treatment Plant								
	STP building	2	G	RCC	-	RCC	Fly Ash Brick Wall	
Switchyard								

Sl. No.	List of Structures / Buildings	No. Reqd.	No. of Storey	Types of Building structure				
				Frame / Structure	Floors	Roof	Side Cladding	Remarks
1	GIS Control Room	1	G+1	RCC	RCC	RCC	Fly Ash Brick Wall	
2	GIS Building	Number shall be as per Electrical requirement	G	RCC	-	RCC on Metal Deck	Fly Ash Brick Wall	
Hydrogen Generation Plant								
1	Hydrogen Generation Building with cylinder storage facility	1	G	RCC/ Steel	-	RCC on Metal Deck / single skin Zincalume sheet roofing (For storage area)	Fly ash brick work with RCC Jally	
FGD (Limestone Based System)								
1	Limestone Storage Building	1	G	Steel	--	Colour coated Zincalume sheet metal slopped roofing	Single skin Colour coated Zincalume sheet metal cladding above 3.0m high fly ash brick wall.	
2	Limestone Crusher	1	Multi-	Steel	RCC	RCC over	Double skin, Zincalume metal	

Sl. No.	List of Structures / Buildings	No. Reqd.	No. of Storey	Types of Building structure				
				Frame / Structure	Floors	Roof	Side Cladding	Remarks
	House		storied			metal deck	cladding with insulation above 3.0m high fly ash brick wall	
3	Limestone Grinding Building	1	G	Steel	--	R.C.C. on metal deck sheet.	Single skin Colour coated Zincalume sheet metal cladding above 3.0m high fly ash brick wall.	
4	Absorber Pump & Oxidation air Blower House	3	G	Steel	--	R.C.C. on metal deck sheet.	Fly Ash Brick wall cladding	
5	Electrical Switchgear & Control Building	1	G+1	R.C.C.	R.C.C.	R.C.C.	Fly Ash Brick wall cladding	
6	Gypsum De-watering House	1	G+2(part plan)	Steel	R.C.C on metal deck sheet	Single skin Colour coated Zincalume sheet metal slopped roofing	Single skin Colour coated Zincalume sheet metal cladding above 3.0m high fly ash brick wall.	
7	Gypsum Storage Building	1	G	Steel	--	Single skin Colour coated Zincalume sheet metal slopped roofing	Single skin Colour coated Zincalume sheet metal cladding above 3.0m high fly ash brick wall.	

Sl. No.	List of Structures / Buildings	No. Reqd.	No. of Storey	Types of Building structure				
				Frame / Structure	Floors	Roof	Side Cladding	Remarks
8	JT	As per mechanical input	As per mechanical input	Steel	RCC over metal deck	Metal deck with RCC	Single skin, Zincalume metal cladding. fly ash brick upto 1m height with sheet overlap 150mm	
NON-PLANT BUILDINGs								
1	Service building	1	G+4	RCC	R.C.C.	R.C.C.	Fly Ash Brick wall cladding	
2	Canteen	1	G	R.C.C.	-	R.C.C.	Fly Ash Brick Wall	
3	Fire Station	1	G	RCC	-	RCC	Fly Ash Brick Wall	
4	Weigh-bridge	3	G	RCC	-	RCC	Fly Ash Brick Wall	
5	Workshop	1	G	Steel	-	Steel Truss with insulated Sheeting	Single skin Colour coated Zincalume sheet metal cladding above 3.0m high fly ash brick wall.	
6	First Aid Centre	1	G	RCC	-	RCC	Fly Ash Brick Wall	
7	Permanent Stores	1	G	RCC	-	Steel Truss with single skin Zincalume sheet roofing and Annex Building-	Fly Ash Brick Wall	

Sl. No.	List of Structures / Buildings	No. Reqd.	No. of Storey	Types of Building structure				
				Frame / Structure	Floors	Roof	Side Cladding	Remarks
						RCC		
8	Construction Store	1	G	Steel and Annex Building- RCC	-	Steel Truss with single skin Zincalume sheet roofing and Annex Building- RCC	Fly Ash Brick Wall	
9	Toilet blocks Separate buildings (1 no for CHS , and 1 no for Boiler area)	2nos.	G	RCC	PCC M25 Grade 100mm thick over 100mm PCC M10 Grade-	RCC	Fly Ash Brick Wall	
10	Cycle/ Scooter/car stand near service building	As required	G	Steel	-	Steel Truss with sheeting	Open	

Note:- All control rooms shall be of RCC framed construction unless noted mentioned anywhere in the specification.

1.01.00 Codes and Standards

The latest revision of Indian codes and standards as on the original scheduled date of tender opening is applicable unless otherwise stated the latest editions / revision of all related and applicable Indian codes and standards (including IRCs as applicable) along with addendums / amendments, if any, shall be followed. In case the specific Indian Codes and standards are not available, accepted International Codes / standards shall be used.

- National Building Code-2016
- TAC/LPA norms
- Local Fire regulations

2.00.00 DESIGN REQUIREMENTS

2.01.00 Architectural Concepts

a) Layout of the plant area shall have definite hierarchy of road network depending upon its usage, aesthetic, visual sensibilities for creating road vistas, focal points, building backdrops, building frames. General layout shall be evolved taking over the basis of landform & local climate & due consideration shall be given to orientation and wind direction. The resulting built mass shall present a definite image width in distinct vocabulary in the form of landmarks, nodes & skyline.

b) Main plant building shall be architecturally treated in such a way that it retains a monumental scale, yet presents a pleasing composition of mass and void with suitable and functionally designed projections and recesses. The overall impact of the building shall be one of aesthetically unified architectural composition having a comprehendible scale, blending tonal values with the surroundings and taking full consideration of the climatic conditions, the building orientation and the existing structures nearby.

c) All other buildings and structures shall be architecturally treated in such a way so as to be in complete harmony with the main plant, surrounding structures and environment. Local architectural characters may be judiciously imbibed. The building shall be designed initiating an architectural control common to all buildings. The architectural control shall be clearly spelt out in terms of scale, man & form.

d) Overall colour scheme of the plant and other buildings shall be designed judiciously and in a comprehensive manner taking into account the mass and void of buildings, its facade, equipment, exposed structural elements, piping, trestles, bus ducts and other service elements.

e) Overall emphasis shall be on developing an eco- friendly architecture, merging with the nature with its own sustainable energy management systems.

The scheme shall be conceptually finalized in totality including that of equipment so that the proper co-ordination with other agencies can be taken up at appropriate time.

2.02.00 Architectural Design

a) Natural light shall be used to the maximum extent especially in the form of north light/skylight. For adequate light and ventilation, National Building Code recommendation shall be followed. However all windows of plant building shall have minimum 1.0m sill height and bottom of lintel height shall be minimum 2.5 m from finished floor level and Minimum door height shall be 2.5 m.

For all windows of non-plant building shall have minimum 1.0m sill height and bottom of lintel height shall be minimum 2.1 from finished floor level. Minimum door height shall be 2.1.

b) Entrance canopies, sunshade (projections, recesses) over openable windows and door rolling shutter openings on exterior facades shall be provided.

c) All the buildings shall be architecturally designed to meet the National Building Code.

d) All architectural drawings shall be prepared under responsibility of an Architect. The Architect shall be registered under Council of Architecture.

e) A comprehensive interior design scheme shall be conceived with the intention of projecting a definite theme and aesthetic appearance to inside working environment. It shall take into account the multidisciplinary engineering activities involving power plant technology and architectural & civil engineering for a smooth control hierarchy and man machine interface.

f) Not Used

g) Rain-water pipes or sanitary pipes shall not be visible from outside. Provision of pipe ducts shall be made to ensure pipe routing.

h) All cable spreader floors shall have proper slopes and provision of fire emulsifying system for drainage.

i) Steel columns within fire hazardous areas like electrical room, Main control room and switch gear room shall be encased with brick work. All steel columns shall have 150mm high concrete base above FFL to

ensure proper floor finishing work and to protect the column base.

j) Minimum 2.1m high headroom clearance has to be maintained at every part of the building including staircases. Vertical Head room clearance shall be maintained as per industry factories Act. Sufficient headroom shall be provided in cable galleries.

k) Based on functional/system requirements, human access shall be provided with steel grid system (1.2M X 1.2M span) catwalk in the false ceiling system.

l) Minimum 1.5M wide passage is to be marked on the floor as safety exit route. Such passages shall lead to Fire-escape staircases or fire-safe zones. Doors of fire-hazardous rooms or areas shall open towards safety exit passage. All external doors shall open towards outside. Fire escape staircases shall be located as per fire-code and TAC.

2.03.00 Plant Buildings

2.03.01 Powerhouse Building

Powerhouse superstructure shall be of structural steel framing with RCC floor slabs on permanent colour coated metal deck sheeting and Fly ash Brick Wall & insulated metal cladding construction. Operating floor being the heart centre of Powerhouse shall be designed as a very impressive floor having high quality finish, material and appropriate ambience.

External facade shall be with full brick thick wall up to approximately 3.0m high, plastered and painted. From 3.0m-upto roof external façade shall be clad with factory fabricated Rockwool / PU insulated metal cladding on A Row& Gable ends. At B row brick cladding will be upto deaerator floor and above deaerator floor double skin metal cladding upto roof level.

On C Row, it will generally be double skin metal cladding above 3m high brick wall above FFL upto roof level of B-C bay. Above 3m level, where brick work is technically required in certain areas like – electrical room etc., single skin metal cladding will be placed externally covering the brick wall as continuation of metal clad façade.

Poly carbonate sheet of 4 mm thick shall be provided along with the metal cladding of Power House building suitably for lighting requirements.

Fire Wall facing towards Transformer yard, shall be as per Electrical/TAC requirements and 250mm thick RCC wall as per Fire Prevention regulation. Single skin metal cladding similar to the Top sheet of Insulated Metal Cladding used for other part of the facia shall be applied over the Fire wall to match the overall elevation treatment. Adequate numbers of fire escape staircases shall be provided in main plant building with fire check doors at each landing as per NBC 2016.

The roof of the TG bay shall be permanent metal decking with in-situ concreting and screed on top and supported on steel truss. The structure is braced in the direction of the crane travel but provided with rigid joints at roof level and framing at other floor levels with the electrical and mill bays in the transverse direction. The roof of the TG Building shall have Electro mechanical roof extractor.

Sufficient natural light and ventilation has to be ensured for every part of the building unless prevented due to technical reasons. Operating floor may have large glazed area made with Structural glazing system. At Crane girder level windows on A Row, B Row and gable ends shall be provided. North Light system shall be provided on roof of power house building at suitable locations so that sufficient natural light can be obtained at TG Hall floor.

Minimum one number down comer shall be provided at each grid column.

Visitor's lounge/gallery provision shall be kept within main control room.
Floors in the power house shall have access to the Service Building Floor with a stylish walk way and significant width for ease of material transport.

The successful bidder shall prepare and submit 3D views of the Power House Building from all sides, with at least three (3) alternatives using different colours and facia treatment/pattern, for selection by the owner.

Architectural Specification of Control Room & Annexure Room

The control room of the Turbine Building is located at Operating Floor level. It is the nerve centre of the plant having state of the art facilities and requires a highly sophisticated hi-tech expression and ambience. The control room layout shall be planned/designed in such a way that no intermediate columns within the control room are allowed in order to have a more aesthetic look.

The front look of the control room shall be visually most attractive. The entire façade of the control room along B Row and its side walls are to be treated. These walls shall be clad with Granite slab, ACP of different matching colours or combination of ACP and other suitable matching light weight decorative material.

The room will be fully air-conditioned and have access from T G hall side through Air locks to reduce the noise level as well as heat load. Each Air-lock space shall have two numbers of double leaf glazed sensor operated sliding aluminium doors. The wall facing the turbine hall shall be fully glazed aluminium partition wall with hermetically sealed insulating glass panels. Control room shall have an internal acoustic partition wall along the entire length of the room, facing operating desks. This partition shall be integrated with Digital Display Boards at different locations and have monolithic fabric finishes with high acoustical properties. It will have granite floor, linear metal false ceiling in combination with Gypsum board with A.C and lighting fixtures and wall with acrylic emulsion paint. Necessary arrangement for sealing

expansion joints on floor, wall and ceiling has to be ensured. Brief technical specifications of different items to be used for the control room are as follows.

a) Flooring:Flooring shall be heavy duty coloured granite slab (of approved colour and shade)of minimum18 mm thick of min.1.2m x 2m size.

b) Skirting: Minimum 150 mm high skirting shall be provided with heavy duty coloured granite slab(of approved colour and shade)of minimum18 mm thick of min.2 m size.

c) Wall finish: Fly ash Brick masonry walls (rear side of CCR and sides), shall be cladded with Lacquered Glass of 8mm thick minimum of approved colour and design , up to the false ceiling level. Attractive and aesthetically appealing interior scheme with different colours, textures can also be achieved for wall cladding. The colour and design composition of wall cladding is to be submitted for approval of the NLCIL/Consultant before erection.

d) False ceiling**:**. In order to achieve Hi-Tech appearance of the control room, Gypsum board shall be used in pattern. The false ceiling work shall take care of all illumination, fire detection & fighting, HVAC and all other service requirement. False ceiling shall be provided with 25 mm thick insulation of resin bonded mineral wool conforming to IS:8183. Under-deck insulation shall be provided as per specification written elsewhere in this document. False ceiling bottom level shall be kept 3500 mm above floor level.

e) Air lock doors: Sensor operated glazed aluminium door with coloured powder coated finish shall be used having glazing thickness 8mmof clear float glass of approved brand. The doors shall be complete with all necessary hardware as per manufacturer's specification.

f) Glazed partition wall(facing TG hall)**: The partition** facing TG hall shall be of double glazed insulating glass panels. The glazed partition wall shall be made of aluminium sections having same finish that of aluminium doors with double-glazed insulating glass panels. This partition height shall be from top of floor finish to the bottom of the false ceiling. Insulating glass shall consist of 2 nos. 6 mm thick toughened glass separated by an air gap of 12mm thick, hermetically sealed, moisture resistant and of approved manufacturer. The inner glass for this insulated glass partition shall be of Lacquered glass of approved colour and design. The partitions shall be weather proof complete with gaskets, clips, hardware, etc. The front look of the control room shall be visually most attractive. The entire façade of the control room along B Row and its side walls are to be treated. These walls except for the portion as mentioned above shall be clad with Granite slab, ACP of different matching colours or combination of ACP and other suitable matching light weight decorative material

g) Internal partition wall of control room**:** The internal partition wall along the entire length of the room, facing operating desk shall consist of Digital Display Boards at different locations, integrated with wall panels laid flush with the display board and two nos. of matching doors on either sides for access to the rear side for maintenance. This special purpose partition shall have rigid frame work consisting of G.I. Studs of adequate size @ 600 mm c/c and floor, ceiling and intermediate channels to provide a strong wall system capable of supporting wall hung C.C.T.V. at designated locations. The framing system shall be integrated with independent floor supported structural framework of digital display board so as to cover the entire exposed surface around the board with partition panels.
The front side of the frame shall have Acoustical Panels 2400/1200 x 600 x 19 mm thick of approved colour. The rear side of partition shall have Acoustical Panels of size 2400/1200x600x19mm thick smooth finished with gypsum plaster and finished with acrylic emulsion paint. The entire wall shall have Class I fire rating as per BS code. The partition shall not transmit any load to false ceiling. The entire partition wall shall have concealed framing system and have monolithic fabric finish of approved colour or composition of two different colours as per approved design to entire exposed surfaces including door panels on control room side.

The other internal partitions and wall panelling of the control room shall be of Lacquered glass (8mm thick minimum) of approved colour with high end finishing items wherever transparency is not required. Other internal areas shall be provided with 12mm thick toughened glass.

The successful bidder should prepare and submit interior 3D views of the Control Room and related adjacent rooms like Shift In charge Room, Engineers Room, Conference Room, etc. from all sides, with at least three (3) alternatives using different colours and facia treatment/pattern, for selection by the owner. Control room front 3D views (on B Row) are also to be submitted.

2.03.02 Mill and Bunker Building

This shall be of steel framed structure having metal cladding to clad Bunker Feed Floor double skin with insulation. The colour and pattern of the sheeting shall match the overall ambiance of Power Island. Sufficient natural light and ventilation shall be provided for Bunker Feed floor. Provision of roof access through stair shall be made. Flooring shall be granolithic flooring with metal hardener, windows shall be coloured powder coated aluminium partially fixed and partially sliding type openable window, escape doors shall be fire check doors. Aluminium louvers shall be provided as per HVAC requirement. For sufficient natural light, high level continuous band of polycarbonate sheet shall be provided. Elastomeric waterproofing treatment shall be applied on RCC roof as per technical rule.

2.03.03 ESP Control Building

This will be RCC framed structure with fly ash brick clad wall. This will be G+3 storied building having cable spreader room at Ground and second floor and switchgear room and control room at first & third floor respectively. This building shall have toilet facility. Windows shall be coloured powder coated aluminium partially fixed and partially sliding type openable window, escape doors shall be fire check doors. Fire doors shall also be provided for switchgear room and cable spreader rooms. Control room shall have glazed aluminium door. Elastomeric waterproofing treatment shall be applied on RCC roof as per technical rule. For finishing schedule please refer Annexure-I.

2.03.04 **Electrical and Control Building for FGD system**

This will be RCC framed structure with fly ash brick clad wall. This will be G+1 storied building having cable spreader room at Ground and switchgear room and control room at first floor respectively. This building shall have toilet facility. Windows shall be coloured powder coated aluminium partially fixed and partially sliding type openable window, escape doors shall be fire check doors. Fire doors shall also be provided for switchgear room and cable spreader rooms. Control room shall have glazed aluminium door. Elastomeric waterproofing treatment shall be applied on RCC roof as per technical rule. For finishing schedule please refer Annexure-I.

2.03.05 Other Plant Buildings

Structures of Other plant buildings shall be as per description stated elsewhere in this Civil/Structural Specification. Architectural concepts of structures shall offer its own identity and will be aesthetically blended to give pleasing appearance maintaining harmony of the plant complex. Functional needs of each building shall be maintained.

2.04.00 Non-Plant buildings

Brief Description of Service Building

The Service Building is a G+4 storied RCC building with filler brick(Fly ash) walls. Building is located adjacent to the Power House Building as shown in the Plot Plan. Minimum 6.0m space between the service building and power house building shall be kept for Approach road. An all-weather covered access corridor to be provided with powerhouse building at operating floor level and at mezzanine floor level..The floor levels will be 0.00m, 4.5m, 9.0m, 13.0m, 17.0m and roof at 21.0m. Overall area of the building shall be approximately 7000 Sqm. However the building size shall be suitably decided during detailed engineering stage. It will have different offices and other facilities in different floors as per O&M requirement of the owner. This building will house O&M staff, laboratories for relay testing, electrical testing, C&I repairs and transmitters besides provision of computer room, conference hall, model room, archives, change room with lockers, telephone exchange, battery room, reception, stores, pantry etc. Building shall have 1 (one) Passenger

elevator (8 passenger), 1 (one) main staircases and 1 (one) fire escape staircase. Overhead water tank of 10,000-litre capacity - 5000 (5X1000) lit service water and 5000 (5X1000) lit potable water shall be provided at roof of the building. Ground floor slab will be RCC floor with sub-grade as per technical rule.
It is an important part of operation and maintenance of the plant having state of the art facilities and requires a highly sophisticated hi-tech expression and ambience.

Details of Major Non-Technological Facilities / Rooms at Various Floors are given below:

Floor	Functional spaces
Ground Floor (0.00Mtr Lev) (General Floor)	Reception room
	Security room
	Display room/ model room
	Meeting room
	Conference room (suitable for 50 persons)
	Telephone room
	Library cum Documentation room
	First Aid Room
	Toilet
	Pantry room and dining hall
First Floor (Civil Floor)	Chief Engineer
	Dy. Chief Engineer (Civil.)
	Dy. Superintendent
	Executive Engineer Engineers Room Store Meeting Rooms
	Civil Maintenance Room
	Dy. Superintendent R&I
	Pantry room and dining hall
	Toilet
Second Floor (Electrical Floor)	Chief Engineer (Electrical)
	Dy. Chief Engineer (Electrical)
	Dy. Superintendent
	Executive Engineer
	HT & LT Cable
	Meeting Room
	Meeting room
	Engineers room
	Store
	Electronic Lab.

Floor	Functional spaces
	Computer Room Record Room Running maintenance room General maintenance room Toilet Express Lab Pneumatic Lab Measurement & Analyzer Lab Electrical Lab Pantry room and dining hall
Third floor (Mechanical Floor)	Chief Engineer (Mechanical)
	Dy. Chief Engineer
	Dy. Superintendent
	Executive Engineer
	Meeting room
	Stores
	Turbine (Staff)
	Boiler (Staff)
	BMS Lab.
	Computer Room
	Running Maintenance room
	General maintenance room
	Pantry room and dining hall
	Toilet
Fourth Floor (C&I Floor)	Chief Engineer (C&I)
	Dy. Chief Engineer
	Dy. Superintendent
	Executive Engineer
	Meeting Room
	Engineers room
	Store
	Electronic Lab.
	Computer Room Record Room Running maintenance room General maintenance room Toilet Express Lab Measurement & Analyzer Lab Pantry room and dining hall

Following additional facilities shall be provided in service building:

i) Separate toilets for ladies, gents as well as physically challenged persons shall be provided & shall have on each floor of service building. Attached toilets will be provided for all senior executive rooms and conference rooms. The facilities provided in the toilet shall depend on the number of users. IS: 1172 shall be followed for working

out the basic requirements for water supply, drainage and sanitation. In addition, IS: 2064 and IS: 2065 shall also be followed.

ii) Unless otherwise specified, the facilities shall be based on the stipulation of NBC. Exhaust fans of suitable ventilation capacity will be provided in toilets.

Gents Toilet

a) All the facilities such as WC, Urinals, wash basins etc. shall be based on occupant load as per NBC and shall be of approved colour. However minimum requirements are given below.

b) WC (Indian type) (minimum 580x440mm) as per IS: 2556 (Part-3) with all fittings including health faucet, flushing arrangement of appropriate capacity and type – 1no.

c) WC western type as per IS: 2556 (part 2) with toilet paper roll holder and health faucet and all fittings including flushing system of appropriate capacity and type – 1 no.

d) Urinal (IWC for ladies toilets) with all fittings including partition with photovoltaic control flushing system as per IS: 2556 (Part-6, Sec.1) – 2 nos.

e) Wash basin (oval shape) with all fittings as per IS: 2556 to be fixed on concrete platform finished with min. 18 mm thick polished granite stone – 2 nos.

f) Wall to wall Bathroom mirror (5.5 mm thick float glass) with beveled edges including all fittings – 2 nos.

g) Stainless steel towel rail (600 x 20mm) - 2 nos.

h) Stainless steel liquid soap holder cum dispenser – 2 nos.

i) Janitor room.

j) Installation of water cooler of adequate capacity.

k) Provision of ventilation shaft.

iii) Ladies toilet will be provided with items b), c), e), f), g), h) , i)& k)

iv) Attached toilets provided for senior executive rooms and conference rooms shall have 1 EWC, 1 urinal, 1 washbasin, 1 mirror, 1 no. Towel rail, 1 liquid soap holder cum dispenser. WC shall be of western type 390 mm high as per IS: 2556(Part-2) with toilet paper roll holder and health faucet and all fittings including flushing valve of appropriate capacity and type.

v) All plumbing, sanitary fittings, connections and service lines shall be provided as per requirement. All service lines, water supply, plumbing

lines and other utility lines shall be concealed within the brick /concrete work and removable wooden panels shall be provided at intervals for access. Two stack systems shall be provided for the toilets.

vi) False ceiling shall be provided in the A/C rooms like conference rooms, higher official's rooms, corridors, etc.

vii) RCC staircase with stainless steel 40 mm dia pipe hand railing with vertical post shall be provided. Fire escape stair(s) is to be suitably located. All stairs shall be provided upto roofs.

viii) Entrance canopy as portico at ground floor entrance shall be provided.

ix) Aluminium Doors, windows, ventilators etc. shall be provided to suit requirements as per Architectural / Technical rule.

x) Inserts and cut outs shall be provided to suit requirement.

xi) PCC apron shall be provided in slope all round the building with side drains.

xii) Suitable access road shall be provided for the building.

xiii) A central Courtyard shall be provided with vents at higher levels / solar chimney arrangement, to draw away the rising hot air. The effect of various chajja-fin combinations shall be explored to reduce the heat gain. Service building shall have a circular atrium with walkway all around . Accordingly, a circular dome shall be used as roof for atrium portion.

xiv) Sufficient live / dead load to install the solar panels shall be taken care of in the design of the roof of the service building shall be considered to facilitate installation of PV power generation system for the service building at a later date.

xv) For external colour and texture, a smooth and light coloured surface that reflects heat and light, shall be considered. White and light shades have higher solar reflectivity and therefore are ideally used for reducing heat gain in the summer months.

xvi) For the air-conditioned areas the glazing shall be tinted toughened insulated glass of Minimum 24 mm thick (6mm + 12mm air gap + 6mm).

xvii) Shaded Parking lot adjacent to service building shall be provided for parking two and four wheelers, with adequate space for planting trees all-round.

The successful bidder shall prepare and submit 3D views of the Service Building from all sides, with at least three (3) alternatives using different colours and facia treatment/pattern, for selection by the owner.
The Building will be centrally air-conditioned. All finishing items, Layout, and other requirements shall be of owner's choice. However modern design approach of an office building like- open & flexible (workstation based) layout, usage of natural light, solar control, energy efficient, etc. shall be considered. Since this is one of the most prestigious buildings, aesthetically this shall achieve landmark quality.

Specially designed long and spacious RCC porch shall be given in front of the main entrance for receiving cars of VIP's.

Special attention to be given for area development and landscaping in front of service building with flowering plants and fountains etc.

Shaded car parking, cycle & scooter parking facility shall be provided as per requirement of the owner

Brief technical specifications of different items to be used for the area as follows:

a) Flooring

Generally floor finish shall be Non-skid, fully vitrified, of Class-I quality 10/11 mm thick or as per manufacturer non-porous, homogenous, and abrasion resistant, floor tiles, of minimum size minimum 600 mm x 600 mm of approved colour & design, and shall be laid over concrete floor with laying compound strictly as per manufacturer's specification. Total thickness of the flooring shall be 50mm thick including the thickness of the tiles, under bed.

For Entry cum reception lounge, VIP lounge, Main meeting/ conference room:-Suitable and approved combination shaded of granite slab and strips shall be used. Floor pattern shall be approved by the owner before erection.

For staircase and Corridors:

Steps–risers & tread, stair skirting, corridor floor shall be combination of two matching shade of granite slab and strips. Wall cladding of Elevator Lobby shall be of polished granite tiles(12mm thick minimum) of approved shade by owner. Stainless steel hand rail and balustrade of approved design shall be used.

For Toilet:
For flooring Minimum 10 mm thick non-skid vitrified tile, of minimum size 400 mm x 400 mm (overall 50 mm thick) and with glazed ceramic tile of same make for walls, Dado shall be 100 mm higher than bottom of lintel level. Only for toilet at operating floor and Third floor, dado shall be topped with 50 mm wide matching moulded ceramic trims.

For other areas like AHU room, Generator room, Electrical room, Etc.: shall have 50 mm thick heavy duty cement concrete granolithic floor with metallic hardener and matching skirting

b) Wall finish

Two coats of Acrylic Emulsion paint of approved colour shall be applied over a coat of approved primer on the plastered masonry surface prepared with White Cement Putty for all area Front wall for elevator shaft shall have polished granite slab wall cladding (min 12 mm thick).

Painting to exterior surfaces of wall shall be painted with Exterior quality Acrylic Emulsion Paint over suitable primer. To accentuate the building façade a suitable combination of Aluminium composite panel (ACP)/granular textured paint may be used.

c) False ceiling

It will be applicable for all areas excluding non A/C areas like AHU room, Generator room, Electrical room, etc., pantry and toilet. It shall be of aluminium linear acoustic false ceiling with rock wool insulation on top similar to LUXALON having approved colour with stove enamel finish, and or Mineral fibre board and or Gypsum MR board as per functional requirement and interior design scheme, integrated with light fixtures, HVAC grills and other ceiling mounted accessories, complete in all respect with metal suspension system, trims, profiles etc.
For pantry and toilet false ceiling shall be perforated aluminium stove enamel finished panels of size 600x600mm.
The minimum ceiling height of air conditioned area of each floor will not be less than 3.0m (up to bottom of false ceiling).

d) Doors

Double acting glazed aluminium door with minimum 15 micron colour powder coated finish shall be used having glazing of clear/tinted float glass of approved brand. The doors shall be complete with weather seal, gaskets, floor spring, door stopper, door locks, push/pull bars of similar finish and all necessary hardware. Glazed partition may be etched with suitable and approved designed. Wooden doors shall be of factory made solid core wooden flush door with C. P. Teak veneered surfaces in wooden frame with wooden architrave. The door frame shall be of Teak Wood.

Toilet & pantry doors shall be hard core FRP door.

Doors for areas like AHU room, Generator room, Electrical room, etc. shall be hollow metal flush door.

e) Glazed Panels

The glazed panels shall be made of aluminium sections having same finish

that of aluminium doors with double-glazed insulating glass panels(between AC and non-AC areas). This partition height shall be from top of floor finish to the bottom of the false ceiling and maximum available width. Insulating glass shall consist of 2 nos. 6 mm thick clear float glass separated by an air gap of 12 mm thick, hermetically sealed, moisture resistant and of approved manufacturer. The partitions shall be weather-proof complete with gaskets, clips, hardware, etc.

Glazed partition may be etched with suitable and approved designed.

f) Windows, Glazed Curtain wall

All windows of A/C areas shall be separated with double insulated glass from non AC areas. Other windows shall be 15micron thick colour powder coated aluminium glazed window with minimum 6mm thick clear float glass. Glazed curtain wall shall be Unitised structural glazing system comprising of 30 micron colour anodised aluminium extrusions with double insulated heat reflecting glass. The system shall be able to withstand wind pressure as per relevant data given elsewhere in this specification at all heights.

g) Utilities

All utility lines like water supply line, Electrical wiring, telephone line, etc. shall be concealed type. Fittings and fixtures for toilets shall be of best quality and to be got approved by Owner prior to installation. Roof treatment, sanitary & sewerage system, roof drainage etc. shall be as per detail technical specification.

h) Any other items of work not specifically mentioned here shall be as per the guidelines indicated in relevant Architectural Technical Specification.

Brief Description Canteen Building

a. This shall be single storey RCC framed structure with fly ash brick cladding. Spacing of columns shall be such that large column free areas are available in the dining area.

b. The dining area shall be fully air-conditioned and with gypsum board false ceiling to accommodate minimum 100 people at one time (Separate accommodation for Permanent employees 50Nos and Separate accommodation for Contract workers 50Nos) and in addition there shall be a separate accommodation for 25 executives

c. Adequate space shall be provided for stores, preparation, cooking, serving and washing facility.

d. Toilet and hand wash shall be kept sufficiently away from cooking area to satisfy statutory requirements.

e. Walls of the dining hall, cooking and serving area shall be given dado of glazed ceramic tiles as per the Finishing Schedule.

f. Adequate exhaust fans and ventilation facility shall be given in the cooking area.

g. Special arrangement shall be made to lead off the wastewater from canteen to the effluent treatment plant.

h. Main entrance door shall be of aluminium glazed swing type with two leaves opening outside. Doors of other areas shall be wooden panel door, hollow metal flush door as applicable.

i. All windows shall be glazed aluminium window.

j. Fuel/Gas store shall be kept away from canteen block as per statutory rules.

Brief Description of Fire Station Building

a. Fire station shall be a single storied RCC framed building with fly ash brick walls in office area.

b. The fire station shall have provision for parking for fire tenders (Nos, as per Mechanical Volume) including one bay for maintenance with pit, office for the station-in-charge, duty room, control room, office, stores, class room, record cum general room, toilet facilities , tool room, spare parts room, recreation room, dining with kitchen, etc.

c. Parking area for tenders shall ensure fast movement of the fire tender in an emergency.

d. In addition, adequate space shall be provided for hose drying and drill at ground level with water tub.

e. The arrangement shall in general satisfy requirement of the Standing Fire Advisory Council or local fire brigade.

Brief Description of Weigh Bridge Control Room(for all weigh bridges)

a. These shall be RCC framed structure with RCC roof and fly ash brick cladding.

b. Adequate aluminium glazed windows with MS grill shall be provided for ventilation & lighting.

c. Roof shall be given water proofing treatment.

d. Hollow metal pressed steel doors shall be used for personnel movement.

e. Toilet facilities shall be provided.

f. The weighbridge control building shall be as per vendor's input, but shall not be less than 6.0m x 3.0m.

Brief Description of Workshop (ERS, ETL, Mechanical Repair Shop)

a. The workshop shall be structural steel building with fly ash brick wall cladding up to 3.0 m from FFL. Wall cladding above this and roof shall be of insulated metal cladding with zincalume sheeting.

b. The workshop shall have provisions as specified in the Tender drawing 18A03-DWG-M-007.

c. Flooring shall be of metallic hardner surface over RCC floor except toilet area.

Brief Description of the First Aid Centre

a. This shall be single storey RCC framed structure with fly ash brick cladding. Spacing of columns shall be such that large column free areas are available in the reception cum waiting area.

b. This building shall be comprised of

- Waiting Hall cum reception
- Dispensary
- Medicine Store
- Doctor's consultation room with attached toilet
- Nurses change and locker room
- Nurses station
- 2 Bedded trauma room with toilet
- Ladies and gents toilet and toilet for physically challenged.
- Room for general staff & driver's rest room
- Pantry room

c. Space shall be provided for eyewash and washing facility and one number Ambulance Parking

d. Walls shall be given dado of glazed ceramic tiles to a height as specified in the Finishing Schedule.

e. Special arrangement shall be made to lead off the wastewater from Medical Centre to the effluent treatment plant.

f. Main entrance door shall be of aluminium glazed swing type with two leaves opening outside. Doors of other areas shall be wooden panel door, hollow metal flush door as applicable.

g. All windows shall be glazed aluminium window.

Brief Description of Permanent Store

a. This will be cluster of building blocks, fly ash brick clad of RCC framed structure with RCC roof for annexed buildings and RCC structure with fly ash brick wall and metal sheet roof roofing for main store building, as per structural design consideration. Total area of the Permanent store shall not be less than 6000 sqm.

b. Heavy and Light material store buildings shall be Steel structure with 3.0m high fly ash brick wall and balance insulated zincalume metal cladding and the sheet roof . In the heavy material storage area, electric hoist of adequate capacity shall be provided. There shall be part mezzanine floor for Heavy and Light Material store buildings.

c. Store building shall have facility to store heavy materials, light materials, electronic equipment & parts, etc. and provision for storage bins with fork lift movement area shall be kept.

d. RCC framed with RCC roof structure shall be for Precision Material, Medicine, etc. Store building and Office Building block. This block shall also provide for office space for superintendent and his supervisory staff, locker room and change room for workers, toilets & drinking water facility, record room, challan receipt and issuing counters, etc.

e. Entry and exit of trucks shall be through adequately sized rolling shutters. In addition a minimum 2 single leaf steel flush door for each store shall be provided for entry of the staff. Three Store Houses shall be separate buildings with a sufficient gap in between for truck movement.

f. Adequate windows shall be provided for ventilation and lighting. Offices inside shall be of glazed partition above 900 mm high single fly ash brick wall. Total height of partition including brickwork shall be 2400 mm. Doors to the cabins shall be of glazed aluminium.

g. Gypsum board false ceiling shall be provided for AC areas.

h. Store complex shall have chain link fencing with in & out Gate under security surveillance.

i. There shall be weigh bridge facility attached to main office of 60T capacity exclusively for this Permanent Store with mini control room.

j. There shall be shaded or open air storage yards within this complex.

k. Necessary approach roads shall also be provided.

l. Toilet facilities shall be as provided as per specification.

Brief Description of Construction store

a. This shall be single storied building with metal sheet roofing over steel truss and steel column support. Building shall be fly ash brick wall clad. However the annexe building shall be of RCC construction.

b. Total area of the store shall not be less than 1000 SqM. However the size, number of stores, internal divisions, etc. shall be as per quantity of material to be stored for a stipulated time period.

c. The buildings shall consist of large storage space with provision for forklift entrance.

d. Provision for office with toilet facility shall also be provided.

e. Ceramic tiles dado shall be provided up to 100mm high over the lintel for toilets and pantry. Toilet facilities shall be provided as per specification.

f. For storing of any precision material or as the case may be, AC store facility is to be constructed within the store building or a separate store building as per owner's direction.

General

All the non-plant buildings shall be provided with Plinth protection, garland drains, access to roof through stair, roof treatment, RCC parapet, UPVC down comers, approach roads as per the architectural requirements.

Car Scooter Parking near Service Building

Covered parking for minimum 20 nos. cars and for minimum 50 nos. two-wheelers & cycle shall be provided as per requirement at the desired location of the owner. Structure shall be of Steel structure with zincalume metal roofing. The structure shall be aesthetically harmonious and attractive. Paving shall be with Heavy duty interlocking paver blocks as per the architectural requirements. Edges of paver block shall be protected with 300 mm wide and 100 mm thick PCC M15.

3.00.00 ARCHITECTURALREQUIREMENTS

3.01.00 Roof Insulation and Ventilation

The roof of buildings which are recommended by HVAC department for insulation shall be under deck insulated as per specification given elsewhere in this document. The roofs/floors housing manpower and precious equipment/instruments and AC rooms exposed to heat environment shall be provided with underdeck insulation with false ceiling.
Extractor fans will be provided over roof of turbine hall for ventilation. For ventilation requirements relevant section of the specification shall be referred.

3.02.00 Roof Waterproofing

Roof waterproofing treatment shall be as per Cl. No.:4.00.00.13

Where technically necessary from HVAC requirement, under deck insulation of required material and thickness shall be provided as per technical specification.

3.03.00 Main/Partition Wall

All main/intermediate walls shall be full brick thick wall in 1:6 cement sand mortar. Half brick thick wall in1:4 cement: sand mortar with 2 nos.6 mm dia. rod in every fourth layer shall be provided. For long walls intermediate RCC pillars and RCC horizontal tie shall be provided with structural steel member at minimum 2.5 m clear height with MS inserts/lugs for anchoring in brick work shall be provided. Similarly MS lugs shall be provided on the structural member at spacing 500/600 mm on vertical face for proper anchorage for brickwork, lugs embedded in concrete and suitable vertical structural member at maximum 5m c/c. Full glazed partition in anodized aluminium frame shall be provided for operator's cubicles for clear view of the operating equipment and in Control room area. Half brick

thick wall shall be permitted in toilet area and shelf supports in other buildings.

3.04.00 Plastering

All fly ash brick walls, ceilings shall be plastered as below:

Exterior & rough side of interior brick wall	20 mm thick minimum sand faced plaster with 1:4 cement-sand mortar in two layers.
Interior wall	12 mm thick with 1:4 cement-sand mortar
Ceiling	10 mm thick with 1:3 cement-sand mortar shall be provided to all exposed ceilings.

Generally river sand confirming to IS 383 shall be used. However the engineer-in-charge of the works may permit use of M sand confirming to zone II in case of non-availability of river sand.

3.05.00 False Ceiling

False ceiling shall be of either lineal panel system or aluminium tile/plank system for control rooms and other important areas, with suspension system as per manufacturer's details.

Areas like office space or where specified, Mineral Fiber Based Acoustic Ceiling Board, in aluminium snap grid suspension system as per manufacturer's specification shall be provided. As an alternative, Moisture & Fire Resistant Gypsum Board false ceiling system may be used as per the manufacturer's specification and wherever specified.

Under deck insulation is to be provided in air-conditioned areas as per HVAC requirement.

All air-conditioned control rooms (wherever located) shall be provided with under deck insulation irrespective of the type (MOC) of false ceiling. Control rooms shall have Air lock facility (Double door) as per Electrical requirement.

The false ceiling work shall take care of all illumination, fire detection & fire

fighting, HVAC and all other service requirement. False ceiling shall be provided with 25 mm thick insulation of resin bonded mineral wool conforming to IS:8183 over the false ceiling panels. Wherever under-deck insulation is required the insulation shall be fixed to the ceiling slab and shall be as per specification mentioned elsewhere in the specification.

3.06.00 Special Finish

a. The main entrance of powerhouse, Service Building, control room shall have high quality aesthetic finish to entrance, floors, walls, ceilings, etc. as mentioned in this specification.

b. The main entrance of control rooms and following buildings shall have high quality aesthetic finish to entrance, floors, walls, ceilings etc.
   - Canteen
   - Fire Station
   - First Aid Centre
   - Permanent Stores

c. The main entrance of ESP control room building shall be finished with granite stone slab and RCC stairs shall be finished with granite slab with SS hand-railing. For other finishes refer Annexure-I.

3.07.00 Doors

a) Generally factory made hollow metal (steel) flush doors with pressed steel frame shall be provided for plant and utility areas.

b) Factory made Solid core wooden flush doors in teak wood frame shall be used in interior office areas. Aluminium doors shall be provided in at entrances and important areas.

c) Rolling steel shutters shall be used where frequent use is not envisaged and large openings-9.0 Sqm and above- are required. Rolling shutters shall be electrically operated. Wherever truck entry is envisaged, minimum size of rolling shutter size shall not be less than 3.5m (W) x 4.0m (H).

d) Control rooms and other office area shall be provided with minimum 15 micron pre-coated i.e. coloured powder coated aluminium glazed partitions with air lock facilities having two sets of doors and preferably double door systems . Two sets of doors with sensor operated door shall be provided for main control room.

e) Minimum 2 hour Fire rated doors with panic bar shall be provided in cable spreader rooms and other areas having fire hazard, electrical rooms and also to all fire exists as per NBC and TAC requirement.

f) Doors shall be provided at appropriate location to prevent dust ingress from outside.

g) Wooden panel doors shall be provided for toilet entrance and toilet internal doors shall be solid core FRP.

h) Weather stripping shall be provided to all outside doors as well as air conditioned areas and all other doors where dust-free environment is required.

3.08.00 Windows & Ventilators

Full glazed windows and ventilators shall be in minimum powder coated and UV protected aluminium window frame shall be provided with 6 mm thick clear float glass and 5.5mm wired glass wherever required from safety point of view. All windows and ventilators shall meet the requirement of industrial windows and Ventilators.

Glazing between AC and Non AC areas shall be Double insulated glass. Aluminium sections shall be of heavy duty and from reputed and approved manufacturer. Windows and ventilators shall be fabricated and painted by the reputed fabricators at their own fabrication shop.

The window area shall be so decided as to allow adequate natural ventilation and light.

Note: Member sizes of Aluminium Glazed doors and windows shall be designed by the manufacturer and to be submitted for approval by the Bidder before execution.

3.09.00 Landscaping

All non-plant Buildings area including its Car Parking shall be accentuated with suitable landscape design.

3.10.00 Facilities in Buildings

Adequate toilet and drinking water facilities shall be provided for personnel working in each building. Each building shall have toilet facilities both for Gents and Ladies and physically challenged persons. Number of toilet fixtures shall be adequate for the occupancy as per National Building Code.Minimum area requirement for Gents toilet shall be of 15 m2 and Ladies toilet shall be 12 m2.

However minimum 1 EWC with health flush with cistern and 1 IWC with cistern, 1 washbasin with mirror, towel rail, soap case, minimum 2urinals shall be provided in each gent's toilet and above fixtures without urinals in each ladies toilet.
1 EWC with hand rest with health flush with cistern, 1 washbasin with mirror, towel rail and soap case shall be provided in each physically challenged

persons Toilet shall be provided in all floors of Main Plant buildings and service building and buildings wherever mentioned.

Each floor shall have drinking water facility connected through potable water with water cooler.
Each floor of TG and service buildings shall have toilet facility of adequate size for gents & ladies and physically challenged persons.

All buildings shall be provided with HDPE (white colour) roof potable water tank (except Power House where it is RCC internally lined with glazed ceramic tiles) of adequate capacity (2 days storage or 1000 liters capacity whichever is higher) as per total requirement of plumbing fixtures. Separate tanks of minimum 1000 liters capacity shall be provided for service water as specified elsewhere in the specification.

Attached toilet 1 EWC with cistern with health flush, 1 washbasin with mirror, towel rail, soap case, shall be provided to the Senior Executive Office rooms in Service Building.

Each floor shall have drinking water facility connected through potable water with water cooler.

Provisions shall be kept for barrier free environment for physically challenged persons like ramps in 1 in 12 slope, lifts, toilets, etc. The main entrances of all the plant buildings shall be provided with ramp.

Pantry provision shall be kept at ground floor and operating floor of power house building, all floors of service building and the areas which has office space, control room or the spaces which will be 24 hours manned.

3.11.00 Potable Water System and Service water Plumbing

This system for various buildings shall be connected to the drinking water and service water systems, the scheme for which is indicated elsewhere in this specification.

Water outlets shall be provided for an instantaneous flow rate of approximately 7Cu.M/Hr.(25GPM).

System will satisfy state and local plumbing codes. Following I.S. Codes for the system shall be followed:

a) IS-2065: Code of Practice for water supply in buildings.

b) IS-1172: Code of basic requirements for water supply, drainage and sanitation.

c) IS-1200: Laying of water and sewer lines including appurtenant

(Pt.XVI) items.

d) IS-1239 Specification for mild steel tubes and mild steel tubular and other wrought steel pipe fittings. (10mm to15 mm nominal diameter).

e) IS-3589: Specification for electrically welded steel pipes for water, gas and sewage (220 mm to 2000 mm nominal diameter).

Potable water shall be supplied to wash basins, sinks, water coolers, showers and other plumbing fixtures. Soil and waste piping shall drain through traps to the yard sanitary sewer system.

Service water shall be supplied to water closets, urinals and other plumbing fixtures.

3.12.00 **Roof Drainage Systems**

The system shall be provided for removal of water from roof surface to avoid damage to the roof structure of all buildings and shall consist of the following:

a) Roof Drain Heads
b) Rain Water Down comers
c) Gully pits

IS-1742 code of practice for building drainage shall be followed for this purpose.

Adequate numbers of rain water drain sheds shall be provided for all roof areas as per standard norms for roof area.

System will be designed to handle rainfall at a rate as specified elsewhere in this specification and in accordance with stipulations of IS-1742.

All RCC roof buildings shall have access through staircase for cleaning of roof drains. Roofs with solar panels shall be accessible through staircase.

Roof drains will conduct water to storm sewers. No rainwater pipes shall be exposed to outside view.

All the drains including plinth protection drains shall be of RCC.

3.13.00 Glazing &Glazed Partition

a) Glazing in Control room between A.C. and non-A.C. areas shall be insulating glass consisting of two 6 mm thick toughened float glass sheet hermetically sealed and separated by 12mm gap for thermal insulation. Clear glass shall be provided where clear view is required. In other areas tinted glass may be provided.

b) 6 mm thick ground glass shall be provided for toilets.

c) Glazing between two A.C. areas shall be with 8 mm thick clear float glass.

d) All glazing shall be in aluminium frame having 15-micron colour powder coated.

e) 5.5 mm thick wired glass shall be used for windows/ ventilators at higher level for safety.

f) 24 mm thick insulated double glazing having 6mm thick tinted heat-reflecting type float glass on outer side and 6 mm thick clear float glass on inner side with 12 m main gap &hermetically sealed shall be mounted on 15 micron coloured anodised aluminium frame suitable for structural glazing system.

g) For glazed aluminium door, 8.0mm thick clear float glass with or without etching is to be provided

3.14.00 Sealant

Silicon sealant around external doors and windows and Polysulphide sealant with polystyrene filler board shall be used in all expansion joints exposed to weather. All joints around exterior doors, windows, and expansion joints, etc. shall be sealed for proper water-lightness.

For expansion joints more than 50mm width special type expansion joint control system with extruded aluminium sections and EPDM membrane shall be used on exposed vertical faces of the expansion joints after sealing, extruded aluminium special type of flashing shall be provided.

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3.15.00 Damp Proof Course

40 mm thick 1:1.5:3 concrete with 12mm Blue Granite Chips and 2% waterproofing admixture or as per manufacturer's recommendation to be provided.

3.16.00 Plinth Protection

Minimum 1000 mm wide (excluding drain width) and minimum 100 mm thick P.C.C. M 20 plinth protection along building periphery shall be provided with surface drain of required size and slope, to suit storm water quantity, shall be provided. The plinth protection shall be laid over prepared sub-grade and base formed with two layers of locally available broken laterite stone/ stone boulders. Each layer shall have a pre-compacted thickness of 150 mm and consolidated to 115mm. Thus the total thickness becomes 230mm.

3.17.00 Miscellaneous Metal Railing

a) For main stair & lobby of Powerhouse building up to operating floor and one half landing above operating floor, around large openings at operating floor, shall have SS Hand rails of 40mm diameter stainless steel railing and post, with minimum 3mm wall thick & decorative seamlessly joined.. Stainless steel pipe handrail in shall be of grade SS-304 and of approved design to meet the functional requirement as well as very good aesthetic appearance. Other hand railings of Power house building shall be MS Galvanised hand railing with 40 mm NB (medium) main post and 40 mm NB (medium) as horizontal rails. With toe guard shall be provided.

b) For important non-plant buildings like Service Building, stainless steel railing with SS posts & decorative SS handrails shall be provided.

c) Hand railings of Plant building shall be MS Galvanised (as per IS 4736) and finished with suitable paint hand railing with 40 mm NB (medium) main post and 40 mm NB (medium) as horizontal rails, as per IS-1161, with toe guard shall be provided.

3.18.00 Painting

Exterior Masonry Surface	:	Buildings shall be finished with waterproof External Quality Acrylic Emulsion Paint 2 coats over approved primer. Granular textured paint may also be combined along with External Quality Acrylic Emulsion Paint to form suitable pattern on building façade. Aluminium composite panels (ACP) may be used to accentuate certain portion of the façade or certain element of the façade as the case may be.
Exterior Steel Work	:	refer relevant clauses as specified elsewhere
All Woodwork	:	Synthetic paint 2 coats over a coat of primer.
All Internal Steel Work	:	Refer relevant clauses as specified elsewhere
Steel in contact with acid /alkali	:	Chemical resistant paint
All interior masonry surfaces	:	Interior Acrylic emulsion paint over 3mm Thick white cement putty punning.
Fire Door	:	Post Office red shade shall be provided.

3.19.00 **Miscellaneous Work**

a) Counter tops in kitchen, Washbasin, pantry & similar areas shall be polished granite over RCC slab.

b) Walkways etc. shall be of heavy duty 75 mm (minimum) thick anti-skid interlocking concrete paver blocks with a minimum compressive strength of 30MPa of approved design and top colour.

c) For windows, powder coated aluminium grill shall be provided. But in specific cases, M.S. grills shall be used as per approved design for security purpose made of 25 mm X 6mm M.S. Flats / 12mm – 20mm M.S. square bar of approved design shall be provided to suit security requirements.

d) For RCC main stair and landing of powerhouse building shall be of Granite slab with all edges and nosing moulded, RCC stair of other plant and non-plant buildings shall be of Kota stone and white marble strip combination with all edges and nosing moulded.

e) RCC staircase shall be provided in main entrance of Turbine building, Facility building and other important buildings. R.C.C. stair railing shall be with Stainless Steel handrails and balusters shall be provided . Other staircase shall be provided with Structural steel work.

f) Anti-termite treatment shall be given to columns pits, foundations, and trenches, below floor as per IS: 6313.

g) Suitable arrangement of floor drain with trap shall be provided in floor where spillage of water / floor washing will occur.

h) Near Service Building, covered car parking stand for 20nos cars module with minimum 75mm thick coloured interlocking cement concrete tile flooring with a minimum compressive strength of 30MPaover reinforced concrete hard standing and module for 50 nos. Two-wheelers & cycle parking stand shall be provided as per requirement at the desired location of the owner. Structure shall be of Steel structure with zincalume metal roofing . The structure shall be aesthetically harmonious.

i) Doors, windows and rolling shutter in all buildings shall have sun-shade either recessed in the wall or projected out. Projection of sunshade shall be 750 mm for door and 600 mm for windows. Projections for Rolling shutter shall be 1000mm. Where doors and windows are side by side, 750 wide continuous sunshades shall be provided.

j) North Light provisions on the powerhouse shall be made of

Polycarbonate sheet fixed to structural framework as per approved design. Arrangement shall have to be provided to prevent ingress of rainwater if any.

k) Roof access: All roofs shall be accessible through proper staircase. Where staircase cannot be provided at least cage ladder shall be provided. (buildings more than one floor i.e. G+1 and above shall necessarily be provided with staircase) Roof access stairs may be open outdoor type. Cage ladder height shall not be more than 6.0m at a stretch. One rest platform shall be given at every 6.0M height of the cage ladder if the ladder height is more than 6.0 m.

l) Window sill: All window sill height shall be measured from finished floor level.

m) Lintel height: All lintel height shall be measured from finished floor level.

n) Parapet height: All RCC roofs shall have minimum 1000mm high parapet wall. Parapet wall shall be of RCC and shall be of 125mm thickness.

o) Internal wall height: Wall height between AC and Non AC areas as well as between two AC areas, shall be full height up to bottom of roof slab or bottom of beam.

p) False ceiling height: Unless specifically mentioned the false ceiling height shall be 3.m within rooms and 2.7m-3.0m at corridors outside the rooms.

q) Floor opening: Any uncovered floor opening more than 0.3sqm in area shall have 150mm high RCC kerb all round and shall be protected with minimum 1000mm high railing.

r) Dado/Skirting height: Unless specifically mentioned the skirting height shall be 150mm from finished floor level and dado height shall be 100mm higher than the door opening height for toilets and kitchen / pantry.

s) All RCC flat roofs as per electrical requirements, shall have adequate provision for erecting Solar Panels as per manufacturer's erection and anchoring specification and also as per civil design(It may be considered in design, the panels will be erected over the entire area of roof). Loading due to panels (Self weight, Wind etc. as applicable) shall be considered in the design of all buildings. Water point shall be provided over the roof for cleaning of panels etc.

t) Scheme to be made and executed rainwater harvesting system for the entire plant area. From individual building roof, rainwater shall be collected through down comers and Rain water from other open areas

let into drains and finally conveyed to Rain water harvesting Pond.

3.20.00 **Chain Link Fencing**

Chain Link fencing shall be as per Cl. No.:4.00.00.19

3.21.00 **Temporary Fencing**

The construction of Temporary Fencing shall be done as mentioned below:

a) 50NB G.I. post and its foundation shall be at 3.0m interval.

b) Fence shall be installed along lines shown on approved drawings.

c) Total height of the posts shall be 2400mm from grade level.

d) Strainer posts shall be provided at sharp changes in grade, at comers at change of direction and where directed, and at every 30.0m interval.

e) All comer post will have two stay posts and every tenth post will have a transverse stay post.

f) Barbed wires shall run post to post and to be fixed to the posts by tightening hooks.

g) Diagonals and vertical per span with barbed wire shall be provided. In general CPWD specification is to be followed.

3.22.00 **Sanitary Drainage System**

a) Diameter of Soil Pipe and Waster Pipe outside the building and vertical / horizontal stack connected with sanitary fixtures shall not be less than 150 mm for rain water and for sewage 110mm OD pipes.

b) Drainage pipes shall be UPVC Type-B pipes as per IS: 13592-1992 (amended to 1995)

Pipes shall be as follows:
DI Pipes --- Plant Buildings
UPVC Pipes ---- Non-plant Buildings
DI Pipes --- Underground Pipes
For sewage line, UPVC pipes above ground and DI pipes below Ground shall be used (DI pipes for less than 200mm dia. and RCC NP3 hume pipes for dia 200mm and more).

c) IS: 1742 - Code of Practice for building drainage & IS: 5329-Code of Practice for sanitary pipe work above ground for buildings shall be followed.

d) If not specified the minimum gradients of soil and drainage pipe line shall be as follows:

I.	100 mm nominal dia.	:	1 in 57
II.	150 mm nominal dia.	:	1 in 100
III.	200 mm nominal dia.	:	1 in 145
IV.	250 mm nominal dia.	:	1 in 195
V.	300 mm nominal dia.	:	1 in 200

e) Each floor drain shall have 'P' or 'S' trap connection as required.

f) Pipe to pipe shall be connected in 45^0 or 135^0 both vertically and horizontally.

g) For cleaning purpose during maintenance, Floor Cleanout and Wall Cleanout shall be provided for horizontal run and vertical run of the pipes.

h) In no case soil pipe shall be connected to waste pipe.

i) In vertical stack proper venting system with anti-siphonage vent pipes shall be provided for all Water Closets.

j) Drop slab of minimum 450mm depth shall be provided for the toilets where technically and aesthetically required.

k) All plumbing and water supply fittings & fixtures, rain water drainage of plants of any building/premises/open area are in the scope of this contract. All the sewerage shall be collected from these area and the same shall be interconnected to the Main Plant Sewer System) at the RCC man hole as per detailed layout requirement.

4.00.00 DESIGN DATA FOR ARCHITECTURAL WORKS

1	Brick works – Internal and external	:	230 mm thick fly ash brick wall with 1:6 Cement- Sand mortar. All non-load bearing Brick work as mentioned in this document shall be with Fly Ash Bricks unless noted otherwise. Chamber burnt clay bricks shall be used in case of non-availability of Fly ash bricks, subject to the approval of NLCIL.
2	Half brick thick wall:		1:4 cement: Sand mortar with 2 nos. 6 mm dia M.S. rod in every fourth layer.
3.	Damp proof course:		40mm thick 1:1.5:3 Concrete with 12mm BG metal and a 2% admixture of water

proofing compound or as per manufacturer's recommendation.

5. 4. Plaster:

Exterior & rough side:	20 mm thick with 1:4 cement- sand of interior brick wall mortar in two layers except where special finish provided.
Interior:	12 mm thick with 1:4 cement- sand mortar
Ceiling:	10 mm thick with 1:3 cement- sand mortar. (chicken wire mesh shall be provided at the junctions between RCC-BW , Steel-BW, etc. before applying Plastering)Also refer Cl 2.02.03/Sec Iv/Part B/G2 of Vol II)

5. White Cement
Putty Punning: 3 mm thick punning to be provided to all areas receiving acrylic emulsion paint.

6. Metal Cladding :

The wall cladding for buildings shall be of single skin or double skin sandwiched/insulated wherever specified. The double skin sandwiched 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 sheet shall have colour coating with silicon modified polyester finish of thickness 20 microns over 5 microns (DFT) back coat for outer surface and 5 microns over 5 microns(DFT)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. The double skin cladding with single skin on either side of the horizontal runners

without insulation wool in the middle shall also be used as per the requirement and as specified

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

Metal Deck Sheets for RCC roofs/Floors

All the buildings/Structures having R.C.C slabs over structural steel framing are provided with troughed metal sheet decking which acts as permanent shuttering. These sheets shall meet the general requirements of IS: 14246 and shall conform to class 3 for durability. The sheeting shall be permanently colour coated on exposed surfaces, galvanised M.S. troughed metal sheet decking of approved profile with minimum base metal thickness of 0.8 mm or as per the design requirement whichever is higher and minimum trough depth of 38 mm. Silicon modified polyester painting shall be used for permanent coating over galvanised surface with minimum rate of galvanising of 180 gm of zinc per sq. m. Dry film thickness of colour coating shall be at least 20 micron.

8. False Ceiling :

Aluminium pre-painted stove enamelled finish false ceiling, either lineal panel system or aluminium tile/plank system.

a) Panels

Panels to be manufactured from pre-painted, stove enamelled, alloy EN-AW-5050 or equivalent (according to EN 1396 and ECCA).

Panels are to be coupled in longitudinal direction by means of panel splices.

Optionally the flange with 3 x 7 ventilation holes can be used to achieve a ventilated ceiling.

b) Suspension

Rows of 0.5 Fe/0.95 Aluminium roll formed carriers shall be installed about 1200mm center on center by means of

adjustable suspensions about a distance of 1200mm, center on center. Carriers will be joined by means of carrier splices. Carriers provided with prongs to hold panels in a standard module of 100mm.

c) Perimeter Profiles

- Clip-on U-profile, 28.6x12.5 x20 mm, made of 0.35 thick aluminium
- Wall L-profile, 29.2x19.4 mm, made of 0.5 mm thick aluminium
- Wall L-profile, 45x18.5 mm, made of 0,8 mm thick aluminium
- Wall W-profile, 45x21x21x18.5 mm, made of 0.8 mm thick aluminium

d) Perforations

Manufacturer shall supply panels with following perforation specifications:

- ∅ 1.0 mm, Δ 2 mm with 23% open area
- ∅ 2.0 mm, Δ 5 mm with 16%open area

Perforated panels to have a nominal plain border along the longitudinal panel direction to assure a maximum flatness and product stability:

- 84C panel, 1 mm perforated to have a plain border of 7 mm
- 84C panel, 2 mm perforated to have a plain border of 6 mm

e) Acoustics

Manufacturer shall supply acoustic non-woven tissue, thickness 0.2 mm factory applied inside the panels. Alternatively the installer can place individual PE wrapped mineral wool pads.

f) Coating

The coating will consist of a tough and durable polyester finish in nominal thickness of 20 microns, applied in a continuous coil-coating process ensuring uniform coating and absolute adhesion.

g) Installation

All materials shall be installed by the approved applicator/ erector of the manufacturer under supervision of the authorized representative of the manufacturer.

9. Floor finish:

a. Generally finish to utility areas shall be 50 mm thick heavy-duty granolithic flooring with metallic hardener on concrete slab.
The heavy-duty overlay shall be ready-to-use, metallic aggregates based powder after application of epoxy based bonding agent of two components, solvent less epoxy resin based. It shall be formulated to meet the requirement of ASTM C881 Type 2, Grade 2, and Class B &C. The Bonding agent shall exhibit minimum open time of 6 hours and shall exceed the tensile strength of concrete in terms of its adhesive bond strength. The Floor topping product shall be high strength with compressive strength of 80 MPa at 28 days; flexural strength exceeding 8 MPa at 28 days. The product shall be capable of resisting metal crawler chassis and shall have abrasive wear less than 0.15 mg/cycle on H22 wheel, ASTM C501 test method. The product shall have adhesive bond strength in excess of 1.5 MPa when tested as per ASTM D4541. Curing of the layer to be done with non-degrading membrane forming curing & sealing compound shall be acrylic resin based formulation. The product shall comply with ASTM C 309 Class B. The product shall exhibit water loss not more than 0.55 kg/m2 in 72 hours when tested as per ASTM C156. The product shall form non-degrading abrasion resistance film which shall also exhibit capability as primer for subsequent protective coatings or bituminous overlays.

b. For T.G.Hall (operating floor) Granite stone flooring finish will be as follows:

Minimum18~20mm thick polished Granite stone slab1.2 x2.0m to be used over minimum 32~30 mm thick under-bed. Stones shall be hard, sound, homogeneous and dense in texture and free from flaws. Angles and edges shall be true, square, and free from chipping and surface shall be plane. The slabs shall preferably be machine cut to the required dimensions. Tolerance of±5mm in dimensions and±2mm in thickness will be allowed. During laying the slabs the edges of the slab shall be buttered with slurry of cement, mixed with pigment matching the colour of the stone slabs. Just before handing over the surface shall be dusted with oxalic acid at the rate of 0.33 gm. Per. Sq.m. water sprinkled on to it and finished by buffing with felt or Hessian bobs.

c. For battery room, battery charger room, chemical laboratories, chlorination room etc., the areas handling corrosive liquids, overall 50 mm thick Acid and Alkali resistant vitrified tiles flooring with 20mm thick tiles with silica based epoxy mortar shall be used. Acid and Alkali resistant vitrified tiles with silica based epoxy mortar up to 2.1M height from finished floor level shall be used as dado. Chemical resistant paint shall be applied up to the ceiling level above Acid and Alkali resistant tiles dado. Ceiling shall also be painted with Chemical resistant paint.

For battery room finished with Epoxy flooring (where required)

On the prepared substrate, one coat of a solvent free, resin based dispersion Primer shall be applied. Density of the primer is around 1kg/lt and the mixing ratio of two components, Comp. A and B:: 1:2.5 by weight.

Over the primed surface, epoxy modified cementitious self levelling floor topping shall be laid maintaining the thickness of 2mm. The mixing ratio of three components Comp. A: Comp. B:Comp.C: 1:2.5:17by weight, compressive strength at 30ºC approx. 45N/mm² after 28days, the mortar density is around 2.2 kg/lt.

Priming shall be done again with a primer of two component product, comp. A: comp. B: 4:1 (By weight). Prior to mixing of these two components, only comp. A shall bestirred mechanically. When all of part B is added to part A, the mix is to be stirred for 3 minutes until a smooth consistency is achieved. Finally, after drying of the primer, two coats of high-build, slightly thixotropic, chemical resistant epoxy protective coating shall be applied as the top coat. Minimum 2 coats are required. This is two component products, comp. A: comp.B:3:1(by weight).The mixed densityis1.5kg/lt. at27^{O}C. The system shall be allowed for curing for 3 days.

d. All areas of toilet, including W.C and urinals have anti-skid vitrified ceramic tiles floor. Dado shall be of glazed tiles of minimum 5/6 mm thickness upto100 mm higher than lintel level starting from finish floor level.

e. Floor/ staircase and the areas prone to slippage due to oil spillage etc. shall be provided with non-skid floor finish.

f. 1000mmwide, minimum, P.C.C. paving as plinth protection, shall be provided around all buildings with surface drain of required size.

g. Risers and treads of concrete staircase of powerhouse and service building shall be of Granite slab and in all other RCC stairs of other plant buildings; same shall be of Kota stone finish with 20/25mm .All areas shall have 150 mm high skirting unless indicated otherwise in the specification.

h. For MCC and Switchgear rooms flexible electric insulated PVC synthetic sheet as per IS: 15652 2006 of minimum 1.0m width shall be applied in front of electrical equipment as per statutory norms.

10. Doors and Windows:

a. Hollow metal door at all levels shall be installed from ISO 9001-2000 certified Manufacturer. All hollow metal general doors with or without vision panel. Pressed Galvanised steel Single /Double leaf to required sizes which consist of frame, shutter, infill and finish as detailed below and conforming to IS 277.
Door frame shall be Single rebate profile of size 100 x 57 mm made out of 1.20 mm thick galvanised steel sheet (18 gauge). Frames shall be mitered and field assembled with self tabs. Frames shall be provided with back plate bracket and anchor fasteners for installation on a finished plastered masonry wall opening. Once frame installed shall be grouted with cement slurry if recommended on the clear masonry opening.
Door leaf shall be 46 mm thick fully flush double skin door with or without vision lite. Door leaf shall be manufactured from 0.8mm (22 gauge) minimum thick galvanised steel sheet. The internal construction of the door shall be rigid with steel stiffeners/ pads and reinforcement. The infill material shall be resin bonded honeycomb core. All doors shall be factory prepped for receiving appropriate hardware and provided with necessary reinforcement for hinges, locks, and door closers. The edges shall be interlocked with a bending radius of 1.4mm. For pair of doors astragals has to be provided on the meeting stile for both active and inactive leaf. Vision lite wherever applicable should be as per joinery details with a screw on glass beading on the inside. The glass shall be 5 mm clear toughened glass. Louvers when recommended shall be site proof and shall be flush fixed on the external surface.

All doors and frames shall be finished with etched primer coating, stove zinc phosphate primer and thermosetting polyurethane aliphatic grade paint of approved colour. The door leaf and frame shall have passed minimum 250 hours of salt spray test.

b. Hollow metal fire rated doors as per IS 3614 part-1 & part-2 for stability and integrity. Pressed Galvanized steel confirming to IS 277 with the following specification shall be used.

Recommended fire door shall have doors tested at CBRI for maximum rating of 2 hrs with vision panel. Test certificates shall be available for vision litters /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 are not allowed. Proper label confirming the type of door and the hourly rating is mandatory.

Door frame shall be double rebate profile of size 143 x 57 mm made out of 1.60 mm (16 gauge) minimum thick galvanized steel sheet. Frames shall be Mitered 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 striking jamb. Frames shall be provided with back plate bracket and anchor fasteners for installation on a finished plastered masonry wall opening. Once frame installed shall be grouted with cement & sand slurry necessary for fire doors on the clear masonry opening.
Door leaf shall be 46 mm thick fully flush double skin door with or without vision lite. Door leaf shall be manufactured from 1.2 mm (18 gauge) minimum thick galvanised steel sheet. The internal construction of the door shall be rigid reinforcement pads for receiving appropriate hardware. The infill material shall be resin bonded honeycomb core. All doors shall be factory prepped for receiving appropriate hardware and provided with necessary reinforcement for 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. 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.
All doors and frames shall be finished with etched primer coating, stove zinc phosphate primer and thermosetting polyurethane aliphatic grade paint of approved colour. The door leaf and frame shall have passed minimum 250 hours of salt spray test.

c. Main Entrance of Control Room shall be provided with air-locked lobby with provision of double doors of aluminium framework with glazing with sensor operated sliding type doors with all necessary hardware.

d. For main entrance of service building, and control equipment room, offices and where technically required double swing type full glazed minimum 3mm thick aluminium i.e. coloured powder

coated aluminium door. Full glazed aluminium partition with airlock shall be provided along (B) row of Turbine hall operating floor where clear view is desired. Glazing between air-conditioned areas shall be single glass whereas that between air- conditioned and non-air- conditioned area shall be with hermetically sealed insulating glass.

e. Doors of W.C and shower shall be hard core FRP door.

f. Full glazed windows and ventilators shall be powder coated and UV protected aluminium window frame with 6 mm thick (depending on the size of panel) clear float glass and 5.5 mm thick clear wired glass where required from safety point of view. All windows and ventilators shall meet the requirement of industrial windows and Ventilators. Glazing between AC and Non AC areas shall be double insulated glass. Aluminium sections shall be of heavy duty and from reputed and approved manufacturer. Windows and ventilators shall be fabricated and painted by the reputed fabricators at their own fabrication shop. Windows shall be glazed aluminium windows conforming to IS: 1949 & IS: 1948.

11. Rolling Shutters:

Rolling shutters as per IS: 6248 with electrically operating arrangement according to size shall be provided in buildings to facilitate handling and transportation of equipment for large openings from 9.0 sqm and above. Wherever truck entry is envisaged, minimum size of rolling shutter size shall not be less than 3.5m (W) x 4.0m (H). For any additional details refer Vol-IIG2/Part-B.

12. Glazing:

a. Glazing for windows in general shall be minimum 6 mm clear float glass and as mentioned elsewhere in this document.

b. Glazing in Control room between A/C & non-A/C area shall be with double glazed insulating glass consisting of 2 nos. 6 mm clear toughened float glass with 12 mm air gap in between, hermetically sealed.

c. Minimum 8.0 mm thick toughened float glass as specified be low shall be provided in doors, partitions, of Power house building, Service Building, , etc.

d. 24 mm thick insulated double glazing having 6 mm thick tinted heat- reflecting type outer float glass and 6 mm

thick plain inner float glass with 12mm air gap & hermetically sealed shall be mounted on powder coated aluminium frame suitable for structural glazing system.

Quality of glass is given below:

- 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.

- 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.

13. Roof waterproofing :

a) Roof waterproofing treatment shall be as follows:
For roofs with structural slope:

Compressed air cleaning has to be done so as to make the surface free of dust, debris, laitance etc. Repairing cracks by cutting and making V-groove in 25x25 mm, with polymer modified mortar, filling the groove with Cement Mortar (1:3) mixed with polymer10% by weight of cement. Top of thoroughly cleaned roof surface shall have a minimum 1.5mm thick sealer coat, which is a single component cold applied elastomeric waterproofing coating with >=500% elongation confirming to ASTM C836 applied by a spray/brush/roller in 2 coats. Water ponding/flood test is to be conducted after application. Water shall be filled up and retained for at least 24 to 48 hours. Loosely laid 120-150 GSM geotextile (non-woven polyester)

shall be provided over the Elastomeric coating. Laying protective slope with 25mm average thick (thickness will depend upon the required slope and span of the building) M 15 grade screed mixed with polypropylene fibres (RECRON or equivalent) and admixed with integral liquid waterproofing compound conforming to IS: 2645. Green stage saw cutting on the screed will be done in panels (3mx4m) with grooves 10mmx10mm. Finally the groove will be sealed with suitable elastomeric sealant. Finally top shall be finished with pressed clay tiles of size 230x230x18 mm laid in waterproofing compound mixed cement mortar (1:3) and sealing of joints using sealing compound.

All around on the roof, at the parapet wall junction, an angular fillet 50mm x 50mm shall be trowel applied in cement-sand mortarin 1:3 proportion. A latex based bonding agent shall be added (10% by weight of cement) and also a glass cloth must be inserted around the junctions while the angle fillet is being constructed.

For roofs having no structural slope:

Compressed air cleaning has to be done so as to make the surface free of dust, debris, laitance etc. Repairing cracks by cutting and making V-groove in25x25 mm, with polymer modified mortar, filling the groove with Cement Mortar (1:3) mixed with polymer10%by weigh to cement. Top of thoroughly cleaned roof surface shall have a minimum 1.5mm thick sealer coat, which is a single component cold applied elastomeric waterproofing coating with>=500% elongation confirming to ASTM C836 applied by a spray/brush/roller in 2 coats. Water ponding/flood test is to be conducted after application. Water shall be filled up and retained for at least 24 to 48 hours. Loosely laid 120-150 GSM geotextile (non-woven polyester) shall be provided over the Elastomeric coating. Laying protective slope (1:100) with 75mm average thick (thickness will depend upon the required slope and span of the building) M 15 grade screed mixed with polypropylene fibres (RECRON or equivalent) and admixed with integral liquid waterproofing compound conforming to IS: 2645. Green stage saw cutting on the screed will be done in panels (3mx4m) with grooves 10mmx10mm. Finally the groove will be sealed with suitable elastomeric sealant. Finally top shall be finished with pressed clay tiles of size 230x230x18 mm laid in waterproofing compound mixed cement mortar (1:3) and sealing of joints using sealing compound.

All around on the roof, at the parapet wall junction, an angular fillet 50mm x 50mm shall be trowel applied in cement-sand mortar in 1:3 proportion. A latex based bonding agent shall be

added (10% by weight of cement) and also a glass cloth must be inserted around the junctions while the angle fillet is being constructed.

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.

b) For efficient disposal of rainwater, the runoff gradient for the roof shall not be less than 1:100. The top surface of finished roof shall be such as to allow quick drainage of rainwater.

c) Heavy duty UPVC pipes of 150mm dia minimum conforming to relevant BIS Code shall be provided to drain off rainwater from the roof for Non plant buildings. The numbers and size of down comers shall be governed by IS: 1742 and IS: 2527. For plant buildings DI pipes of 150mm dia. shall be provided.

14. Painting:

a) External masonry surfaces of all buildings shall be finished with External Quality Acrylic Emulsion paint 2 coats(over a coat of primer) over plaster. Granular textured paint may also be combined along with External Quality Emulsion paint to form suitable pattern on building façade.

b) Acrylic plastic emulsion paint of reputed make,2 coats over a coat of primer approved by owner shall be provided in control room, control equipment room, computer room, UPS room, all office areas and all air-conditioned areas including entrance lobby.

c) All other areas shall also be provided with Acrylic Emulsion paint 2 coats over a coat of primer.

d) Internal surface of walls in rooms for pumps, machineries and maintenance shall be painted with washable synthetic enamel paint of dark shade 2 coats over a coat of primer up to a height of 1.5 m above floor level.

e) Battery room and all other areas coming in contact with acid/alkali or other corrosive liquid shall be painted with chemical resistant paint. Chemical resistant paint shall be applied up to the ceiling level above Acid and Alkali resistant tiles dado as specified elsewhere in this section. Ceiling shall also be painted with Chemical resistant paint.

h) All structural steel members including doors, windows, ventilators, louvers, rolling shutters and all other exposed steel work shall have two or more coats anti-corrosive paint and shall have minimum 110 micron DFT. Anti-corrosive paint shall be Specification in short: Self Priming, Single Pack, Elastomeric (450% elongation), thermoplastic, fire retardant, Coating skin tensile strength 18 to 21 kg. Per sq. Cm. Antifungal, antibacterial, anticorrosive, nontoxic graft Co-polymer coating as specified elsewhere.

i) All woodwork shall be painted with two coats of synthetic enamel paint over a coat of approved primer. DFT shall conform to IS specification.

j) All fire exit doors shall be painted in Post Office red 2 coats over a coat of primer.

k) Epoxy paint shall be provided in oil equipment room, oil canal, fuel oil pump house, etc.

l) Fire-proof putty for cable penetration openings on walls of cable spreader rooms is to be provided for fire sealing.

m) In general unless otherwise specified, Two coats of paint shall be applied over a coat of primer paint as per manufacturer's recommendation.

n) Internal Acrylic Emulsion Paint 2 coats over a coat of primer are to be applied over 3mm thick white cement putty finish.

15. Aluminium Composite Panels

1. Material:

Total thickness of the panel–4mm. Thickness of the aluminium skin– 0.5mm, Tensile strength of aluminium skin–120N/mm 2 minimum, Density of PEcore–920–980Kg/m3(Non toxic grade

Polyethylene) Coating –PVDF Adhesive film–DUPONT,USA Coating thickness(front foil)– 24µ-30µin PVDF including primer.15µ-18µin polyester coating. Coating thickness (back foil)– 4µ-7µ polyester coating.

2. Colour–as indicated in the drawing.

3. Fixing arrangement–aluminium composite sheets shall be folded inwardly on four edges(without cutting the outer skin) to from Aluminium Composite Panels(ACP)and shall be riveted to the aluminium extruded section like angle or channel. There shall be at least one rivet at the both ends of the folded edge and other rivets shall be 200 mm c/c per panel edge/fold. Aluminium angles shall form a frame around the panel and shall be fixed to the steel sub-frame by self tapping screws with EPDM shim to prevent by-metallic reaction. The gap/groove between two adjacent panels shall be filled with Silicon sealant of approved make(GE or similar make) to prevent water seepage.

4. The supply fabrication and erection of ACP is inclusive of steel sub-base frame work if necessary as per site condition. The Bidder shall take site measurement and produce working drawings for approval of engineer before erection of ACP.

16. **Polycarbonate Sheet:**

a) 4 mm thick Compact Polycarbonate sheet, transparent or smoke tinted, of Lexan Polycarbonate or MAKROLON Polycarbonate sheet or similar approved.

b) Framing shall be specially designed aluminium sections, colour anodised, with EPDM Gasket as per system provider's details. Framing shall be fixed to the steel structure as per site measurement, drawings and – Engineer in Charge.

c) Sealing of joints shall be done with Silicon sealant.

d) Minimum Density required for Multiwall Polycarbonate and Compact sheets:-

- 6 mm Multiwall Sheets: - 1.3 kg/m2
- 8 mm Multiwall Sheets: - 1.5 kg/m2
- 10 mm Multiwall Sheets: - 1.7 kg/m2
- 16 mm Multiwall Sheets:- 2.8 kg/ m2
- Compact Sheets: - 1.2 kg/m2/mm

e) The sheets shall have the minimum co-extruded UV coating of min 45 Micron

f) The fixing shall be done Aluminium Clamping profile (top and bottom) min 60mm wide profile with EPDM gasket by using self-driving and self-tapping screws.

g) The sheet should be produced and supplied Preferably by local manufacturer

h) The sheet shall pass the ISI 14443 specification for Multiwall system.

17. Stairs:

a) All stairs shall have not more than 12 risers in one flight. All staircases shall comply with all staircase related norms of National Building Code 2016, Part-4.
Height of risers and width of treads shall be150 mm (maximum) and 275 mm (minimum) respectively for fire escape stairs and 150 mm (maximum) & 275mm (minimum) for general staircases(for both RCC and Steel). Minimum width of stairs(for both steel and RCC) shall be 1500mm for indoor stairs and 1200mm for outdoor stairs (Unless specified otherwise). In general preferred rises shall be 150 mm high. For public buildings, the riser shall not exceed 150 mm height. The above is for all the buildings/structures under civil scope only.

b) Aluminium angle nosing shall be provided for edge protection of RCC stairs. Moulded granite nosing shall be provided for the main stairs finished with granite slab/ kota slab finishes.

c) 40ø NB stainless steel pipe handrail for stair in Service Building & T.G. Hall area and 40øNB medium class G.I pipe Handrail & vertical post and 40ØNB medium class G.I horizontal mid rails for stairs in other areas is to be provided. Minimum 1.0m high hand railing, shall be provided around all floor/roof openings, projections/balconies, walkways platforms, concrete and steel stairs.1200mm high railing may be provided for external fire escape stairs. Handrail shall be two rail systems with the top rail 1000mm / 1200mm (for higher elevation) above the walkway/ platform/ floor surface and the intermediate rail 500mm below the top rail. Guardrail post spacing will be proportional to the length of the protected horizontal opening but will not exceed 1500mm c/c to posts. Stainless steel class shall be 304 grades. 150mm high toe guard is to be provided.

18. Draining out water from floors

In all buildings, suitable floor drainage system to drain out water collected from equipment, blow downs, leakages, floor washings, fire fighting etc., shall be provided in each floor.

19. Fencing :

Minimum 3.00 meter high chain link fencing above toe wall shall be provided around building transformer area & other areas where fencing is necessary due to statutory requirements. Fencing shall comprise 3.00 metre high galvanized chain link fencing of minimum 3.15 mm diameter G.I. wire of mesh size 75 mm. The diameter of steel line wire for chain link fencing shall not be less than 4.0 mm. Steel entry gate matching construction shall be provided for all fenced areas. Top of the toe wall shall be minimum 200 mm above the formation level. Chain-link fencing shall be as per IS: 2721. Galvanisation on chain link shall be as per IS: 12753, hard coated finish. Vertical posts shall be 80NB G.I. pipe as per IS: 1161 (medium class) at 2.5m interval and with strainer posts wherever necessary.

20. Water Supply and Sanitation:

a) 1 no. Potable roof water tank and 1 no service water tank (HDPE white colour)of adequate capacity (minimum 1000 litres capacity each)depending on the number of users shall be provided for all the buildings except Power house where it is of RCC(internally lined with glazed ceramic tiles).

b) Galvanized MS Pipe of medium class shall be used for internal piping work for potable water supply. All water supply pipes inside the Non plant buildings are to be laid as concealed type

c) Extra heavy DI pipes or UPVC pipes with thermoplastic joints shall be used for sanitary work below ground.

d) UPVC pipes with proper sealing shall be used for sanitary work above ground level.

e) Drainage pipes shall be UPVC Type-B pipes as per IS: 13592-1992 (amended to 1995)

Pipes shall be as follows:
DI Pipes --- Plant Buildings
UPVC Pipes ---- Non-plant Buildings
DI Pipes --- Underground Pipes

f) Each toilet shall contain following best quality fittings/porcelain fixtures in adequate numbers as per National Building Code. In toilets primarily meant for workers an additional squatting type WC shall be provided. Minimum one exclusive toilet facilities for handicapped shall be provided in each floor as specified elsewhere.

Minimum fixtures in each toilet shall be as follow.

- All the facilities such as WC, Urinals, wash basins etc. shall be based on occupant load as per NBC and shall be of approved colour. However minimum requirements are given below.
- WC (Indian type) (minimum 580x440mm) as per IS: 2556 (Part-3) with all fittings including health faucet, flushing arrangement of appropriate capacity and type – 1no.
- WC western type as per IS: 2556 (part 2) with toilet paper roll holder and health faucet and all fittings including flushing system of appropriate capacity and type – 1 no.
- Urinal with sensor operated (IWC for ladies toilets) with all fittings including partition with photovoltaic control flushing system as per IS: 2556 (Part-6, Sec.1) – 2 nos.
- Wash basin (oval shape) with all fittings as per IS: 2556 to be fixed on concrete platform finished with min. 18 mm thick polished granite stone – 2 nos.
- Stainless steel towel rail (600 x 20mm) - 2 nos.
- Stainless steel liquid soap holder cum dispenser – 2 nos.
- Janitor room.
- Provision for ventilation shaft.
- Ladies toilet will be provided with items as in Gents Toilet except urinals.
- Sink–Stainless steel sink with integrated drain-board to be provided in janitor's closets, kitchen, pantry areas of approved make.
- Metal storage cabinets, under- counter as well as over head, shall be provided in janitor's room, kitchen, pantry and similar areas as per requirement of Owner.
- Minimum600mmlong Chromium plated tray.
- Chromium plated toilet paper roll holder
- Recessed Chromium plated soap tray in shower area.

- Robe hooks
- Drinking fountains in adequate numbers.

The exact number of fittings and fixtures, brand, colour etc. shall, however be finalized during detail engineering stage and same shall be of Owner's choice and Approval. However minimum 1 EWC and 1 IWC with cistern, 1 washbasin with mirror, towel rail, soap case, minimum 2 urinals shall be provided in each Gents toilet and all above fixtures without urinals for ladies toilet.

Note Toilets in Power House Operating Floor, Operating floor of service shall have coloured fixtures including counter-top wash basins with wide mirror, European type water closet with flush valve, sensor operated urinal, exclusive shower set etc. Other toilets in general shall have fixtures, low down cisterns, sensor operated urinals etc. Toilets for handicapped persons shall have adequate grab bars, barrier-free access and appropriate fittings and fixtures (minimum one EWC, Wash basin and mirror).

21. Under-Deck Insulation

a. Insulation material shall be Closed Cell Elastomeric Nitrile Rubber

b. Density of Material shall be between 40 to 60 Kg/m3

c. Thermal conductivity of elastomeric nitrile rubber shall not exceed 0.035 W/m°K at an average temperature of 0°C

d. 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. 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.

e. Under-deck insulation shall be provided for all AC areas having roof exposed to sun/floor exposed to heat atmosphere.

f. Thickness:

- For Concrete Slab: 50 mm thick sheet is used
- For Corrugated or metal ceiling: 50 mm thick sheet

22. Sealant:

1. Polysulphide Elastomeric joint sealant shall be, two-component, high performance polysulfide formulation having weathering resistance to ultraviolet ray property. The product shall exhibit shore 'A' hardness of 25 and have movement accommodation factor of 25%. The sealant must comply with the performance specifications as laid in BS:4254 and ASTM C 920. All the joints must be primed using compatible primer for the substrate from the. Sealant application shall be carried out, strictly in accordance with Manufacturer's recommendations.

2. Polyurethane based single component joint sealant materials based upon polyurethane resins shall be. They have been formulated with different modulus of elasticity 0.25-0.45 N/mm^2 and Shore 'A' hardness of 15-30 which makes them suitable for slightly different applications. The product shall exhibit elongation at break 600 % and recovery of 80%.

23. Expansion joints may be as per following locations:

a) Floor to Floor Joints at all internal locations
b) Roof to Roof Joints
c) Floor to Wall joints at internal locations
d) Roof to Wall Joints
e) Wall to Wall joints in exterior locations

During construction of RCC slab, beam, column the expansion gap shall be maintained by using polystyrene filler board.
During finishing stage expansion gaps shall be finished with the either elastomeric EPDM profile or elastomeric extruded poly vinyl chloride fitted in extruded aluminium sections with aluminium joint cover to form an integral system as manufactured by Three R Construction solutions Pvt Ltd. or an approved equivalent.

Expansion gap between metal cladding shall be finished with metal of same material having 'U' or 'W' shape and shall be covered with metal cladding –fixed at one end and fixed with slotted hole on other end or as per manufacturer's detail.
Externally the expansion joint sealing system shall form a continuum vertical and horizontal sealing system to make the building envelop water tight.

24. Statutory rules :

a) Design shall be complied with all applicable statutory rules pertaining to Factories Act as applicable for the State,

Rules of Tariff Advisory Committee (TAC), and Water Act for

pollution control etc.

b) Provision of safety, health and welfare according to Factories Act shall be complied with. These shall include provision of continuous walkway, minimum 500 mm wide, along the crane girder at crane girder level on both sides, comfortable approach to EOT crane cabin, fire escape, locker room for workmen, pantry, toilets, restrooms etc.

c) Provision for fireproof doors, number of staircases, fire separation walls, encasing of structural members (in fire prone areas) etc. shall be made according to the recommendation of Loss Prevention Association of India /Tariff Advisory Committee.

d) Statutory clearance and norms of State Pollution Control Board shall be followed as per Water Act for effluent quality from plant.

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INTERIOR FINISH SCHEDULE

SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
Turbine and its related Auxiliaries							
Turbine Building							
1	T.G. Hall Area,	Overall 50mm thick flooring shall be finished with 18 mm thick polished Granite stone slab. Unloading areas and walkways shall be demarcated with 75 mm wide and 18 mm thick Granite stone (black) on both sides of Granite stone finished walkways.	Acrylic emulsion paint over white cement putty on masonry surfaces wherever necessary and all other wall surface shall be with Acrylic Emulsion, Polished Granite slab minimum 18 mm thick wall cladding on (B) row wall (outer) upto false ceiling level/upto Roof slab of Control Room facade. There shall be minimum joints between granite slabs. The quality including colour texture etc. of granite shall be approved by the owner. The façade of control room may also be finished with ACP	T.G. Hall – anti-corrosive paint to metal deck and all metal works. Acrylic emulsion on exposed plastered ceiling (without false ceiling). Aluminium lineal pattern false ceiling / Aluminium plan or tiles type in combination with Gypsum board/ Acoustical type board shall be used for false ceiling areas.	Hollow metal flush door in general and 2Hr Fire Check door for fire escape stairs and electrical rooms. Important areas shall have Glazed aluminium door. For main entrance to Main control room shall be sensor operated glazed sliding door.	Aluminium glazed window. Main glazed partition for Main control room shall be insulated double glazed as per specification. A Row shall have structural glazing with low E glass blue tinted toughened glass on outer face and clear toughened float low E glass on inner face as per specification.	All painting works are 2 coats over a coat of primer.

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SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
			cladding / Exterior type wooden panels or any other latest state of the art façade treatment material as approved by the Owner. Above false ceiling of control room & Annexure room there shall be exposed plastered masonry surfaces. A row and gable end shall have double skin metal cladding system.				
2	Switchgear Room, MCC Room & Battery charger Room,	1.0m wide Electric insulated flexible PVC sheet as per IS: 15625-2006 to be laid in front of equipment over heavy duty vitrified tiles flooring or PU flooring. Overall thickness shall be 50mm.	Acrylic Emulsion	Acrylic Emulsion	Hollow metal flush door / fire door	-Do-	All painting works are 2 coats over a coat of primer
3	Control Rooms, Control Equipment Room, UPS room ,Computer	Non-skid, fully vitrified, 10 mm thick non-porous, homogenous, abrasion resistant, floor tiles of minimum size minimum 600	Fly Ash Brick masonry walls, columns, or any other element within the room as the case may be, shall be clad	Lineal pre-coated aluminium alloy ceiling stove enamelled on both sides similar to 'Luxalon' with Gypsum	Aluminium glazed door	-Do-	

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INTERIOR FINISH SCHEDULE

SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
	Rooms, etc. Other than Main Control Room.	mm x 600 mm of approved colour and shall be laid over concrete floor with laying compound strictly as per manufacturer's specification. Total thickness of the flooring shall be 50mm thick including the thickness of the tiles and under bed.	with polyester coated 4mm thick Aluminium Composite Panels (Aluminium thickness minimum 0.50 mm) of approved make up to the false ceiling level. The colour and design composition of ACP cladding to be submitted for approval of the authority before erection.	board to form pattern including suspension system as per manufacturer's details. The false ceiling work shall take care of all illumination, fire detection & fighting, HVAC and all other service requirement. False ceiling shall be provided with 25 mm thick insulation of resin bonded mineral wool conforming to IS: 8183. Wherever under-deck insulation is required the insulation shall be Closed Cell Elastomeric Nitrile Rubber.			
4	Main Control Room	As mentioned in the specification	As mentioned in the specification	As mentioned in the specification	As mentioned in the specification	As mentioned in the specification	

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INTERIOR FINISH SCHEDULE

SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
5	All office areas, Conference Room and other important areas in connection with main control room.	10 mm thick non-skid fully vitrified tiles of minimum size 600 mm x 600 mm" (overall 50 mm thick) laid in pattern with different colour of tiles.	Acrylic emulsion paint over white cement putty.	Acoustic mineral fibre board ceiling on aluminium grid system. Acrylic emulsion paint over white cement putty in areas without false ceiling.	Aluminium glazed door single or double leaf with 8mm thick toughened, tinted & etched float quality glass as per owner's choice with floor spring, mortise lock & latch and all accessories.	Aluminium glazed window with minimum 6mm thick clear float glass of specific values as mentioned in the specification with all accessories. Windows shall be partially open able and partially closed type having shutter size not more than 750Wx1500H mm.	All painting works are 2 coats over a coat of primer
6	Main Stair & Landing	Granite slab 18 mm thick (min.) with larger possible size to be approved by the owner.	Acrylic emulsion paint over white cement putty.	Acrylic emulsion paint over white cement putty.	Aluminium glazed door/ fire door	-Do-	All painting works are 2 coats over a coat of primer

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SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
7	Lift lobby	Granite slab 18 mm thick (min.) with larger possible size to be approved by the owner.	Granite slab(12mm) cladding	Aluminium lineal pattern false ceiling	Aluminium glazed door/ fire door	-Do-	
8	Battery Room	Acid/Alkali resistant vitrified tiles flooring along with 2100 mm high dado of same material.	Chemical resistant paint.	Chemical resistant paint.	Hollow metal flush fire door	-Do-	All painting works are 2 coats over a coat of primer
9	Chemical Feed Station	Acid/Alkali resistant vitrified tiles flooring along with 2100 mm high dado of same material.	Chemical resistant paint	Chemical resistant paint.	Hollow metal flush fire door with chemical resistant paint finish	-Do-	All painting works are 2 coats over a coat of primer
10	AHU Rooms, Air Washer Rooms, Cable Spreader Rooms & all other service areas	50 mm thick heavy-duty cement concrete floor with metallic hardener.	Acrylic emulsion Paint	Acrylic emulsion Paint	Hollow metal flush fire door. For AHU Room and Air Washer rooms airtight doors are to be provided.	-Do-	All painting works are 2 coats over a coat of primer
11	Toilet and other wet areas	Minimum 10 mm thick non-skid vitrified tile minimum size 400 mm x 400 mm	1st quality coloured glazed ceramic tiles of minimum 5 mm	Acrylic emulsion paint over white cement putty. Aluminium false	Main entry to toilet or wet areas shall	Aluminium glazed window/ ventilator	All painting works are 2 coats over a

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SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
		(overall 50 mm thick) with glazed ceramic tile of same make dado topped with 50 mm wide matching moulded ceramic trims. Dado height shall be 100 mm higher than lintel level starting from finish floor level.	thickness up to 100 mm higher than lintel level starting from finished floor level. Acrylic emulsion paint over white cement putty above dado.	ceiling where required.	be wooden panel door in hard wood frame and doors for WCs shall be FRP door frame &shutter.		coat of primer Toilets for Gents and ladies shall be provided in all floors , Along with toilet for Physically challenged in operating /ground floor
12	Oil Spillage area	Non-skid self-levelling epoxy over IPS (overall 50 mm thick)	Epoxy paint.	Epoxy paint.	Hollow metal flush door / fire door	-Do-	All painting works are 2 coats over a coat of primer
13	Electrical Switchgear Room, MCC Room, etc.	1.0m wide Electric insulated flexible PVC sheet as per IS: 15625-2006 to be laid in front of equipment over heavy duty vitrified tiles flooring or PU flooring. Overall thickness shall be 50mm.	Acrylic Emulsion	Acrylic Emulsion	Hollow metal flush door / fire door	-Do-	All painting works are 2 coats over a coat of primer
14	All other general areas except operating floor	Overall 50 mm thick heavy-duty concrete Granolithic floor with metallic hardener.	Acrylic Emulsion	Acrylic Emulsion	Hollow metal flush door / fire door	-Do-	All painting works are 2 coats over a

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INTERIOR FINISH SCHEDULE

SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
							coat of primer
CPU Regeneration Building							
1	CPU Regeneration Area	50 mm thick heavy duty cement concrete floor with metallic hardener and matching skirting	Synthetic enamel paint with cement putty up to 1.50mts height and Acrylic Emulsion for balance height	Acrylic Emulsion	Hollow metal flush door / fire door. For AHU Room and Air Washer rooms airtight doors are to be provided	Aluminium glazed window / ventilator	All painting works are 2 coats over a coat of primer
2	Cable Spreader Room	Overall 50 mm thick heavy-duty concrete Granolithic floor with metallic hardener.	Acrylic Emulsion	Acrylic Emulsion	Hollow metal flush door / fire door	-Do-	All painting works are 2 coats over a coat of primer
3	Control Room	10 mm thick non-skid fully vitrified tiles of minimum size 600 mm x 600 mm" (overall 50 mm thick) laid in pattern with different colour of tiles.	Acrylic emulsion paint over white cement putty.	Acoustic mineral fibre board ceiling on aluminium grid system.	Aluminium glazed door single or double leaf	Aluminium glazed window	All painting works are 2 coats over a coat of primer
4	Electrical Room	Overall 50 mm thick heavy-duty concrete Granolithic floor with metallic hardener.	Acrylic Emulsion	Acrylic Emulsion	Hollow metal flush door / fire door	Aluminium glazed window / ventilator	All painting works are 2 coats over a

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INTERIOR FINISH SCHEDULE

SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
							coat of primer
5	PAC Room	Overall 50 mm thick heavy-duty concrete Granolithic floor with metallic hardener.	Acrylic Emulsion	Acrylic Emulsion	Hollow metal flush door / fire door	Aluminium glazed window / ventilator	
6	Toilet	Minimum 10 mm thick non-skid vitrified tile minimum size 400 mm x 400 mm (overall 50 mm thick) with glazed ceramic tile of same make dado topped with 50 mm wide matching moulded ceramic trims. Dado height shall be 100 mm higher than lintel level starting from finish floor level.	1st quality coloured glazed ceramic tiles of minimum 5 mm thickness up to 100 mm higher than lintel level starting from finished floor level. Acrylic Emulsion paint over white cement putty above dado.	Acrylic Emulsion paint over white cement putty. Aluminium false ceiling where required.	Main entry to toilet or wet areas shall be wooden panel door in hard wood frame and doors for WCs shall be FRP door frame & shutter.	Aluminium glazed window/ ventilator	Toilets for Gents , ladies
7	Staircase	Kota stone slab	Acrylic Emulsion	Acrylic Emulsion	Fire door	Aluminium glazed window / ventilator	All painting works are 2 coats over a coat of primer
	CST Pump Shed						

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SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
	General area	50 mm thick heavy duty cement concrete floor with metallic hardener and matching skirting	Open	Exposed painted steel structure			All painting works are 2 coats over a coat of primer
	ACW pump house						
1	ACW Pump Room	50 mm thick heavy duty cement concrete Granolithic floor with metallic hardener and matching skirting	Synthetic enamel paint with cement putty up to 1.50mts height and Acrylic Emulsion for balance h eight	Acrylic Emulsion	Hollow metal flush door / fire door	Aluminium glazed window / ventilator	All painting works are 2 coats over a coat of primer
2	Air Washer Room	50 mm thick heavy duty cement concrete Granolithic floor with metallic hardener and matching skirting	Synthetic enamel paint with cement putty up to 1.50mts height and Acrylic Emulsion for balance height	Acrylic Emulsion	. Air Washer rooms airtight doors are to be provided	Aluminium glazed window / ventilator	Toilets for Gents and ladies shall be provided ,
DG Shed							

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INTERIOR FINISH SCHEDULE

SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
	General area	50 mm thick heavy duty cement concrete Granolithic floor with metallic hardener and matching skirting	Open	Exposed painted steel structure			All painting works are 2 coats over a coat of primer
Plant IA/SA Compressor House							
	General area	50 mm thick heavy duty cement concrete Granolithic floor with metallic hardener and matching skirting	Acrylic Emulsion paint	Acrylic Emulsion paint	Hollow metal flush door with louver.	Aluminium glazed window / ventilator	All painting works are 2 coats over a coat of primer Toilets for Gents and ladies shall be provided ,
A/C plant building and Inert gas room							
		50 mm thick heavy duty cement concrete Granolithic floor with metallic hardener and matching skirting	Acrylic Emulsion paint	-	Hollow metal flush door painted with Synthetic enamel paint, both ways.	All round fly ash brick wall with RCC jally.	
Boiler and its related Auxiliaries							

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INTERIOR FINISH SCHEDULE

SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
Mill &Bunker Building							
		50 mm thick heavy duty cement concrete floor with metallic hardener and matching skirting	Synthetic enamel paint up to 1.00mts height wall and double skin metal cladding for balance height.	Exposed painted structure.	Hollow metal flush door / fire door	Aluminium glazed window / ventilator	Polycarbonate sheet shall be combined with metal cladding to form pattern. Toilets for Gents and ladies shall be provided ,
Boiler Maintenance Building							
	MCC Room	10 mm thick non-skid fully vitrified tiles of minimum size 600 mm x 600 mm (overall 50 mm thick) laid in pattern. MCC rooms shall have flexible electric insulated PVC synthetic sheet in front of MCC Panels.	Acrylic Emulsion paint over white cement putty.	Pre-coated aluminium panelled (600mmx600mm size) ceiling.	Hollow metal flush fire door	Aluminium window / ventilator	
	Electrical & Mechanical Store Rooms	50mm thick heavy duty granolithic flooring with metallic hardener. Flexible electric insulated PVC synthetic sheet in front of electrical equipment.	Synthetic enamel paint up to 1.50mts height and Acrylic Emulsion paint over white cement putty for balance height.	Exposed painted structure	Hollow metal flush door	Aluminium window / ventilator	

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INTERIOR FINISH SCHEDULE

SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
	Office	10 mm thick non-skid fully vitrified tiles of minimum size 600 mm x 600 mm (overall 50 mm thick) laid in pattern.	Acrylic emulsion paint over white cement putty.	Pre-coated aluminium panelled (600mmx600mm size) ceiling.	Hollow metal flush door	Aluminium glazed window / ventilator	
	Toilet & other wet areas	10 mm thick non-skid fully vitrified tiles of make of minimum size 400 mm x 400 mm (overall 50 mm thick) laid in pattern with 5 mm thick glazed ceramic tile dado of same make topped with 50 mm wide matching ceramic trims. Height of dado shall be 100mm higher than the lintel level starting from floor finish level.	1st quality coloured glazed ceramic tiles of minimum 5 mm thickness up to 100 mm higher than lintel level starting from finish floor level. And balance portion with Acrylic Emulsion paint over white cement putty.	Pre-coated aluminium panelled (600mmx600mm size) ceiling	Main entry to toilet or wet areas shall be wooden panel door in hard wood frame and doors for WCs shall be FRP door frame & shutter.	Aluminium glazed window / ventilator	Toilets for Gents and ladies shall be provided ,
	Maintenance Bay	50mm thick heavy duty granolithic flooring with metallic hardener.	Synthetic enamel paint up to 1.50mts height and Acrylic Emulsion paint over white cement putty for balance height.	Exposed painted structure.	Hollow metal flush door & Rolling shutter.	Aluminium glazed window / ventilator	
ESP Control Building							

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INTERIOR FINISH SCHEDULE

SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
	Control room, Control panel room, Control equipment room	10 mm thick non-skid fully vitrified tiles of minimum size 600 mm x 600 mm (overall 50 mm thick) laid in pattern for Control room.	Acrylic emulsion paint over white cement putty for control room	Pre-coated aluminium panelled (600mmx600mm size) ceiling similar to 'Luxalon" in Control room and air-conditioned areas.	Hollow metal flush fire door/ Aluminium glazed door	Aluminium window / ventilator	
	Switchgear room, Cable spreader room, other electrical rooms	50mm thick heavy duty granolithic flooring with metallic hardener.1.0m wide Flexible electric insulated PVC synthetic sheet in front of electrical equipment.	Synthetic enamel paint up to 1.50mts height and Acrylic Emulsion paint over white cement putty for balance height.	Acrylic Emulsion paint	Hollow metal flush fire door/ Aluminium glazed door	Aluminium window / ventilator	
	MCC Room	10 mm thick non-skid fully vitrified tiles of minimum size 600 mm x 600 mm (overall 50 mm thick) laid in pattern. MCC rooms shall have 1.0m wide flexible electric insulated PVC synthetic sheet in front of MCC Panels.	Acrylic Emulsion paint over white cement putty.	Pre-coated aluminium panelled (600mmx600mm size) ceiling.	Hollow metal flush fire door/ Aluminium glazed door	Aluminium window / ventilator	
	Toilet & other wet areas	10 mm thick non-skid fully vitrified tiles of make of minimum size 400 mm x 400 mm (overall 50 mm	1st quality coloured glazed ceramic tiles of minimum 5 mm thickness up to 100	Acrylic Emulsion paint	Main entry to toilet or wet areas shall be wooden	Aluminium glazed window / ventilator	Toilets for Gents and ladies shall be provided in all

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INTERIOR FINISH SCHEDULE

SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
		thick) laid in pattern with 5 mm thick glazed ceramic tile dado of same make topped with 50 mm wide matching ceramic trims. Height of dado shall be 100mm higher than the lintel level starting from floor finish level.	mm higher than lintel level starting from finish floor level. And balance portion with Acrylic Emulsion paint over white cement putty.		panel door in hard wood frame and doors for WCs shall be FRP door frame & shutter.		floors , Along with toilet for Physically challenged in operating /ground floor
	Staircase & Lobby	Overall 50mm thick granite slab flooring with 20mm thick granite slab and matching skirting.	Acrylic Emulsion Paint over white cement putty	Acrylic Emulsion Paint	Fire check doors -2hr rated.	Aluminium glazed window / ventilator	SS railing for stairs.
Fuel Oil Unloading cum Pressurising Pump House							
		Self-levelling PU/epoxy floor on oily areas and heavy duty Granolithic flooring with hardener in balance areas.	Synthetic enamel paint up to 1.50mts height and Acrylic Emulsion paint with white cement putty for balance height	Acrylic Emulsion paint	Hollow metal flush door / fire door	Aluminium glazed window / ventilator	
Auxiliary Boiler MCC & Control Room							
	Control Room and office area	10 mm thick non-skid fully vitrified tiles of minimum size 600 mm x 600 mm (overall 50 mm thick) laid in pattern.	Acrylic emulsion paint over white cement putty .	Pre-coated alu. linear ceiling similar to 'Luxalon in air-conditioned areas. Exposed painted	Hollow metal flush fire door/ Aluminium glazed door	Aluminium glazed window / ventilator	

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SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
				structure in other areas.			
	Switchgear room, Cable spreader room, other electrical rooms	50mm thick heavy duty granolithic flooring with metallic hardener. 1.0m wide Flexible electric insulated PVC synthetic sheet in front of electrical equipment.	Synthetic enamel paint up to 1.50mts height and Acrylic Emulsion paint over white cement putty for balance height.	Acrylic Emulsion paint	Hollow metal flush fire door/ Aluminium glazed door	Aluminium window / ventilator	
	MCC Room	10 mm thick non-skid fully vitrified tiles of minimum size 600 mm x 600 mm (overall 50 mm thick) laid in pattern. MCC rooms shall have 1.0m wide flexible electric insulated PVC synthetic sheet in front of MCC Panels.	Acrylic Emulsion paint over white cement putty.	Pre-coated aluminium panelled (600mmx600mm size) ceiling.	Hollow metal flush fire door/ Aluminium glazed door	Aluminium window / ventilator	
	Other areas	50 mm thick heavy duty cement concrete floor with metallic hardener and matching skirting	Synthetic enamel paint up to 1.50mts height and Acrylic Emulsion paint over white cement putty	Acrylic Emulsion paint	Hollow metal flush door	Aluminium glazed window / ventilator	

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SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
	Toilet & other wet areas	10 mm thick non-skid fully vitrified tiles of make of minimum size 400 mm x 400 mm (overall 50 mm thick) laid in pattern with 5 mm thick glazed ceramic tile dado of same make topped with 50 mm wide matching ceramic trims. Height of dado shall be 100mm higher than the lintel level starting from floor finish level.	1st quality coloured glazed ceramic tiles of minimum 5 mm thickness up to 100 mm higher than lintel level starting from finish floor level. And balance portion with Acrylic Emulsion paint over white cement putty.	Pre-coated aluminium panelled (600mmx600mm size) ceiling	Main entry to toilet or wet areas shall be wooden panel door in hard wood frame and doors for WCs shall be FRP door frame & shutter.	Aluminium glazed window / ventilator	Toilets for Gents and ladies shall be provided in all floors , Along with toilet for Physically challenged in operating /ground floor
Compressor Shed in Ammonia Storage Area							
		Alkali acid resistant tiles over 50 mm thick heavy duty cement concrete floor and matching skirting	Open.	sheet roof			
MCC / Operator Room for SCR System							
	MCC Room	10 mm thick non-skid fully vitrified tiles of minimum size 600 mm x 600 mm (overall 50 mm thick) laid	Acrylic Emulsion paint over white cement putty.	Pre-coated aluminium panelled (600mmx600mm size) ceiling.	Hollow metal flush fire door	Aluminium window / ventilator	Toilets for Gents and ladies shall be provided

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SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
		in pattern. MCC rooms shall have flexible electric insulated PVC synthetic sheet in front of MCC Panels.					
RIO-cum-VFD Panel Room							
	R I/O room	10 mm thick non-skid fully vitrified tiles of minimum size 600 mm x 600 mm (overall 50 mm thick) laid in pattern.	Acrylic emulsion paint over white cement putty.	Pre-coated aluminium panelled (600mmx600mm size) ceiling.	Hollow metal flush fire door	Aluminium window / ventilator	Toilets for Gents and ladies shall be provided
Coal Handling System and its related Auxiliaries							
1	**Receiving Tower**	50 mm thick heavy duty cement concrete floor with metallic hardener and matching skirting	Single skin sheet metal cladding in combination with polycarbonate sheets	Painted exposed structure-Synthetic enamel on steel and Acrylic Emulsion on RCC	Hollow metal flush door / fire door	Powder coated and UV protected Aluminium glazed window / ventilator	
2	**Drive House**	50 mm thick heavy duty cement concrete Granolithic floor with metallic hardener	Single skin, Zincalume metal cladding in combination with	Painted exposed structure-Synthetic enamel on steel and Acrylic Emulsion on	Hollow metal flush door painted with	Powder coated and UV protected Aluminium	

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SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
			polycarbonate sheets. Acrylic emulsion paint on fly ash brick wall.	RCC	Synthetic enamel paint, both ways.	glazed window / ventilator	
3	**Crusher House**	50 mm thick heavy duty cement concrete floor with metallic hardener and matching skirting	Double skin sheet metal cladding in combination with polycarbonate sheets. Acrylic emulsion paint on 3m high fly ash brick wall.	Painted exposed structure-Synthetic enamel on steel and Acrylic Emulsion on RCC	Hollow metal flush door / fire door	Powder coated and UV protected Aluminium glazed window / ventilator	Toilets for Gents and ladies shall be provided in Ground floor
4	**Junction towers**	-Do-	Single skin sheet metal cladding in combination with polycarbonate sheets and Acrylic emulsion paint on fly ash brick wall.	-Do-	-Do-	-Do-	
5	**Conveyor gallery**	-Grade slab shall be finished with 50mm concrete with metallic hardener.	Single skin sheet metal cladding in combination with polycarbonate sheets.	Synthetic enamel Painted on Steel	Hollow metal flush door / fire door	Powder coated and UV protected Aluminium glazed window	

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SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
						/ ventilator	
6	**CHP Control room cum switchgear building**						
	Control Room	10 mm thick non-skid fully vitrified tiles of minimum size 600 mm x 600 mm (overall 50 mm thick) laid in pattern and matching skirting	Acrylic emulsion paint over white cement putty.	Mineral Fibre Based Acoustic Ceiling Board false ceiling with insulation on top.	Aluminium glazed door and at the Main entrances collapsible door shall also be provided	Powder coated and UV protected Aluminium glazed window / ventilator	
	Electrical Room & switchgear room	10 mm thick non-skid fully vitrified tiles of minimum size 600 mm x 600 mm (overall 50 mm thick) laid in pattern and matching skirting1.0m wide flexible electric insulated PVC synthetic sheet is to be laid in front of electrical equipment.	White cement wall putty for full height Synthetic enamel paint up to 1.50mts height and Acrylic Emulsion paint for balance height	Acrylic Emulsion Paint.	Hollow metal flush door / fire door	-Do-	

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SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
	Battery Room	Minimum 20 mm thick acid and alkali resistant tile set in and jointed with epoxy mortar (overall 50mm thick) along with 2100mm high dado of same tile.	Chemical resistant paint	Chemical resistant paint	Hollow metal flush door	-Do-	
	Toilet & other wet areas	10 mm thick non-skid fully vitrified tiles of minimum size 400 mm x 400 mm (overall 50 mm thick) laid in pattern with 5 mm thick glazed ceramic tile dado of same make topped with 50 mm wide matching ceramic trims. Height of dado shall be 100mm higher than the lintel level starting from floor finish level.	1st quality coloured glazed ceramic tiles of minimum 5 mm thickness up to 100 mm higher than lintel level starting from finish floor level. And balance portion with Acrylic Emulsion paint over white cement putty.	Acrylic Emulsion paint.	Main entry to toilet or wet areas shall be wooden panel door in hard wood frame and doors for WCs shall be FRP door frame & shutter.	-Do-	Toilets for Gents and ladies shall be provided in all floors , Along with toilet for Physically challenged in ground floor
7	Pump cum compressor houses for	50 mm thick heavy duty cement concrete floor with metallic hardener and	White cement wall putty. Synthetic enamel paint up to	Acrylic Emulsion paint.	Hollow metal flush door / fire	Powder coated and UV protected	Toilets for Gents shall be provided

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SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
	DDS/ DFDS	matching skirting	1.50mts height and Acrylic Emulsion paint for balance height		door	Aluminium glazed window / ventilator	
8	Coal Handling system maintenance Building	50mm thick heavy duty granolithic flooring with metallic hardener.	Synthetic enamel paint up to 1.50mts height and Acrylic Emulsion paint over white cement putty for balance height.	Exposed painted structure.	Hollow metal flush door & Rolling shutter.	Aluminium glazed window / ventilator	
Ash Handling System and its related Auxiliaries							
1	**Ash water pump house**						
	Pump house	50 mm thick heavy duty cement concrete floor with metallic hardener and matching skirting	White cement wall putty. Synthetic enamel paint up to 1.50mts height and Acrylic Emulsion paint for balance height	Acrylic Emulsion paint	Hollow metal flush door / fire door	Powder coated and UV protected Aluminium glazed window / ventilator	Toilets for Gents shall be provided
	Control room	10 mm thick non-skid fully vitrified tiles of minimum size 600 mm x 600 mm (overall 50 mm thick) laid in pattern and matching	Acrylic emulsion paint over white cement putty.	Mineral Fibre Based Acoustic Ceiling Board false ceiling with insulation on	Aluminium glazed door.	-Do-	Toilets for Gents and ladies shall be provided .

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SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
		skirting		top.			
2	**Silo utility building cum HCSD pump house**						
	General area	50 mm thick heavy duty cement concrete floor with metallic hardener and matching skirting	White cement wall putty. Synthetic enamel paint up to 1.50mts height and Acrylic Emulsion paint for balance height	Acrylic Emulsion	Hollow metal flush door / fire door	Powder coated and UV protected Aluminium glazed window / ventilator	
	Control room	10 mm thick non-skid fully vitrified tiles of minimum size 600 mm x 600 mm (overall 50 mm thick) laid in pattern and matching skirting.	Acrylic emulsion paint over white cement putty.	Mineral Fibre Based Acoustic Ceiling Board false ceiling with insulation on top.	Aluminium glazed door.	-Do-	
	Battery room	Minimum 20 mm thick acid and alkali resistant tile set in and jointed with epoxy mortar (overall 50mm thick) along with 2100mm	Chemical resistant paint	Chemical resistant paint	Hollow metal flush door	-Do-	

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SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
		high dado of same tile.					
	Toilet	10 mm thick non-skid fully vitrified tiles of minimum size 400 mm x 400 mm (overall 50 mm thick) laid in pattern with 5 mm thick glazed ceramic tile dado of same make topped with 50 mm wide matching ceramic trims. Height of dado shall be 100mm higher than the lintel level starting from floor finish level.	1st quality coloured glazed ceramic tiles of minimum 5 mm thickness up to 100 mm higher than lintel level starting from finish floor level. And balance portion with Acrylic Emulsion paint over white cement putty.	Acrylic Emulsion paint	Main entry to toilet or wet areas shall be wooden panel door in hard wood frame and doors for WCs shall be FRP door frame & shutter.	-Do-	Toilets for Gents and ladies shall be provided .
3	**Compressor house and Main control room**						
	Control room	10 mm thick non-skid fully vitrified tiles of minimum size 600 mm x 600 mm	Acrylic emulsion paint over white cement putty.	Mineral Fibre Based Acoustic Ceiling Board false ceiling	Aluminium glazed door	-Do-	

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SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
		(overall 50 mm thick) laid in pattern and matching skirting		with insulation on top.			
	MCC & Switchgear rooms	10 mm thick non-skid fully vitrified tiles of minimum size 600 mm x 600 mm (overall 50 mm thick) laid in pattern and matching skirting1.0m wide flexible electric insulated PVC synthetic sheet is to be laid in front of electrical equipment.	White cement wall putty. Synthetic enamel paint up to 1.50mts height and Acrylic Emulsion paint for balance height	Acrylic Emulsion paint	Hollow metal flush door / fire door	-Do-	
	Toilet & other wet areas	10 mm thick non-skid fully vitrified tiles of minimum size 400 mm x 400 mm (overall 50 mm thick) laid in pattern with 5 mm thick glazed ceramic tile dado of same make topped with 50 mm wide matching ceramic trims. Height of dado shall be 100mm higher than the lintel level starting from floor finish level.	1st quality coloured glazed ceramic tiles of minimum 5 mm thickness up to 100 mm higher than lintel level starting from finish floor level. And balance portion with Acrylic Emulsion paint over white cement putty.	Acrylic Emulsion paint	Main entry to toilet or wet areas shall be wooden panel door in hard wood frame and doors for WCs shall be FRP door	-Do-	Toilets for Gents and ladies shall be provided in all floors , Along with toilet for Physically challenged at ground floor.

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SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
					frame & shutter.		
	Other area	50 mm thick heavy duty cement concrete floor with metallic hardener and matching skirting	White cement wall putty. Synthetic enamel paint up to 1.50mts height and Acrylic Emulsion paint for balance height	Acrylic Emulsion paint	Hollow metal flush door / fire door and at the Main entrances collapsible door shall also be provided.	Powder coated and UV protected Aluminium glazed window / ventilator	
4	**Ash water Transfer pump house**						
	50 mm thick heavy duty cement concrete floor with metallic hardener and matching skirting	White cement wall putty. Synthetic enamel paint up to 1.50mts height and Acrylic Emulsion paint for balance height	Acrylic Emulsion	Hollow metal flush door / fire door	Powder coated and UV protected Aluminium glazed window / ventilator	-Do-	Toilets for Gents shall be provided

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SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
Raw Water Intake & Transfer System							
1	**Raw water Transfer pump house**						
	Pump room and maintenance bay	50 mm thick heavy duty cement concrete floor with metallic hardener and matching skirting	White cement wall putty. Synthetic enamel paint up to 1.50mts height and Acrylic Emulsion paint for balance height	Acrylic Emulsion	Hollow metal flush door / fire door	Powder coated and UV protected Aluminium glazed window / ventilator	
	Control Room, Offices	10 mm thick non-skid fully vitrified tiles of minimum size 600 mm x 600 mm (overall 50 mm thick) laid in pattern and matching skirting.	Vitrified tiles dado up to 1.50 m height and Acrylic emulsion paint over white cement putty for balance height for control room and Acrylic emulsion paint over white cement putty for offices for full height	Mineral Fibre Based Acoustic Ceiling Board false ceiling with insulation on top.	Aluminium glazed door	Powder coated and UV protected Aluminium glazed window / ventilator	

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SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
	MCC & Switch gear rooms	50mm thick heavy duty granolithic flooring with metallic hardener. 1.0m wide Flexible electric insulated PVC synthetic sheet in front of electrical equipment.	White cement wall putty. Synthetic enamel paint up to 1.50mts height and Acrylic Emulsion paint for balance height	Acrylic Emulsion	Hollow metal flush door / fire door	Powder coated and UV protected Aluminium glazed window / ventilator	
	Toilet & other wet areas	10 mm thick non-skid fully vitrified tiles of minimum size 400 mm x 400 mm (overall 50 mm thick) laid in pattern with 5 mm thick glazed ceramic tile dado of same make topped with 50 mm wide matching ceramic trims. Height of dado shall be 100mm higher than the lintel level starting from floor finish level.	1st quality coloured glazed ceramic tiles of minimum 5 mm thickness up to 100 mm higher than lintel level starting from finish floor level. And balance portion with Acrylic Emulsion paint over white cement putty.	Acrylic Emulsion paint	Main entry to toilet or wet areas shall be wooden panel door in hard wood frame and doors for WCs shall be FRP door frame & shutter.	-Do-	Toilets for Gents and ladies shall be provided .
2	**Raw water intake pump house**	50 mm thick heavy duty cement concrete floor with metallic hardener and	White cement wall putty. Synthetic enamel paint up to 1.50mts height and	Acrylic Emulsion	Hollow metal flush door / fire	-Do-	Toilets for Gents shall be provided

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SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
		matching skirting	Acrylic Emulsion paint for balance height		door		
	Switchgear/ MCC room	-Do-	-Do-	-Do-	-Do-	-Do-	-Do-
Water Pre-treatment & DM Water System							
1	**Chemical House with treatment Plant/ Lab**						
	Offices	10 mm thick non-skid fully vitrified tiles of minimum size 600 mm x 600 mm (overall 50 mm thick) laid in pattern and matching skirting..	Acrylic emulsion paint over white cement putty.	Mineral Fibre Based Acoustic Ceiling Board false ceiling with insulation on top.	Aluminium glazed door and at the Main entrances collapsible door shall also be provided	Powder coated and UV protected aluminium window Aluminium glazed window / ventilator	
	Laboratories	Minimum 20 mm thick acid and alkali resistant tile set in and jointed with epoxy mortar (overall 50mm thick) along with 2100mm high dado of same tile.	Chemical resistant paint	-Do-	-Do-	-Do-	

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SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
	Chemical store	Minimum 20 mm thick acid and alkali resistant tile set in and jointed with epoxy mortar (overall 50mm thick) along with 2100mm high dado of same tile.	Chemical resistant paint	Chemical resistant paint	Hollow metal flush door	-Do-	
	MCC room, chlorine tonner room, & maintenance room	50mm thick heavy duty granolithic flooring with metallic hardener. 1.0m wide Flexible electric insulated PVC synthetic sheet in front of electrical equipment.	White cement wall putty. Synthetic enamel paint up to 1.50mts height and Acrylic Emulsion paint for balance height	Acrylic Emulsion	Hollow metal flush door / fire door	-Do-	
	Toilet and wet areas	10 mm thick non-skid fully vitrified tiles of minimum size 400 mm x 400 mm (overall 50 mm thick) laid in pattern with 5 mm thick glazed ceramic tile dado of same make topped with 50 mm wide matching ceramic trims. Height of dado shall be 100mm higher than the lintel level starting from	1st quality coloured glazed ceramic tiles of minimum 5 mm thickness up to 100 mm higher than lintel level starting from finish floor level. And balance portion with Acrylic Emulsion paint over white cement putty.	Acrylic Emulsion paint	Main entry to toilet or wet areas shall be wooden panel door in hard wood frame and doors for WCs shall be	-Do-	Toilets for Gents and ladies shall be provided in all floors , Along with toilet for Physically challenged in ground floor

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SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
		floor finish level.			FRP door frame & shutter.		
2	**PW Chlorination plant building**						
	General area	Minimum 20 mm thick acid and alkali resistant vitrified tile or minimum 37mm thick Acid /Alkali resistant brick, set in and jointed with epoxy mortar (overall 50 mm thick) along with 2100 mm high dado of same tile having 20mm thickness. Where required, other areas with 50mm thick heavy duty flooring with metallic hardener.	White cement wall putty. Chemical resistant paint in acid & alkali prone area and rest with Synthetic enamel paint up to 1.50mts height and Acrylic Emulsion paint for balance height	Chemical resistant paint for acid & alkali resistant area and other areas with Acrylic Emulsion paint.	Hollow metal flush door / fire door	Powder coated and UV protected Aluminium glazed window / ventilator	Toilets for Gents and ladies shall be provided
3	**UF Permeate storage tank & pump house**						

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SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
	General area	50 mm thick heavy duty cement concrete floor with metallic hardener and matching skirting	Open. Acrylic Emulsion paint for bottom brick portion	Acrylic Emulsion paint	-	-	
4	**DM plant building with switchgear room and control room**						
	Plant area	Minimum 20 mm thick acid and alkali resistant Vitrified tile set in and jointed with epoxy mortar (overall 50mm thick)	20mm thick acid resistant tiles over bitumen primer up to 1.20mts height and Acid/Alkali resistant epoxy paint for balance height in acid & alkali prone area and rest with Acrylic Emulsion paint	Chemical resistant paint for acid & alkali resistant area and other areas with Acrylic Emulsion paint	Hollow metal flush door / fire door	Powder coated and UV protected Aluminium glazed window / ventilator	
	Switchgear Room	50mm thick heavy duty granolithic flooring with metallic hardener. 1.0m wide Flexible electric insulated PVC synthetic sheet in front of electrical equipment.	White cement wall putty. Synthetic enamel paint up to 1.50mts height and Acrylic Emulsion paint for balance height	Acrylic Emulsion	Hollow metal flush door / fire door	Powder coated and UV protected Aluminium glazed window / ventilator	

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SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
	Battery Room	Minimum 20 mm thick acid and alkali resistant tile set in and jointed with epoxy mortar (overall 50mm thick) along with 2100mm high dado of same tile.	Chemical resistant paint	Chemical resistant paint	Hollow metal flush door	-Do-	
	Control Room & Offices	10 mm thick non-skid fully vitrified tiles of make of minimum size 600 mm x 600 mm (overall 50 mm thick) laid in pattern and matching skirting	Acrylic emulsion paint over white cement putty.	Mineral Fibre Based Acoustic Ceiling Board false ceiling with insulation on top.	Aluminium glazed door	-Do-	
	Laboratories	Minimum 20 mm thick acid and alkali resistant tile set in and jointed with epoxy mortar (overall 50mm thick) along with 2100mm high dado of same tile.	Chemical resistant paint	-Do-	-Do-	-Do-	
	Toilet	10 mm thick non-skid fully vitrified tiles of minimum size 400 mm x 400 mm (overall 50 mm thick) laid	1st quality coloured glazed ceramic tiles of minimum 5 mm thickness up to 100	Acrylic Emulsion Paint	Main entry to toilet or wet areas shall be	-Do-	Toilets for Gents and ladies shall be provided in all

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SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
		in pattern with 5 mm thick glazed ceramic tile dado of same make topped with 50 mm wide matching ceramic trims. Height of dado shall be full height	mm higher than lintel level starting from finish floor level. And balance portion with Acrylic Emulsion paint over white cement putty.		wooden panel door in hard wood frame and doors for WCs shall be FRP door frame & shutter.		floors , Along with toilet for Physically challenged in ground floor
5	**Clarified water pump houses**						
	Pump room	50 mm thick heavy duty cement concrete floor with metallic hardener and matching skirting	White cement wall putty. Synthetic enamel paint up to 1.50mts height and Acrylic Emulsion paint for balance height	Acrylic Emulsion	Hollow metal flush door / fire door and door At the Main entrances collapsible door shall also be provided	Powder coated and UV protected Aluminium glazed window / ventilator	

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SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
	Control Room	10 mm thick non-skid fully vitrified tiles of make of minimum size 600 mm x 600 mm (overall 50 mm thick) laid in pattern and matching skirting	Acrylic emulsion paint over white cement putty.	Mineral Fibre Based Acoustic Ceiling Board false ceiling with insulation on top.	Aluminium glazed door	-Do-	
	MCC & Switch gear rooms	50mm thick heavy duty granolithic flooring with metallic hardener. 1.0m wide Flexible electric insulated PVC synthetic sheet in front of electrical equipment.	White cement wall putty. Synthetic enamel paint up to 1.50mts height and Acrylic Emulsion paint for balance height	Acrylic Emulsion	Hollow metal flush door / fire door	Powder coated and UV protected Aluminium glazed window / ventilator	
	Toilet	10 mm thick non-skid fully vitrified tiles of minimum size 400 mm x 400 mm (overall 50 mm thick) laid in pattern with 5 mm thick glazed ceramic tile dado of same make topped with 50 mm wide matching ceramic trims. Height of dado shall be full height	1st quality coloured glazed ceramic tiles of minimum 5 mm thickness up to 100 mm higher than lintel level starting from finish floor level. And balance portion with Acrylic Emulsion paint over white cement	Acrylic Emulsion Paint	Main entry to toilet or wet areas shall be wooden panel door in hard wood frame and doors for WCs shall be	-Do-	Toilets for Gents and ladies shall be provided .

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SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
			putty.		FRP door frame & shutter.		
	Battery Room	Minimum 20 mm thick acid and alkali resistant vitrified tile Minimum 37 mm thick Acid /Alkali resistant brick, set in and jointed with epoxy mortar (overall 50 mm thick) along with 2100 mm high dado of same tile having 20 mm thickness.	20mm thick acid resistant tiles over bitumen primer up to 1.20mts height and Chemical resistant epoxy paint for balance height	Acid/Alkali resistant paint.	Hollow metal flush/ fire door	-Do-	
6	Degassed water storage pump house	50 mm thick heavy duty cement concrete floor with metallic hardener and matching skirting	White cement wall putty. Synthetic enamel paint up to 1.50mts height and Acrylic Emulsion paint for balance height	Acrylic Emulsion	Hollow metal flush door / fire door	Powder coated and UV protected Aluminium glazed window / ventilator	Toilets for Gents shall be provided
7	Pump house for Rain water harvesting	-Do-	-Do-	-Do-	-Do-	-Do-	Toilets for Gents shall be provided .

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SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
8	**Switchgear/ MCC Room**	50mm thick heavy duty granolithic flooring with metallic hardener. 1.0m wide Flexible electric insulated PVC synthetic sheet in front of electrical equipment.	-Do-	-Do-	-Do-	-Do-	Toilets for Gents and ladies shall be provided
Effluent Treatment Plant							
1	**E T P building including pump house and control room**						
	General area	50 mm thick heavy duty cement concrete floor with metallic hardener and matching skirting	White cement wall putty. Synthetic enamel paint up to 1.50mts height and Acrylic Emulsion paint with white cement putty for balance height	Acrylic Emulsion	Hollow metal flush door / fire door. Main entrances collapsible door shall also be provided	Powder coated and UV protected Aluminium glazed window / ventilator	

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SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
	Control Room & Offices	10 mm thick non-skid fully vitrified tiles of make of minimum size 600 mm x 600 mm (overall 50 mm thick) laid in pattern and matching skirting	Acrylic emulsion paint over white cement putty.	Mineral Fibre Based Acoustic Ceiling Board false ceiling with insulation on top.	Aluminium glazed door	-Do-	
	Toilet	10 mm thick non-skid fully vitrified tiles of minimum size 400 mm x 400 mm (overall 50 mm thick) laid in pattern with 5 mm thick glazed ceramic tile dado of same make topped with 50 mm wide matching ceramic trims. Height of dado shall be full height	1st quality coloured glazed ceramic tiles of minimum 5 mm thickness up to 100 mm higher than lintel level starting from finish floor level. And balance portion with Acrylic Emulsion paint over white cement putty.	Acrylic Emulsion Paint	Main entry to toilet or wet areas shall be wooden panel door in hard wood frame and doors for WCs shall be FRP door frame & shutter.	-Do-	Toilets for Gents and ladies shall be provided Along with toilet for Physically challenged in ground floor
2	**ETP CTBD/ RO building**						

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INTERIOR FINISH SCHEDULE

SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
	General area	50 mm thick heavy duty cement concrete floor with metallic hardener and matching skirting	White cement wall putty. Synthetic enamel paint up to 1.50mts height and Acrylic Emulsion paint for balance height	Acrylic Emulsion	Hollow metal flush door / fire door. Main entrances collapsible door shall also be provided	Powder coated and UV protected Aluminium glazed window / ventilator	
	Laboratories	Minimum 20 mm thick acid and alkali resistant tile set in and jointed with epoxy mortar (overall 50mm thick) along with 2100mm high dado of same tile.	Chemical resistant paint	Mineral Fibre Based Acoustic Ceiling Board false ceiling with insulation on top.	Aluminium glazed door	-Do-	

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INTERIOR FINISH SCHEDULE

SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
	Toilet	10 mm thick non-skid fully vitrified tiles of minimum size 400 mm x 400 mm (overall 50 mm thick) laid in pattern with 5 mm thick glazed ceramic tile dado of same make topped with 50 mm wide matching ceramic trims. Height of dado shall be full height	1st quality coloured glazed ceramic tiles of minimum 5 mm thickness up to 100 mm higher than lintel level starting from finish floor level. And balance portion with Acrylic Emulsion paint over white cement putty.	Acrylic Emulsion Paint	Main entry to toilet or wet areas shall be wooden panel door in hard wood frame and doors for WCs shall be FRP door frame & shutter.	-Do-	Toilets for Gents and ladies shall be provided
3	**ETP reject treatment plant building**						
	General area	50 mm thick heavy duty cement concrete floor with metallic hardener and matching skirting	White cement wall putty. Synthetic enamel paint up to 1.50mts height and Acrylic Emulsion paint for balance height	Acrylic Emulsion	Hollow metal flush door / fire door. Main entrances collapsible door shall also be provided	Powder coated and UV protected Aluminium glazed window / ventilator	Toilets for Gents shall be provided

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INTERIOR FINISH SCHEDULE

SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
Sewage Treatment Plant							
	STP Building						
	Control Room	10 mm thick non-skid fully vitrified tiles of minimum size 600 mm x 600 mm (overall 50 mm thick) laid in pattern.	Vitrified tiles dado up to 1.50 m height and Acrylic emulsion paint over white cement putty for balance height	Mineral Fibre Based Acoustic Ceiling Board false ceiling with insulation on top.	Aluminium glazed door	Powder coated and UV protected Aluminium glazed window / ventilator	
	MCC & Switch gear rooms and other areas	50mm thick heavy duty granolithic flooring with metallic hardener. 1.0m wide Flexible electric insulated PVC synthetic sheet in front of electrical equipment.	White cement wall putty. Synthetic enamel paint up to 1.50mts height and Acrylic Emulsion paint for balance height.	Acrylic Emulsion paint	Hollow metal flush/ fire door	-Do-	
	Toilet & other wet areas	10 mm thick non-skid fully vitrified tiles of minimum size 400 mm x 400 mm (overall 50 mm thick) laid in pattern with 5 mm thick glazed ceramic tile dado of	1st quality coloured glazed ceramic tiles of minimum 5 mm thickness up to 100 mm higher than lintel level starting from	Acrylic Emulsion paint	Main entry to toilet or wet areas shall be wooden panel door	-Do-	Toilets for Gents shall be provided

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SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
		same make topped with 50 mm wide matching ceramic trims. Height of dado shall be 100mm higher than the lintel level starting from floor finish level.	finish floor level. And balance portion with Acrylic Emulsion paint over white cement putty.		in hard wood frame and doors for WCs shall be FRP door frame & shutter.		
Circulating Water System							
1.	**CW pump house with Switchgear room & RIO room**						
	RIO room, Control Room, Offices	10 mm thick non-skid fully vitrified tiles of minimum size 600 mm x 600 mm (overall 50 mm thick) laid in pattern and matching skirting.	Vitrified tiles dado up to 1.50 m height and Acrylic emulsion paint over white cement putty for balance height for control room and Acrylic emulsion paint over white cement putty for offices for full height	Mineral Fibre Based Acoustic Ceiling Board false ceiling with insulation on top.	Aluminium glazed door	Powder coated and UV protected Aluminium glazed window / ventilator	
	MCC & Switch gear rooms	50mm thick heavy duty granolithic flooring with metallic hardener.	White cement wall putty. Synthetic enamel paint up to	Acrylic Emulsion	Hollow metal flush door / fire	Powder coated and UV protected	

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SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
		1.0m wide Flexible electric insulated PVC synthetic sheet in front of electrical equipment.	1.50mts height and Acrylic Emulsion paint for balance height		door. Main entrances collapsible door shall also be provided	Aluminium glazed window / ventilator	
	Pump room & Other areas	-Do-	-Do-	-Do-	-Do-	-Do-	
	Toilet & other wet areas	10 mm thick non-skid fully vitrified tiles of minimum size 400 mm x 400 mm (overall 50 mm thick) laid in pattern with 5 mm thick glazed ceramic tile dado of same make topped with 50 mm wide matching ceramic trims. Height of dado shall be 100mm higher than the lintel level starting from floor finish level.	1st quality coloured glazed ceramic tiles of minimum 5 mm thickness up to 100 mm higher than lintel level starting from finish floor level. And balance portion with Acrylic Emulsion paint over white cement putty.	Acrylic Emulsion paint	Main entry to toilet or wet areas shall be wooden panel door in hard wood frame and doors for WCs shall be FRP door frame & shutter.	-Do-	Toilets for Gents and ladies shall be provided in all floors , Along with toilet for Physically challenged in ground floor

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INTERIOR FINISH SCHEDULE

SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
	Battery Room	Minimum 20 mm thick acid and alkali resistant vitrified tile Minimum 37 mm thick Acid /Alkali resistant brick, set in and jointed with epoxy mortar (overall 50 mm thick) along with 2100 mm high dado of same tile having 20 mm thickness	20mm thick acid resistant tiles over bitumen primer up to 1.20mts height and chemical resistant epoxy paint for balance height	Chemical resistant paint.	Hollow metal flush/ fire door	-Do-	
2.	**CW Treatment cum Chlorination plant building**						
	Control room & Offices	10 mm thick non-skid fully vitrified tiles of minimum size 600 mm x 600 mm (overall 50 mm thick) laid in pattern	Vitrified tiles dado up to 1.50 m height and Acrylic emulsion paint over white cement putty for balance height for control room and Acrylic emulsion paint over white cement putty for offices for full height	Mineral Fibre Based Acoustic Ceiling Board false ceiling with insulation on top.	Aluminium glazed door and at the Main entrances collapsible door shall also be provided	Powder coated and UV protected aluminium window Aluminium glazed window / ventilator	
	Chemical store	Minimum 20 mm thick acid and alkali resistant tile set in and jointed with epoxy	Chemical resistant paint	Chemical resistant paint	Hollow metal flush door	-Do-	

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SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
		mortar (overall 50mm thick) along with 2100mm high dado of same tile.					
	Battery room	-Do-	-Do-	-Do-	-Do-	-Do-	
	MCC room, chlorine tonner room, maintenance room and other areas	50mm thick heavy duty granolithic flooring with metallic hardener. 1.0m wide Flexible electric insulated PVC synthetic sheet in front of electrical equipment.	White cement wall putty. Synthetic enamel paint up to 1.50mts height and Acrylic Emulsion paint for balance height	Acrylic Emulsion	Hollow metal flush door / fire door	-Do-	
	Toilet	10 mm thick non-skid fully vitrified tiles of minimum size 400 mm x 400 mm (overall 50 mm thick) laid in pattern with 5 mm thick glazed ceramic tile dado of same make topped with 50 mm wide matching ceramic trims. Height of dado shall be 100mm higher than the lintel level starting from floor finish level.	1st quality coloured glazed ceramic tiles of minimum 5 mm thickness up to 100 mm higher than lintel level starting from finish floor level. And balance portion with Acrylic Emulsion paint over white cement putty.	Acrylic Emulsion paint	Main entry to toilet or wet areas shall be wooden panel door in hard wood frame and doors for WCs shall be FRP door	-Do-	Toilets for Gents and ladies shall be provided

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INTERIOR FINISH SCHEDULE

SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
					frame &shutter.		
Fire Protection & Detection System							
1	Fire Water PH	50mm thick heavy duty granolithic flooring with metallic hardener. 1.0m wide Flexible electric insulated PVC synthetic sheet in front of electrical equipment.	White cement wall putty. Synthetic enamel paint up to 1.50mts height and Acrylic Emulsion paint for balance height	Acrylic Emulsion	Hollow metal flush door / fire door. Main entrances collapsible door shall also be provided	Powder coated and UV protected Aluminium glazed window / ventilator	Toilets for Gents shall be provided
2	Fire Water Booster PH	-do-	do	do	do	do	
Switchyard							
1.	**Switch yard control building**						
	Control Room, Offices	10 mm thick non-skid fully vitrified tiles of minimum size 600 mm x 600 mm (overall 50 mm thick) laid	Vitrified tiles dado up to 1.50 m height and Acrylic emulsion paint over white cement	Stove-enamelled Aluminium false ceiling, similar or equal to LUXALON	Aluminium glazed door	Powder coated and UV protected Aluminium	

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INTERIOR FINISH SCHEDULE

SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
		in pattern	putty for balance height for control room and Acrylic emulsion paint over white cement putty for offices for full height	with either lineal panel system or aluminium tile/plank system with insulation on top.		glazed window / ventilator Windows of yard side shall be continuous to view the yard area.	
	MCC & Switch gear rooms& other areas	50mm thick heavy duty granolithic flooring with metallic hardener. 1.0m wide Flexible electric insulated PVC synthetic sheet in front of electrical equipment.	White cement wall putty. Synthetic enamel paint up to 1.50mts height and Acrylic Emulsion paint for balance height.	Acrylic Emulsion paint	Hollow metal flush door	Powder coated and UV protected Aluminium glazed window / ventilator	
	Toilet & other wet areas	10 mm thick non-skid fully vitrified tiles of minimum size 400 mm x 400 mm (overall 50 mm thick) laid in pattern with 5 mm thick glazed ceramic tile dado of same make topped with 50 mm wide matching ceramic	1st quality coloured glazed ceramic tiles of minimum 5 mm thickness up to 100 mm higher than lintel level starting from finish floor level. And balance portion with	Acrylic Emulsion paint	Main entry to toilet or wet areas shall be wooden panel door in hard wood frame	-Do-	Toilets for Gents and ladies shall be provided Along with toilet for Physically challenged in

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SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
		trims. Height of dado shall be 100mm higher than the lintel level starting from floor finish level.	Acrylic Emulsion paint over white cement putty.		and doors for WCs shall be FRP door frame & shutter.		ground floor
	Battery Room	Minimum 20 mm thick acid and alkali resistant tile set in and jointed with epoxy mortar (overall 50mm thick) along with 2100mm high dado of same tile.	Chemical resistant paint	Chemical resistant paint	Hollow metal flush door	-Do-	
2.	**GIS Building**						
		2.2 mm Self Levelling Epoxy – Polyurethane System (EPU) over hardened concrete flooring	Synthetic enamel paint up to 1.50mts height and Acrylic Emulsion paint over white cement putty	Acrylic Emulsion paint	Hollow metal flush/ fire door	-Do-	Toilets for Gents and ladies shall be provided
Hydrogen Generation Plant							
1	**Hydrogen Generation**	50 mm thick heavy duty cement concrete Granolithic floor with	Acrylic Emulsion paint	-	Hollow metal flush door painted	All round fly ash brick wall	Toilets for Gents shall be

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SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
	Building	metallic hardener and matching skirting			with Synthetic enamel paint, both ways.	with RCC jally.	provided
Flue Gas De-sulphurisation (FGD) Plant							
1	Limestone Storage Building`	50 mm thick heavy duty cement concrete granolithic floor with metallic hardener and matching skirting	Acrylic emulsion paint for wall and sheet metal cladding for balance height	Painted exposed structure	Hollow metal flush door / Rolling shutter	Powder coated and UV protected Aluminium glazed window / ventilator	
2	Limestone Crusher House	-Do-	-Do-	-Do-	-Do-	-Do-	Toilets for Gents and ladies shall be provided in Ground floor
3	Limestone Grinding Building	-Do-	-Do-	-Do-	-Do-	-Do-	
4	Absorber Pump & Oxidation air blower House	-Do-	Acrylic Emulsion paint with white cement putty for the full height	-Do-	-Do-	-Do-	Toilets for Gents shall be provided

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SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
5	Electrical Switchgear & Control Building						
	Control Room	10 mm thick non-skid fully vitrified tiles of minimum size 600 mm x 600 mm (overall 50 mm thick) laid in pattern and matching skirting	Acrylic emulsion paint over white cement putty.	Moisture & Fire Resistant Gypsum Board false ceiling with insulation on top.	Aluminium glazed door and at the Main entrances collapsible door shall also be provided	Powder coated and UV protected Aluminium glazed window / ventilator	
	Electrical Room & switchgear room	50mm thick heavy duty granolithic flooring with metallic hardener. 1.0m wide Flexible electric insulated PVC synthetic sheet in front of electrical equipment.	Acrylic emulsion paint with white cement putty for the full height	Acrylic Emulsion Paint.	Hollow metal flush door / fire door	-Do-	
	Toilet & other wet areas	10 mm thick non-skid fully vitrified tiles of minimum size 400 mm x 400 mm (overall 50 mm thick) laid in pattern with 5 mm thick glazed ceramic tile dado of same make topped with 50 mm wide matching ceramic trims. Height of dado shall	1st quality coloured glazed ceramic tiles of minimum 5 mm thickness up to 100 mm higher than lintel level starting from finish floor level. And balance portion with Acrylic emulsion paint	Acrylic Emulsion paint.	Main entry to toilet or wet areas shall be wooden panel door in hard wood frame and doors	-Do-	Toilets for Gents and ladies shall be provided in all floors , Along with toilet for Physically challenged in ground floor

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SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
		be 100mm higher than the lintel level starting from floor finish level.	over white cement putty.		for WCs shall be PVC door frame & shutter.		
6	Gypsum De-watering House	50 mm thick heavy duty cement concrete granolithic floor with hardener and matching skirting	Acrylic emulsion paint for the full height and sheet metal cladding balance height	Painted exposed structure	Hollow metal flush door / Rolling shutter	-Do-	Toilets for Gents shall be provided
7	Gypsum Storage Building	-Do-	-Do-	-Do-	-Do-	-Do-	Toilets for Gents shall be provided
8	**Junction towers**	50 mm thick heavy duty cement concrete floor with metallic hardener and matching skirting	Single skin sheet metal cladding in combination with polycarbonate sheets and Acrylic emulsion paint on fly ash brick wall.	Painted exposed structure-Synthetic enamel on steel and Acrylic Emulsion on RCC	Hollow metal flush door / fire door	Powder coated and UV protected Aluminium glazed window / ventilator	Toilets for Gents and ladies shall be provided in Ground floor
Non plant building							

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INTERIOR FINISH SCHEDULE

SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
1	**Service Building**	As mentioned in the specification	As mentioned in the specification	As mentioned in the specification	As mentioned in the specification	As mentioned in the specification	Toilets for Gents and ladies shall be provided in all floors , Along with toilet for Physically challenged
2	**Canteen**						
	Kitchen, Dining hall etc.	10 mm thick non-skid fully vitrified tiles" of minimum size 600 mm x 600 mm (overall 50 mm thick) laid in pattern with 5 mm thick glazed ceramic tile dado of same make topped with 50 mm wide matching ceramic tiles. Dado shall be full height for Kitchen and 1500mm. high for other areas. All counters for Kitchen and service areas shall have Polished	1st quality coloured glazed tiles of minimum 5mm thickness up to 1.50m height and balance height with Acrylic emulsion paint over primer and white cement putty. Dado shall be full height for Kitchen.	Acrylic Emulsion paint over white cement putty. Air conditioned areas shall Mineral Fibre Based Acoustic Ceiling Board false ceiling with insulation on top of approved make as per specification	Aluminium glazed door	Powder coated and UV protected Aluminium glazed window / ventilator	

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SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
		Granite slab over RCC slab.					
	Other areas	Kota stone flooring and skirting	White cement wall putty. Synthetic enamel paint up to 1.50mts height and Acrylic Emulsion paint for balance height	Acrylic Emulsion paint	Solid core flush door	-Do-	
	Toilet & wash areas	10 mm thick non-skid fully vitrified tiles of minimum size 400 mm x 400 mm (overall 50 mm thick) laid in pattern with 5 mm thick glazed ceramic tile dado of same make topped with 50 mm wide matching ceramic trims. Height of dado shall be 100mm higher than the lintel level starting from floor finish level.	1st quality coloured glazed ceramic tiles of minimum 5 mm thickness up to 100 mm higher than lintel level starting from finish floor level. And balance portion with Acrylic Emulsion paint over white cement putty.	Acrylic Emulsion paint	Main entry to toilet or wet areas shall be wooden panel door in hard wood frame and doors for WCs shall be FRP door frame &	-Do-	Toilets for Gents and ladies shall be provided in all floors , Along with toilet for Physically challenged. in ground floor

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SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
					shutter.		
3	**Fire Station**						
	Office area, Training room, Kitchen / Dining area, Dormitory,	10 mm thick non-skid fully vitrified tiles of minimum size 600 mm x 600 mm (overall 50 mm thick) laid in pattern for office, dormitory area with 150 high matching skirting with 5 mm thick glazed ceramic tile dado of approved make topped with 50 mm wide matching ceramic trims 2200mm. High.	Acrylic Emulsion paint over white cement wall putty. Office, dormitory area with 150 high matching skirting with 5 mm thick glazed ceramic tile dado of approved make topped with 50 mm wide matching ceramic trims 2200mm. High.	Acrylic Emulsion paint Air conditioned areas(office room) shall have Mineral Fibre Based Acoustic Ceiling Board false ceiling with insulation on top. of approved make as per specification	Aluminium glazed door/ hollow metal flush door	Powder coated and UV protected Aluminium glazed window / ventilator	
	Stores	50 mm thick heavy duty cement concrete floor with metallic hardener and matching skirting	White cement wall putty. Synthetic enamel paint up to 1.50mts height and Acrylic Emulsion paint for balance height.	Acrylic Emulsion paint	Hollow metal flush fire door	-Do-	

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INTERIOR FINISH SCHEDULE

SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
	Toilet & other wet areas	10 mm thick non-skid fully vitrified tiles of minimum size 400 mm x 400 mm (overall 50 mm thick) laid in pattern with 5 mm thick glazed ceramic tile dado of same make topped with 50 mm wide matching ceramic trims. Height of dado shall be 100mm higher than the lintel level starting from floor finish level.	1st quality coloured glazed ceramic tiles of minimum 5 mm thickness up to 100 mm higher than lintel level starting from finish floor level. And balance portion with Acrylic Emulsion paint over white cement putty.	Acrylic Emulsion paint	Main entry to toilet or wet areas shall be wooden panel door in hard wood frame and doors for WCs shall be FRP door frame & shutter.	-Do-	Toilets for Gents and ladies shall be provided
	Fire tender parking area and equipment store	50mm thick heavy duty cements concrete Granolithic flooring with metallic hardener with matching skirting. or Paving with 75 mm thick pressed interlocking precast blocks	External quality acrylic emulsion paint and for equipment store Acrylic Emulsion all be used	For Parking area External quality acrylic emulsion paint and for equipment store Acrylic Emulsion shall be used.	Aluminium glazed door/ hollow metal flush door for equipment store	-Do-	
4	**Weigh-bridge control room.**	10 mm thick non-skid fully vitrified tiles of minimum size 600 mm x 600 mm (overall 50 mm thick) laid	Vitrified tiles dado up to 1.50 m height and Acrylic emulsion paint over white cement	Mineral Fibre Based Acoustic Ceiling Board false ceiling with insulation on	Aluminium glazed door	Powder coated and UV protected Aluminium	Toilets for Gents shall be provided.

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SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
		in pattern.	putty for balance height	top.		glazed window / ventilator	
5	**First Aid Centre**						
	Reception, waiting area, Minor OT, Doctor 's chambers &rest room	10 mm thick non-skid fully vitrified tiles of minimum size 600 mm x 600 mm (overall 50 mm thick) laid in pattern and matching skirting.	Vitrified tiles dado up to 2.1 m height and Acrylic emulsion paint over white cement putty for balance height	Mineral Fibre Based Acoustic Ceiling Board false ceiling with insulation on top.	Aluminium glazed door	Powder coated and UV protected Aluminium glazed window / ventilator	
	Other areas	Kota stone flooring(overall 50mmthick) and skirting	White cement wall putty. Synthetic enamel paint up to 1.50mts height and Acrylic emulsion paint for balance height	Acrylic Emulsion paint	Solid core flush door	-Do	
	Toilet & wash areas	10 mm thick non-skid fully vitrified tiles of minimum size 400 mm x 400 mm (overall 50 mm thick) laid in pattern with 5 mm thick glazed ceramic tile dado of	1st quality coloured glazed ceramic tiles of minimum 5 mm thickness up to 100 mm higher than lintel level starting from	Acrylic Emulsion paint	Main entry to toilet or wet areas shall be wooden panel door	-Do-	Toilets for Gents and ladies shall be provided, Along with toilet for

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SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
		same make topped with 50 mm wide matching ceramic trims. Height of dado shall be 100mm higher than the lintel level starting from floor finish level.	finish floor level. And balance portion with Acrylic emulsion paint over white cement putty.		in hard wood frame and doors for WCs shall be FRP door frame & shutter.		Physically challenged
6	**Construction Stores**						
		50 mm thick heavy-duty cement concrete floor with metallic hardener and matching skirting. For office areas & AC stores vitrified tiles shall be used.	Acrylic Emulsion paint with white cement putty for office & AC store areas and Synthetic enamel paint up to 1.50mts height and Acrylic Emulsion paint with white cement putty(full height) for balance height for other areas	Acrylic Emulsion paint over white cement putty. Air conditioned areas shall have Mineral Fibre Based Acoustic Ceiling Board false ceiling with insulation on top. of approved make as per specification	Hollow metal flush fire door/ Aluminium glazed door. Rolling shutter wherever necessary	Powder coated and UV protected Aluminium glazed window / ventilator	Toilets for Gents and ladies shall be provided
7	**Car and Cycle/ Scooter stand**	Minimum 75mm thick coloured and polished interlocking concrete tiles with pattern as approved		Single skin zincalume roof sheeting over Steel framed structure.			

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SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
		by the owner, set on sand bed over RCC under bed.					
8	**Workshop**						
	Workshop area	50 mm thick heavy-duty cement concrete floor with metallic hardener and matching skirting.	White cement wall putty. Synthetic enamel paint up to 1.50mts height and Acrylic emulsion paint with for balance height	Acrylic Emulsion paint	Hollow metal flush fire door/ Aluminium glazed door. Rolling shutter wherever necessary	Powder coated and UV protected Aluminium glazed window / ventilator	
	Office	10 mm thick non-skid fully vitrified tiles of minimum size 600 mm x 600 mm (overall 50 mm thick) laid in pattern	Acrylic Emulsion paint over white cement putty	Mineral Fibre Based Acoustic Ceiling Board false ceiling with insulation on top.	Aluminium glazed door	Powder coated and UV protected Aluminium glazed window / ventilator	
	Electrical room	10 mm thick non-skid fully vitrified tiles of minimum size 600 mm x 600 mm (overall 50 mm thick) laid	White cement wall putty. Synthetic enamel paint up to 1.50mts height and	Acrylic Emulsion paint	Hollow metal flush fire door	-Do-	

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SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
		in pattern and matching skirting1.0m wide flexible electric insulated PVC synthetic sheet is to be laid in front of electrical equipment	Acrylic Emulsion paint for balance height.				
	Tool room, Store	50 mm thick heavy duty cement concrete floor with metallic hardener and matching skirting	White cement wall putty. Synthetic enamel paint up to 1.50mts height and Acrylic Emulsion paint for balance height	Acrylic Emulsion	Hollow metal flush door / fire door and door At the Main entrances collapsible door shall also be provided	Powder coated and UV protected Aluminium glazed window / ventilator	
	Toilets	10 mm thick non-skid fully vitrified tiles of minimum size 400 mm x 400 mm (overall 50 mm thick) laid in pattern with 5 mm thick glazed ceramic tile dado of same make topped with 50 mm wide matching ceramic trims. Height of dado shall	1st quality coloured glazed ceramic tiles of minimum 5 mm thickness up to 100 mm higher than lintel level starting from finish floor level. And balance portion with Acrylic Emulsion paint	Acrylic Emulsion paint	Main entry to toilet or wet areas shall be wooden panel door in hard wood frame and doors	-Do-	Toilets for Gents and ladies shall be provided

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SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
		be 100mm higher than the lintel level starting from floor finish level.	over white cement putty.		for WCs shall be FRP door frame &shutter.		
9	**Permanent Store**						
	Office, Store-in-Charge room, Challan receipt and issuing section, Record room, Office Store, etc.	10 mm thick non-skid fully vitrified tiles of minimum size 600 mm x 600 mm (overall 50 mm thick) laid in pattern with matching skirting.	Acrylic Emulsion paint over white cement putty	Mineral Fibre Based Acoustic Ceiling Boardfalse ceiling with insulation on top.	Aluminium glazed door	Powder coated and UV protected Aluminium glazed window / ventilator	
	Precision Material and Electronic Material Store	10 mm thick non-skid fully vitrified tiles of minimum size 600 mm x 600 mm (overall 50 mm thick) laid in pattern with matching skirting.	Acrylic Emulsion paint over white cement putty	Stove-enamelled Aluminium false ceiling, similar or equal to LUXALON with either lineal panel system or aluminium tile/plank system false ceiling with insulation on top.	Aluminium glazed door	Powder coated and UV protected Aluminium glazed window / ventilator	

ANNEXURE –I

INTERIOR FINISH SCHEDULE

SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
	Toilets	10 mm thick non-skid fully vitrified tiles of minimum size 400 mm x 400 mm (overall 50 mm thick) laid in pattern with 5 mm thick glazed ceramic tile dado of same make topped with 50 mm wide matching ceramic trims. Height of dado shall be 100mm higher than the lintel level starting from floor finish level.	1st quality coloured glazed ceramic tiles of minimum 5 mm thickness up to 100 mm higher than lintel level starting from finish floor level. And balance portion with Acrylic Emulsion paint over white cement putty.	Acrylic Emulsion paint	Main entry to toilet or wet areas shall be wooden panel door in hard wood frame and doors for WCs shall be FRP door frame & shutter.	-Do-	Toilets for Gents and ladies shall be provided, Along with toilet for Physically challenged.
	Heavy Material Store & Light Material Store	50 mm thick heavy duty cement concrete floor with metallic hardener and matching skirting	White cement wall putty. Synthetic enamel paint up to 1.50mts height and Acrylic Emulsion paint for balance height	Acrylic Emulsion	Hollow metal flush door / fire door and door At the Main entrances collapsible door shall also be provided	Powder coated and UV protected Aluminium glazed window / ventilator	

ANNEXURE –I

INTERIOR FINISH SCHEDULE

SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
	Store Keeper room	50 mm thick heavy duty cement concrete floor with metallic hardener and matching skirting	White cement wall putty. Synthetic enamel paint up to 1.50mts height and Acrylic Emulsion paint for balance height	Acrylic Emulsion	Hollow metal flush door / fire door and door At the Main entrances collapsible door shall also be provided	Powder coated and UV protected Aluminium glazed window / ventilator	
	Toilet s within Heavy & Light Material Stores	10 mm thick non-skid fully vitrified tiles of minimum size 400 mm x 400 mm (overall 50 mm thick) laid in pattern with 5 mm thick glazed ceramic tile dado of same make topped with 50 mm wide matching ceramic trims. Height of dado shall be 100mm higher than the lintel level starting from floor finish level.	1st quality coloured glazed ceramic tiles of minimum 5 mm thickness up to 100 mm higher than lintel level starting from finish floor level. And balance portion with Acrylic Emulsion paint over white cement putty.	Acrylic Emulsion paint	Main entry to toilet or wet areas shall be wooden panel door in hard wood frame and doors for WCs shall be FRP door frame &shutter.	-Do-	Toilets for Gents and ladies shall be provided

ANNEXURE –I

INTERIOR FINISH SCHEDULE

SL. NO.	BUILDING /AREA	FLOORING/SKIRTING/ DADO	WALL	CEILING	DOOR	WINDOW	REMARKS
10	**Toilet Blocks (1 no for CHS , and 1 no for Boiler area)**	10 mm thick non-skid fully vitrified tiles of minimum size 400 mm x 400 mm (overall 50 mm thick) laid in pattern with 5 mm thick glazed ceramic tile dado of same make topped with 50 mm wide matching ceramic trims. Height of dado shall be 100mm higher than the lintel level starting from floor finish level.	1st quality coloured glazed ceramic tiles of minimum 5 mm thickness up to 100 mm higher than lintel level starting from finish floor level. And balance portion with Acrylic Emulsion paint over white cement putty.	Acrylic Emulsion paint	Main entry to toilet or wet areas shall be wooden panel door in hard wood frame and doors for WCs shall be FRP door frame &shutter.	Powder coated and UV protected Aluminium glazed window / ventilator	One EWC , Two IWC , Two Bath rooms , 2 Urinals and 2 wash basins with mirror shall be provided

Note: Wherever metal deck sheets are provided for the ceiling the painting for the exposed surface shall be as specified in clause 4.00.00 of this section

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:

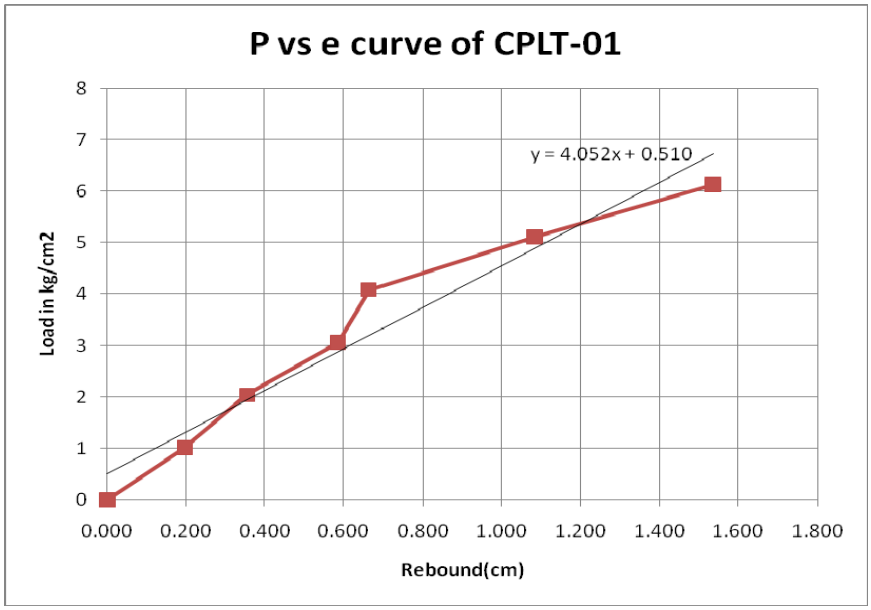
Soil parameters determined from cyclic plate load test are furnished in following table.

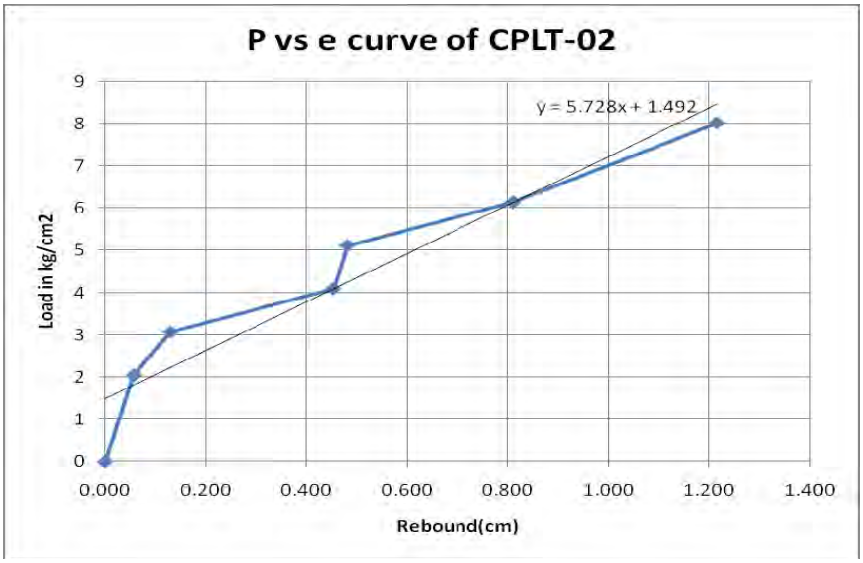
PLT No.	Soil Type	Depth of Test (m)	Max Load (kPa)	Settlement (mm)	
				Gross	Net
CPLT-1	Silty Clay/Clayey Silt	2.50	613.80	40.53	25.17
CPLT-2	Sandy Silty Clay	2.25	801.35	43.36	31.20

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.

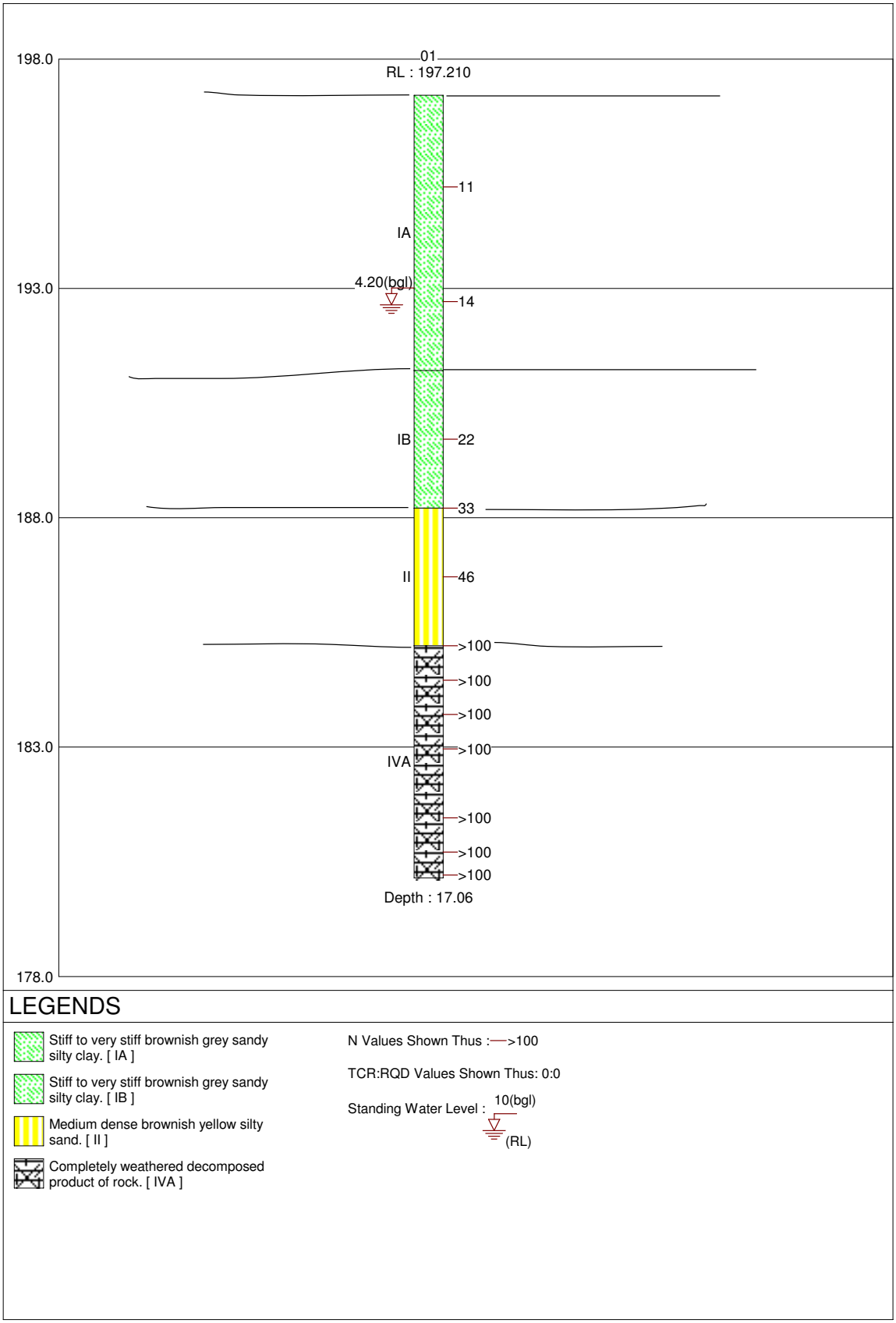
d. It is suggested to carry out the excavation and sub-structures work in the dry season, if possible. Special care needs to be taken during excavation for foundations so that the founding stratum does not get disturbed by excavation process and especially by ground/seepage water.

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

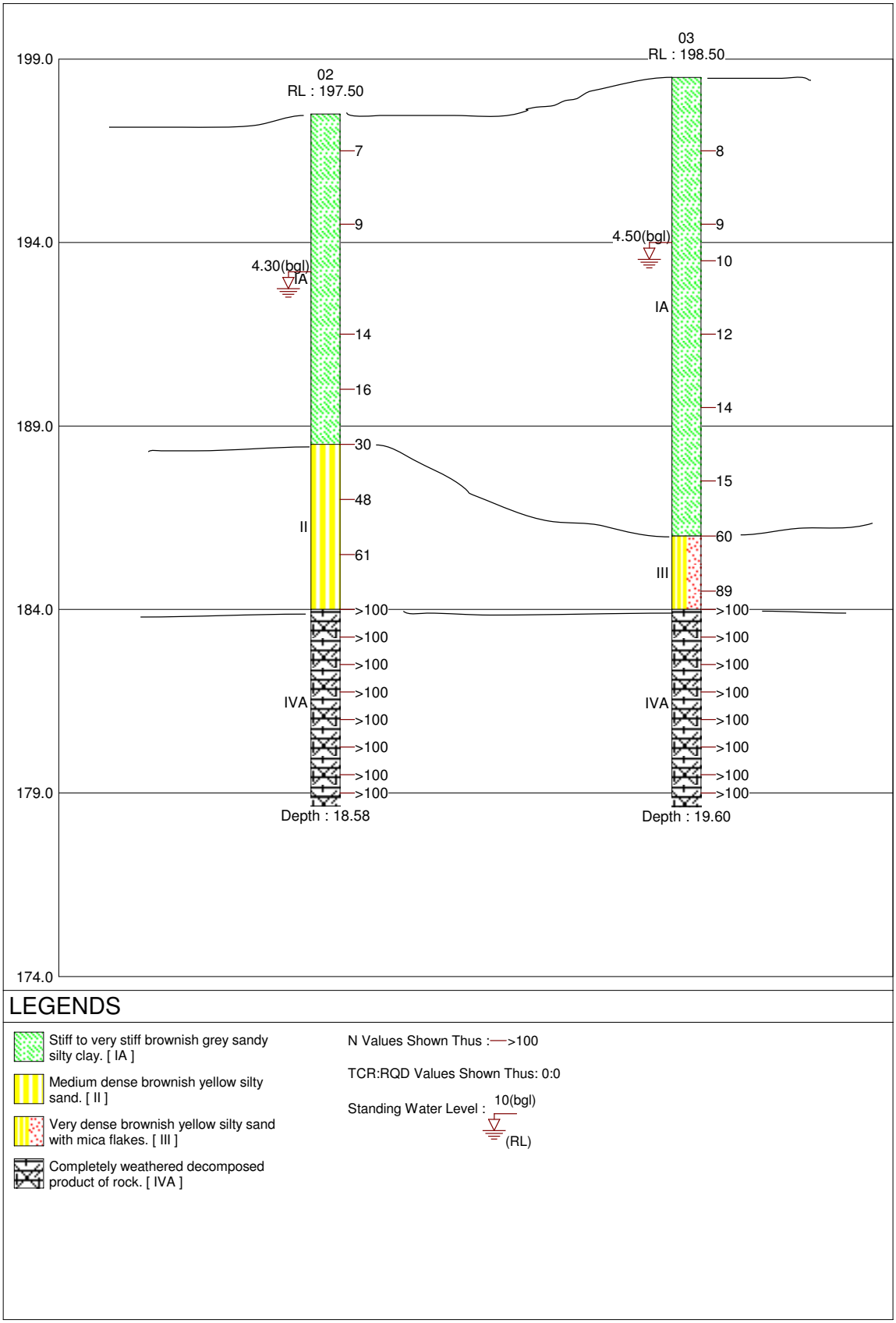
TCR:RQD Values Shown Thus: 0:0

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

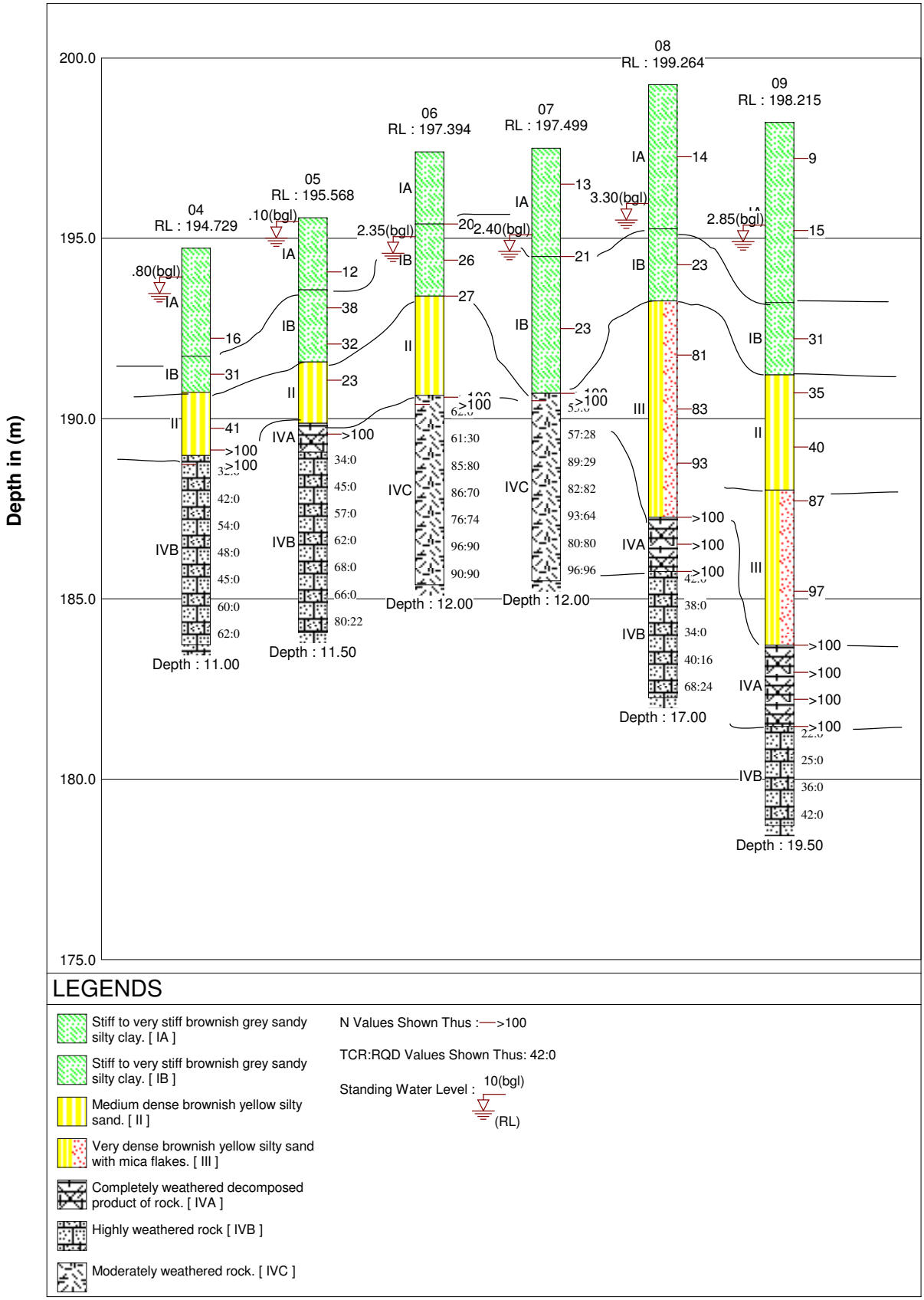
TCR:RQD Values Shown Thus: 0:0

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

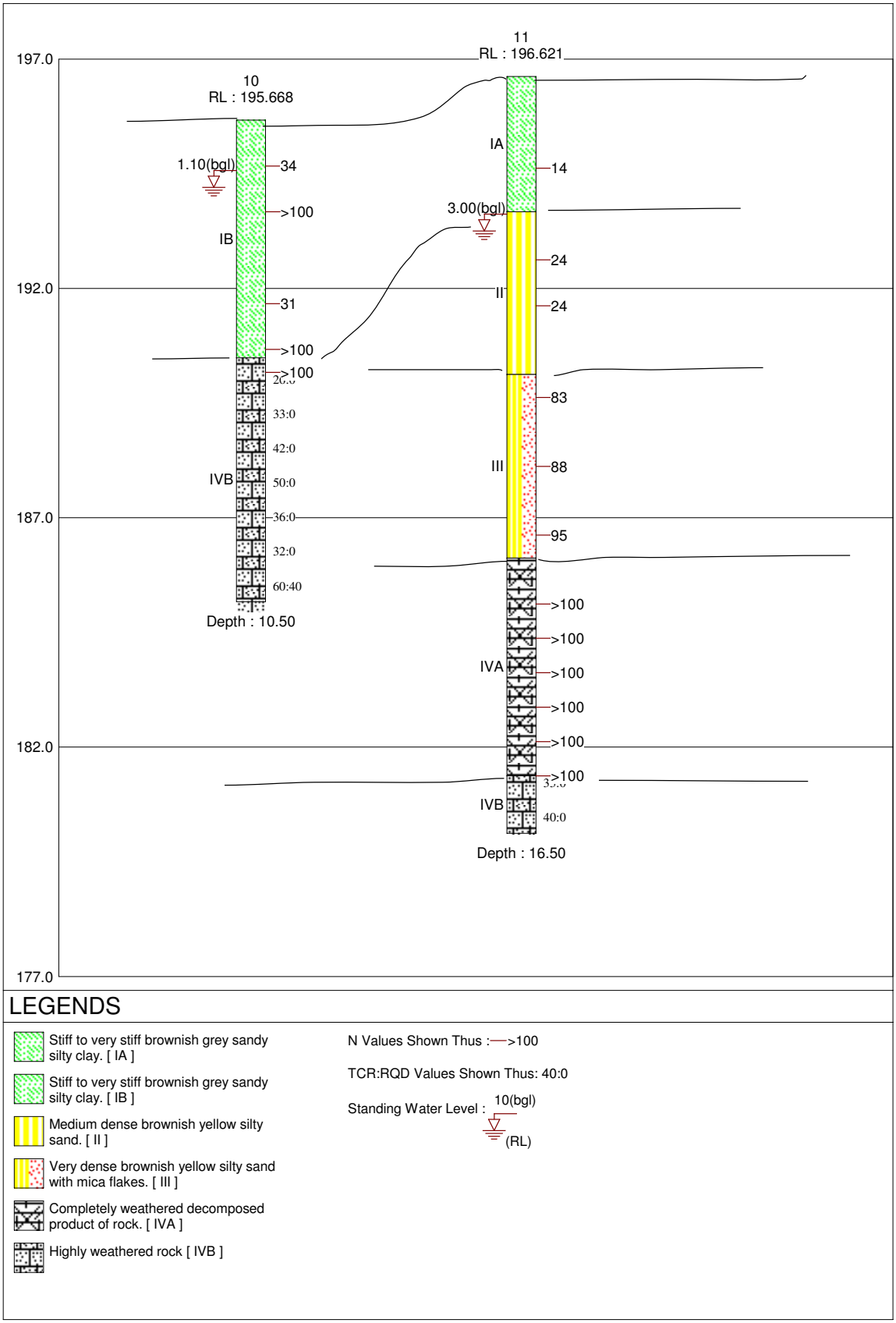
Standing Water Level : 10(bgl)

(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

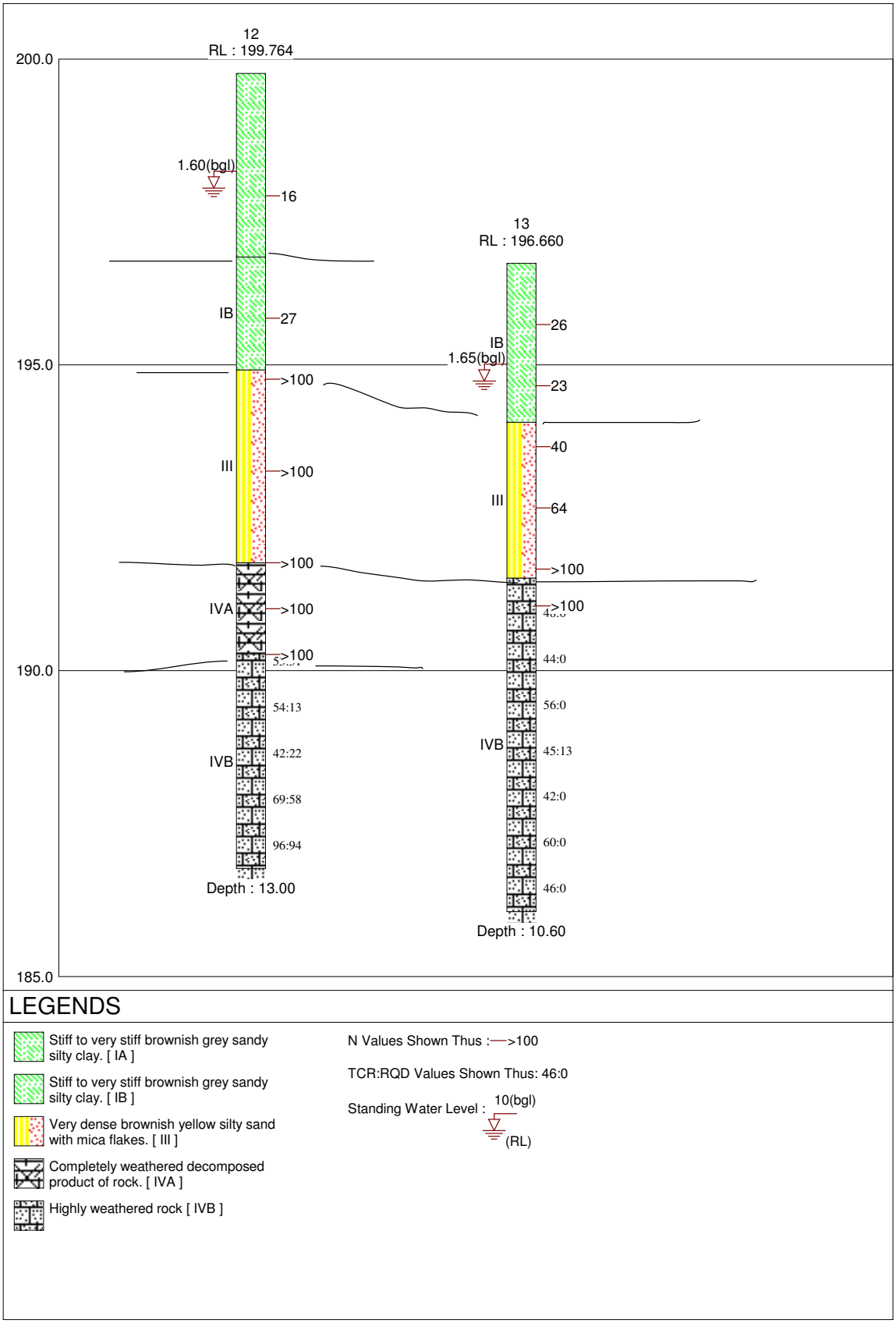
Standing Water Level : 10(bgl)

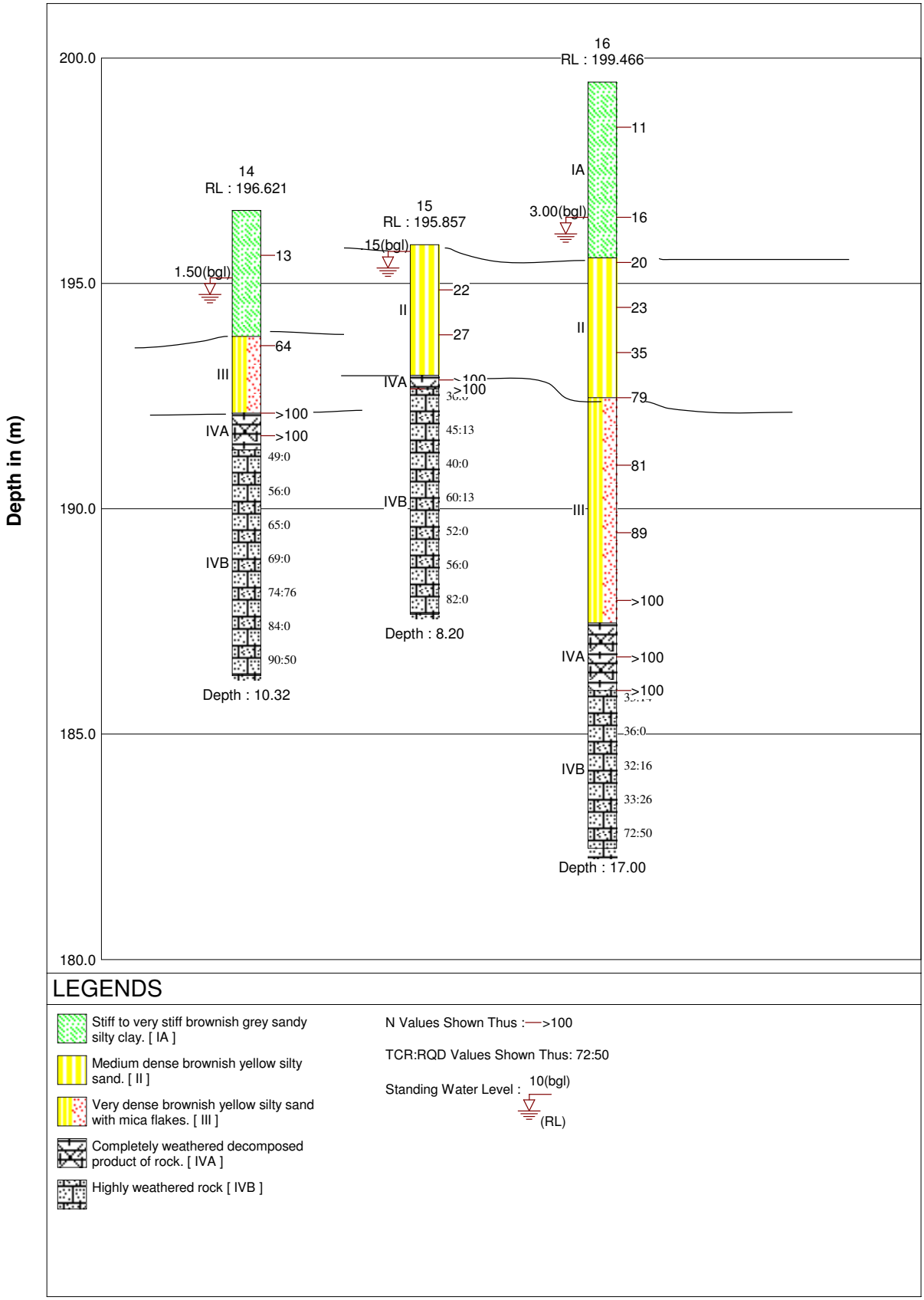
(RL)

CROSS SECTION OF SOIL PROFILE

Job No.: 30796

Sheet


12
RL : 199.764
13
RL : 196.660
200.0
195.0
190.0
185.0
Depth in (m)
1.60(bgl)
1.65(bgl)
IB
III
IVA
IVB
16
27
26
23
40
64
>100
>100
>100



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

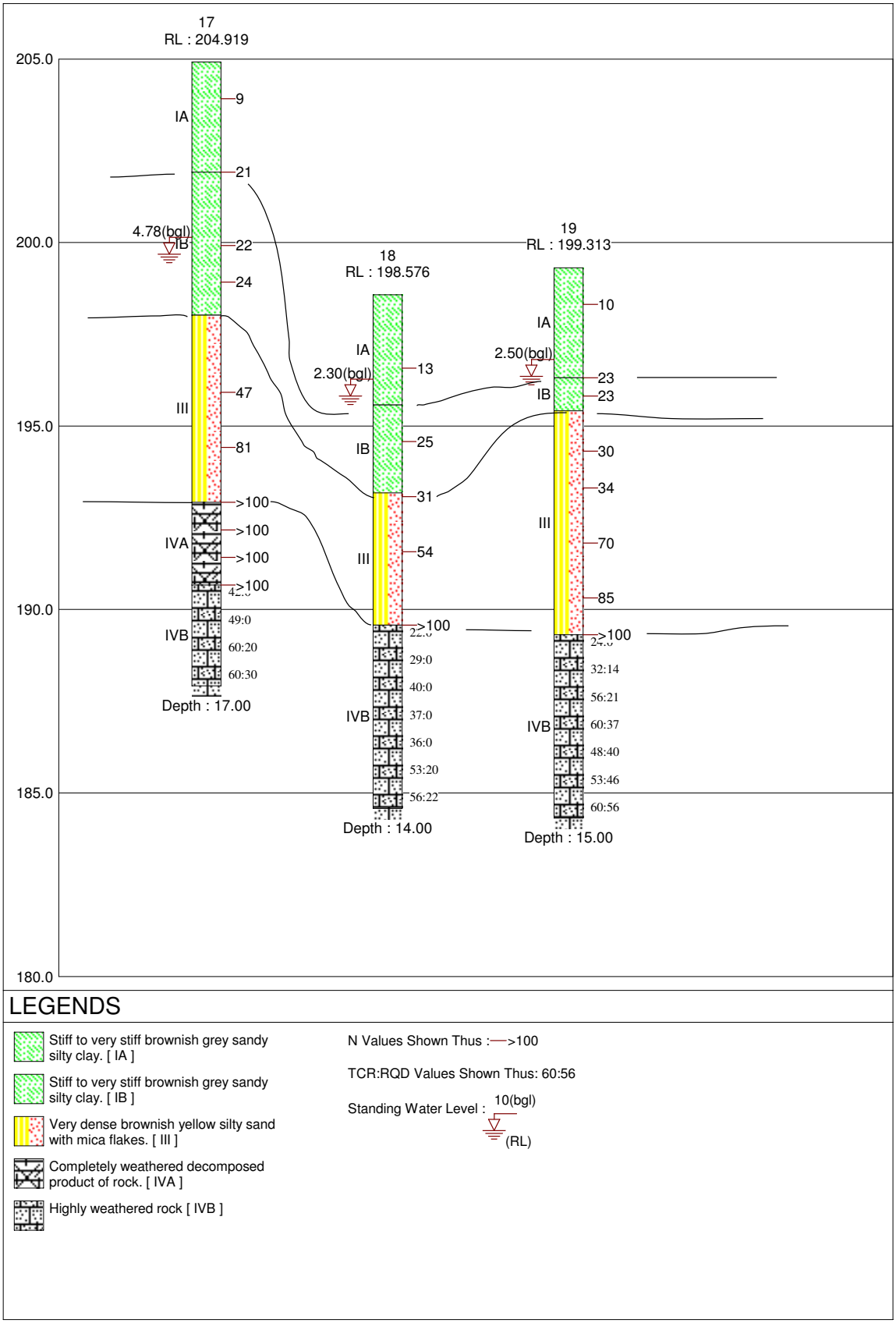
TCR:RQD Values Shown Thus: 72:50

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

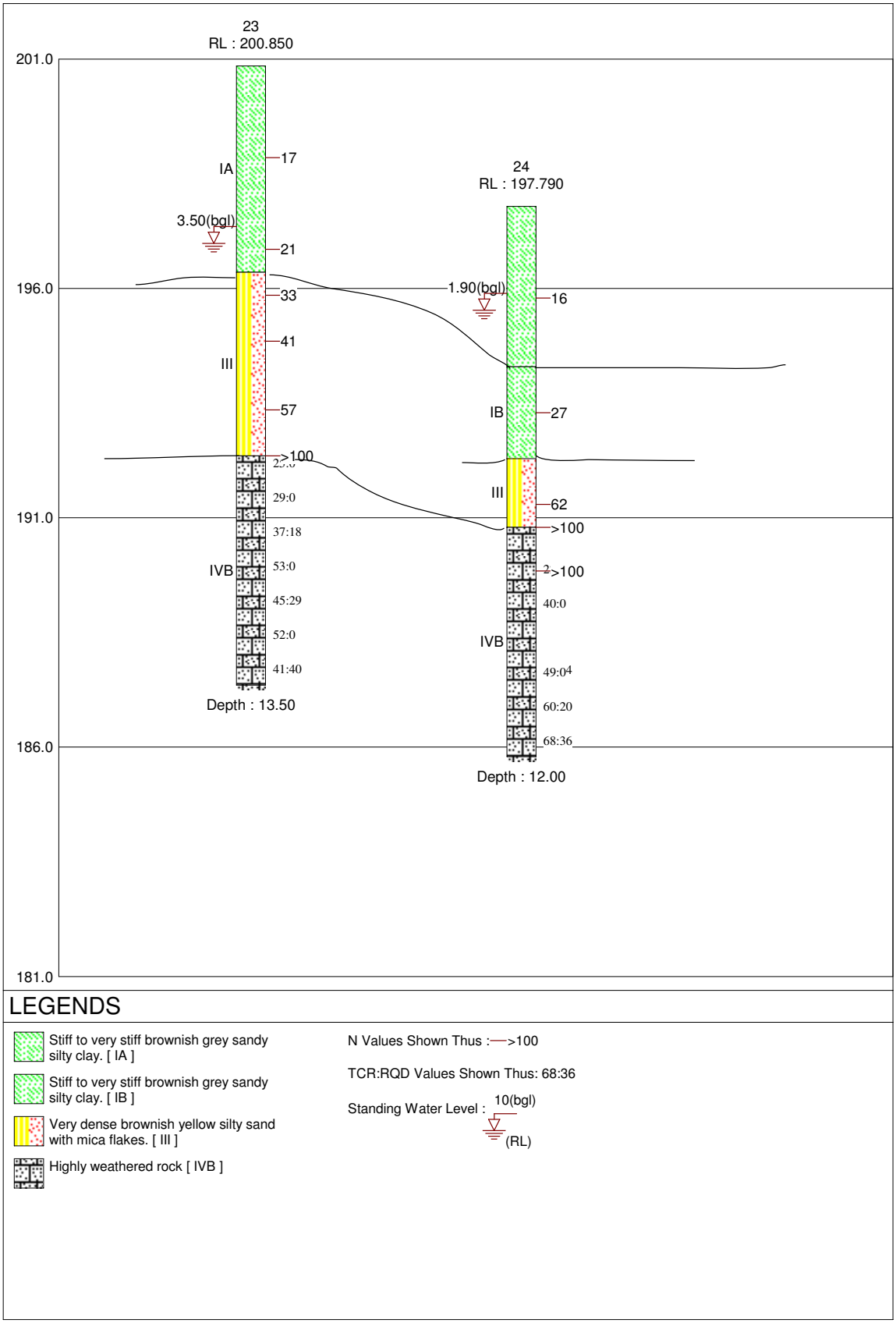
Standing Water Level : 10(bgl)

(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

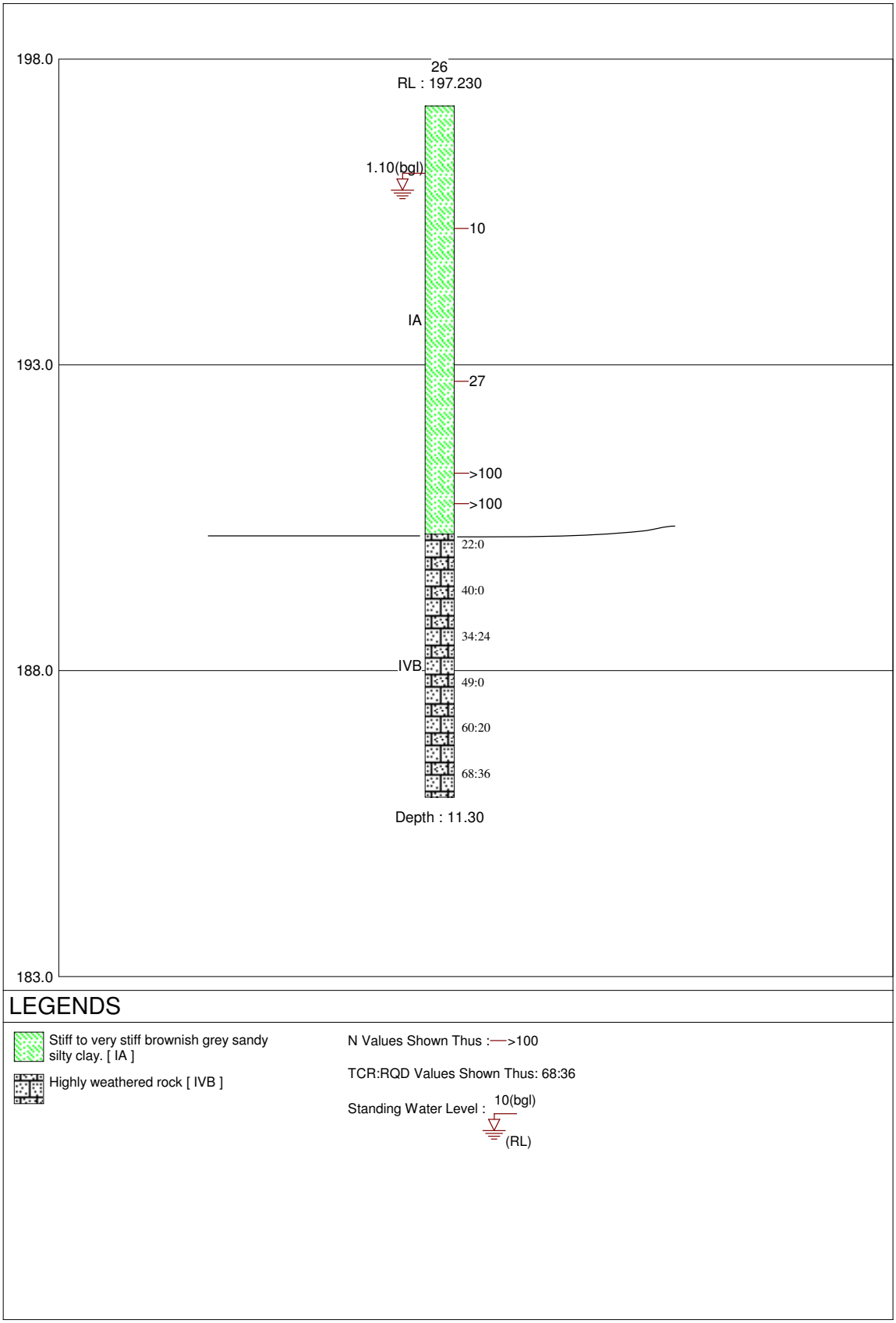
TCR:RQD Values Shown Thus: 68:36

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

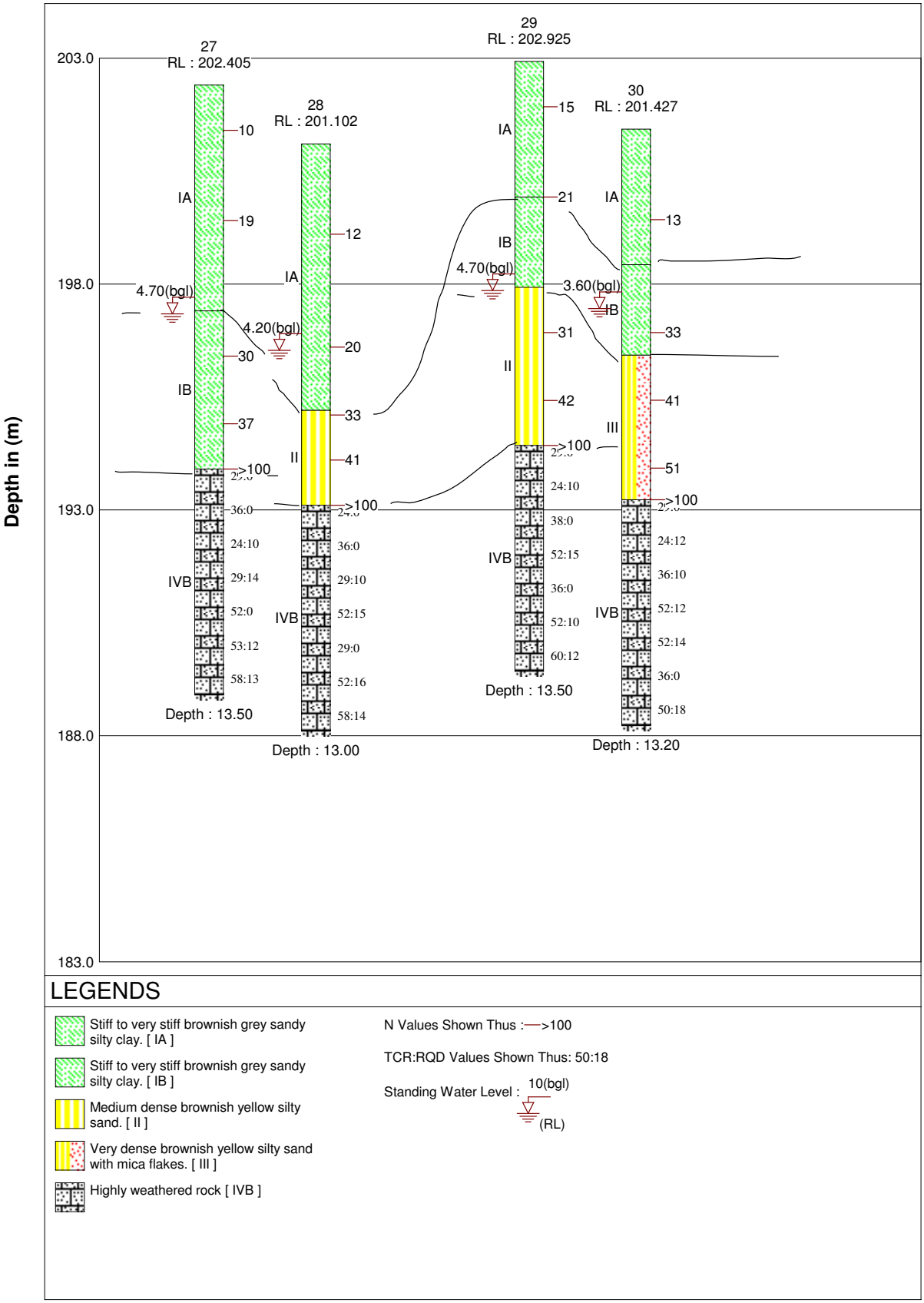
TCR:RQD Values Shown Thus: 68:36

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						
4.00 - 4.45	P	100875	3.90	9			Stiff brownish grey to dark grey silty clay with occasionally black spots and a few small nodules.	IA	
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 - 12.95	P	100882	12.40	60		12.50		186.00	
14.00 - 14.45	P	100883	13.90	89			Very dense brownish grey silty sand with a few nodules and clay lump observed.	III	
14.50 - 14.75	P	100884	13.90	>100		14.50		184.00	
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	Date and Depth (m)	Depth (BGL) (m)	Orientation : Vertical	Date : 21.01.2018	
Depth (m)	Type	No.					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	-			
						19.60	End of BoreHole	178.90

IVA

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	-		Highly to moderately weathered dark grey rock.	IVB
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	-	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
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	-
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	-

Moderately to slightly weathered greyish yellow rock. — IVC

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 (m)	Type	No.				13.50		185.76
13.50 - 13.56	P	-	11.90	>100			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)**	**Orientation : Vertical**	**Date : 08.11.2017**

From To (m)	TCR %	RQD %	Water Loss	Color of Ret. Water	N Value	Depth (BGL) (m)	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						
4.00 - 4.45	P	100858	3.90	24			Medium dense to dense brownish yellow clayey silty sand.	II	
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			Completely weathered brownish yellow decomposed product of rock.	IVA	

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		190.26
9.50 - 9.57	P	-	8.20	>100			Highly to moderately weathered greyish yellow rock.	IVB

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	-

Continued

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	Complete weathered yellowish brown decomposed product of rock.	IVA
								185.97
							Highly to moderately weathered brownish yellow rock.	IVB
							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)	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 : 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)

3.00

(BGL)

196.47

(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 : 1 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)**	**Orientation : Vertical**	**Date : 01.02.2018**

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	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				Very stiff brownish grey to yellowish brown silty clay with low % of nodules and a few sand occasionally observed.	IB	
4.00 - 4.45	U	100521	3.90						
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					

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	-

14.25 — 190.67 — Highly to moderately weathered greyish yellow rock. IVB

Continued

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			Dense to Very dense brownish yellow silty sand with mica.	III	
6.00 - 6.45	P	100510	5.90	34					
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	
							Highly to moderately weathered greyish yellow rock.	IVB	
						13.00	End of BoreHole	185.61	

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	-

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							
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				Stiff dark grey to yellowish brown silty clay with nodules and a few sand.	IA	
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		196.10	
7.50 - 7.95	P	120119	7.40	32			Very stiff dark grey to yellowish brown silty clay with nodules and a few sand.	IB	
8.50 - 8.58	P	120120	8.40	>100		7.40		193.70	
							Dense yellowish brown silty sand.	II	
						8.40		192.70	
							Highly to moderately weathered yellowish grey rock.	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.		**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	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	-		Highly to moderately weathered yellowish grey rock.	IVB	
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	-				
						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.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 : 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- 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 : 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

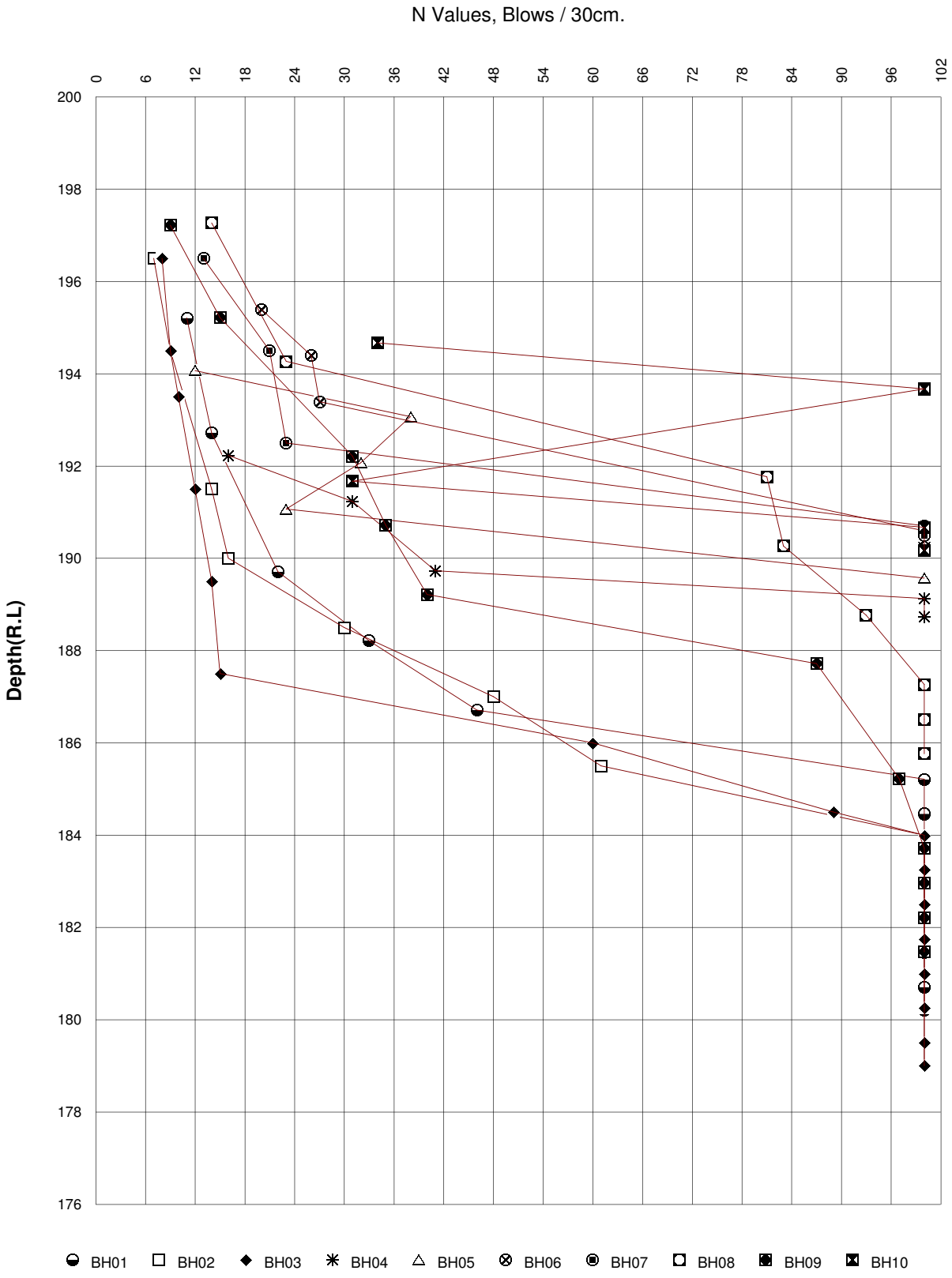
(RL)

D.D.

Supervisor

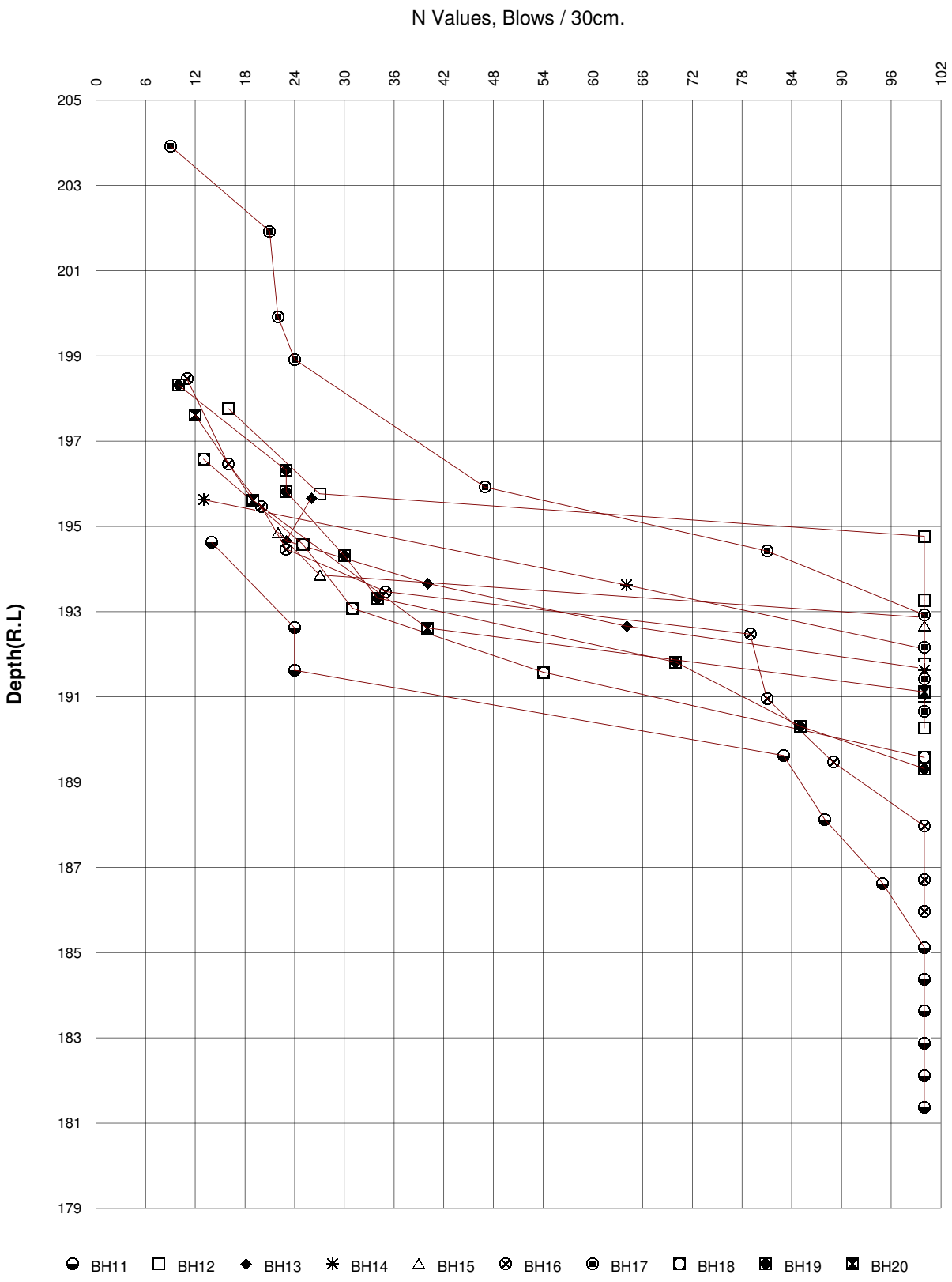
D- Disturbed Sample
B- Bulk Sample
W- Water Sample
U- Undisturbed sample
P- Standard Penetration Test
V- Vane Test
PC- Cone Penetration Test

Job No: 30796



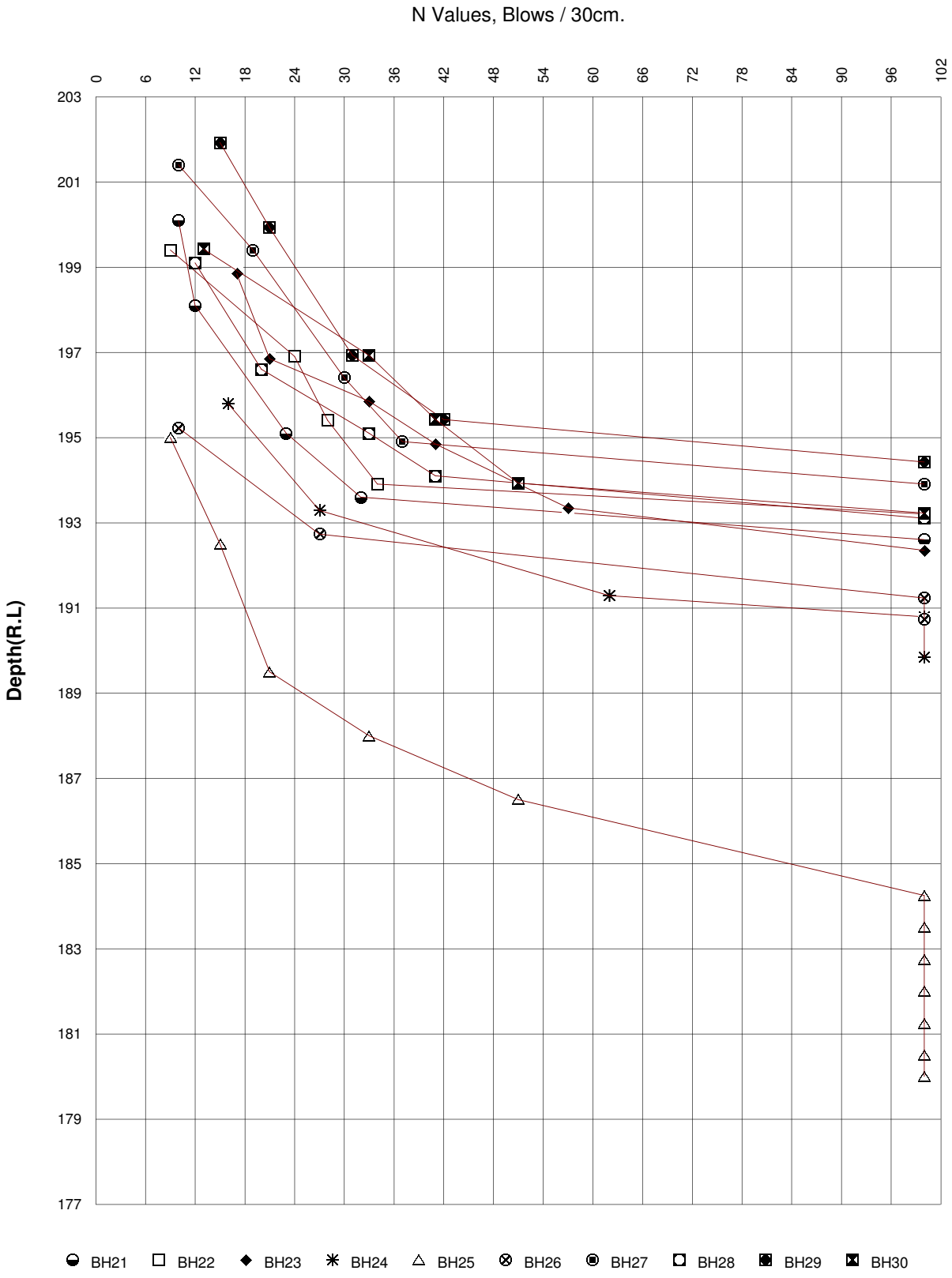
GRAPHICAL VIEW OF STANDARD PENETRATION TEST

Job No: 30796



GRAPHICAL VIEW OF STANDARD PENETRATION TEST

Job No: 30796

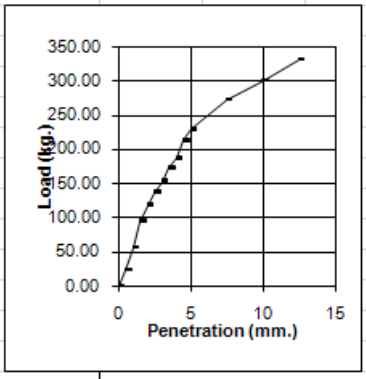


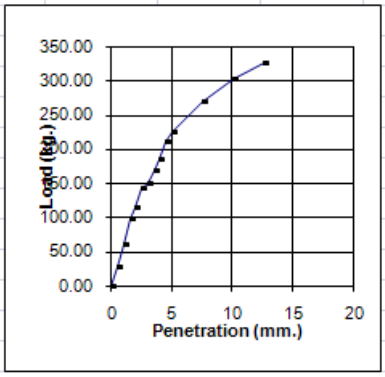
GRAPHICAL VIEW OF STANDARD PENETRATION TEST

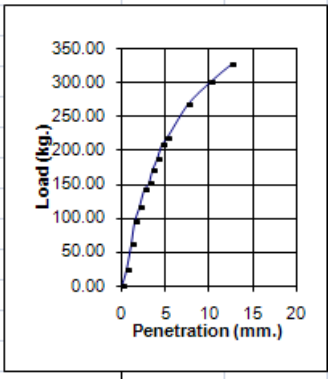
Job No: 30796

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	





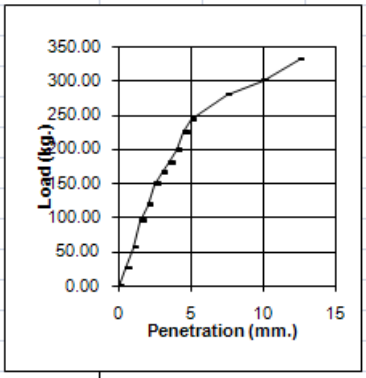


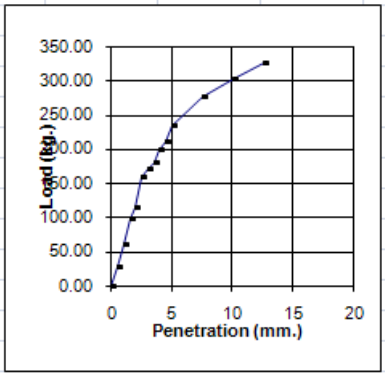
C.B.R. Test Results

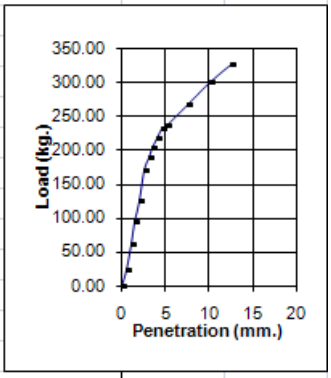
Penetration (mm)	Bearing Ratio (%)			Average (%)
2.5	9.99	10.34	10.34	10.34
5	11.14	10.91	10.57	10.74

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	





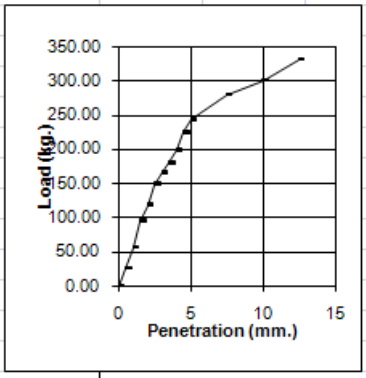


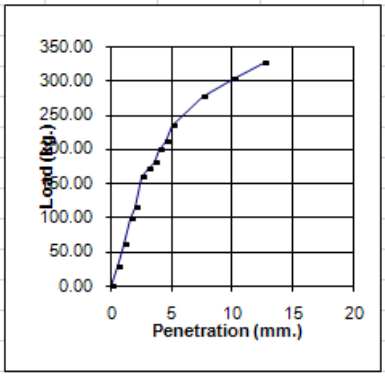
C.B.R. Test Results

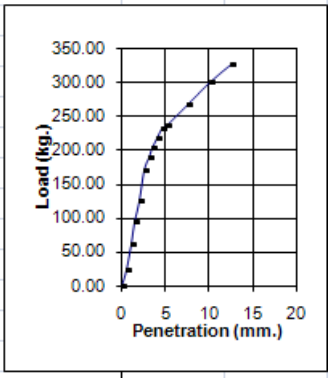
Penetration (mm)	Bearing Ratio (%)			Average (%)
2.5	10.85	11.54	12.40	11.97
5	11.83	11.37	11.48	11.43

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	





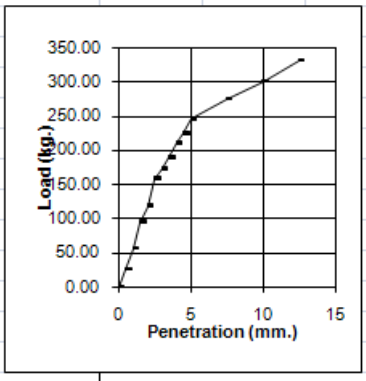


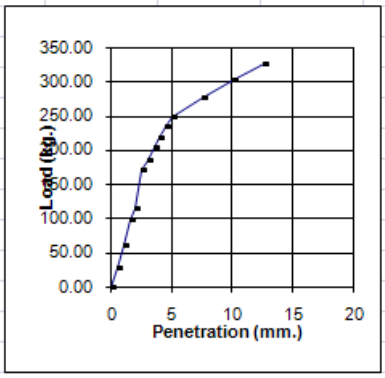
C.B.R. Test Results

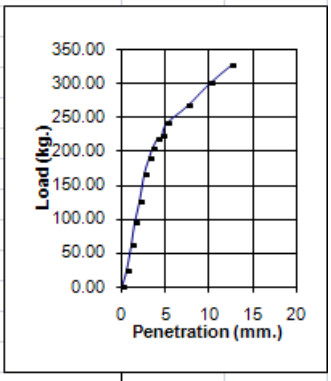
Penetration (mm)	Bearing Ratio (%)			Average (%)
2.5	10.85	11.54	12.40	11.97
5	11.83	11.37	11.48	11.43

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	





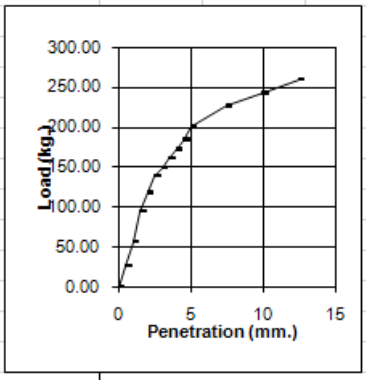


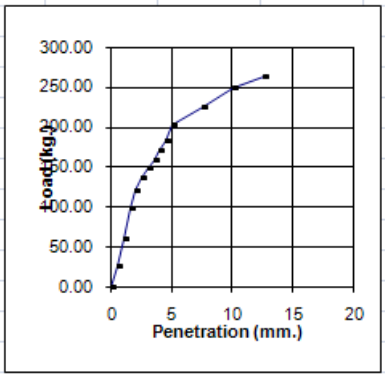
C.B.R. Test Results

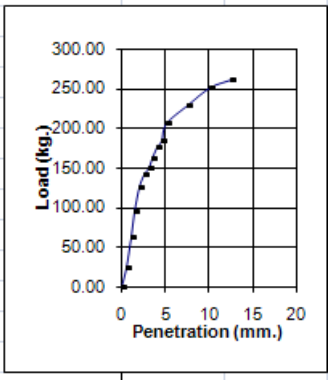
Penetration	Bearing Ratio (%)			Average (%)
2.5	11.54	12.40	12.06	12.23
5	11.94	12.06	11.71	11.89

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	

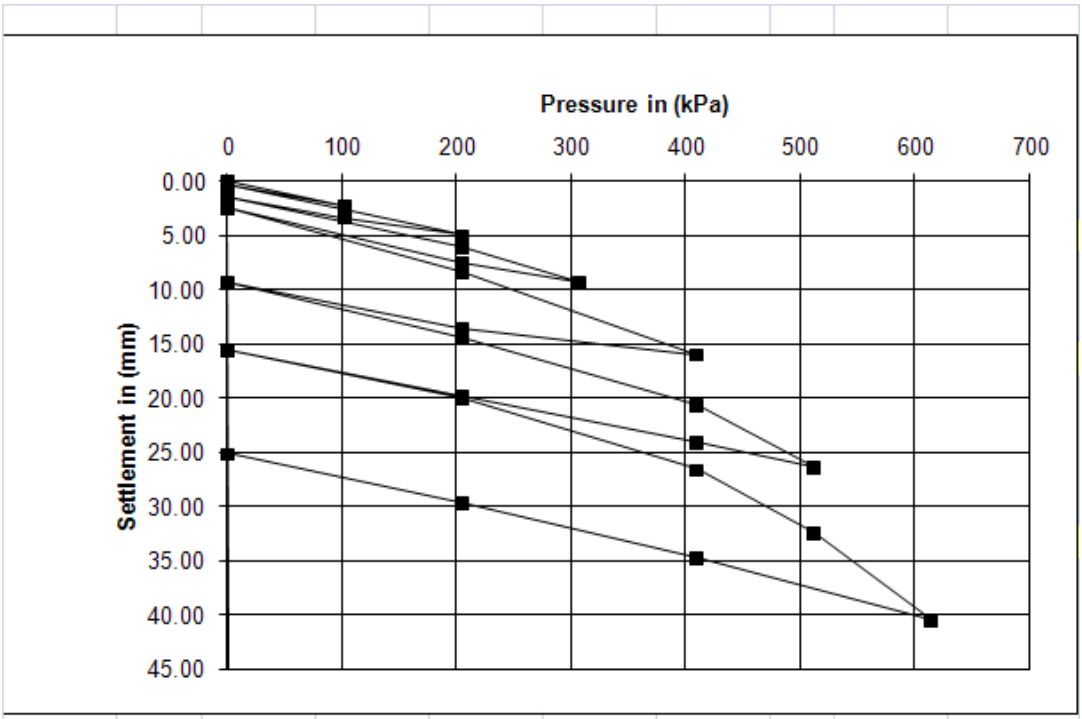






C.B.R. Test Results

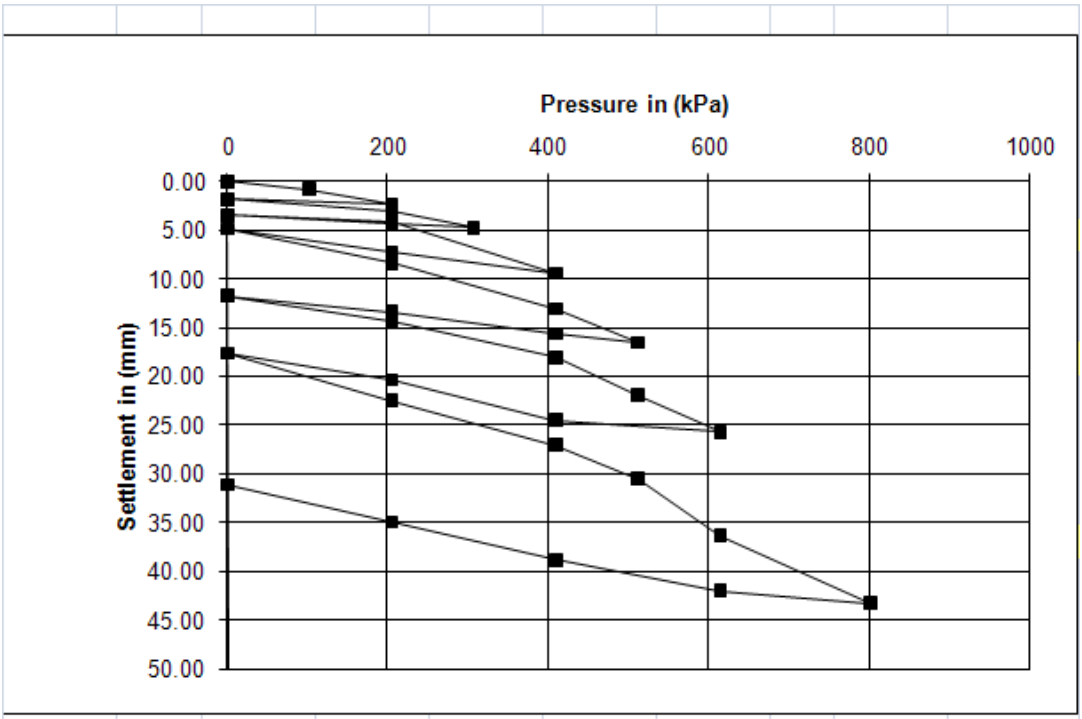
Penetration (mm)	Bearing Ratio (%)			Average (%)
2.5	10.16	9.99	10.34	10.16
5	9.76	9.88	9.99	9.93



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

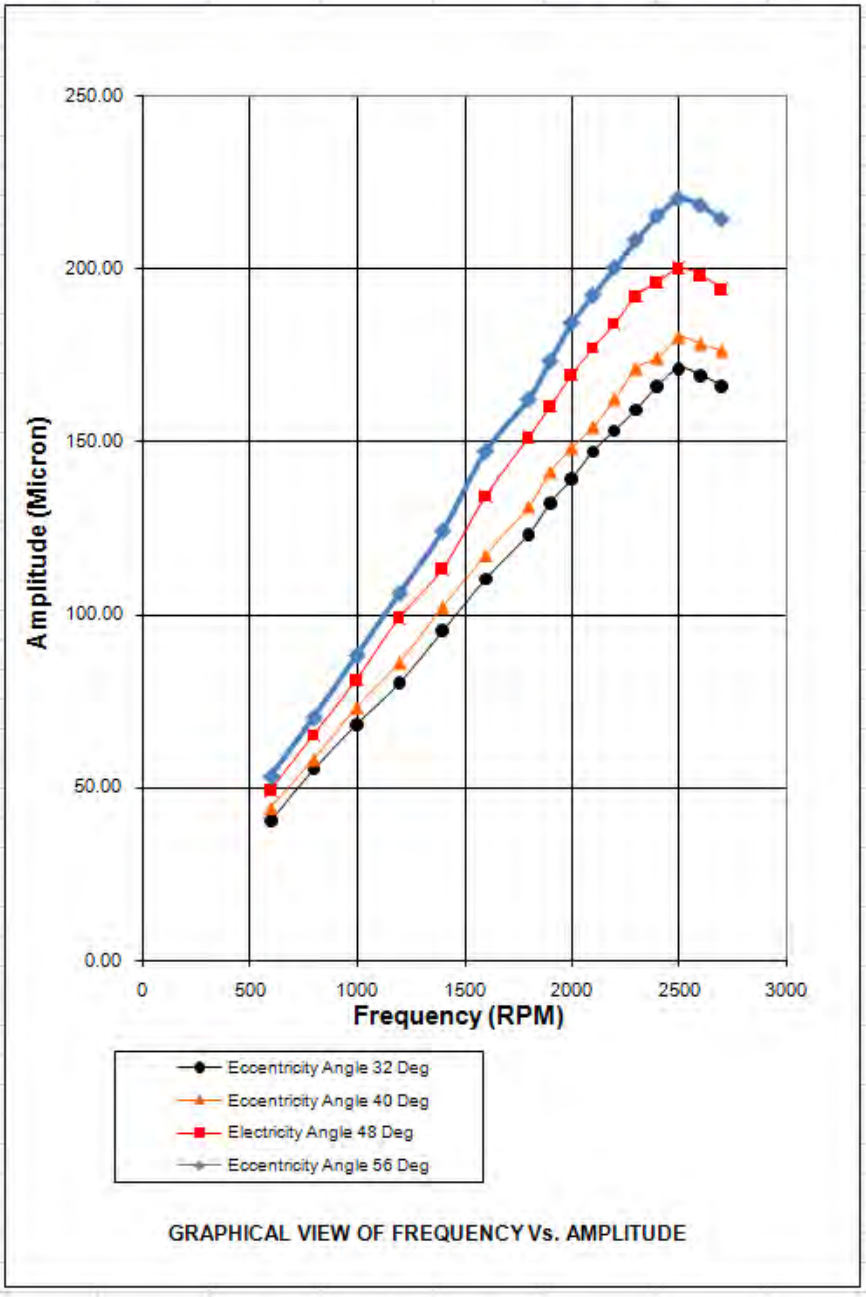


Test No.	: CPLT.-02	R.L. of G.L.	196.621m
Plate Size	: 600mm x 600mm.	Dial Gauge Constant	: 0.01mm.
Pit Size	: 3 m x 3 m (Bottom)	L.C. of Pressure Gauge	: 5 kg/cm2
Depth of Test	: 2.25 m. b.g.l.	Ram Dia.	: 12.5cm.
Date of Test	: 12.02.2018	Site	: Sambalpur
Location of Test	N: 2411120.00, 809085.00		

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



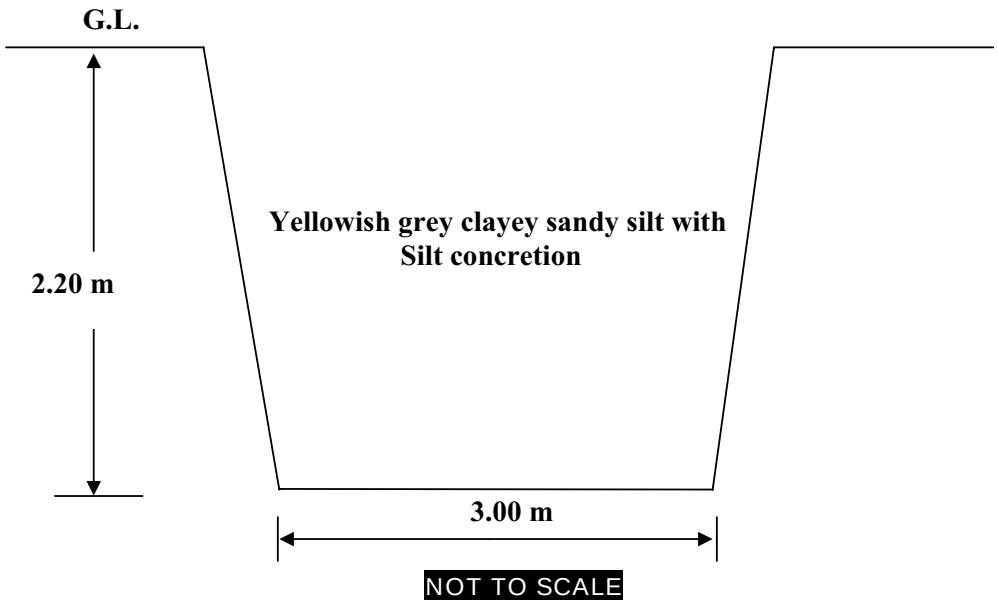
BLOCK VIBRATION TEST

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	

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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				

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				

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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				

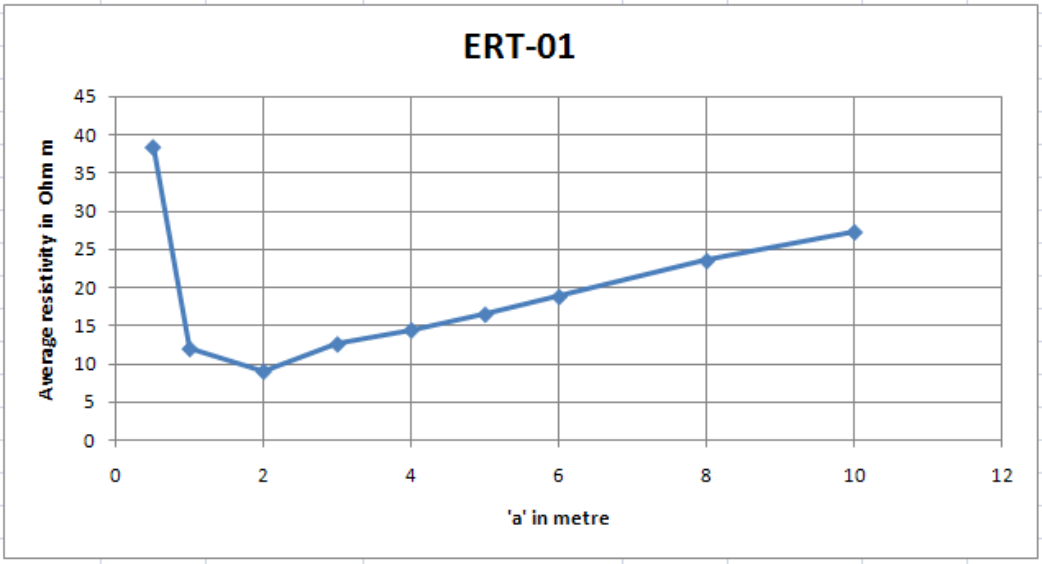
SKM Geosurvey

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				

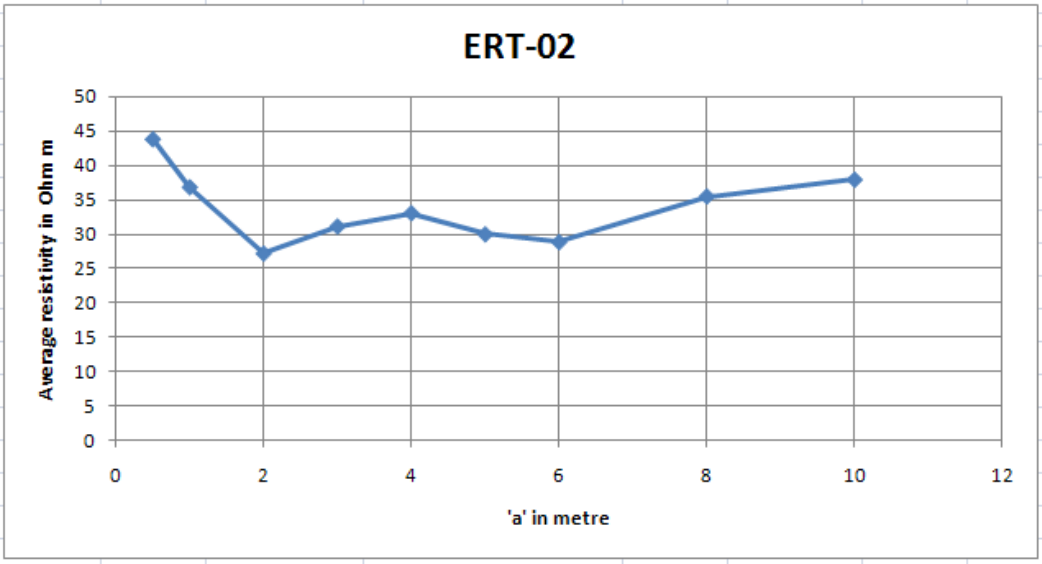
ERT TEST CURVE



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

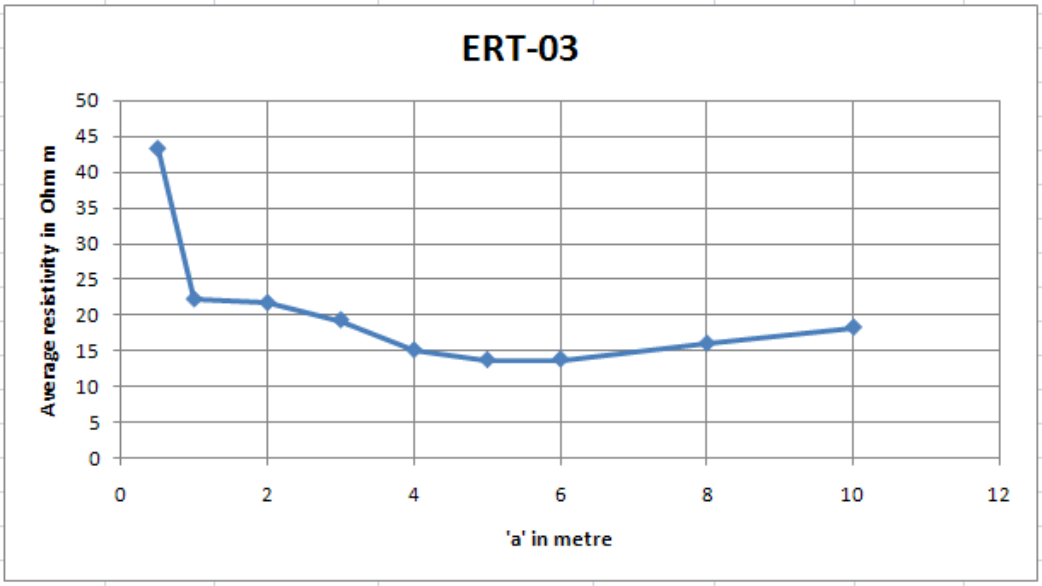
Sl No.	Spacing(m)	Mean Resistivity(ohm.m)
1	Upto 0.50m	38.35
2	0.50-8.00	13.9
3	8.00-10.00	25.37

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

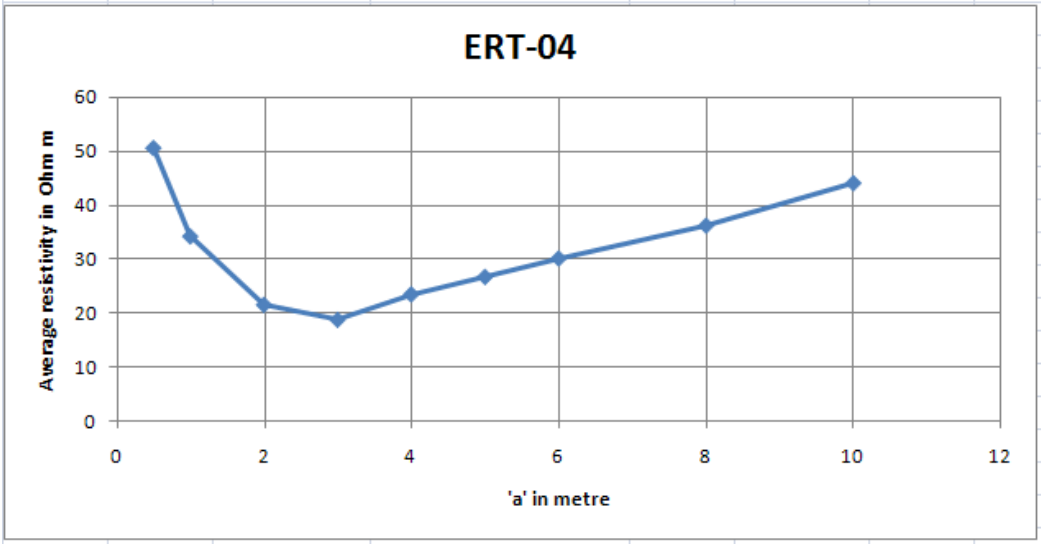
ERT TEST CURVE



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

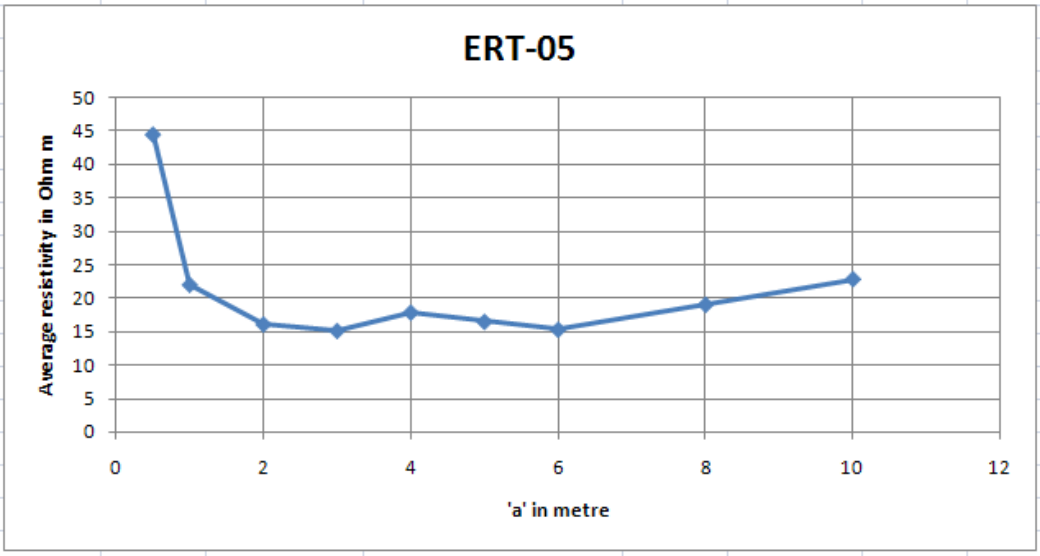
ERT TEST CURVE



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

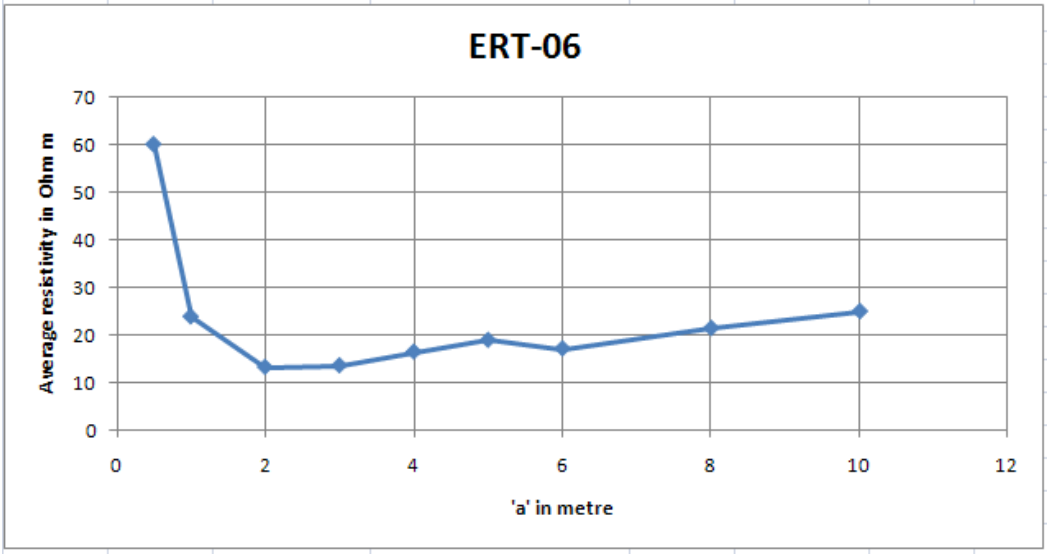
ERT TEST CURVE



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

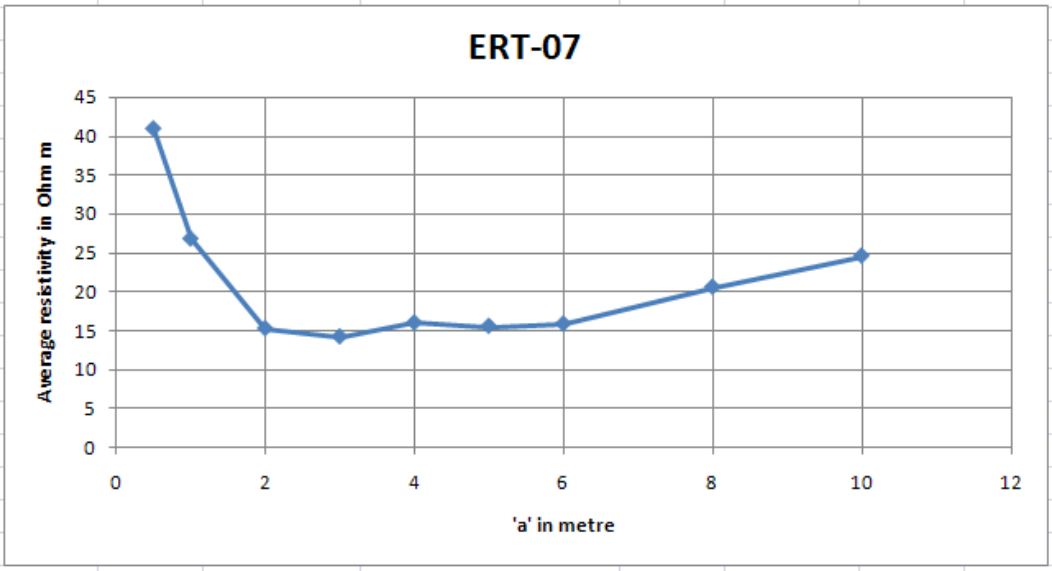
ERT TEST CURVE



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

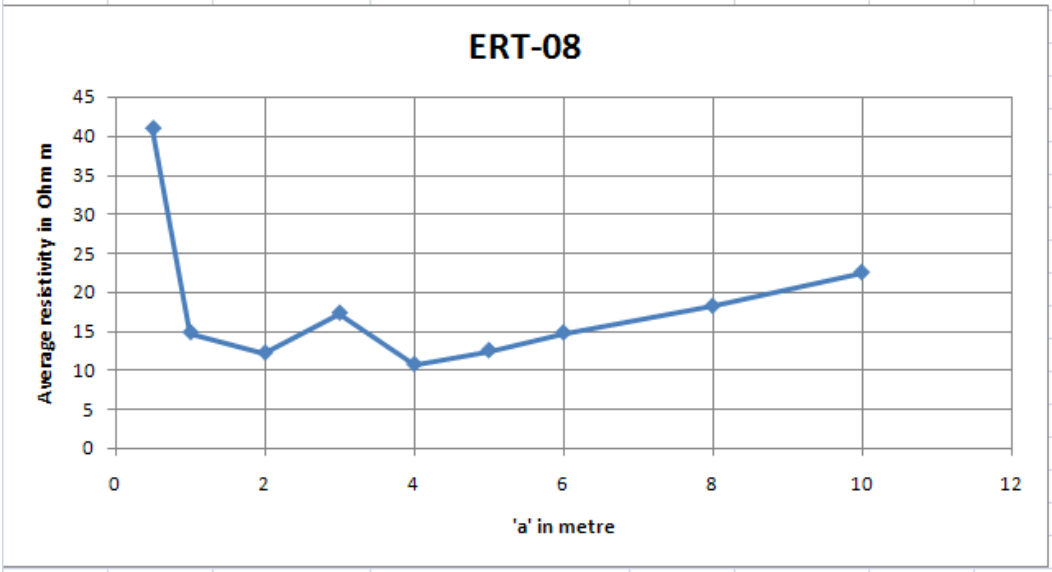
ERT TEST CURVE



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

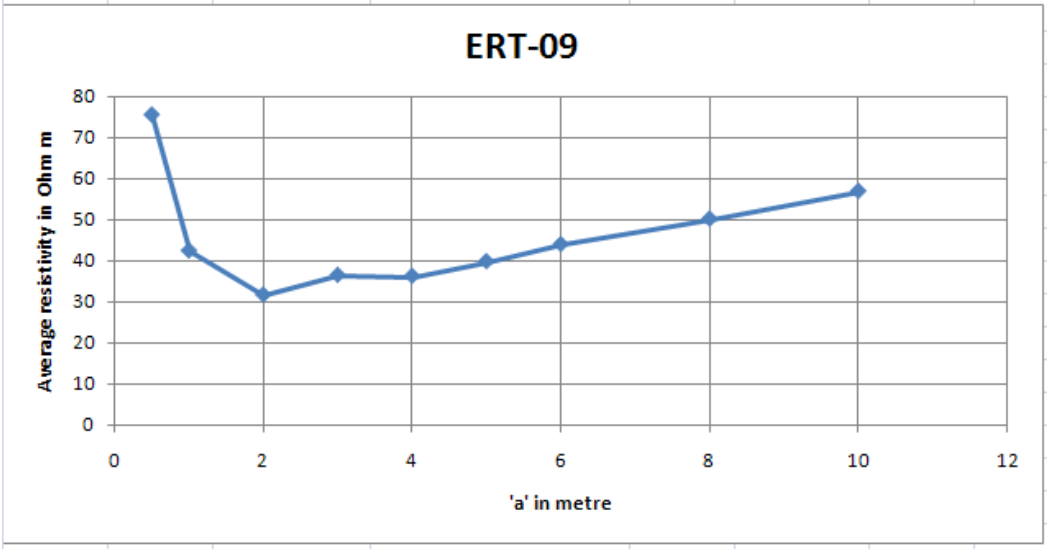
ERT TEST CURVE



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

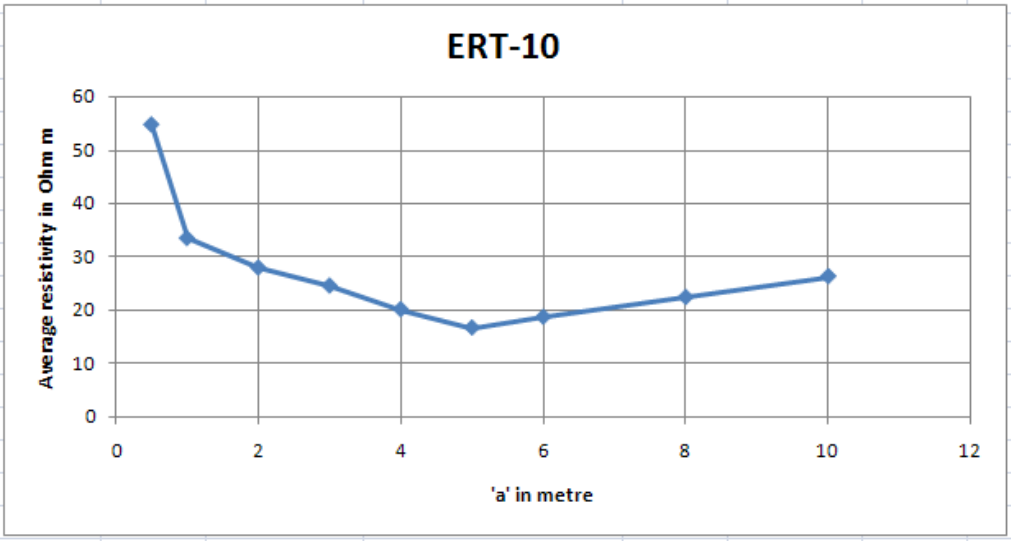
ERT TEST CURVE



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

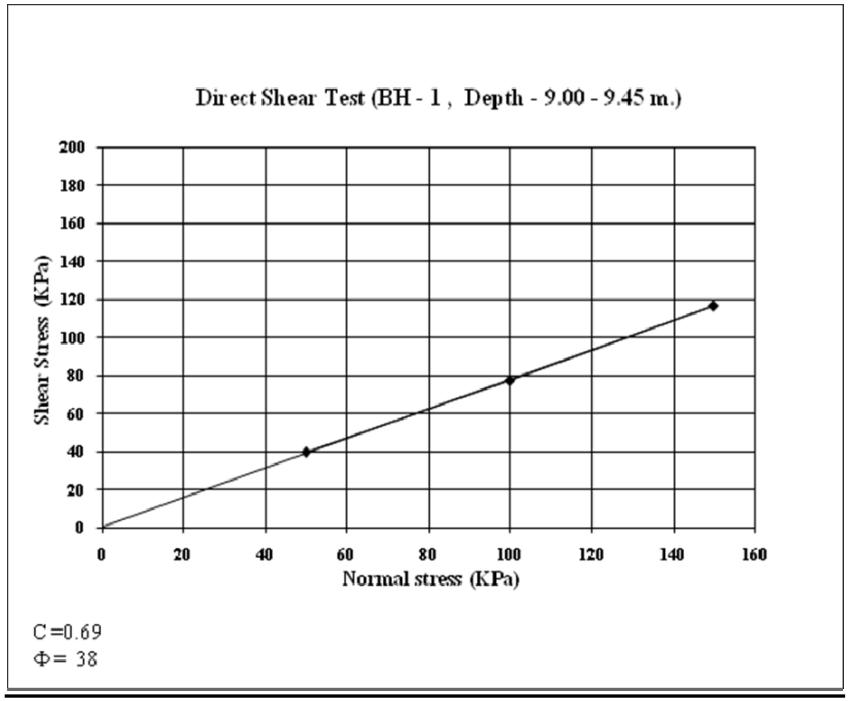
ERT TEST CURVE



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



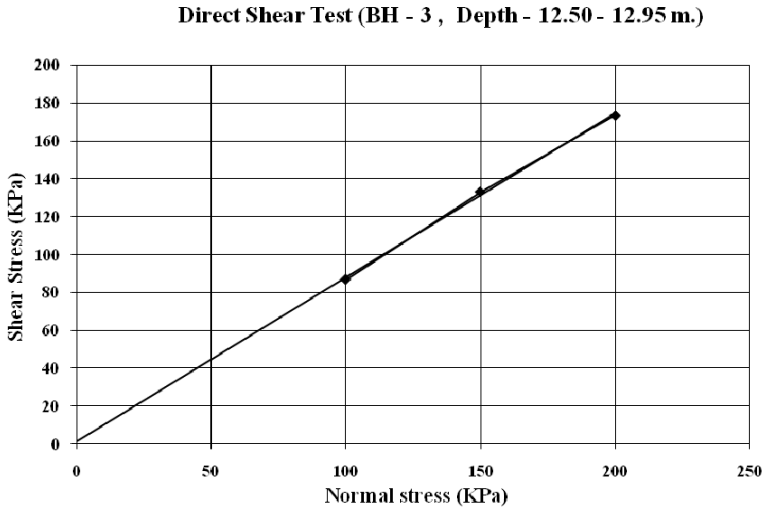
BH No.	Depth (m)	Type of Test	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Water Content (%)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
01	9.00-9.45	DS	20.10	16.60	21	0.69	38

Note: DS: DIRECT SHEAR TEST

JOB NO. 30796

SKM Geosurvey

DIRECT SHEAR TEST RESULTS



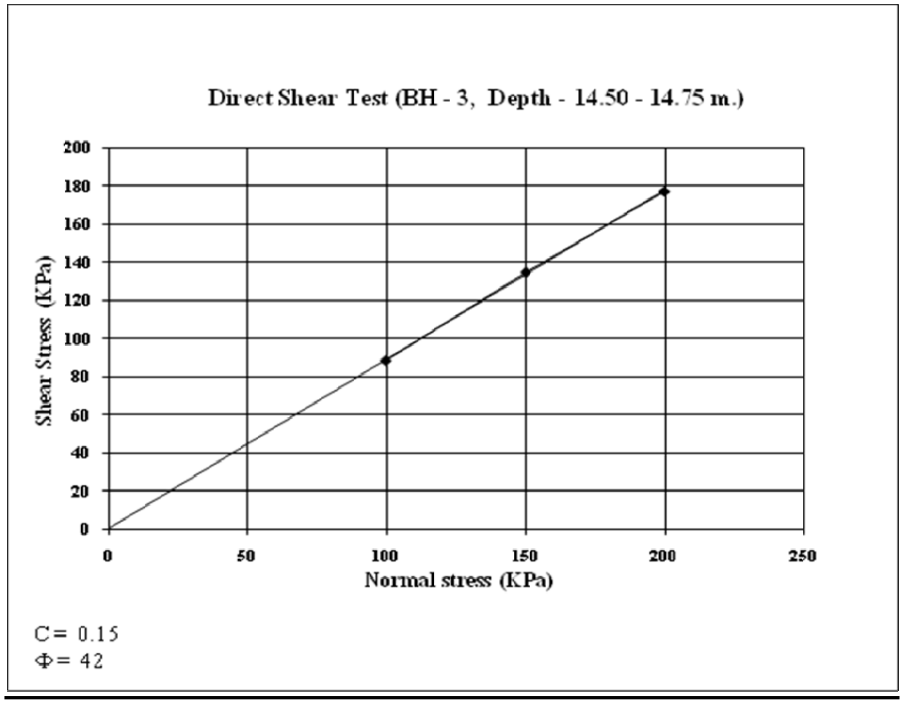
BH No.	Depth (m)	Type of Test	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Water Content (%)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
03	12.50-12.95	DS	20.40	17.00	20	0.98	41

Note: DS: DIRECT SHEAR TEST

JOB NO. 30796

SKM Geosurvey

DIRECT SHEAR TEST RESULTS



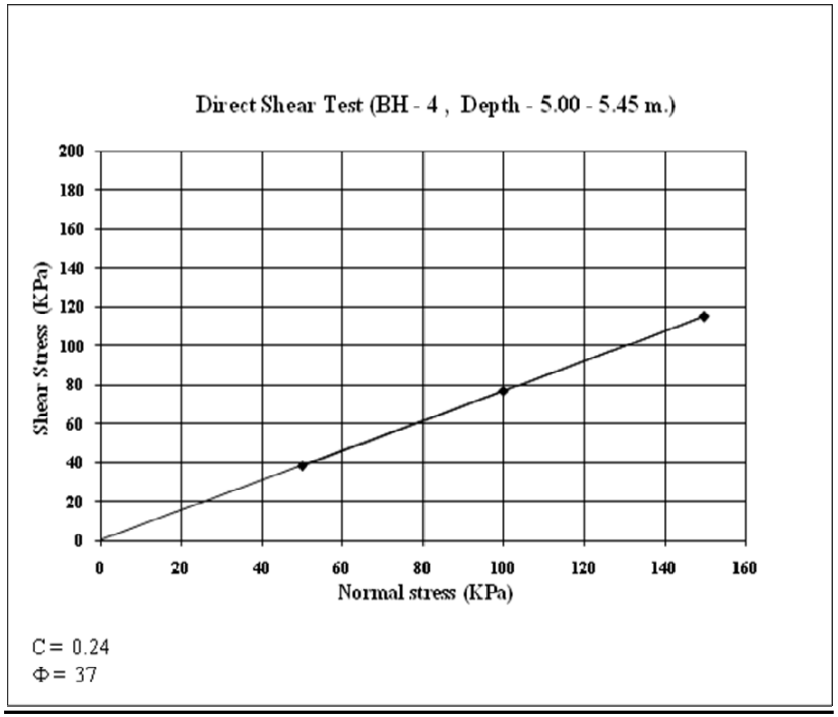
BH No.	Depth (m)	Type of Test	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Water Content (%)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
03	14.50-14.75	DS	20.50	17.20	19	0.15	42

Note: DS: DIRECT SHEAR TEST

JOB NO. 30796

SKM Geosurvey

DIRECT SHEAR TEST RESULTS



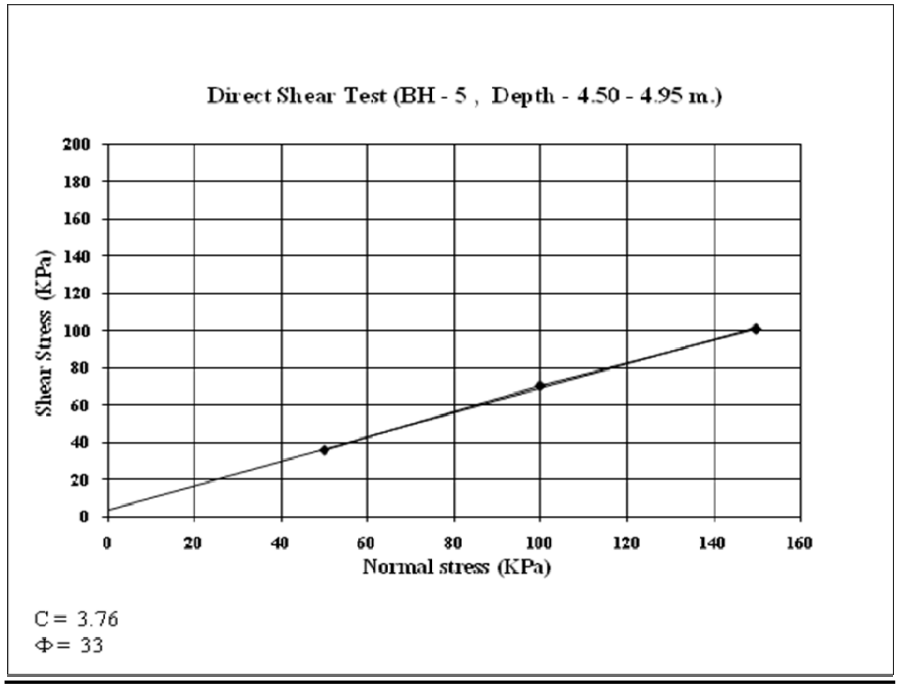
BH No.	Depth (m)	Type of Test	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Water Content (%)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
04	5.00-5.45	DS	19.70	15.90	24	0.24	37

Note: DS: DIRECT SHEAR TEST

JOB NO. 30796

SKM Geosurvey

DIRECT SHEAR TEST RESULTS



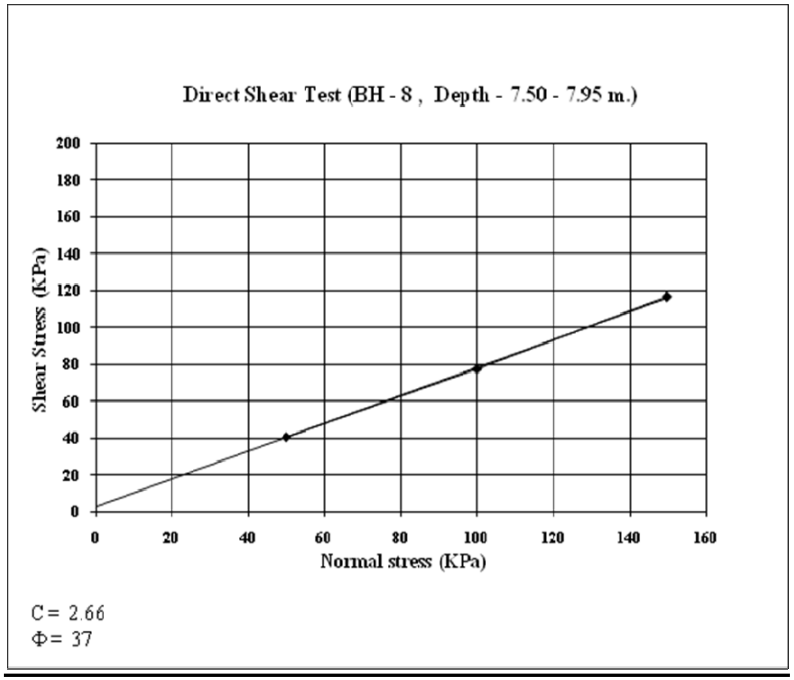
BH No.	Depth (m)	Type of Test	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Water Content (%)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
05	4.50-4.95	DS	19.60	15.70	25	3.76	33

Note: DS: DIRECT SHEAR TEST

JOB NO. 30796

SKM Geosurvey

DIRECT SHEAR TEST RESULTS



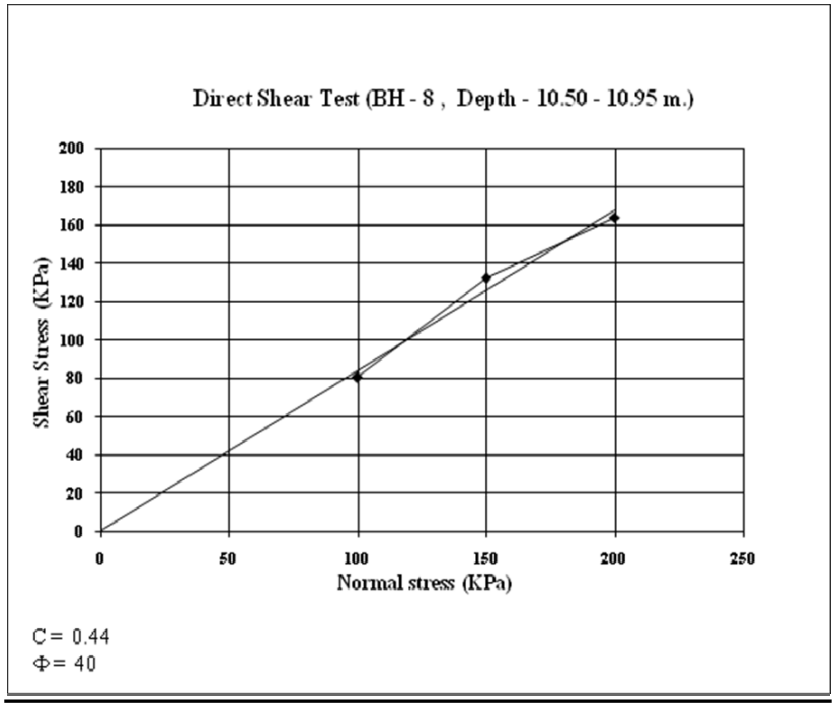
BH No.	Depth (m)	Type of Test	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Water Content (%)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
08	7.50-7.95	DS	20.20	16.60	22	2.66	37

Note: DS: DIRECT SHEAR TEST

JOB NO. 30796

SKM Geosurvey

DIRECT SHEAR TEST RESULTS



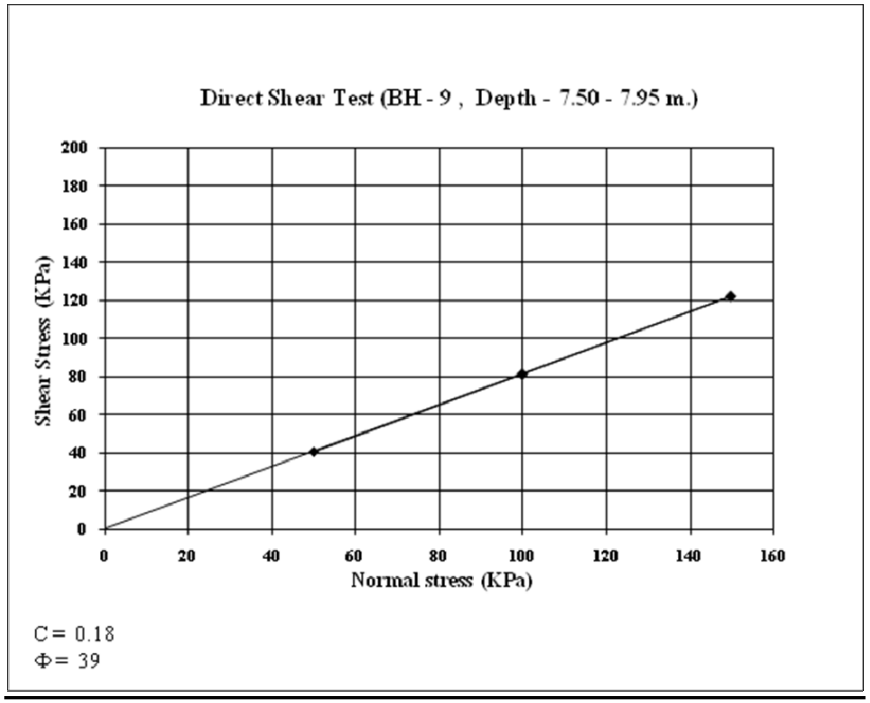
BH No.	Depth (m)	Type of Test	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Water Content (%)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
08	10.50-10.95	DS	20.30	16.90	20	0.44	40

Note: DS: DIRECT SHEAR TEST

JOB NO. 30796

SKM Geosurvey

DIRECT SHEAR TEST RESULTS



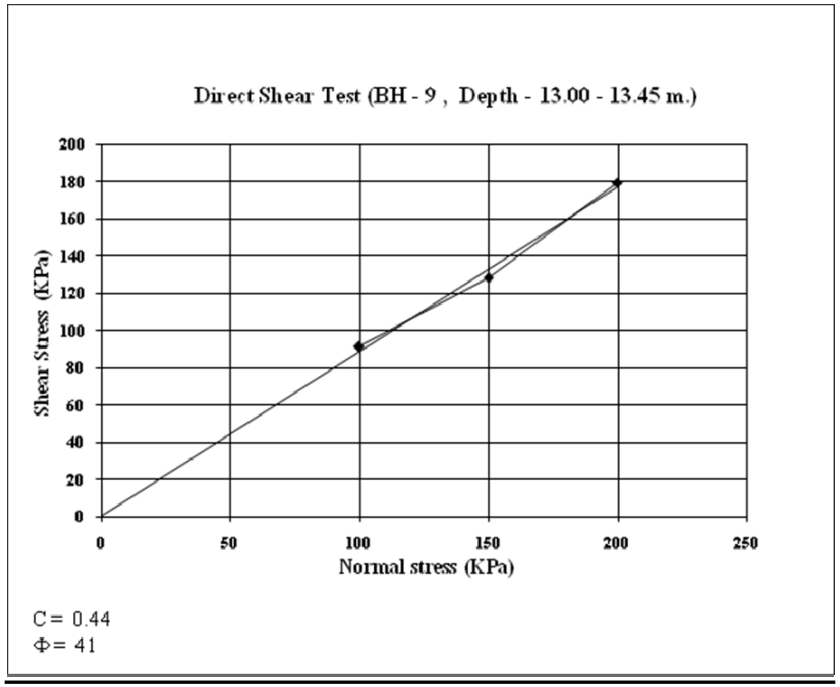
BH No.	Depth (m)	Type of Test	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Water Content (%)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
09	7.50-7.95	DS	20.10	16.30	23	0.18	39

Note: DS: DIRECT SHEAR TEST

JOB NO. 30796

SKM Geosurvey

DIRECT SHEAR TEST RESULTS



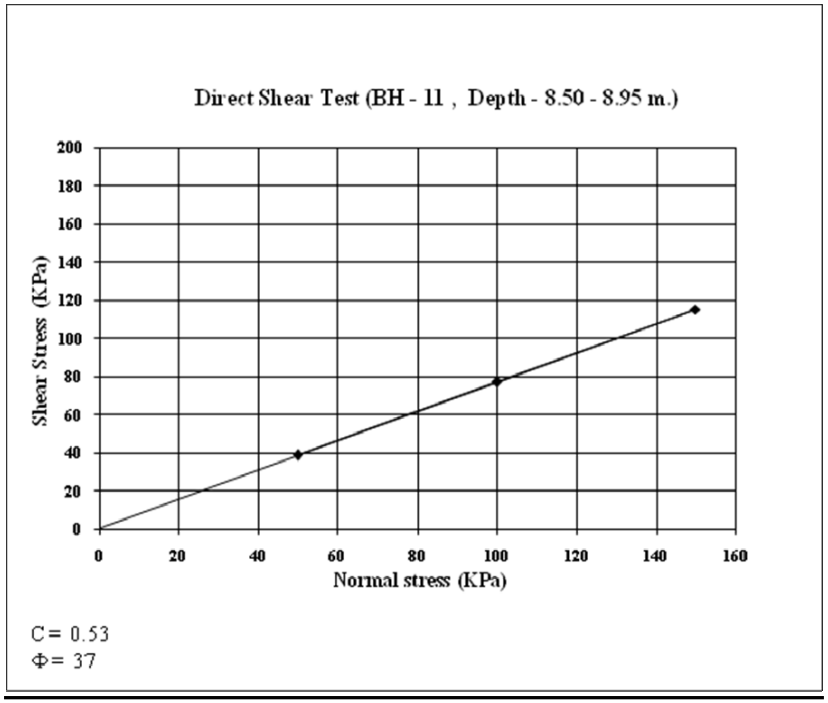
BH No.	Depth (m)	Type of Test	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Water Content (%)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
09	13.00-13.45	DS	20.40	17.10	19	0.44	41

Note: DS: DIRECT SHEAR TEST

JOB NO. 30796

SKM Geosurvey

DIRECT SHEAR TEST RESULTS



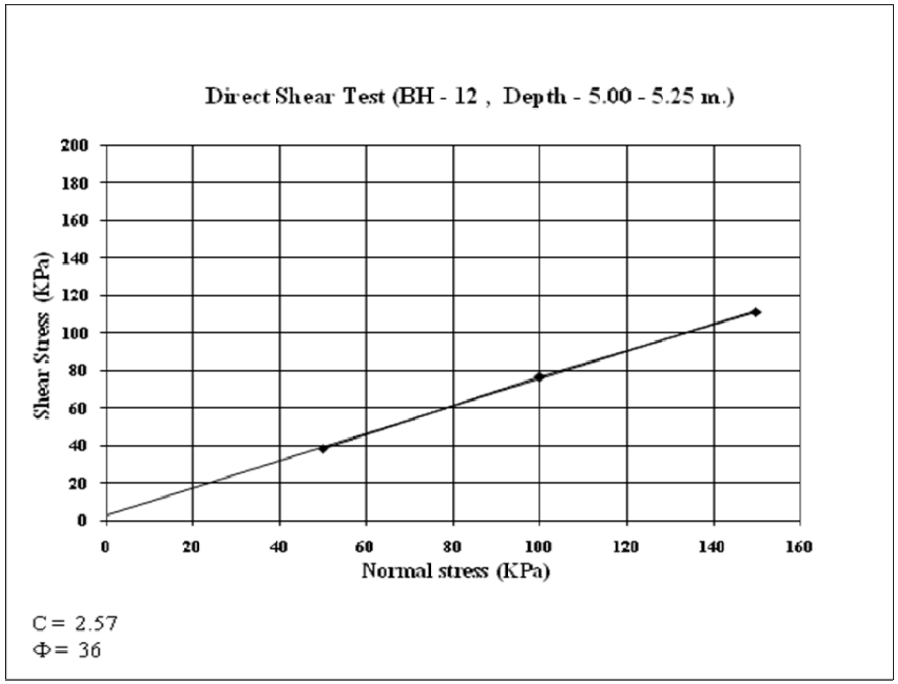
BH No.	Depth (m)	Type of Test	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Water Content (%)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
11	8.50-8.95	DS	20.20	16.40	23	0.53	37

Note: DS: DIRECT SHEAR TEST

JOB NO. 30796

SKM Geosurvey

DIRECT SHEAR TEST RESULTS



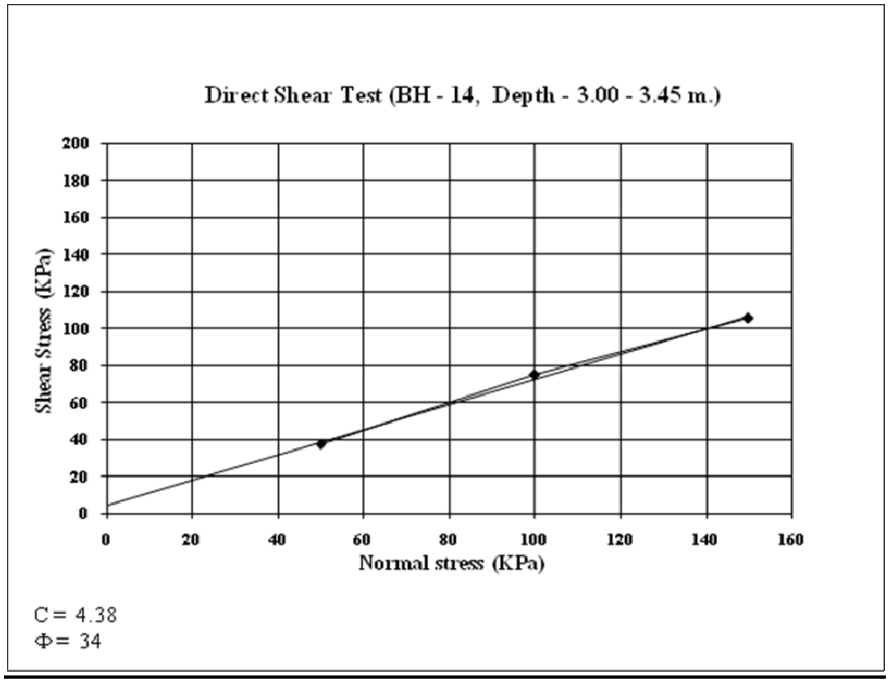
BH No.	Depth (m)	Type of Test	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Water Content (%)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
12	5.00-5.25	DS	19.80	16.10	23	2.57	36

Note: DS: DIRECT SHEAR TEST

JOB NO. 30796

SKM Geosurvey

DIRECT SHEAR TEST RESULTS



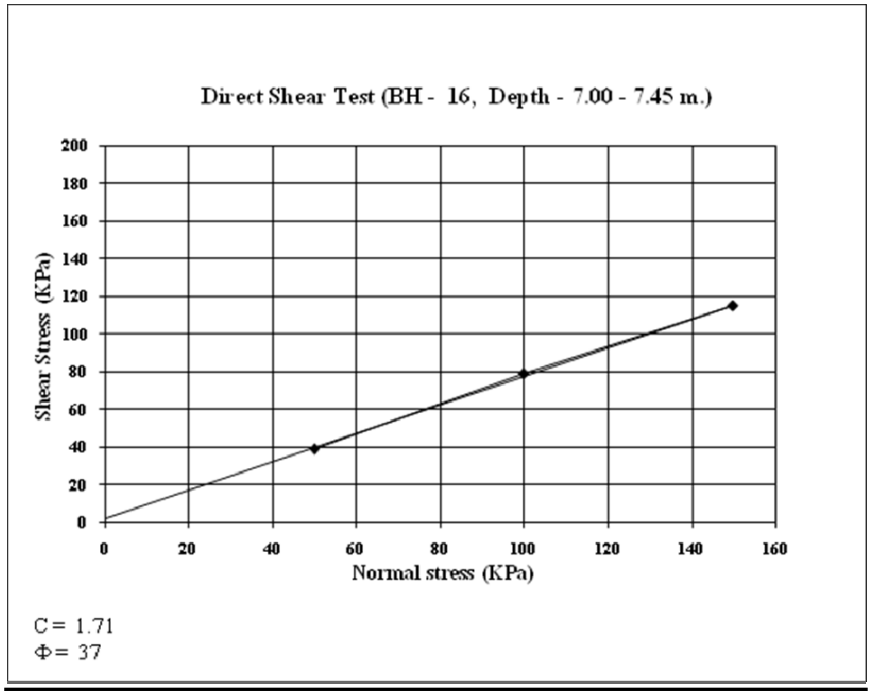
BH No.	Depth (m)	Type of Test	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Water Content (%)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
14	3.00-3.45	DS	19.70	15.80	25	4.38	34

Note: DS: DIRECT SHEAR TEST

JOB NO. 30796

SKM Geosurvey

DIRECT SHEAR TEST RESULTS



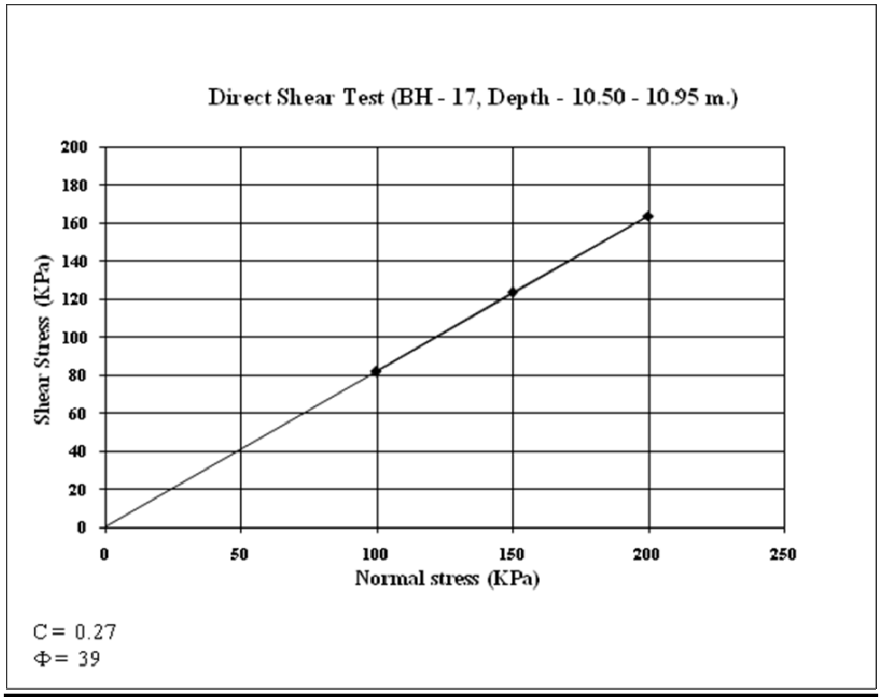
BH No.	Depth (m)	Type of Test	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Water Content (%)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
16	7.00-7.45	DS	20.00	16.40	22	1.71	37

Note: DS: DIRECT SHEAR TEST

JOB NO. 30796

SKM Geosurvey

DIRECT SHEAR TEST RESULTS



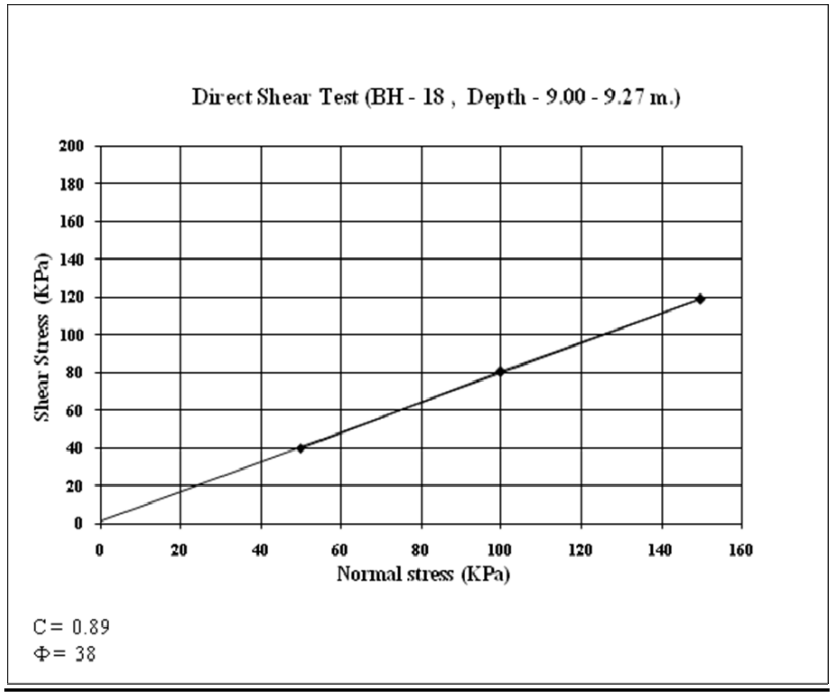
BH No.	Depth (m)	Type of Test	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Water Content (%)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
17	10.50-10.95	DS	20.30	16.80	21	0.27	39

Note: DS: DIRECT SHEAR TEST

JOB NO. 30796

SKM Geosurvey

DIRECT SHEAR TEST RESULTS



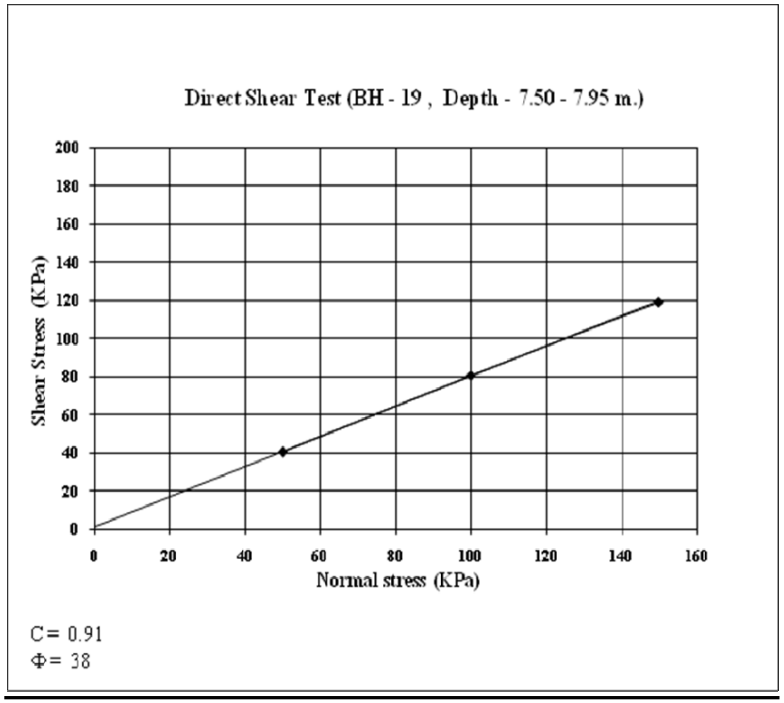
BH No.	Depth (m)	Type of Test	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Water Content (%)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
18	9.00-9.27	DS	20.20	16.70	21	0.89	38

Note: DS: DIRECT SHEAR TEST

JOB NO. 30796

SKM Geosurvey

DIRECT SHEAR TEST RESULTS



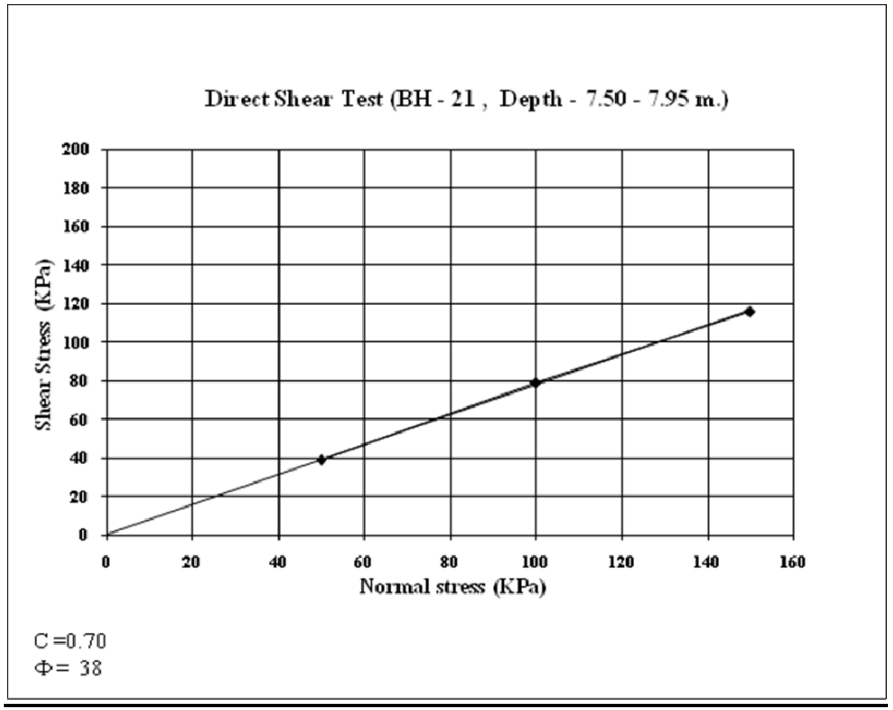
BH No.	Depth (m)	Type of Test	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Water Content (%)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
19	7.50-7.95	DS	20.00	16.30	23	0.91	38

Note: DS: DIRECT SHEAR TEST

JOB NO. 30796

SKM Geosurvey

DIRECT SHEAR TEST RESULTS



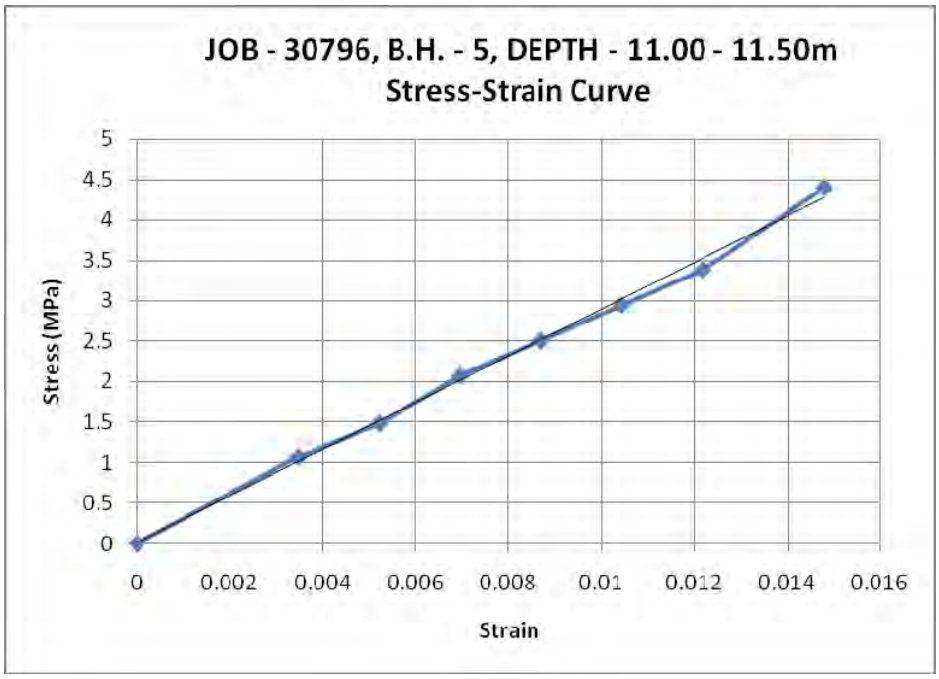
BH No.	Depth (m)	Type of Test	Bulk Density (KN/m^3)	Dry Density (KN/m^3)	Water Content (%)	Cohesion (kPa)	Angle of Internal Friction (Degrees)
21	7.50-7.95	DS	20.10	16.50	22	0.70	38

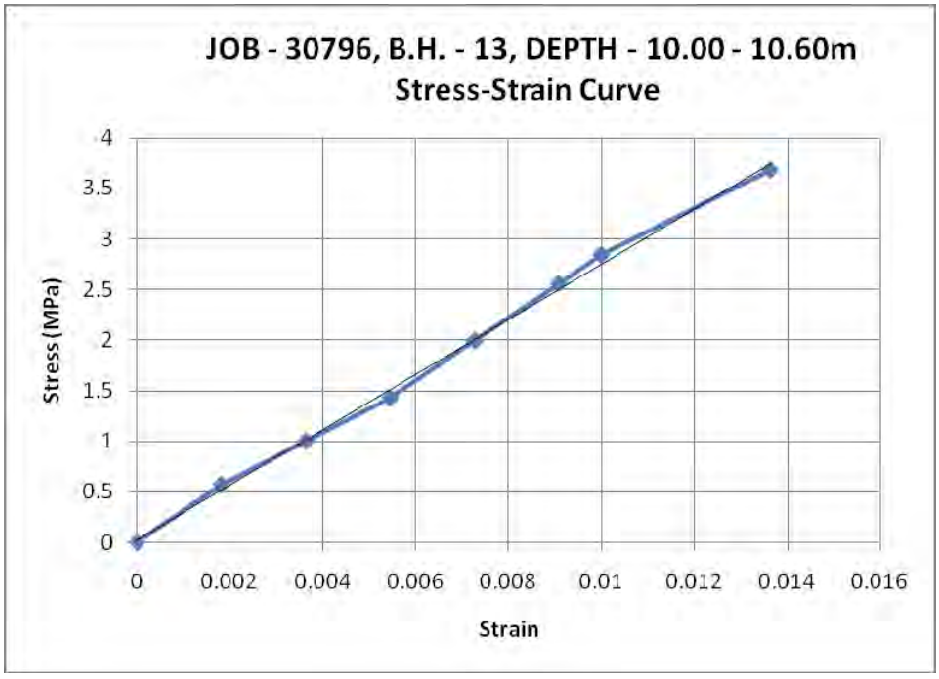
Note: DS: DIRECT SHEAR TEST

JOB NO. 30796

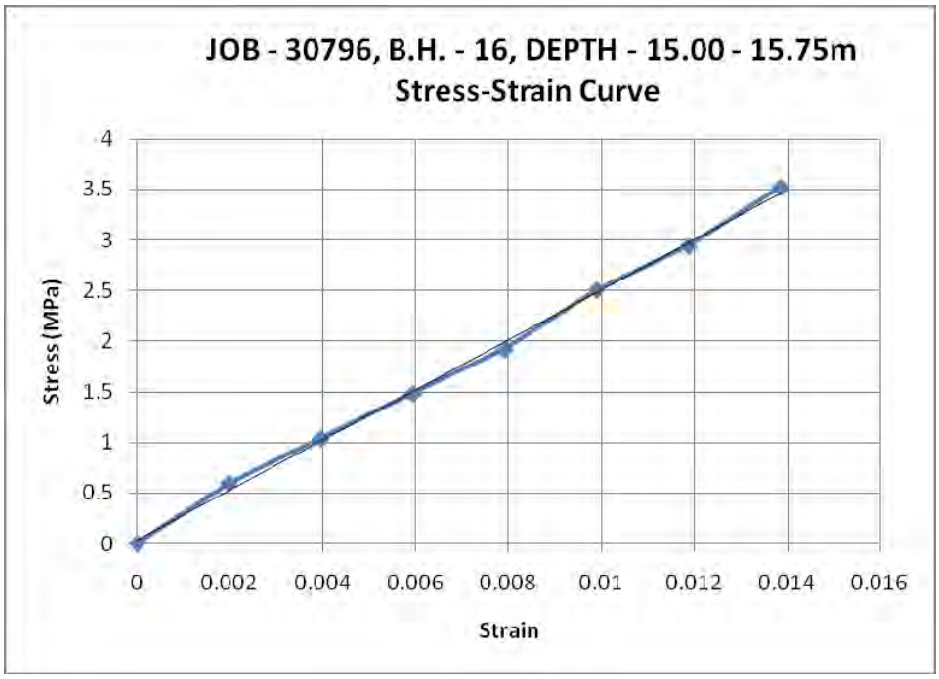
SKM Geosurvey

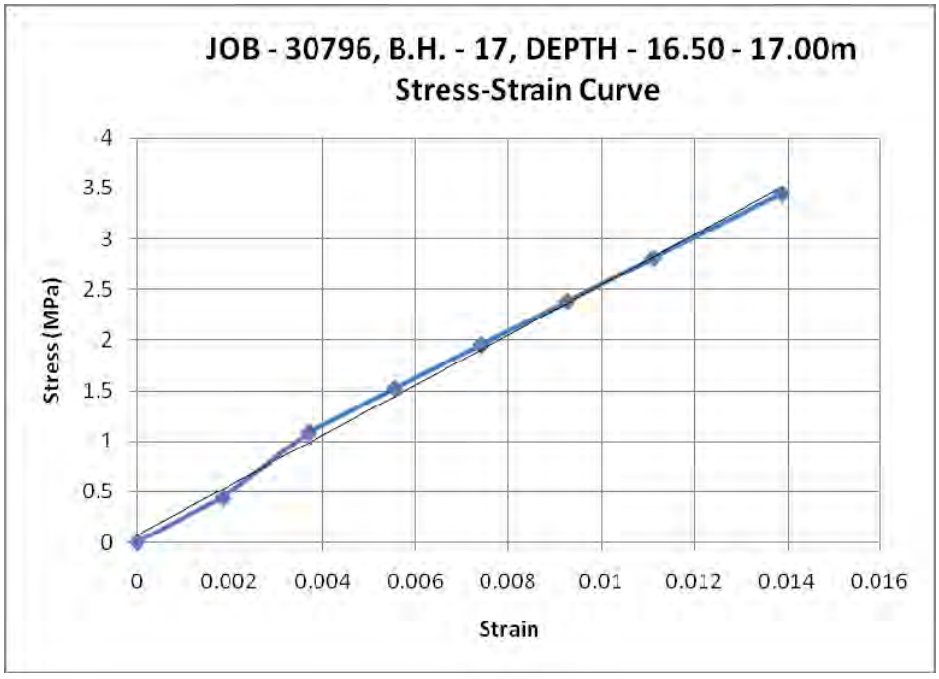
Stress-Strain Curve of Rock



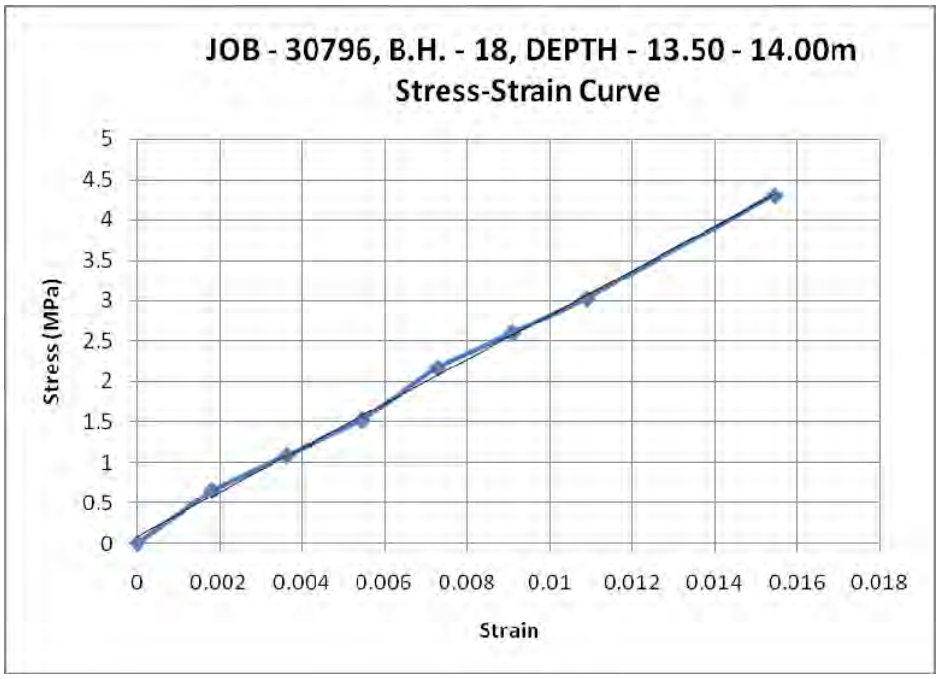


Stress-Strain Curve of Rock



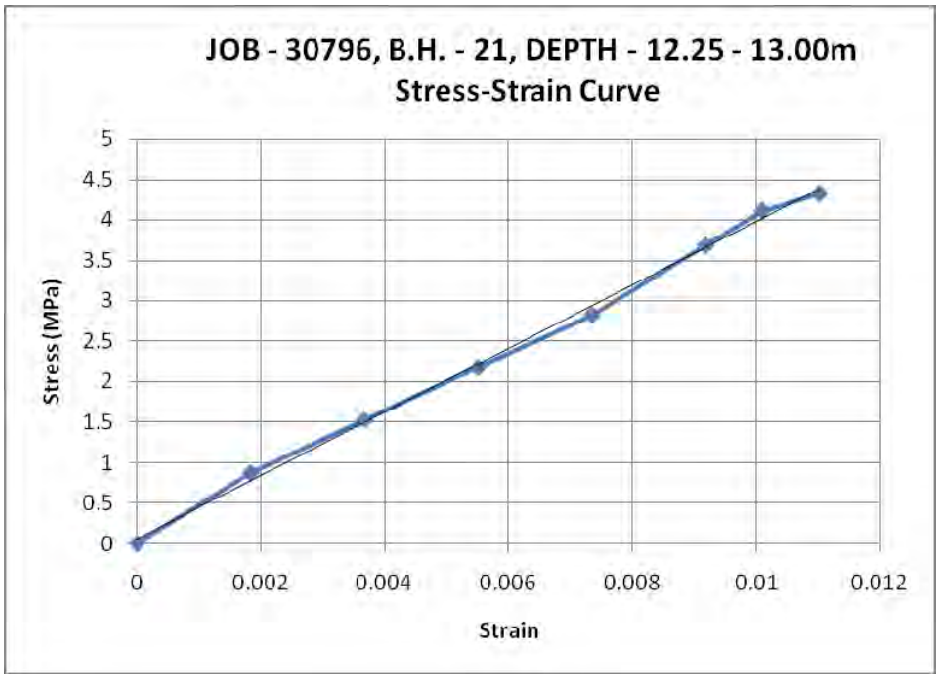


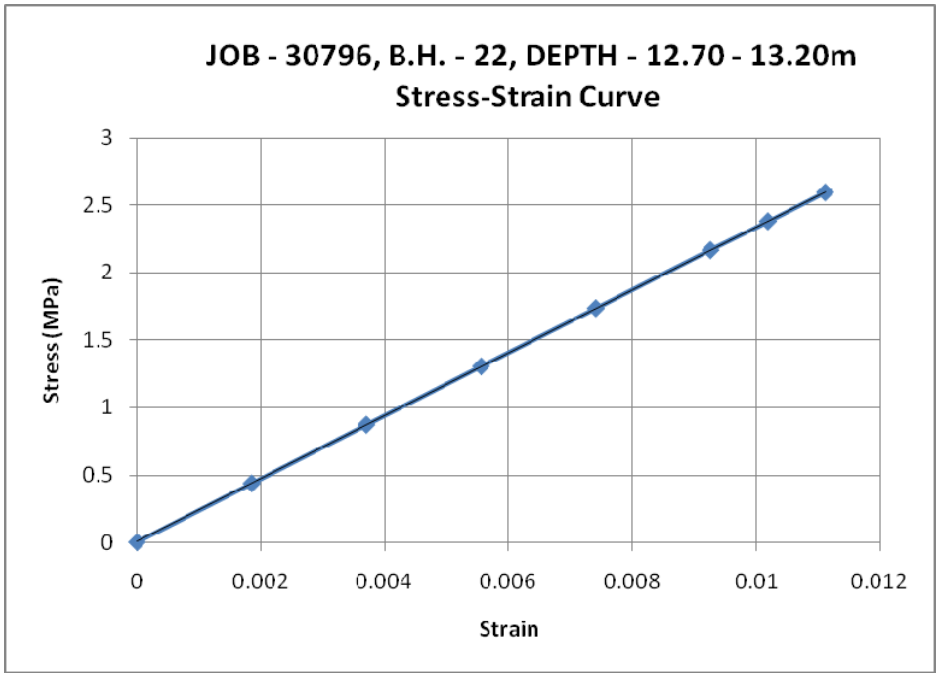
Stress-Strain Curve of Rock



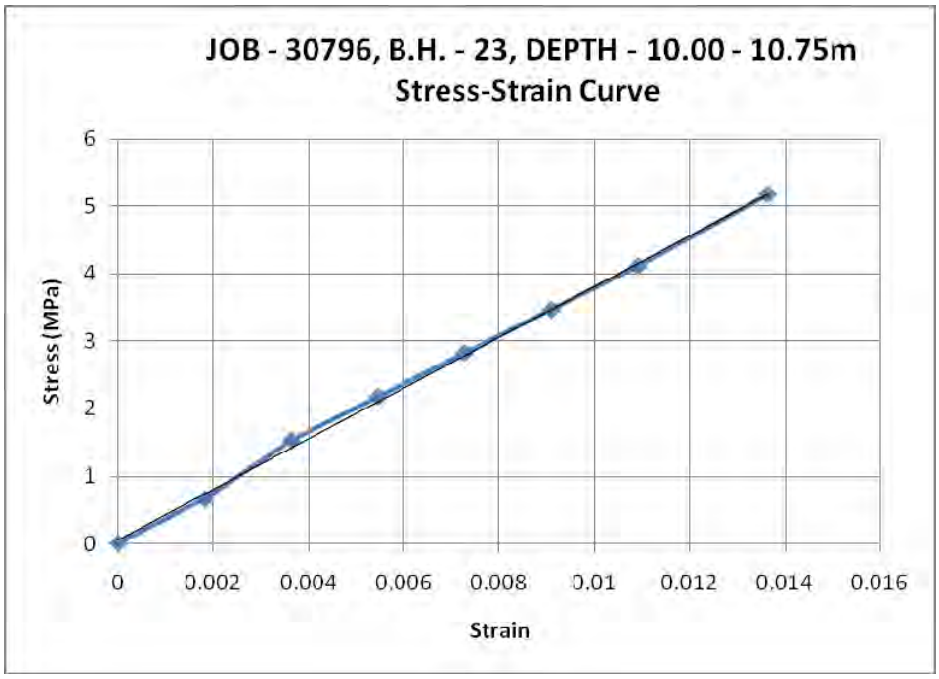


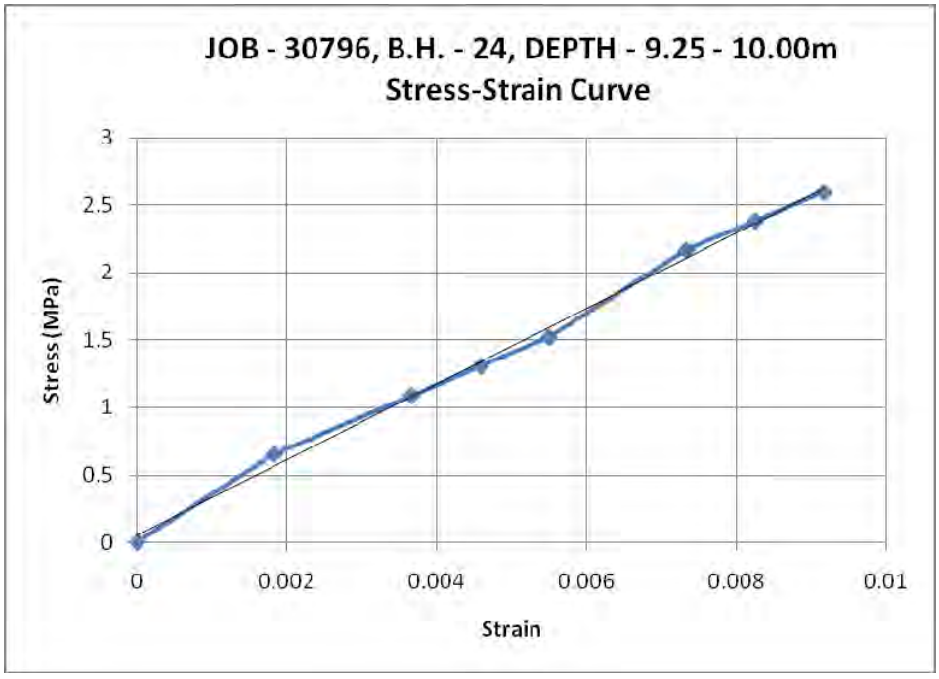
Stress-Strain Curve of Rock





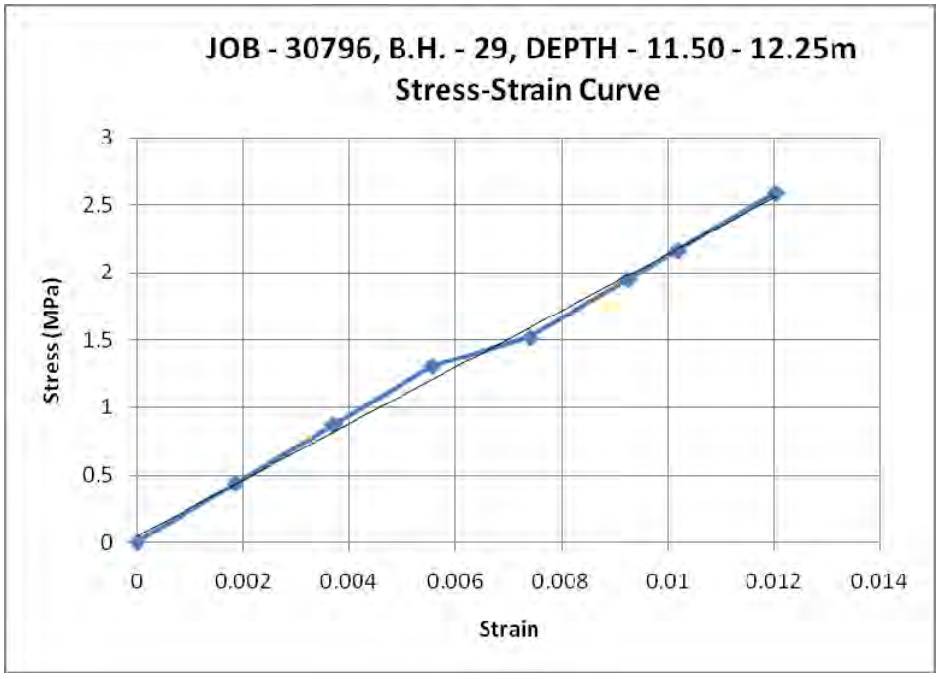
Stress-Strain Curve of Rock

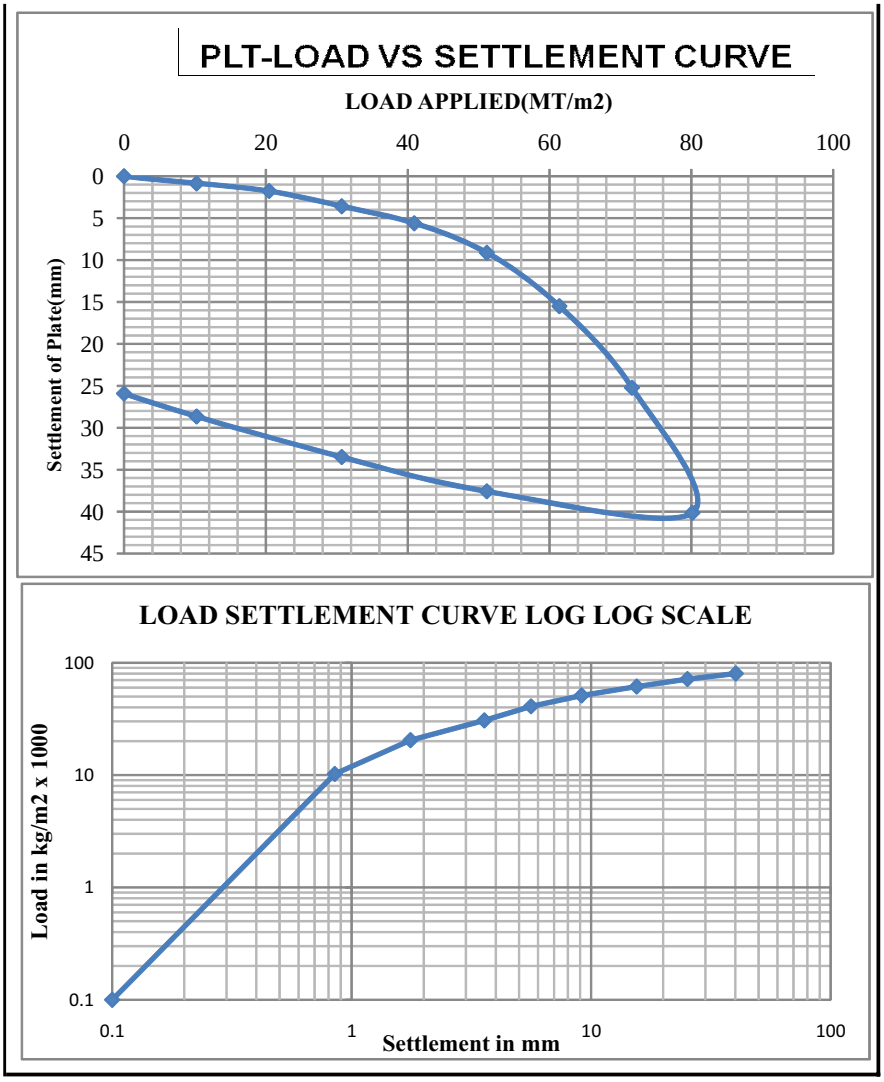




Stress-Strain Curve of Rock



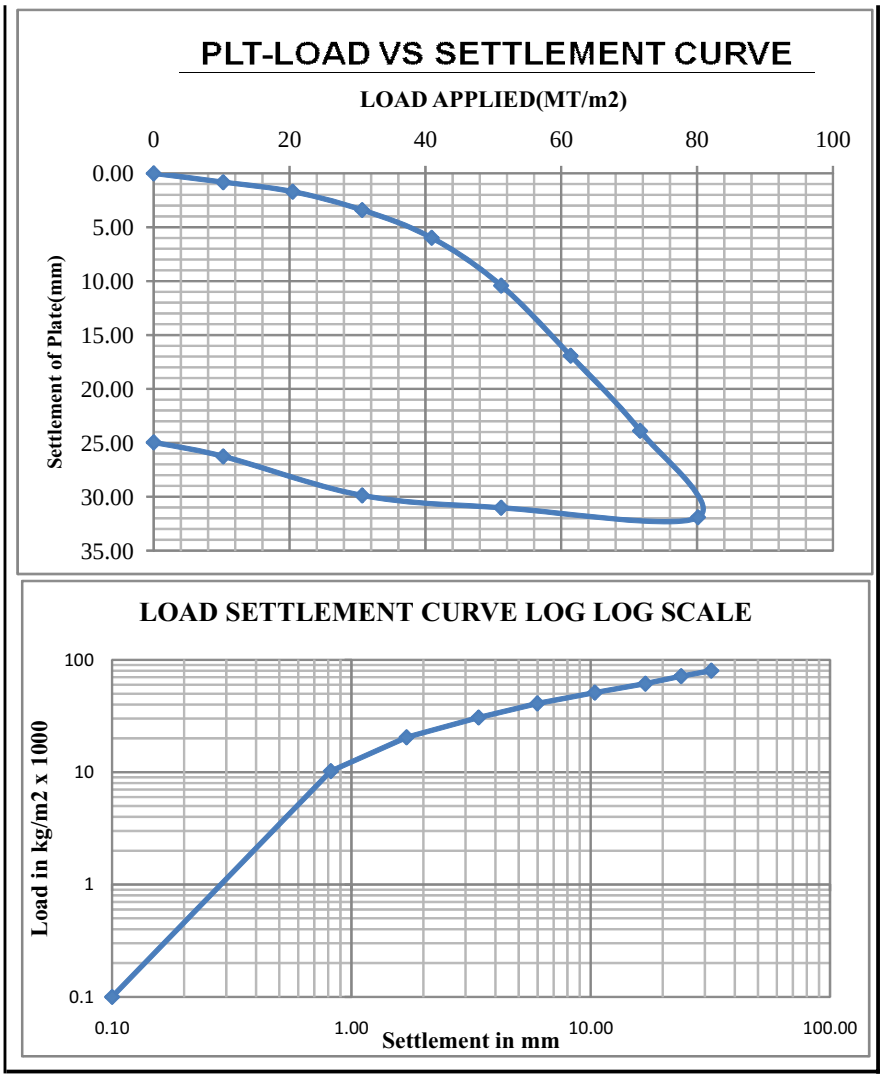




Test No.	**: PLT.01**	**R.L. of G.L.**	**: 197.50m**
Plate Size	**: 60cm x 60cm.**	**Dial Gauge Constant**	**: 0.01mm.**
Pit Size	**: 3 m x 3 m**	**L.C. of Pressure Gauge**	**: 5 kg/cm2**
Depth of Test	**: 2.50m. b.g.l.**	**Ram Dia.**	**: 12.5cm.**
Date of Test	**: 05.02.2018**	**Site**	**: Sambalpur**
Location of Test	**: N: 2411027.00, E: 8**	**Client**	**: NLC India Ltd.**
Soil Type: Silty clay			

PLATE LOAD TEST

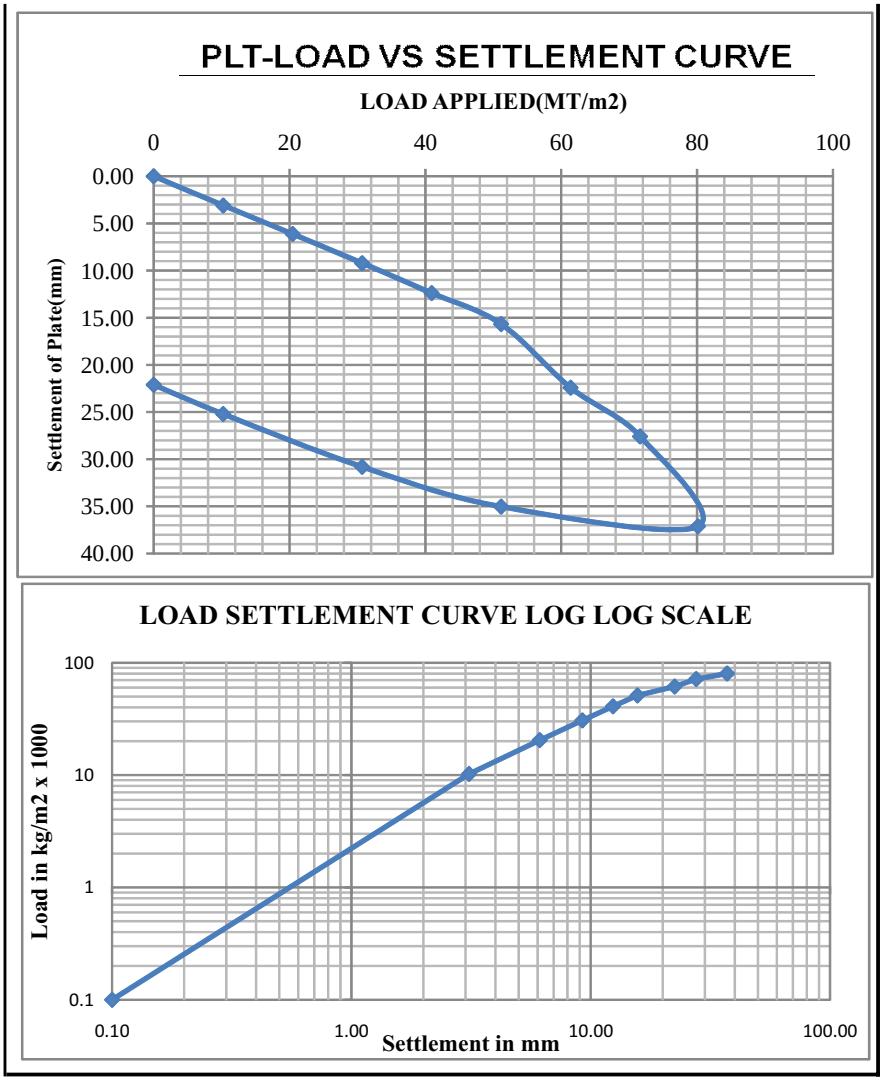
TEST NO. : PLT - 01



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

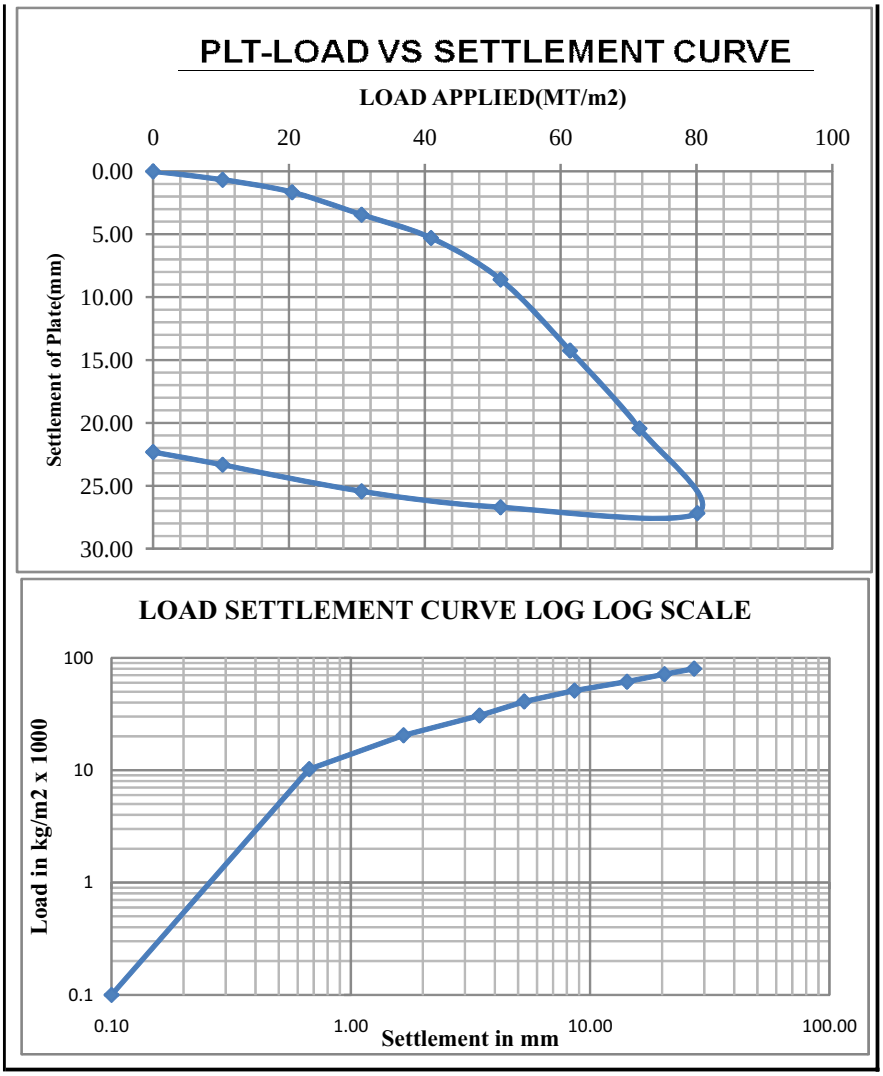
TEST NO. : PLT - 02



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

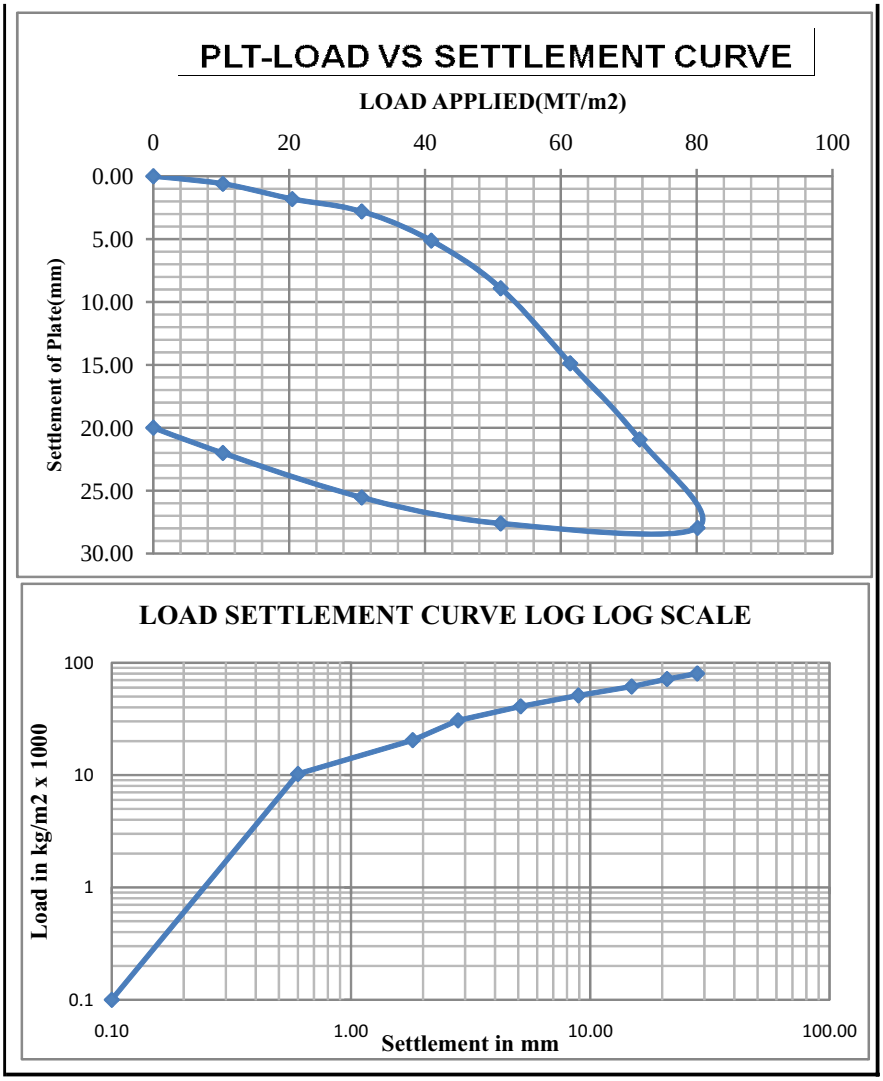
TEST NO. : PLT - 03



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

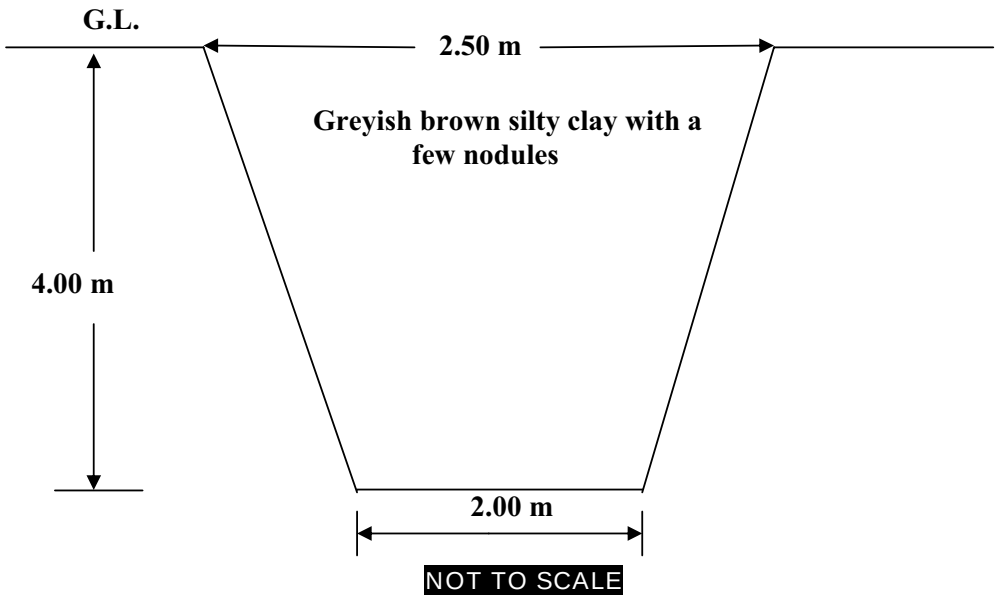
TEST NO. : PLT - 05

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

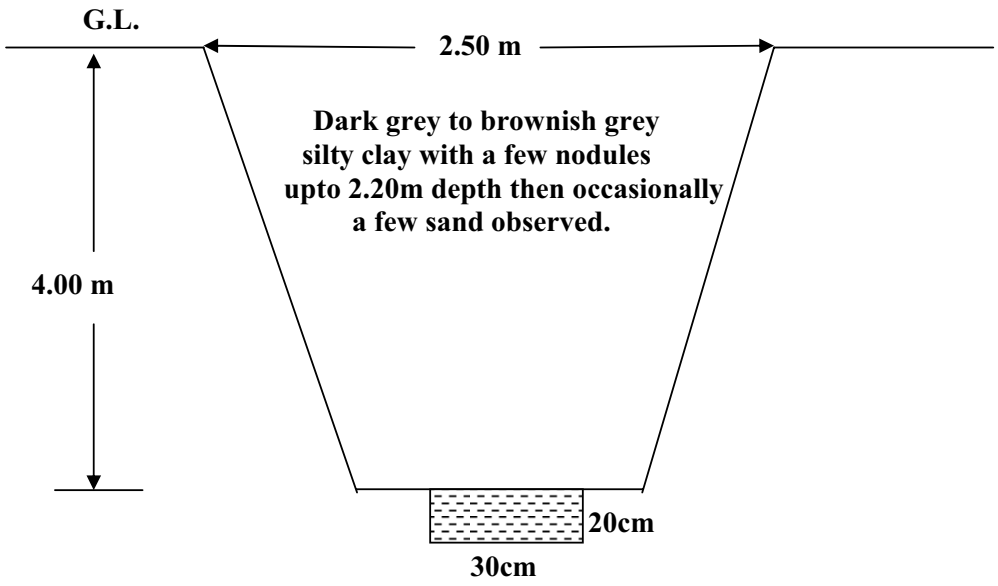
Date	Type of sample	Ref No.	Depth (m)	Remarks
19.02.2018	DS	162191	1.00	Silty clay
19.02.2018	UDS	162192	2.00	Silty clay
19.02.2018	DS	162193	3.00	Silty clay
19.02.2018	UDS	169194	4.00	Silty clay

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

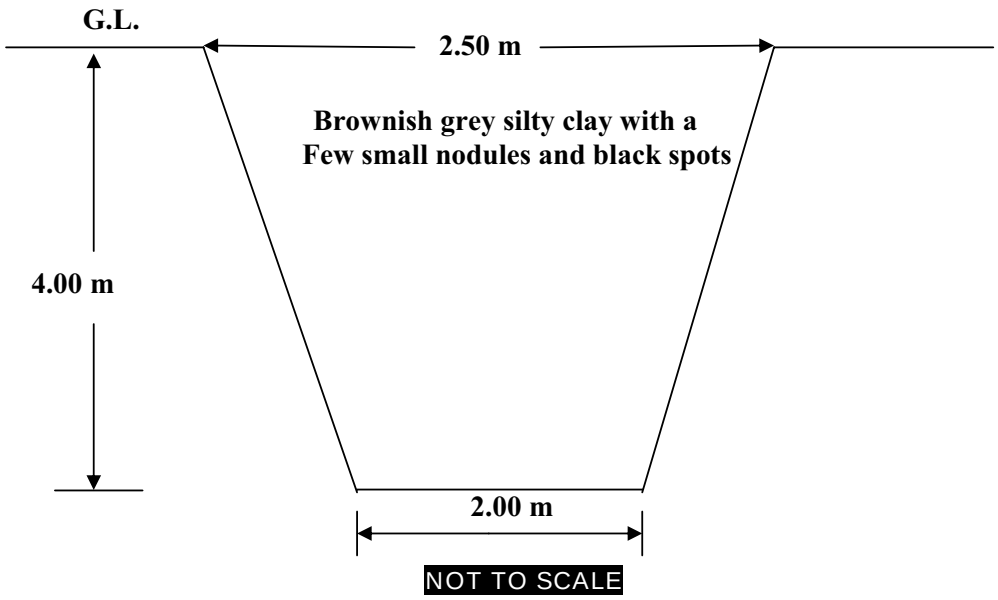
Date	Type of sample	Ref No.	Depth (m)	Remarks
03.02.2018	DS	100675	1.00	Silty clay
03.02.2018	UDS	100676	2.00	Silty clay
03.02.2018	DS	100677	3.00	Silty clay
03.02.2018	UDS	100678	4.00	Silty clay

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

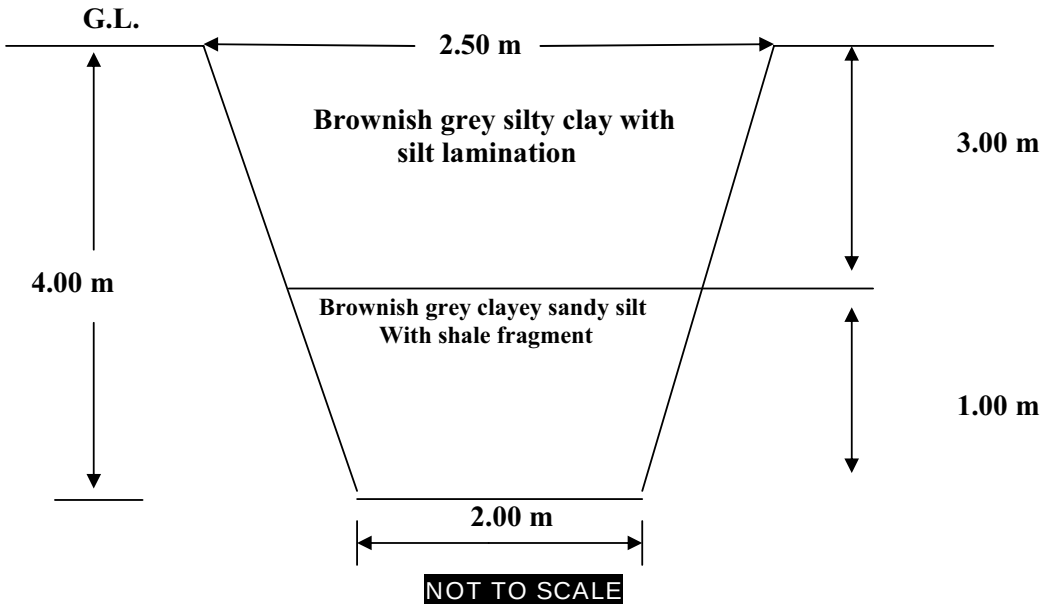
Date	Type of sample	Ref No.	Depth (m)	Remarks
01.02.2018	DS	106100	1.00	Silty clay
01.02.2018	UDS	106101	2.00	Silty clay
01.02.2018	DS	106102	3.00	Silty clay
01.02.2018	UDS	106103	4.00	Silty clay

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

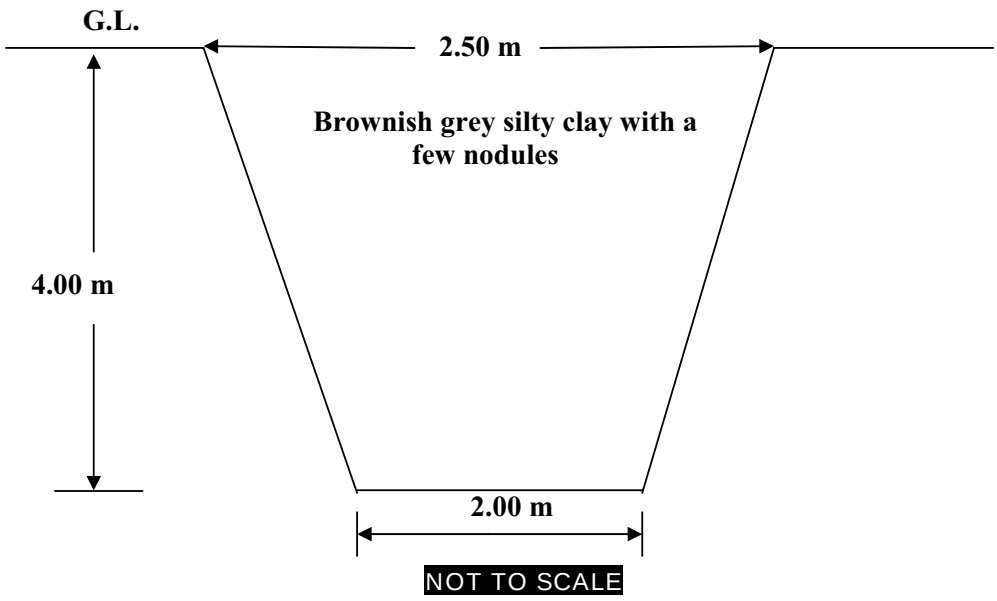
Date	Type of sample	Ref No.	Depth (m)	Remarks
01.02.2018	DS	106104	1.00	Silty clay
01.02.2018	UDS	106105	2.00	Silty clay
01.02.2018	DS	106106	3.00	Sandy clayey silt
01.02.2018	UDS	106107	4.00	Sandy clayey silt

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

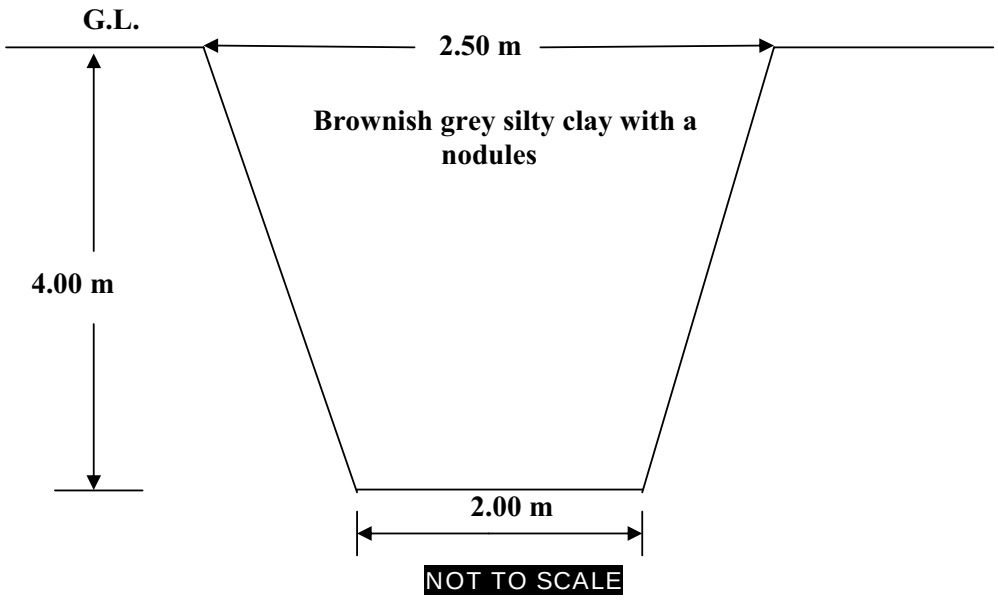
Date	Type of sample	Ref No.	Depth (m)	Remarks
19.02.2018	UDS	151251	1.00	Silty clay
19.02.2018	DS	151252	2.00	Silty clay
19.02.2018	UDS	151253	3.00	Silty clay
19.02.2018	DS	151254	4.00	Silty clay

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

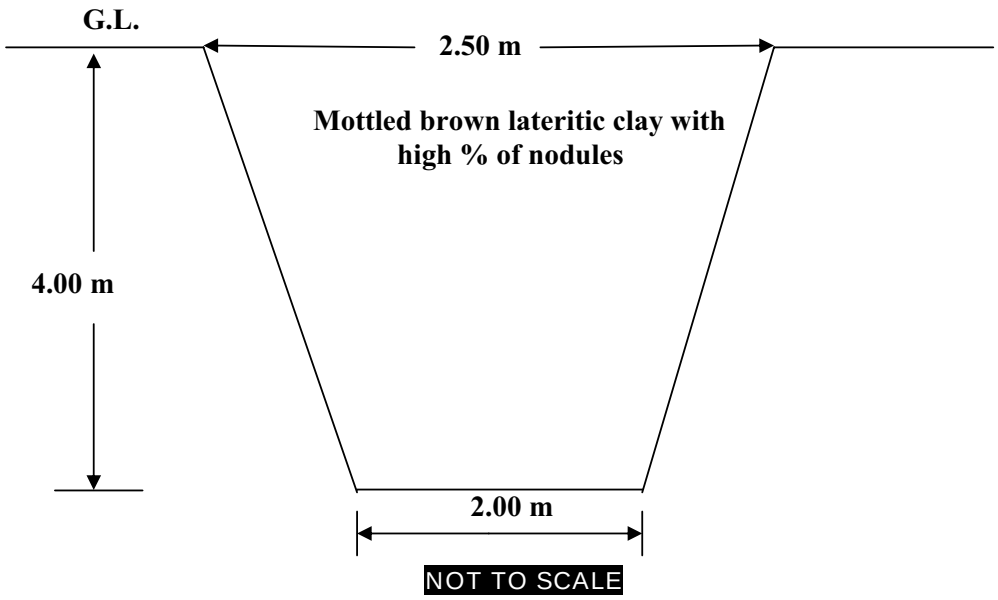
Date	Type of sample	Ref No.	Depth (m)	Remarks
19.02.2018	UDS	171620	1.00	Silty clay
19.02.2018	DS	171621	2.00	Silty clay
19.02.2018	UDS	171622	3.00	Silty clay
19.02.2018	DS	171623	4.00	Silty clay

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

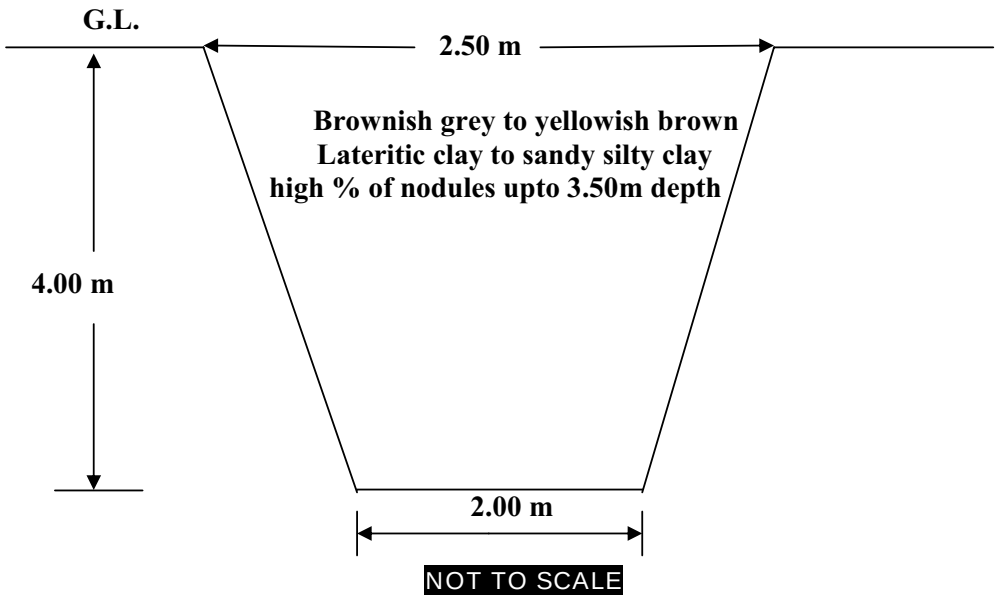
Date	Type of sample	Ref No.	Depth (m)	Remarks
03.02.2018	DS	100710	1.00	Lateritic clay
03.02.2018	UDS	100711	2.00	Lateritic clay
03.02.2018	DS	100712	3.00	Lateritic clay
03.02.2018	DS	100713	4.00	Lateritic clay

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

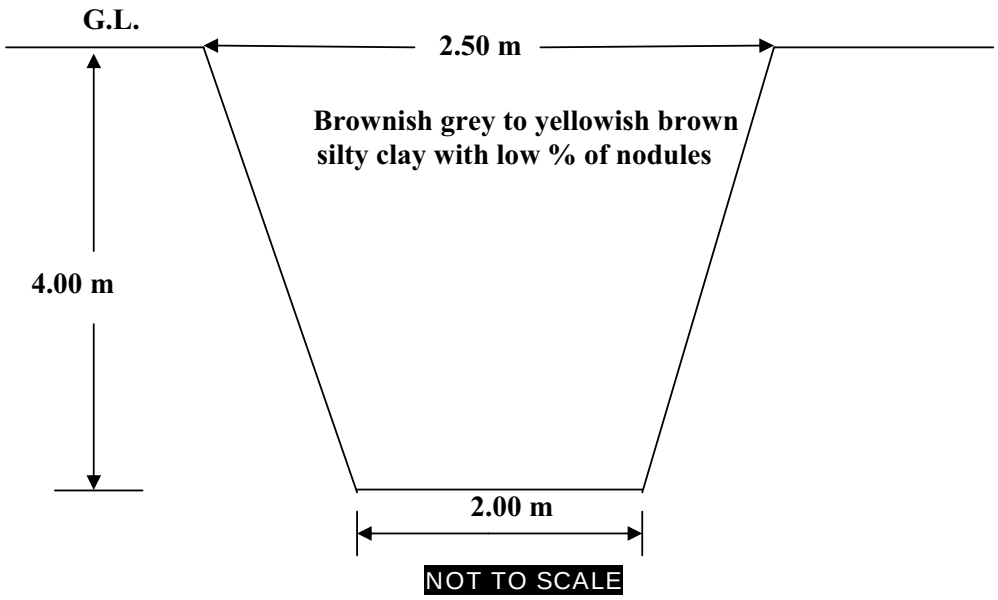
Date	Type of sample	Ref No.	Depth (m)	Remarks
31.02.2018	DS	105129	1.00	Lateritic clay
31.02.2018	UDS	105130	2.00	Lateritic clay
31.02.2018	UDS	105131	3.00	Lateritic clay
31.02.2018	DS	105132	4.00	Lateritic clay

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

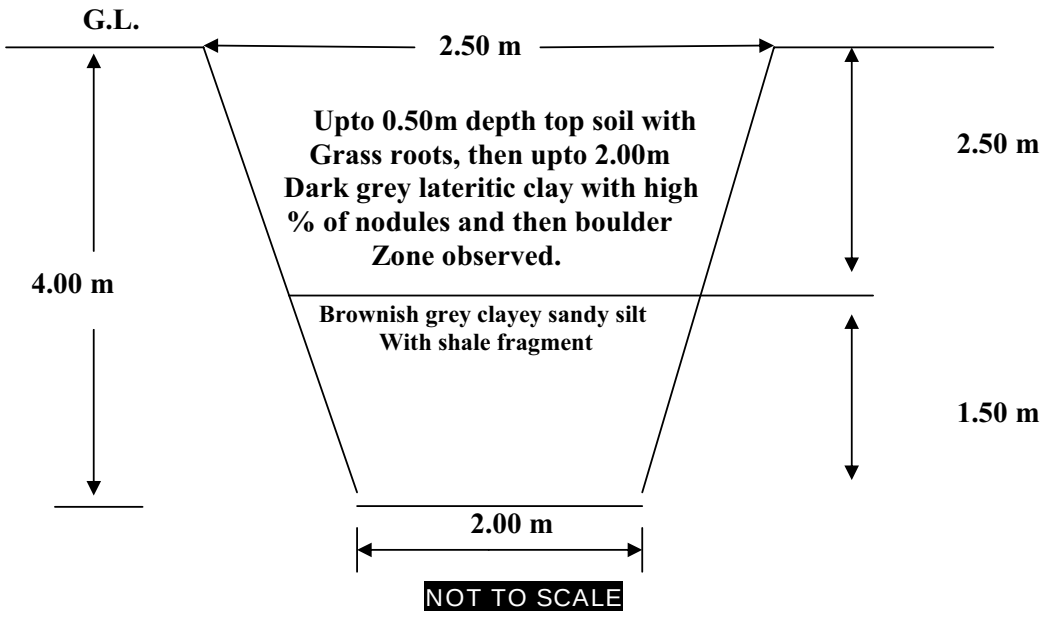
Date	Type of sample	Ref No.	Depth (m)	Remarks
04.02.2018	UDS	120150	1.00	Silty clay
04.02.2018	DS	120151	2.00	Silty clay
04.02.2018	UDS	120152	3.00	Clayey silt
04.02.2018	DS	120153	4.00	Clayey silt

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

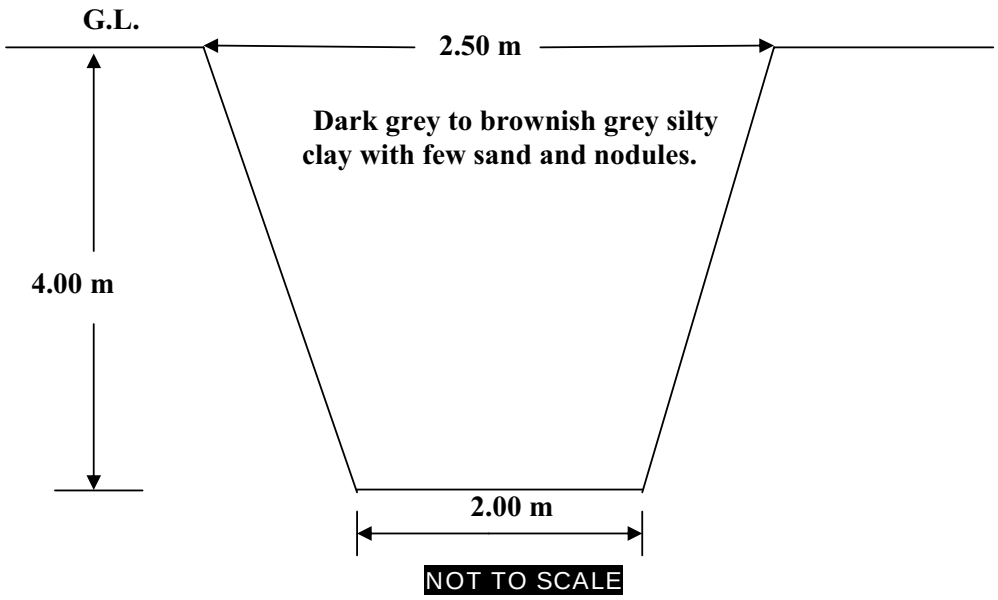
Date	Type of sample	Ref No.	Depth (m)	Remarks
31.01.2018	DS	105133	1.00	Lateritic soil
31.01.2018	DS	105134	2.00	Boulders
31.01.2018	UDS	105135	3.00	Silty clay
31.01.2018	DS	105136	4.00	Sandy clayey silt

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

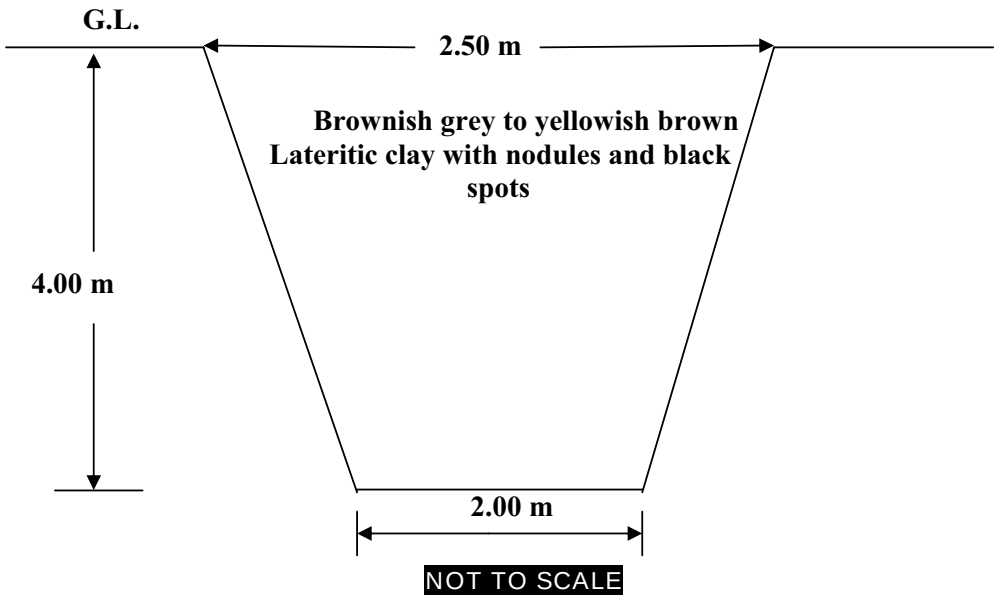
Date	Type of sample	Ref No.	Depth (m)	Remarks
04.02.2018	UDS	150122	1.00	Silty clay
04.02.2018	DS	150123	2.00	Silty clay
04.02.2018	UDS	150124	3.00	Clayey silt
04.02.2018	DS	150125	4.00	Clayey silt

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

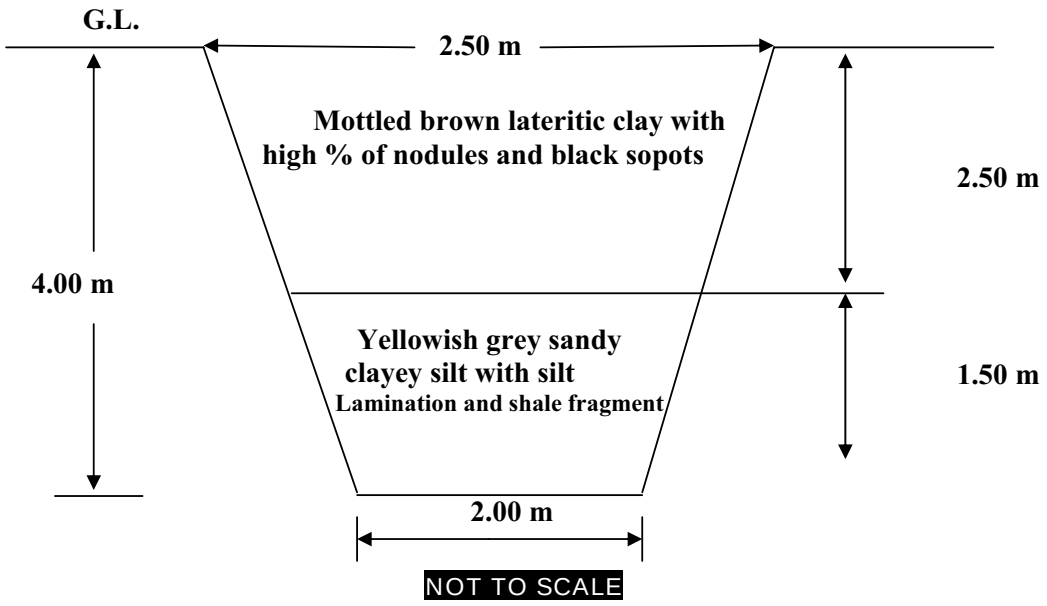
Date	Type of sample	Ref No.	Depth (m)	Remarks
02.02.2018	UDS	106112	1.00	Lateritic clay
02.02.2018	DS	106113	2.00	Lateritic clay
02.02.2018	UDS	106114	3.00	Lateritic clay
02.02.2018	DS	106115	4.00	Lateritic clay

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

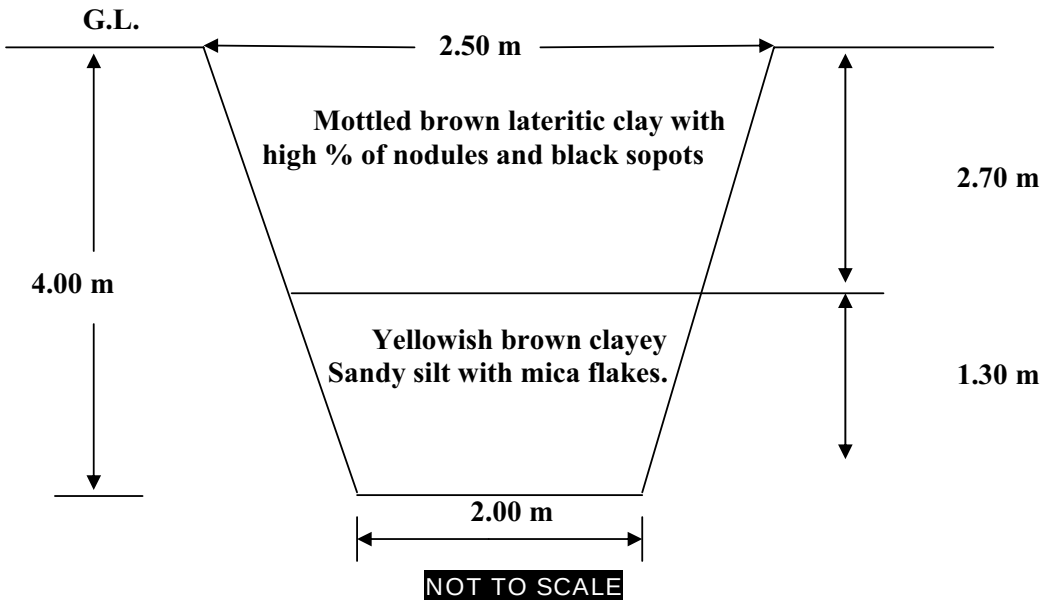
Date	Type of sample	Ref No.	Depth (m)	Remarks
31.01.2018	DS	105121	1.00	Lateritic clay
31.01.2018	DS	105122	2.00	Lateritic clay
31.01.2018	DS	105123	3.00	Sandy clayey silt
31.01.2018	DS	105124	4.00	Sandy clayey silt

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

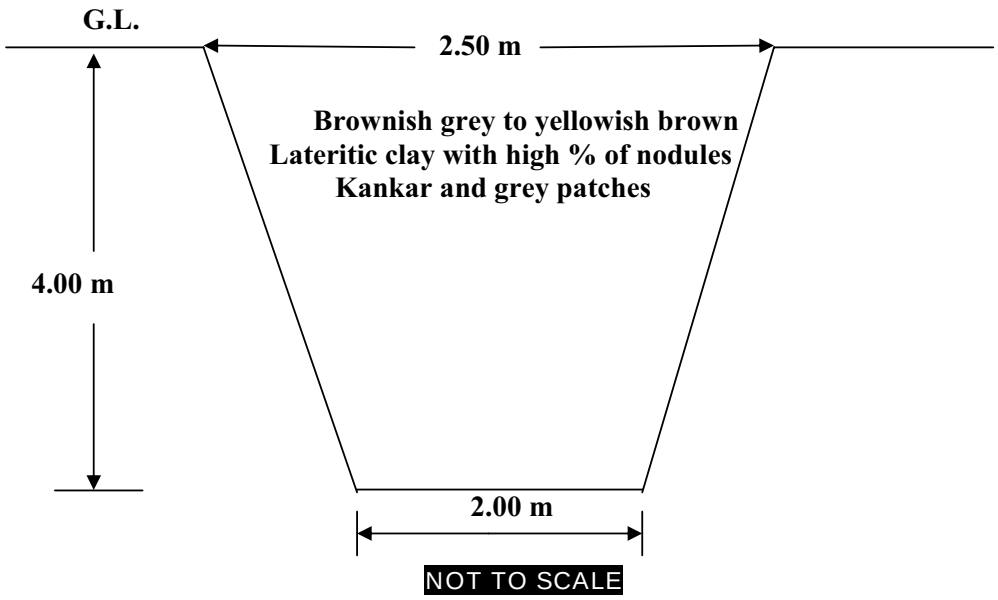
Date	Type of sample	Ref No.	Depth (m)	Remarks
31.01.2018	DS	105125	1.00	Sandy silty clay
31.01.2018	UDS	105126	2.00	Sandy silty clay
31.01.2018	DS	105127	3.00	Clayey sandy silt
31.01.2018	DS	105128	4.00	Clayey sandy silt

Trial Pit Log

Trial Pit –15 (Fifteen)

Site : NLC, Sambalpur
Pit Volume: 2.0m x 2.0m x 4m
Date : 02.02.2018

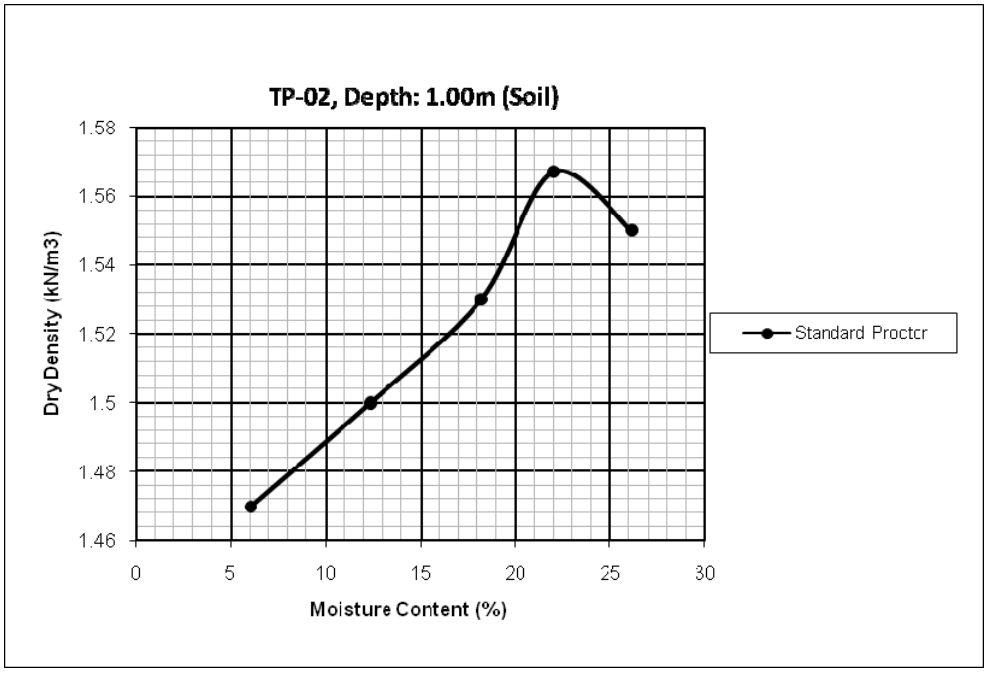
RL : 199.466m
Depth : 4.00m
Co-Ordinate: N:2410812, E: 809090



Sample Collected

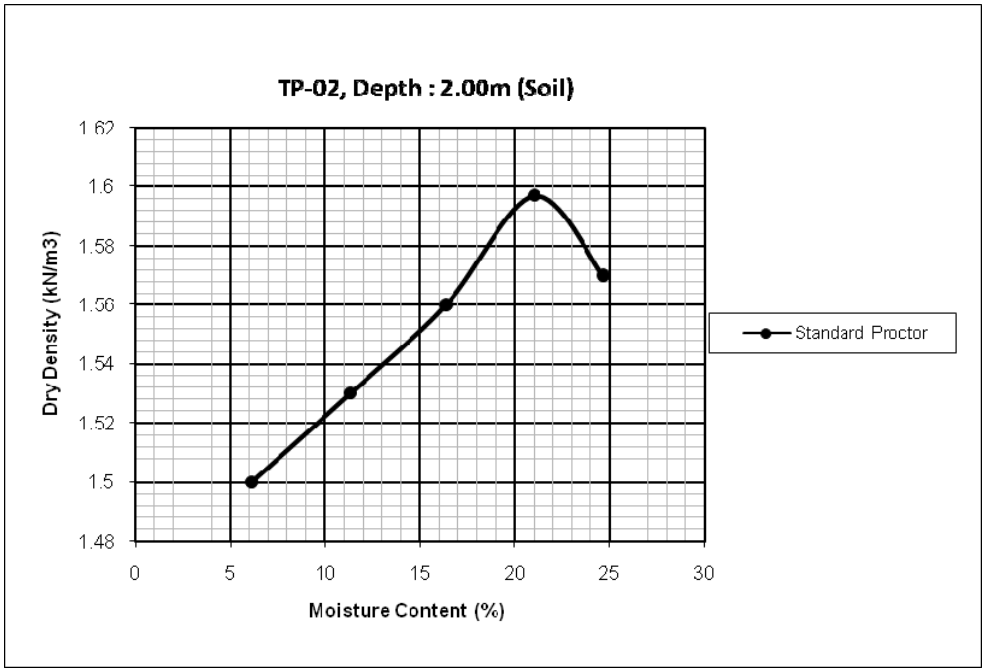
Date	Type of sample	Ref No.	Depth (m)	Remarks
02.02.2018	UDS	106108	1.00	Lateritic clay
02.02.2018	DS	106109	2.00	Lateritic clay
02.02.2018	UDS	106110	3.00	Lateritic clay
02.02.2018	DS	106111	4.00	Lateritic clay

PROCTOR CURVE



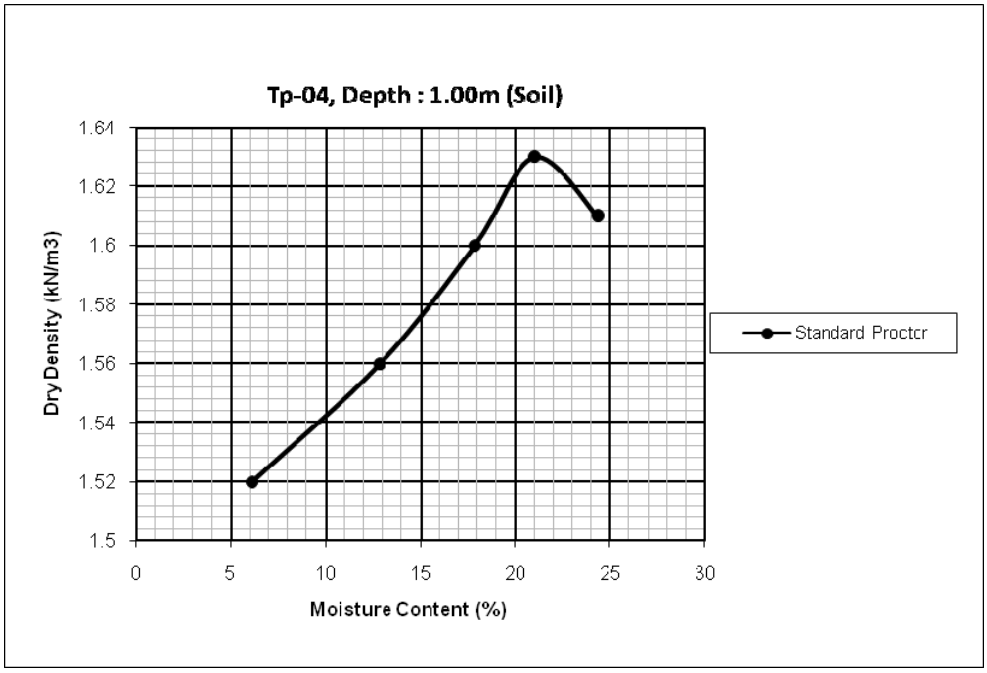
OMC(%)	MDD (KN/m^3)
22	1.567

PROCTOR CURVE



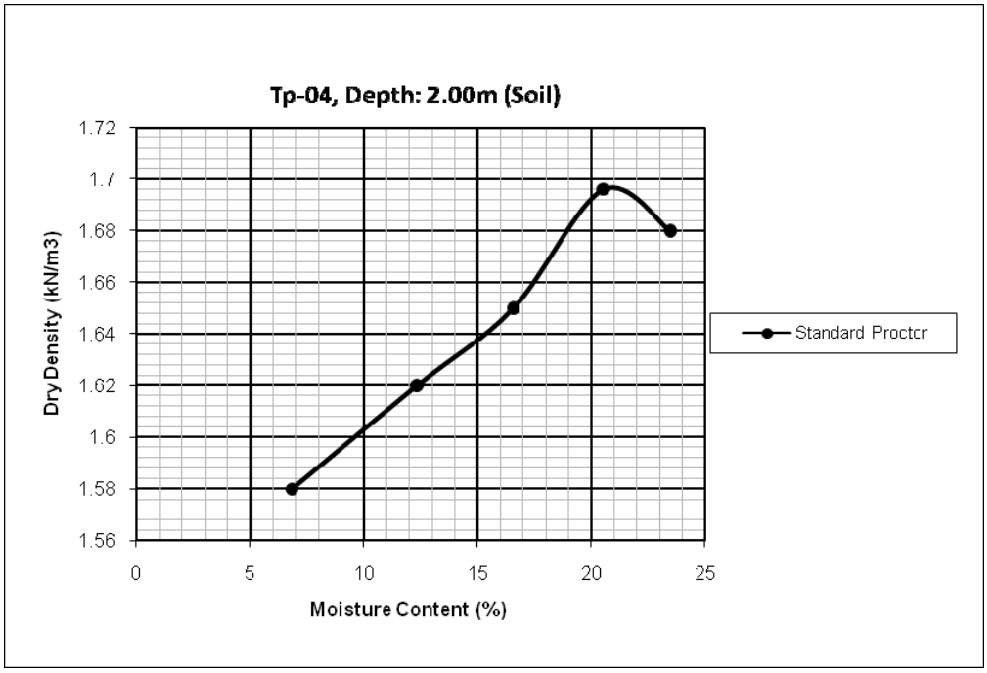
OMC(%)	MDD (KN/m^3)
21	1.597

PROCTOR CURVE



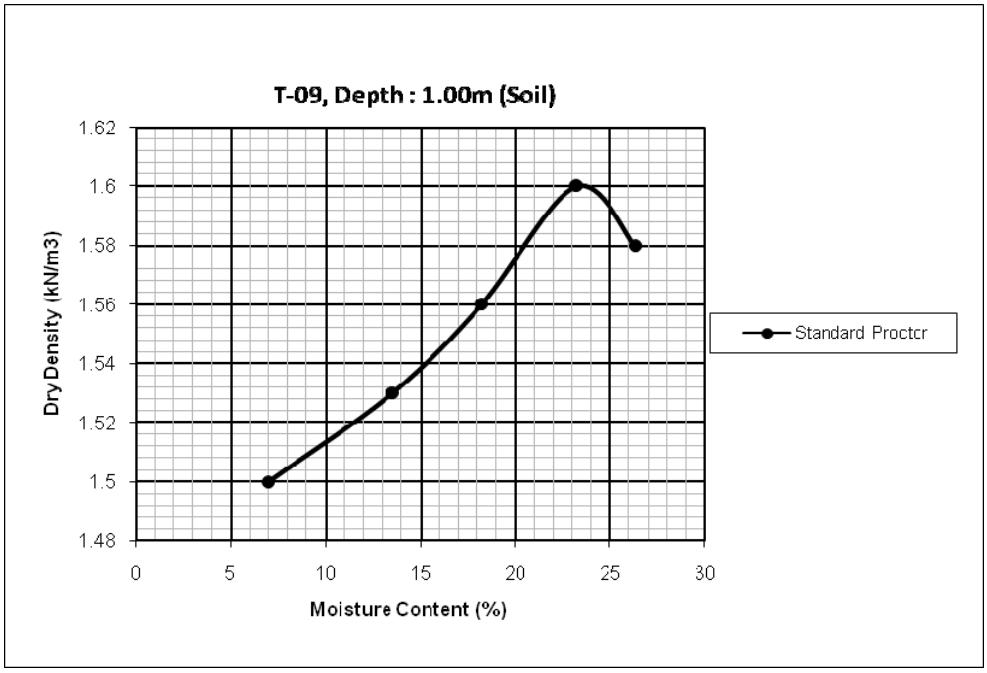
OMC(%)	MDD (KN/m^3)
21	1.63

PROCTOR CURVE



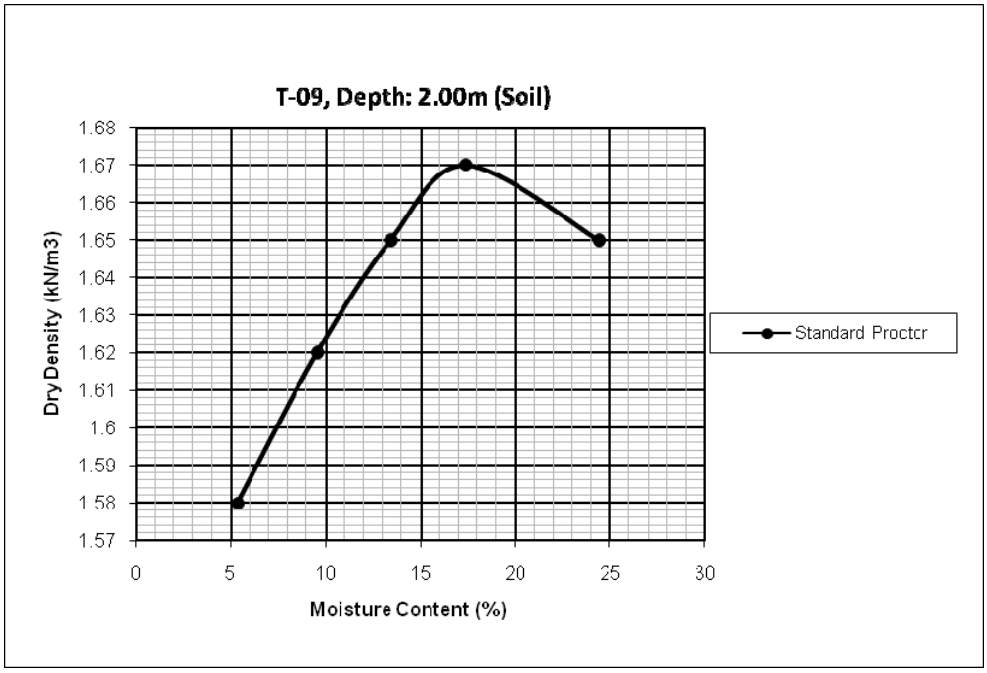
OMC(%)	MDD (KN/m^3)
20.5	1.696

PROCTOR CURVE



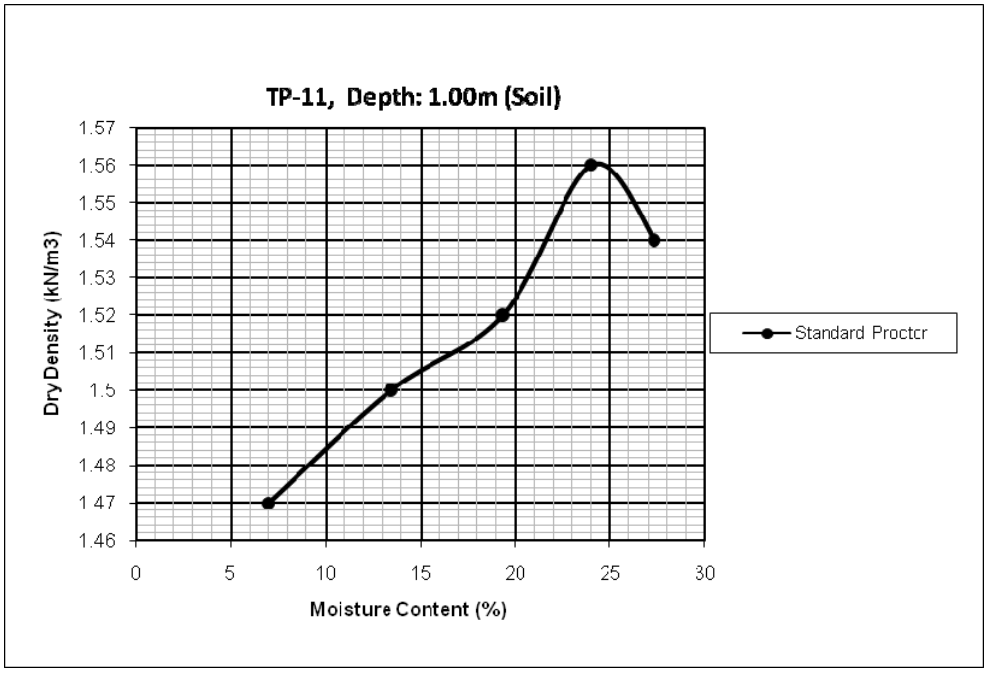
OMC(%)	MDD (KN/m^3)
23.2	1.6

PROCTOR CURVE



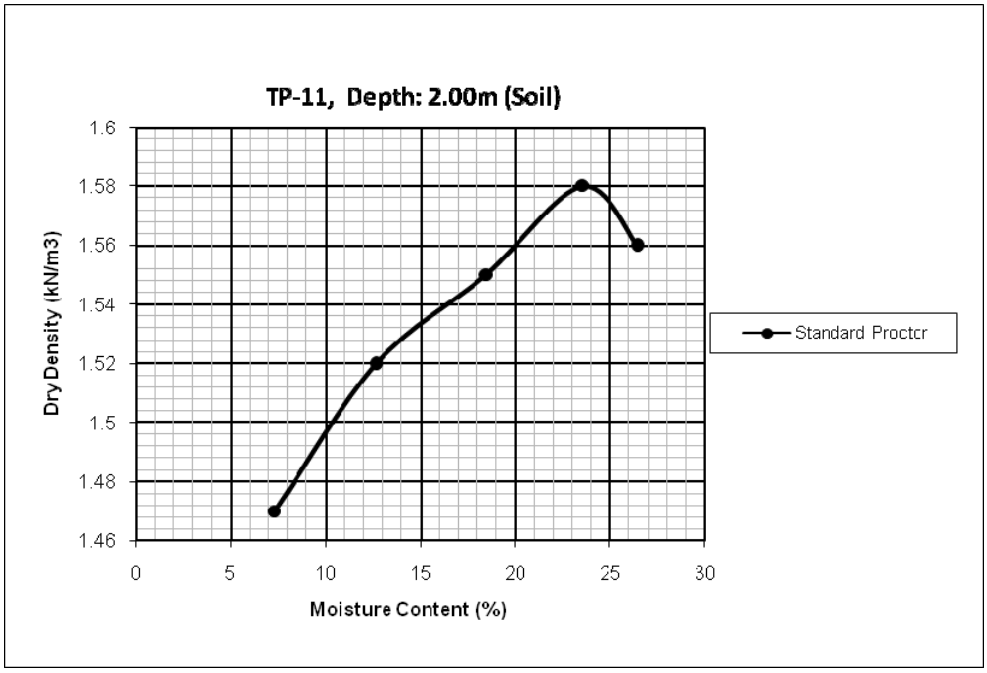
OMC(%)	MDD (KN/m^3)
17.36	1.67

PROCTOR CURVE



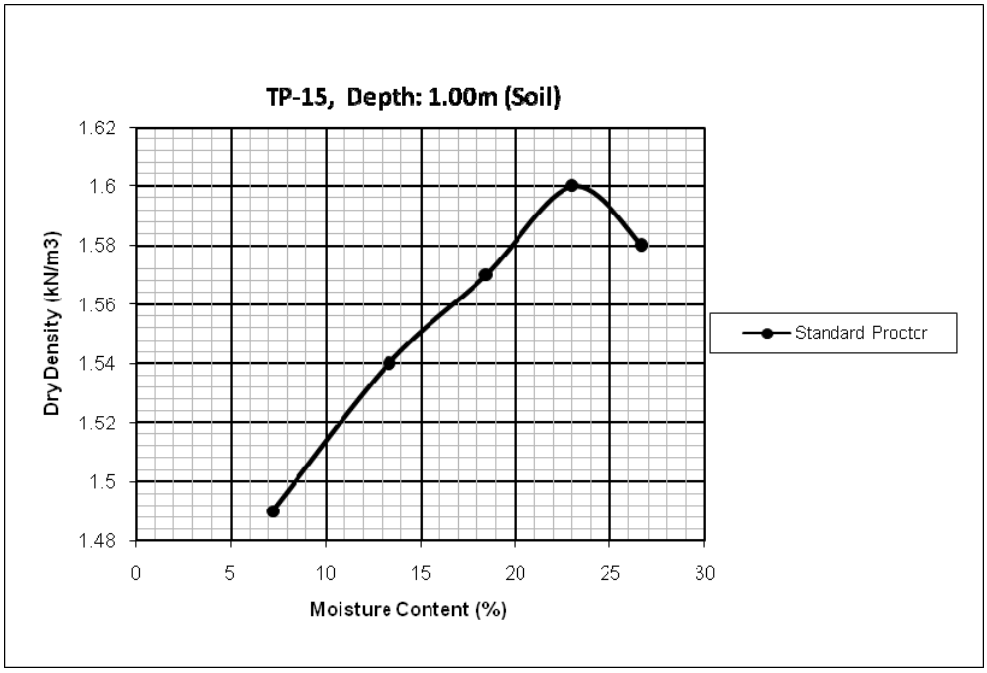
OMC(%)	MDD (KN/m^3)
24	1.56

PROCTOR CURVE



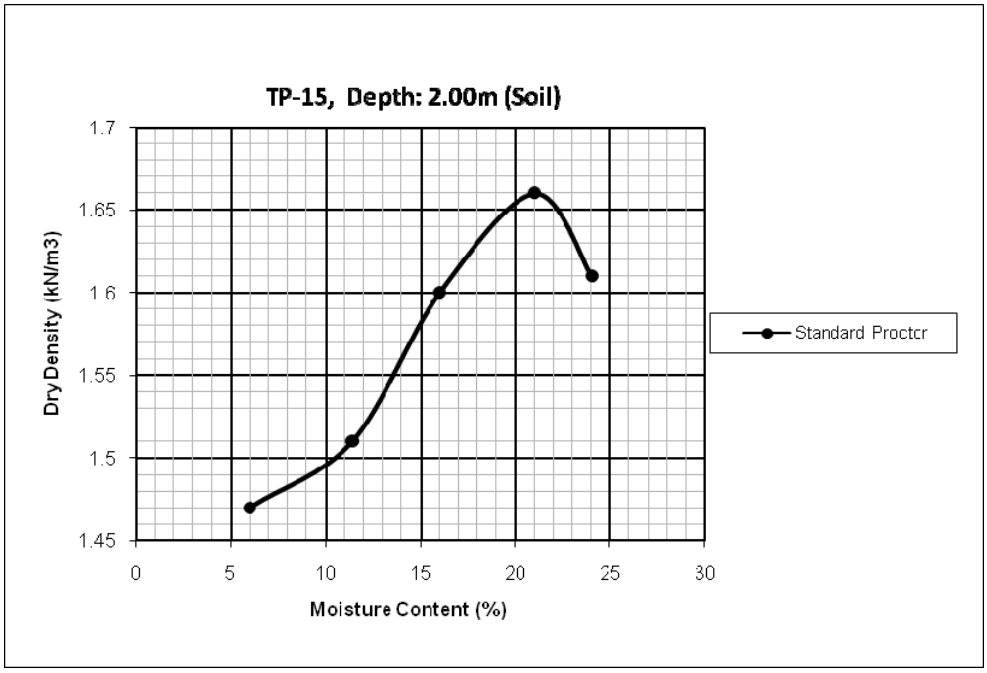
OMC(%)	MDD (KN/m^3)
23.5	1.58

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

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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				
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

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				
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

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				
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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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				
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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SKM Geosurvey

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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SKM Geosurvey

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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SKM Geosurvey

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

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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

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)	$mv \times 10^{-4}$ (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		

Job No.: 30796

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×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		

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		

Job No.: 30796

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

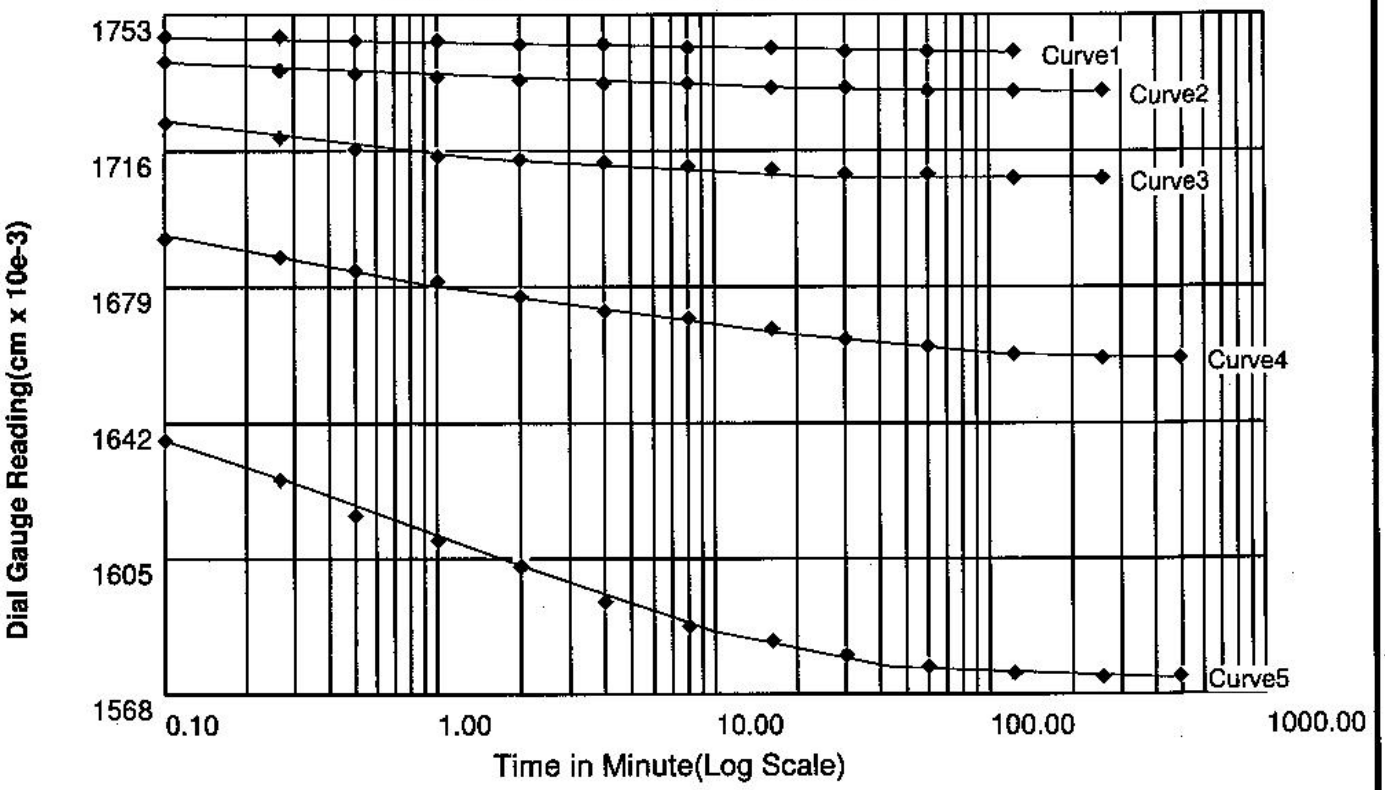
Pressure Range kPa	Pressure Increment kPa	Increase in thickness cm.	Change in Void Ratio Δe	Equilibrium Void Ratio e	av (m^2/KN)	mv×10^{-4} (m^2/KN)
0 - 10	10.000	-0.00100	-0.00087	0.61781	0.0000866	0.5350455
10 - 25	15.000	-0.00200	-0.00173	0.61608	0.0001154	0.7133940
25 - 50	25.000	-0.00500	-0.00433	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 :01 Depth(m) :6.00-6.45 Sample No. :177128

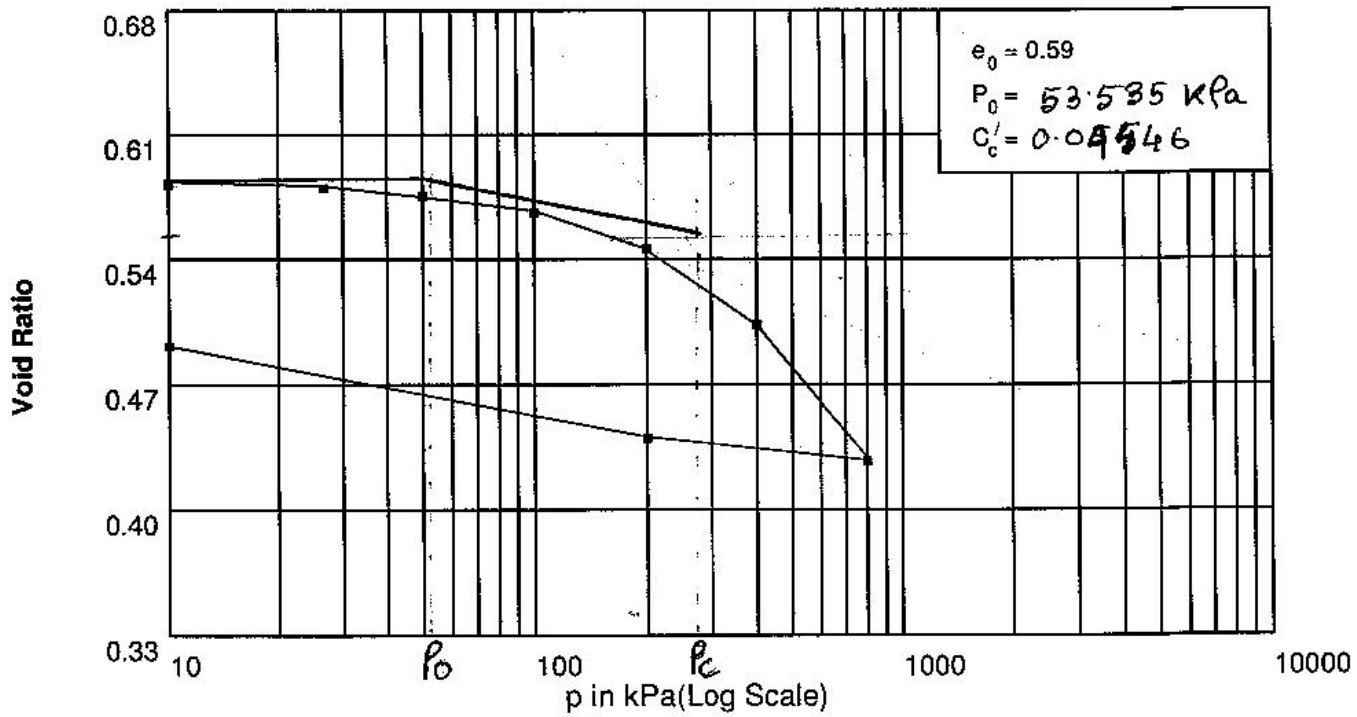
LOG TIME VS SETTLEMENT CURVE



◆ Curve1 :25 - 50 kPa ◆ Curve2 :50 - 100 kPa ◆ Curve3 :100 - 200 kPa

◆ Curve4 :200 - 400 kPa ◆ Curve5 :400 - 800 kPa

e Vs LOG(P)



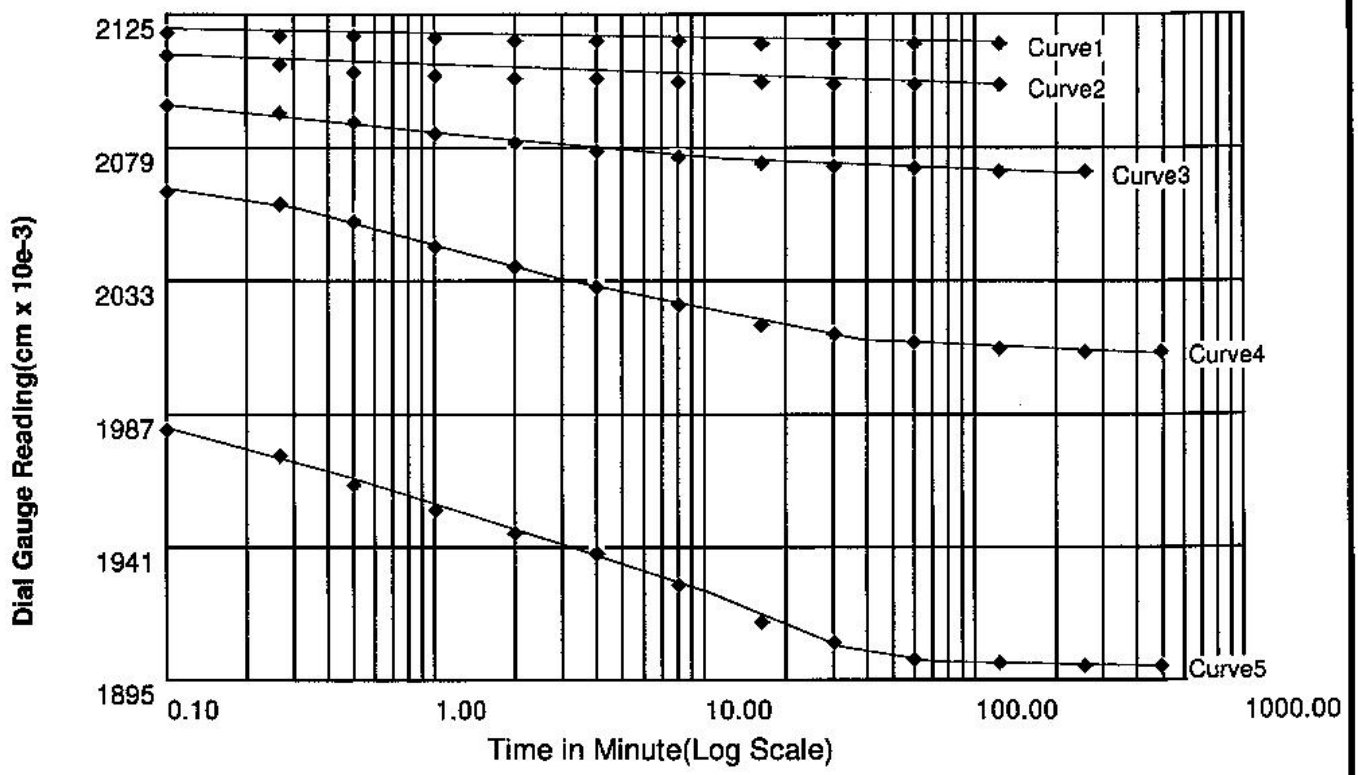
CONSOLIDATION TEST CURVES

Job No. :30796

SKM Geosurvey

Borehole No :02 Depth(m) :2.00-2.45 Sample No. :160124

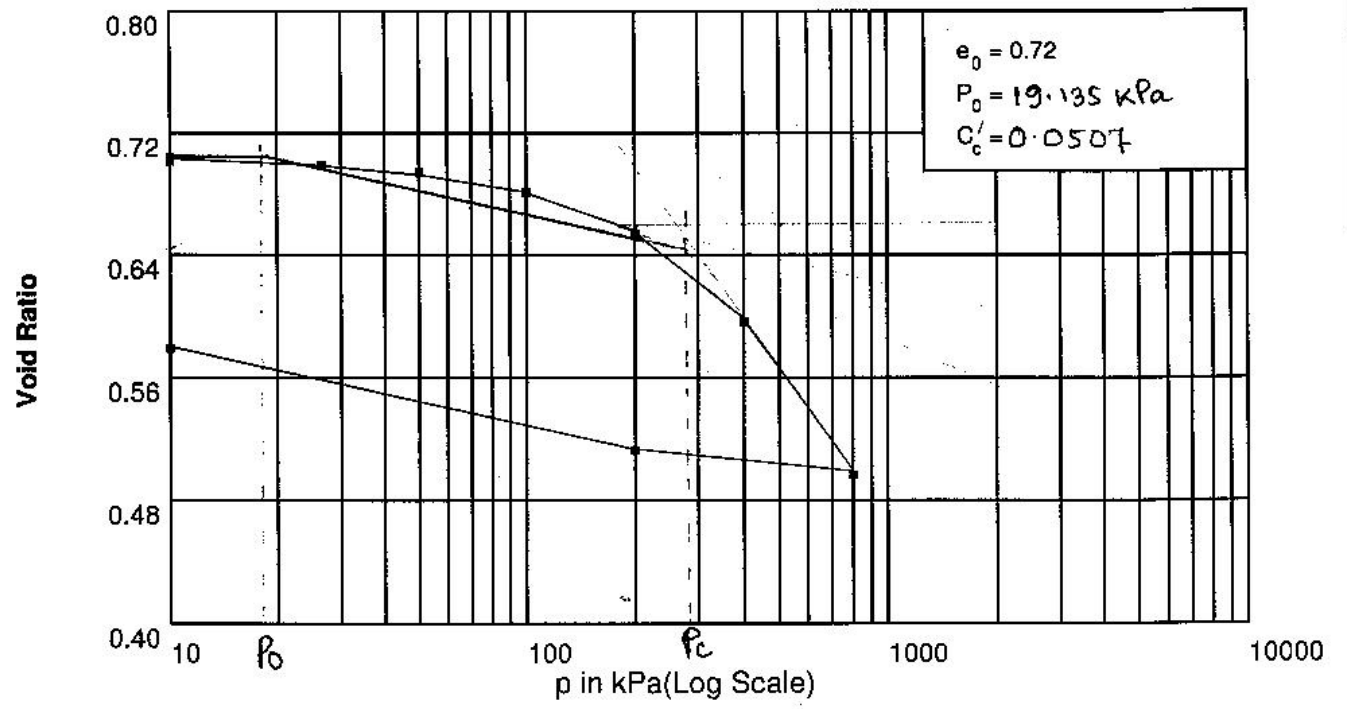
LOG TIME VS SETTLEMENT CURVE



◆ Curve1 :25 - 50 kPa ◆ Curve2 :50 - 100 kPa ◆ Curve3 :100 - 200 kPa

◆ Curve4 :200 - 400 kPa ◆ Curve5 :400 - 800 kPa

e Vs LOG(P)



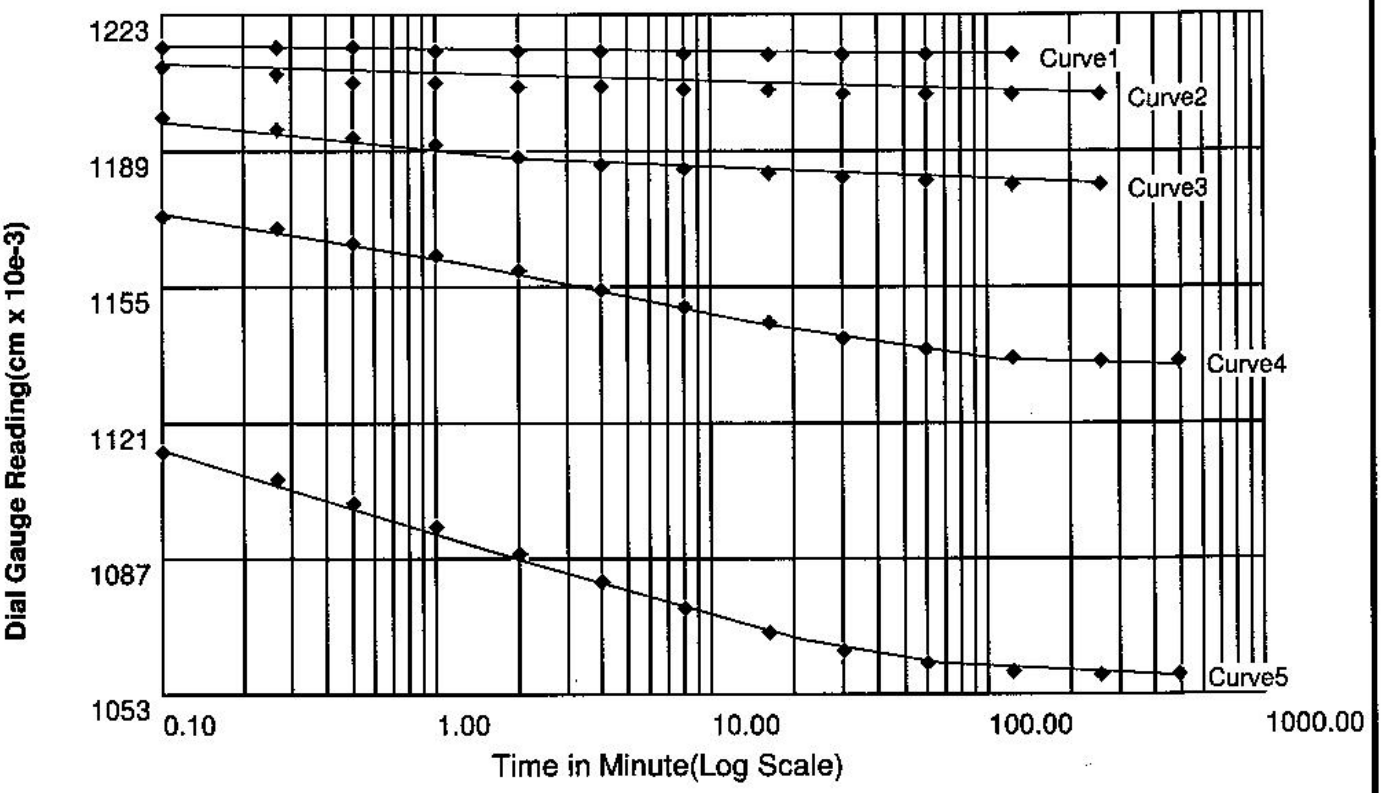
CONSOLIDATION TEST CURVES

Job No. :30796

SKM Geosurvey

Borehole No :03 Depth(m) :1.00-1.45 Sample No. :100869

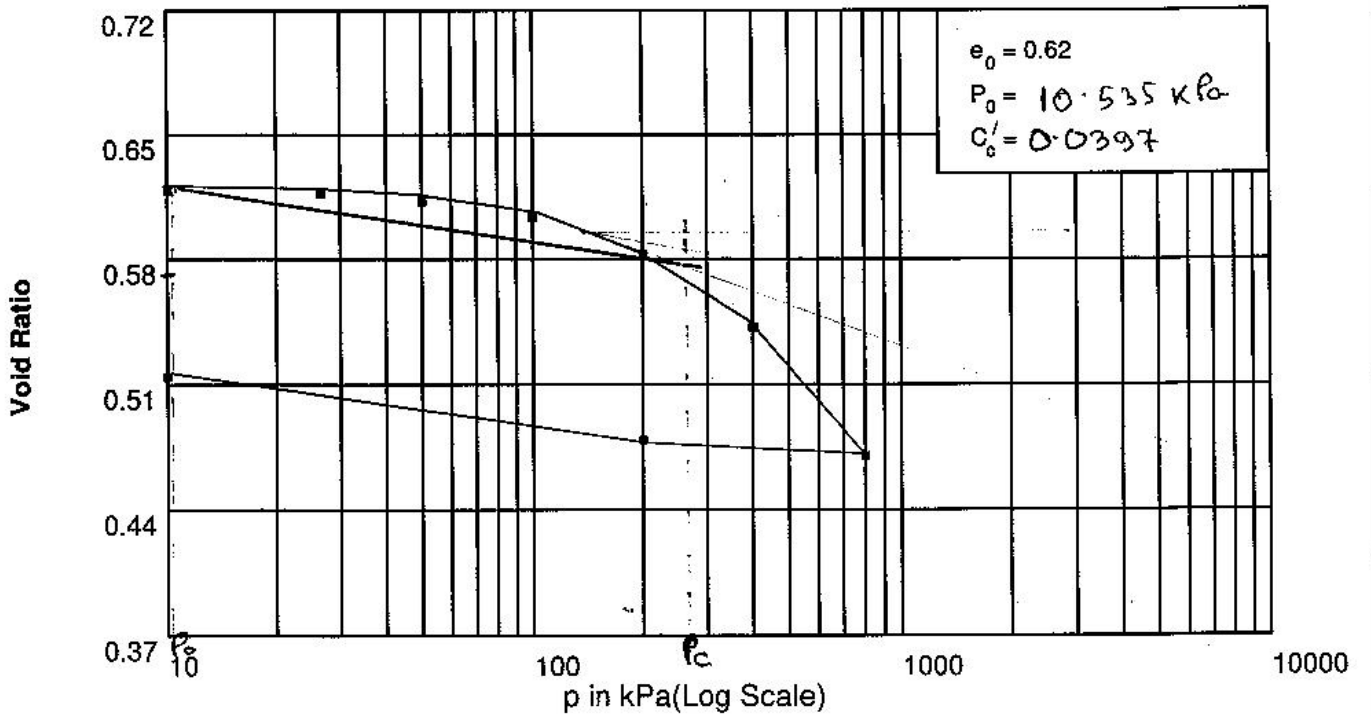
LOG TIME VS SETTLEMENT CURVE



◆ Curve1 :25 - 50 kPa ◆ Curve2 :50 - 100 kPa ◆ Curve3 :100 - 200 kPa

◆ Curve4 :200 - 400 kPa ◆ Curve5 :400 - 800 kPa

e Vs LOG(P)



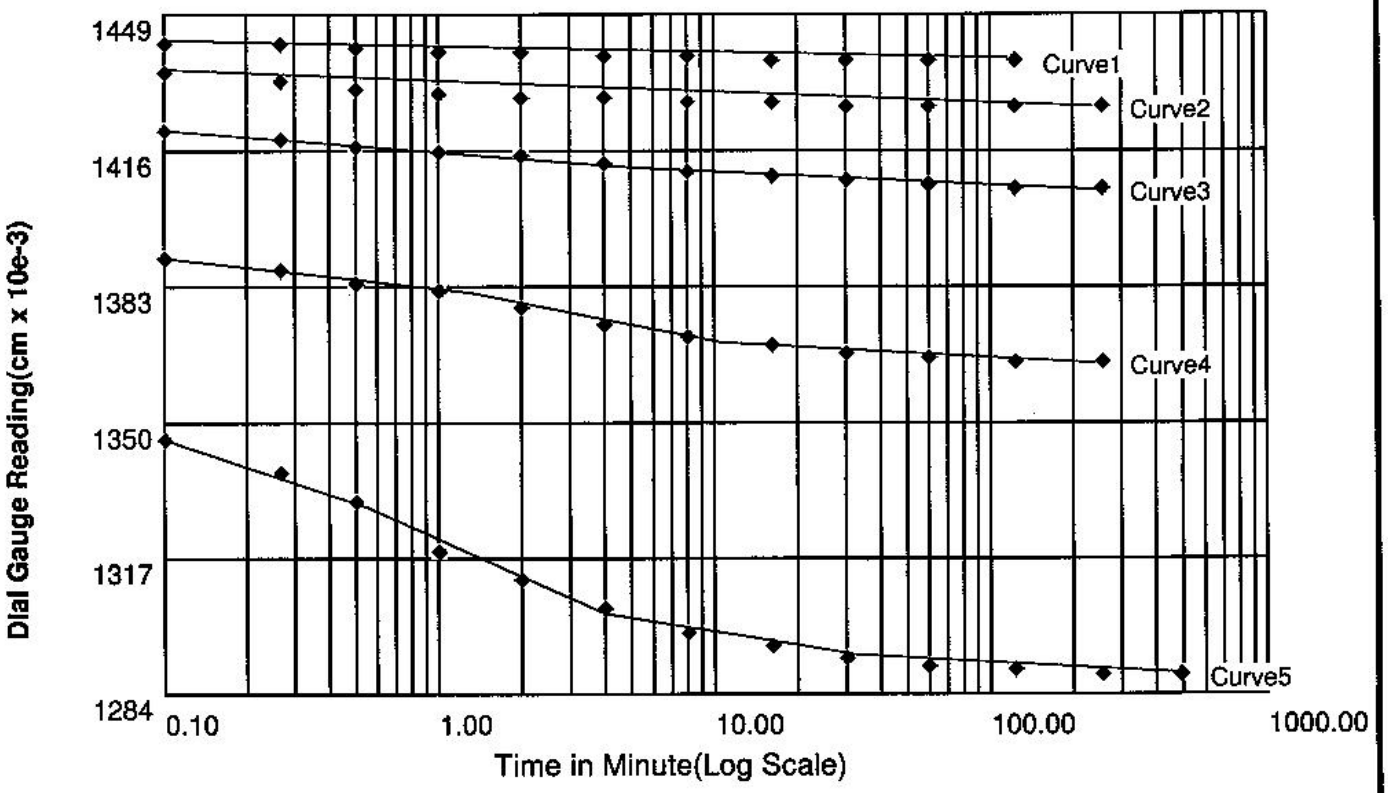
CONSOLIDATION TEST CURVES

Job No. :30796

SKM Geosurvey

Borehole No :03 Depth(m) :6.00-6.45 Sample No. :100877

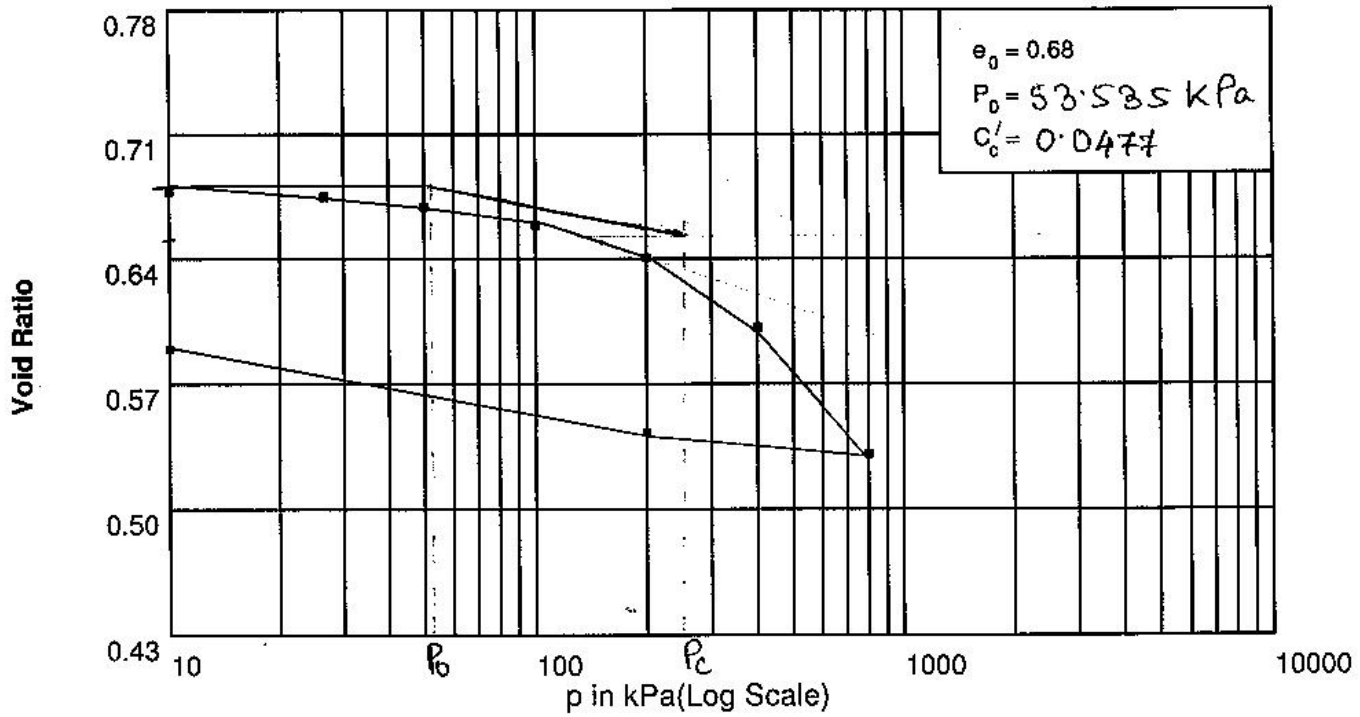
LOG TIME VS SETTLEMENT CURVE



◆ Curve1 :25 - 50 kPa ◆ Curve2 :50 - 100 kPa ◆ Curve3 :100 - 200 kPa

◆ Curve4 :200 - 400 kPa ◆ Curve5 :400 - 800 kPa

e Vs LOG(P)



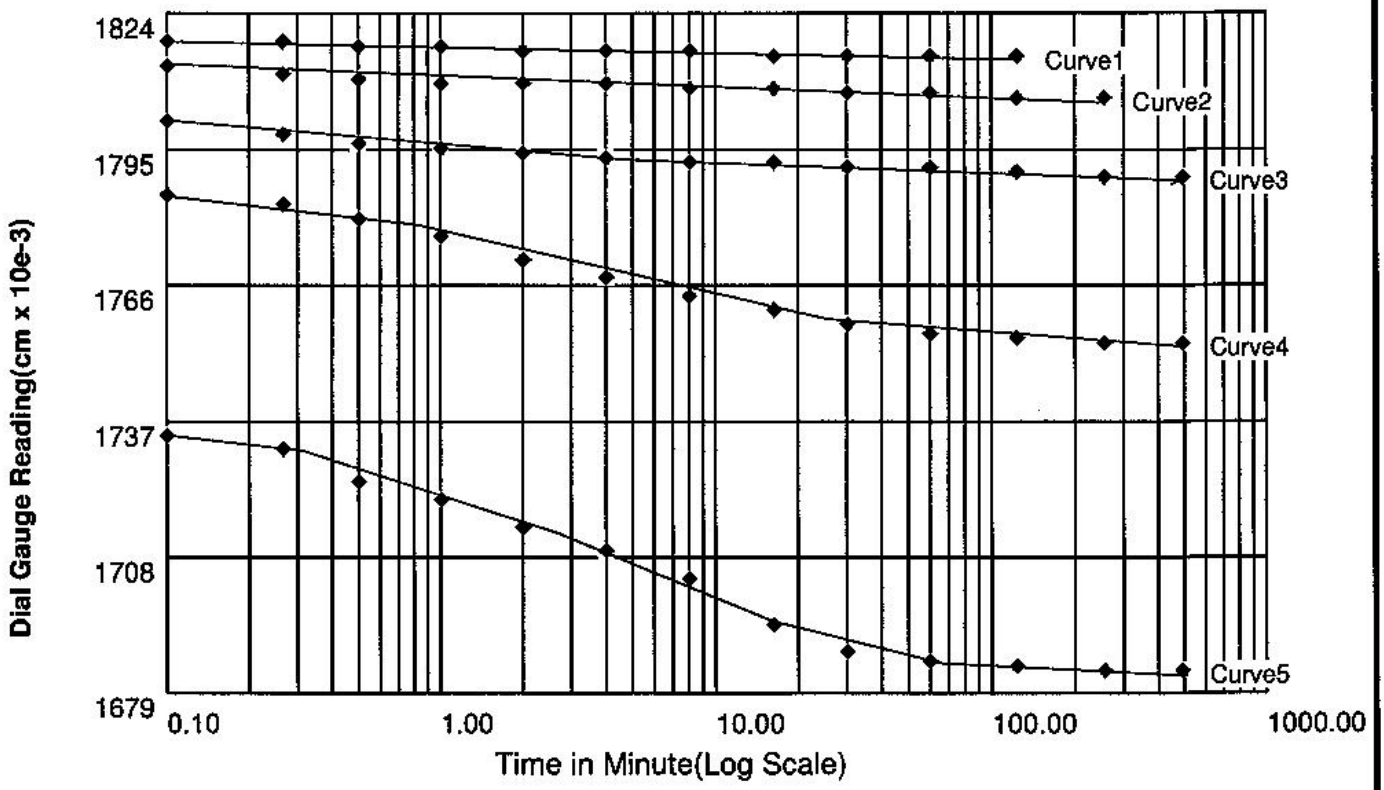
CONSOLIDATION TEST CURVES

Job No. :30796

SKM Geosurvey

Borehole No :04 Depth(m) :1.50-1.95 Sample No. :100902

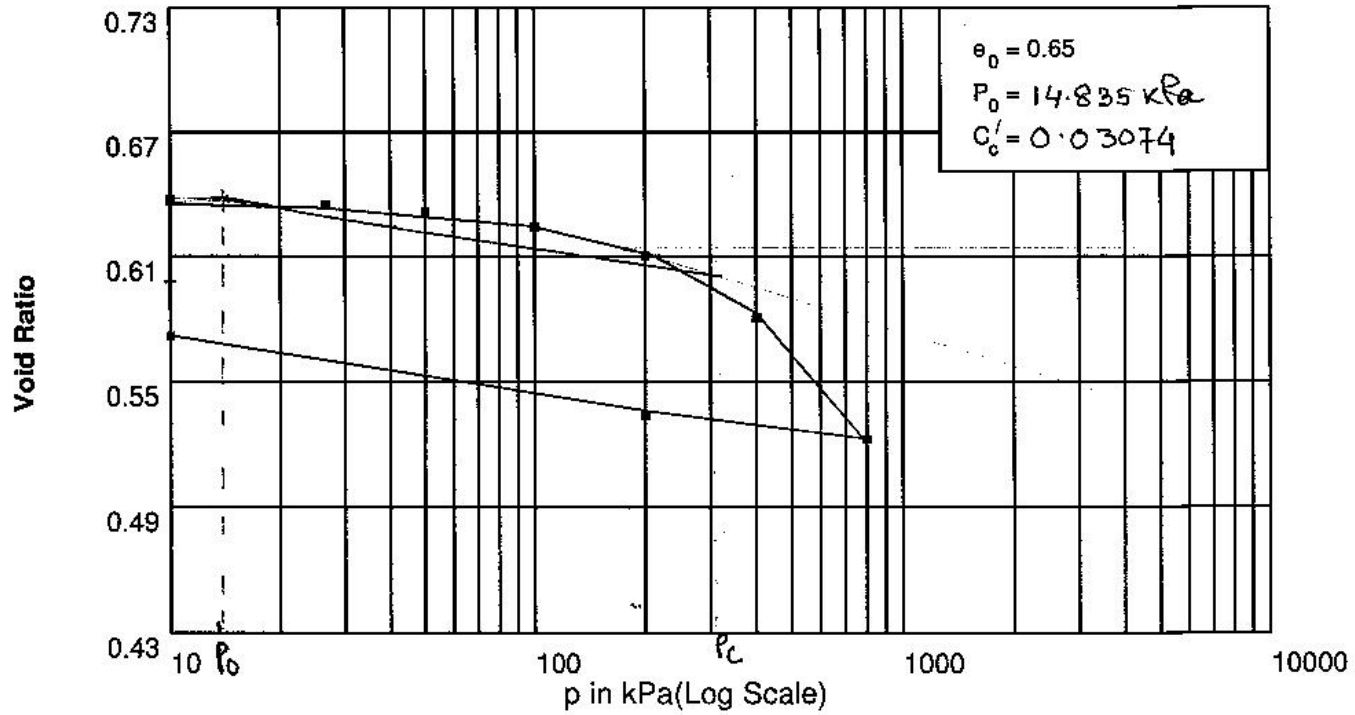
LOG TIME VS SETTLEMENT CURVE



◆ Curve1 :25 - 50 kPa ◆ Curve2 :50 - 100 kPa ◆ Curve3 :100 - 200 kPa

◆ Curve4 :200 - 400 kPa ◆ Curve5 :400 - 800 kPa

e Vs LOG(P)



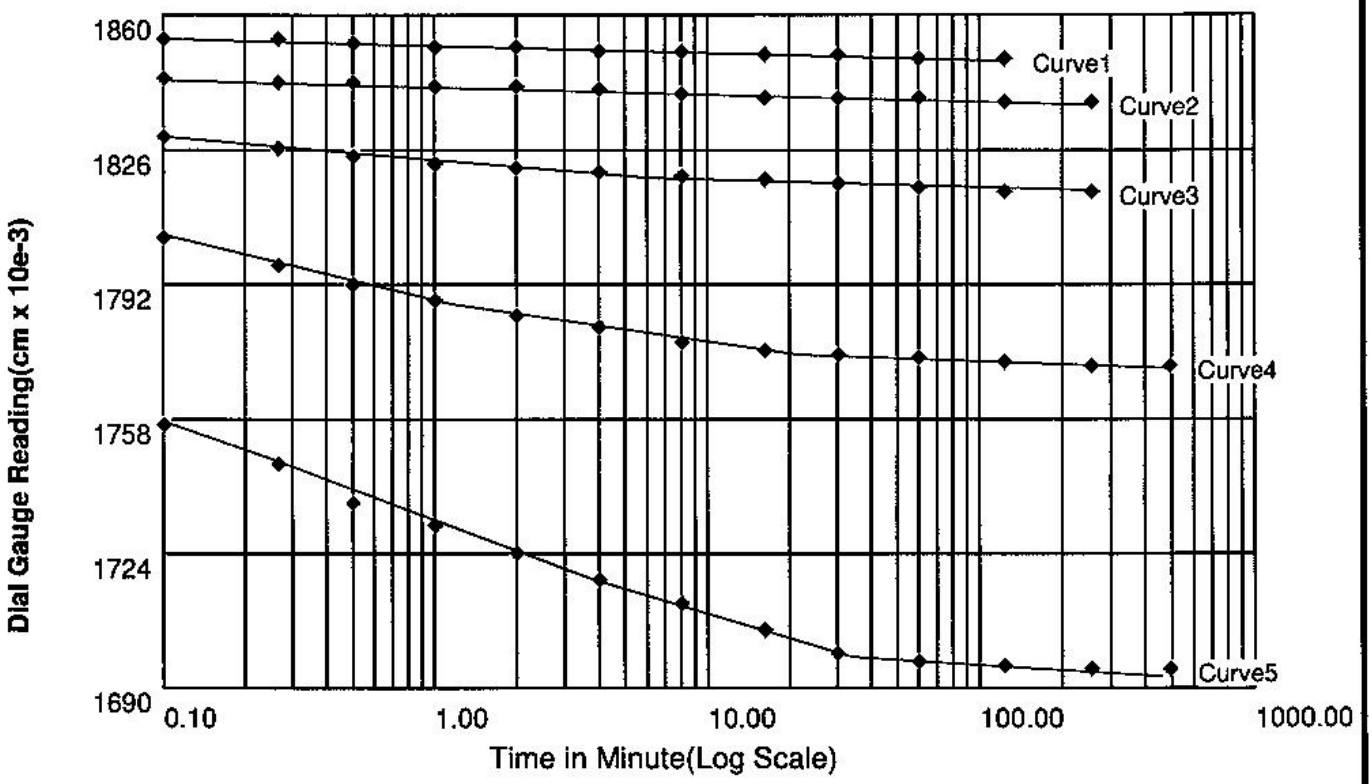
CONSOLIDATION TEST CURVES

Job No. :30796

SKM Geosurvey

Borehole No :06 Depth(m) :1.00-1.45 Sample No. :105112

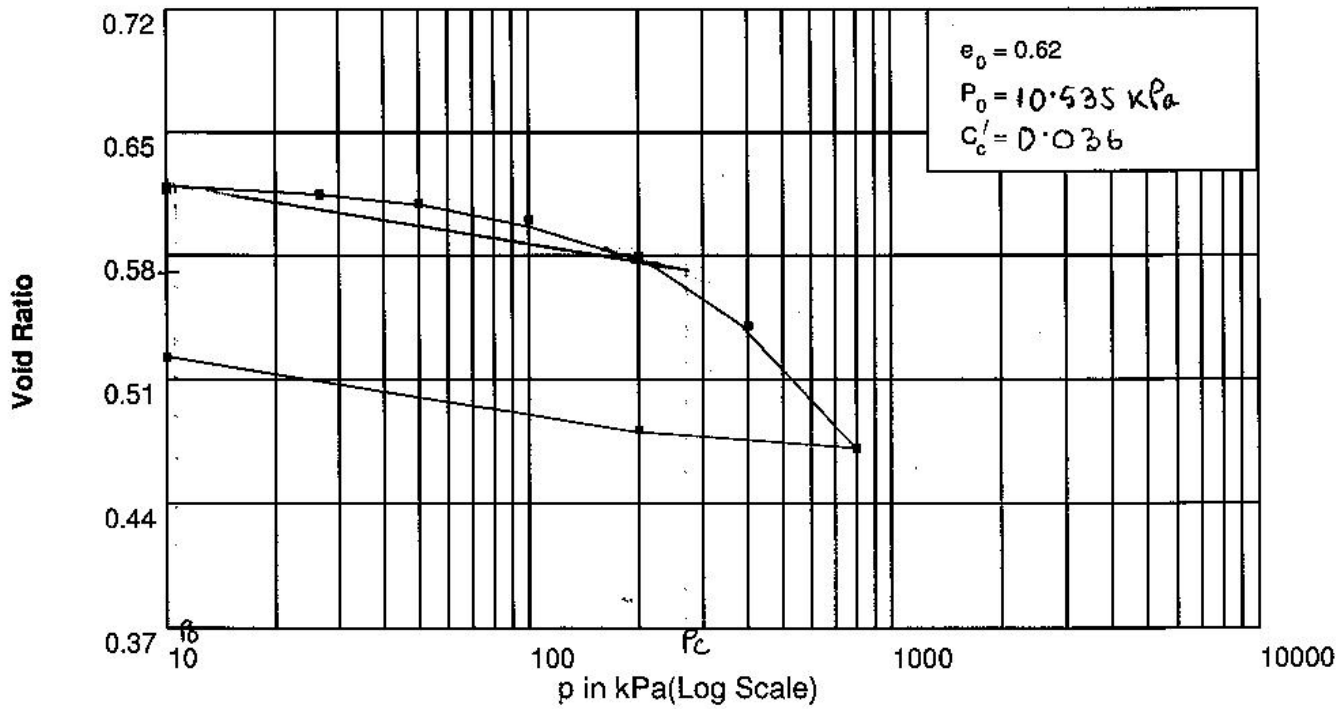
LOG TIME VS SETTLEMENT CURVE



◆ Curve1 :25 - 50 kPa ◆ Curve2 :50 - 100 kPa ◆ Curve3 :100 - 200 kPa

◆ Curve4 :200 - 400 kPa ◆ Curve5 :400 - 800 kPa

e Vs LOG(P)



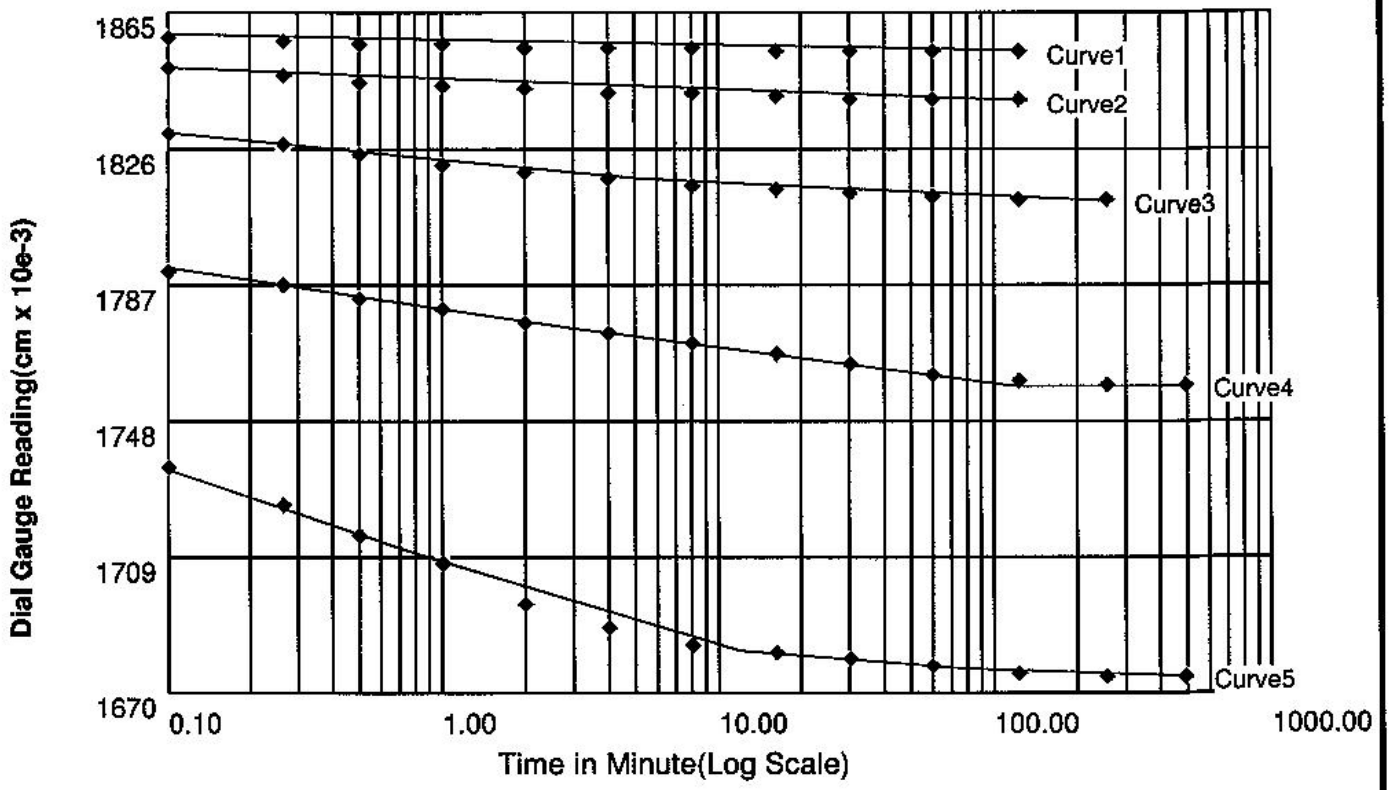
CONSOLIDATION TEST CURVES

Job No. :30796

SKM Geosurvey

Borehole No :07 Depth(m) :2.00-2.45 Sample No. :105104

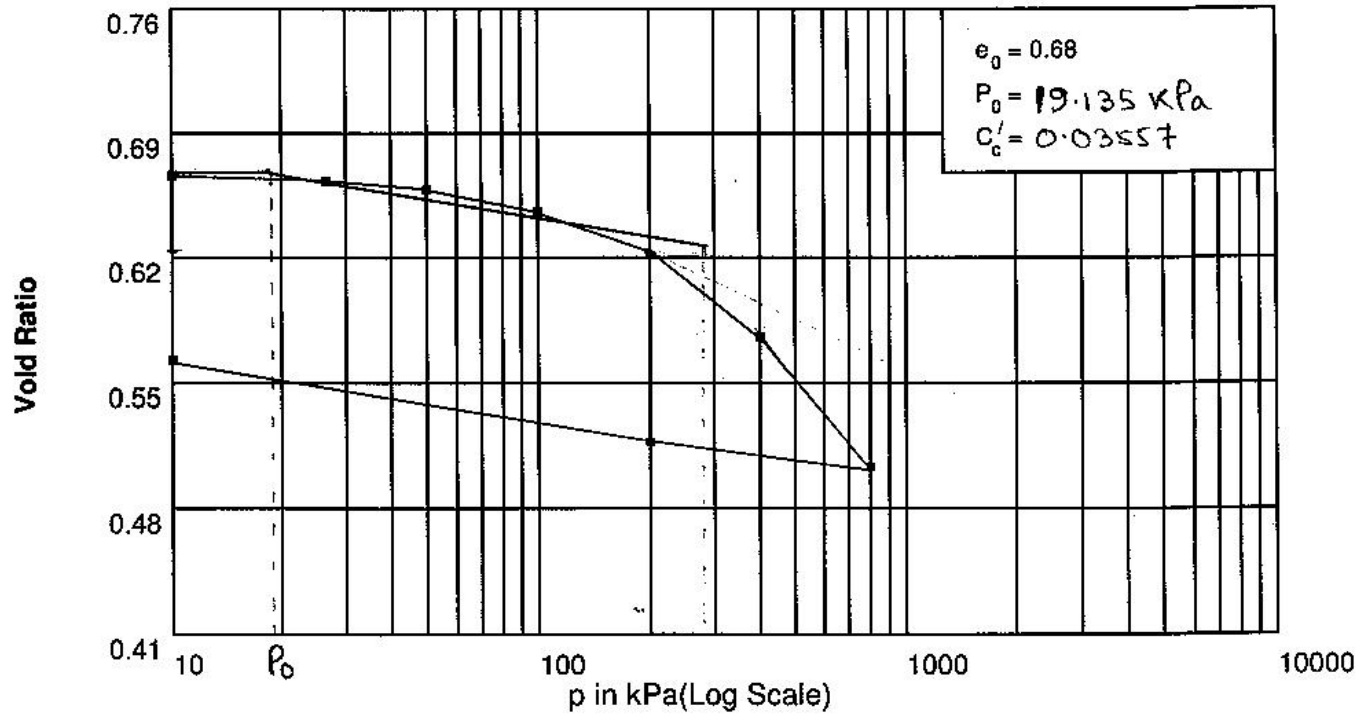
LOG TIME VS SETTLEMENT CURVE



◆ Curve1 :25 - 50 kPa ◆ Curve2 :50 - 100 kPa ◆ Curve3 :100 - 200 kPa

◆ Curve4 :200 - 400 kPa ◆ Curve5 :400 - 800 kPa

e Vs LOG(P)



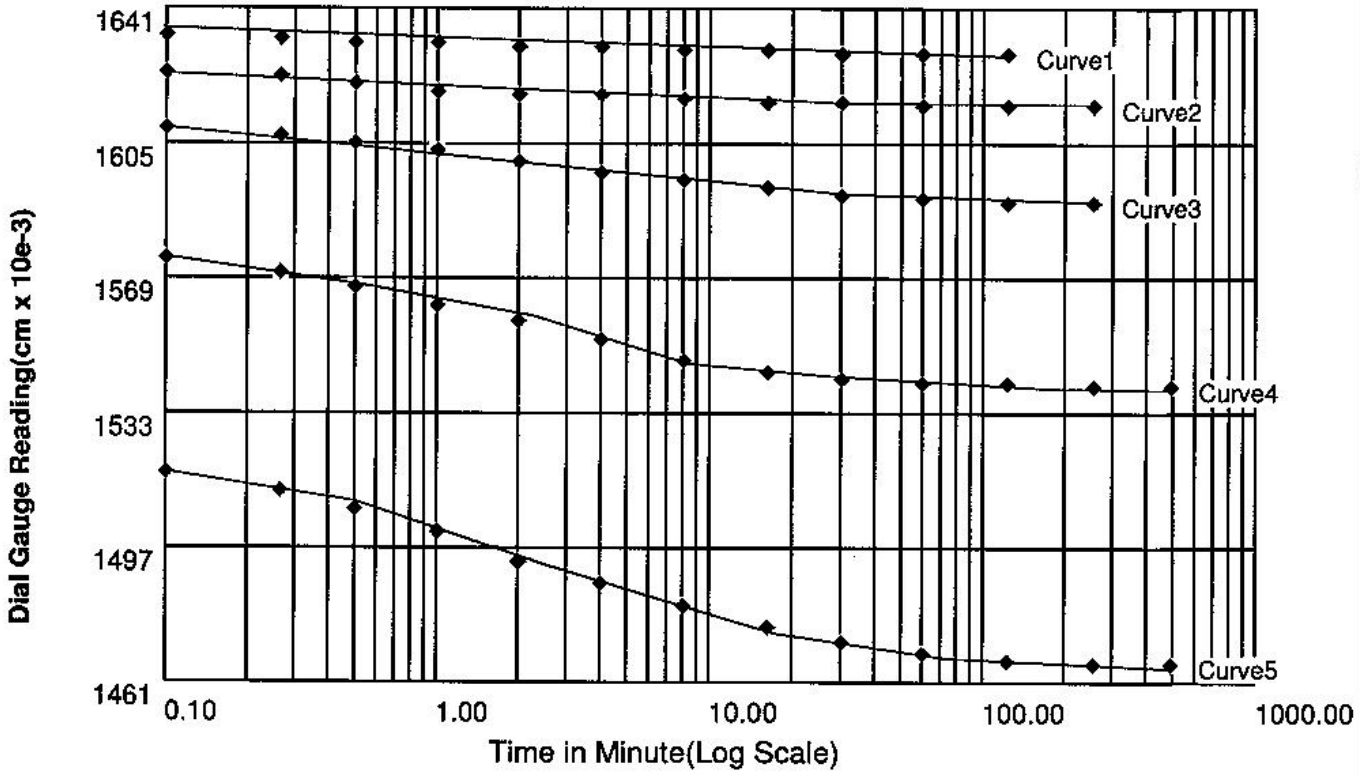
CONSOLIDATION TEST CURVES

Job No. :30796

SKM Geosurvey

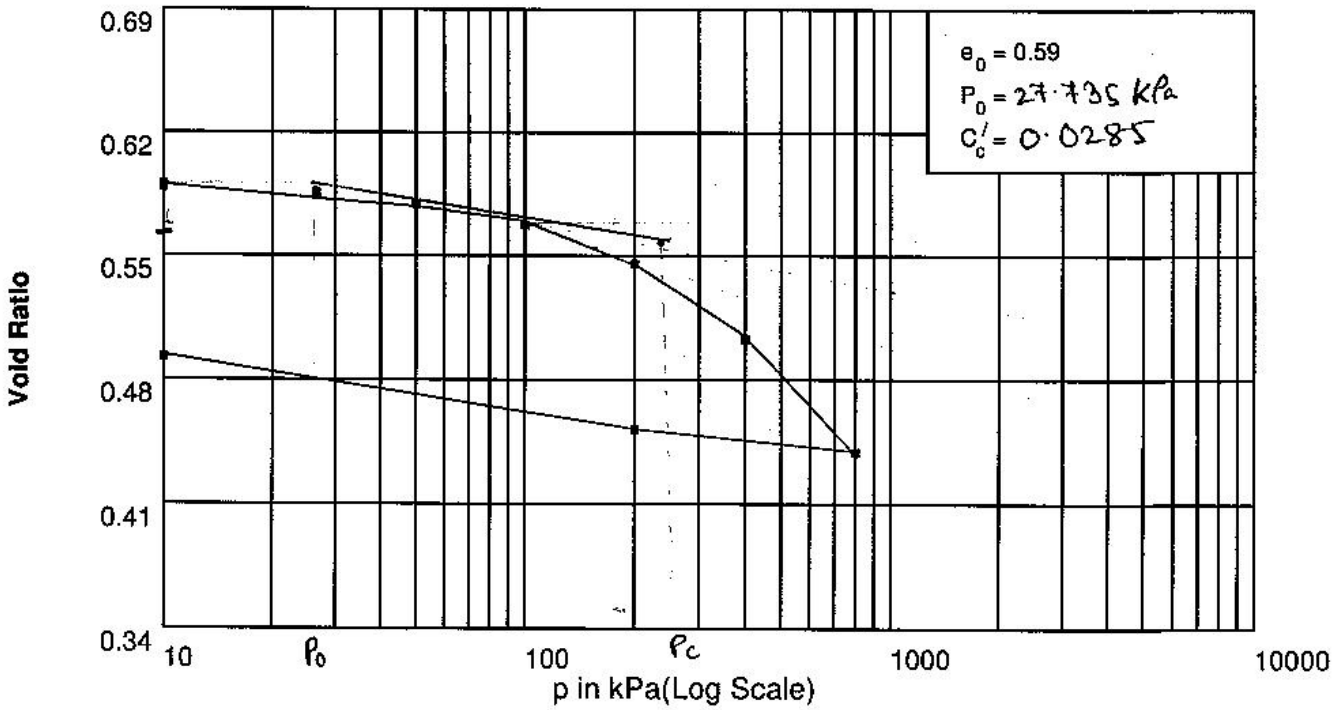
Borehole No :08 Depth(m) :3.00-3.45 Sample No. :100972

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)



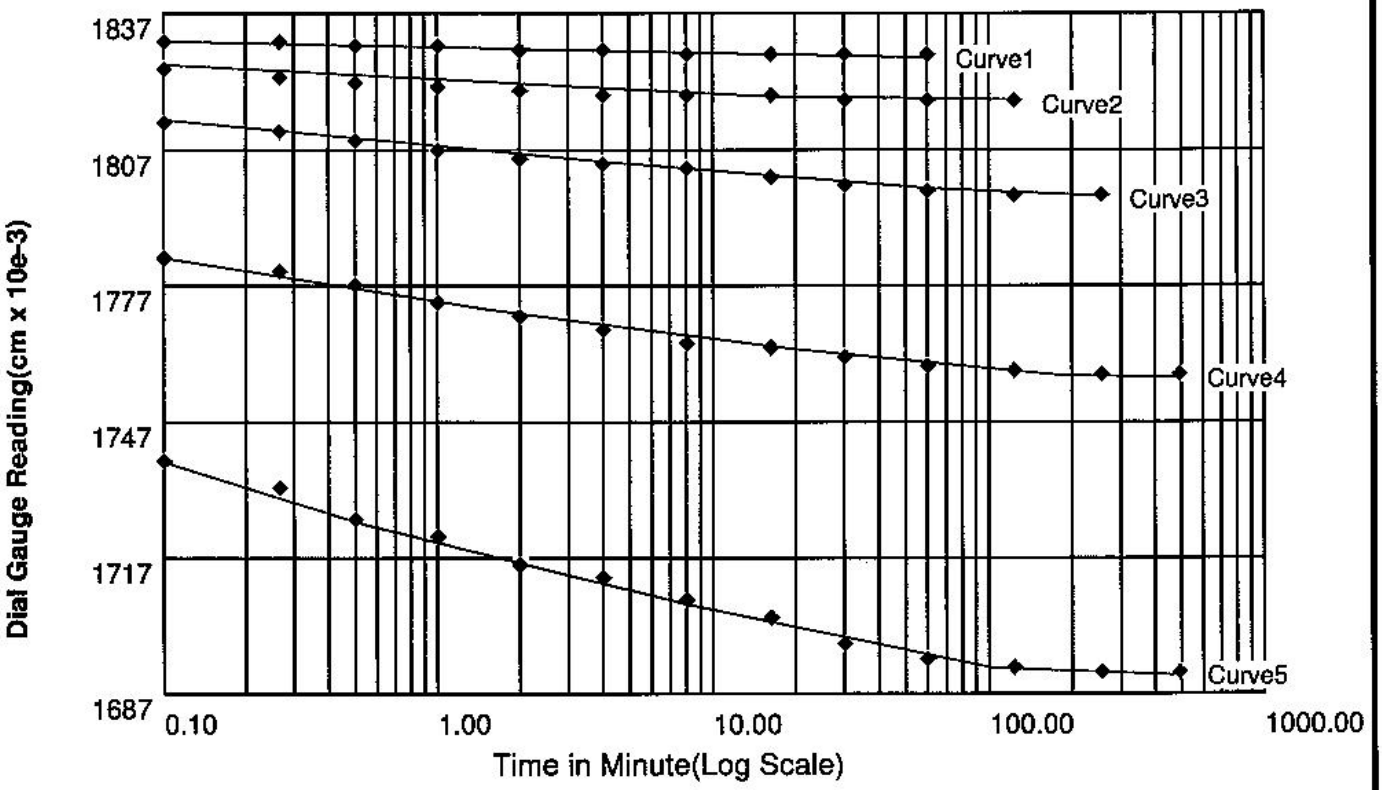
CONSOLIDATION TEST CURVES

Job No. :30796

SKM Geosurvey

Borehole No :09 Depth(m) :2.00-2.45 Sample No. :100878

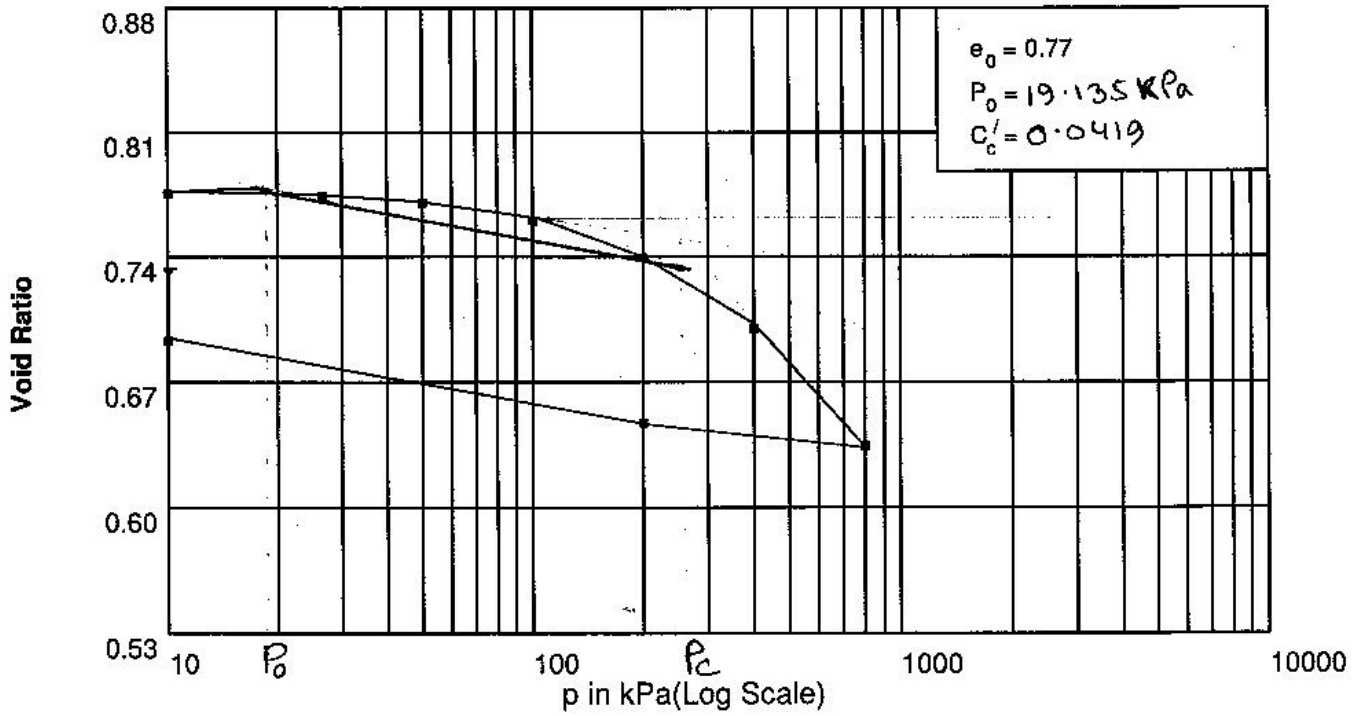
LOG TIME VS SETTLEMENT CURVE



◆ Curve1 :25 - 50 kPa ◆ Curve2 :50 - 100 kPa ◆ Curve3 :100 - 200 kPa

◆ Curve4 :200 - 400 kPa ◆ Curve5 :400 - 800 kPa

e Vs LOG(P)



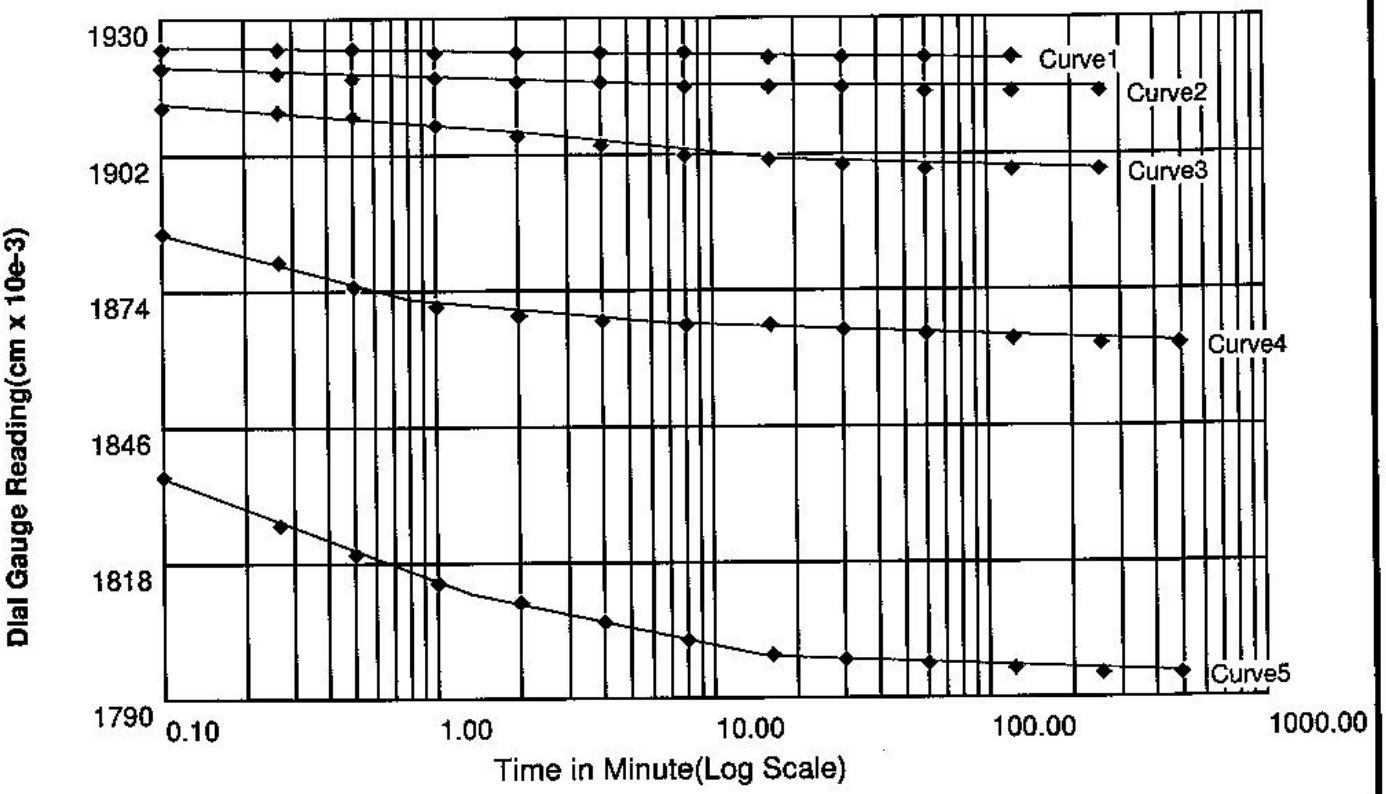
CONSOLIDATION TEST CURVES

Job No. :30796

SKM Geosurvey

Borehole No :09 Depth(m) :4.50-4.95 Sample No. :100882

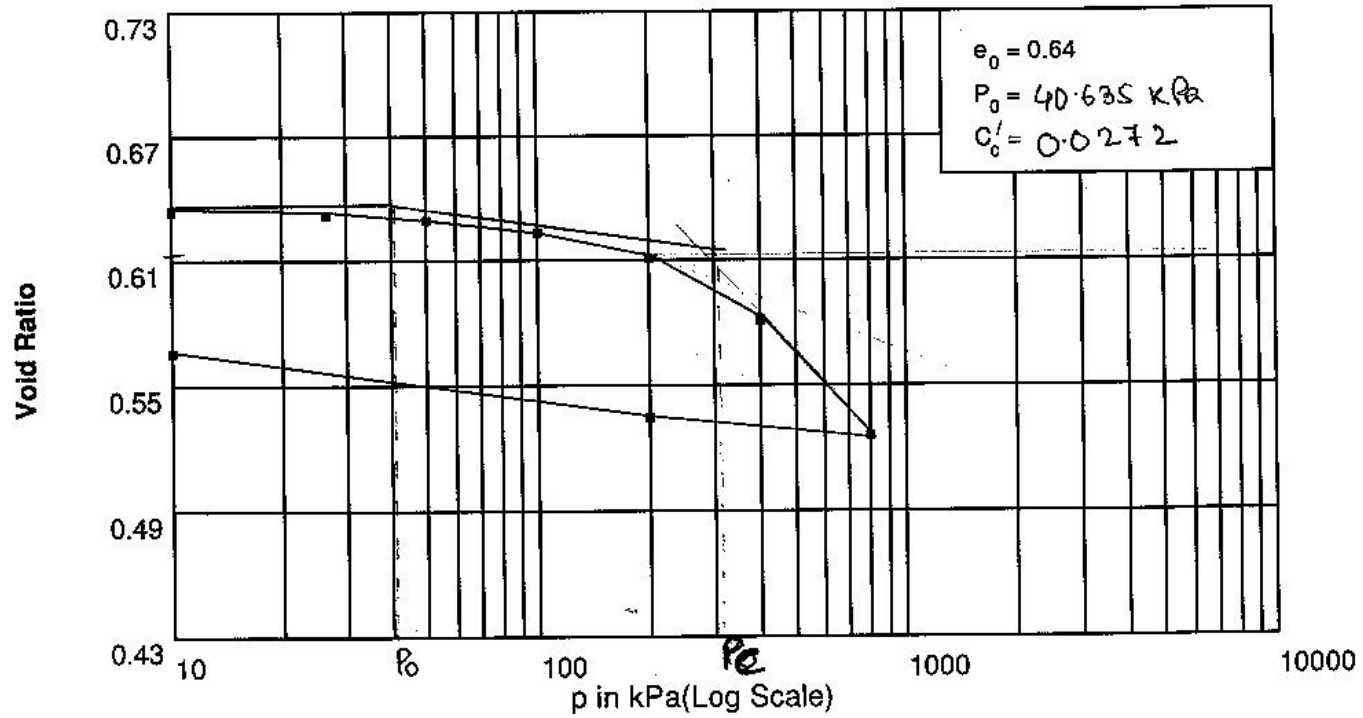
LOG TIME VS SETTLEMENT CURVE



◆ Curve1 :25 - 50 kPa ◆ Curve2 :50 - 100 kPa ◆ Curve3 :100 - 200 kPa

◆ Curve4 :200 - 400 kPa ◆ Curve5 :400 - 800 kPa

e Vs LOG(P)



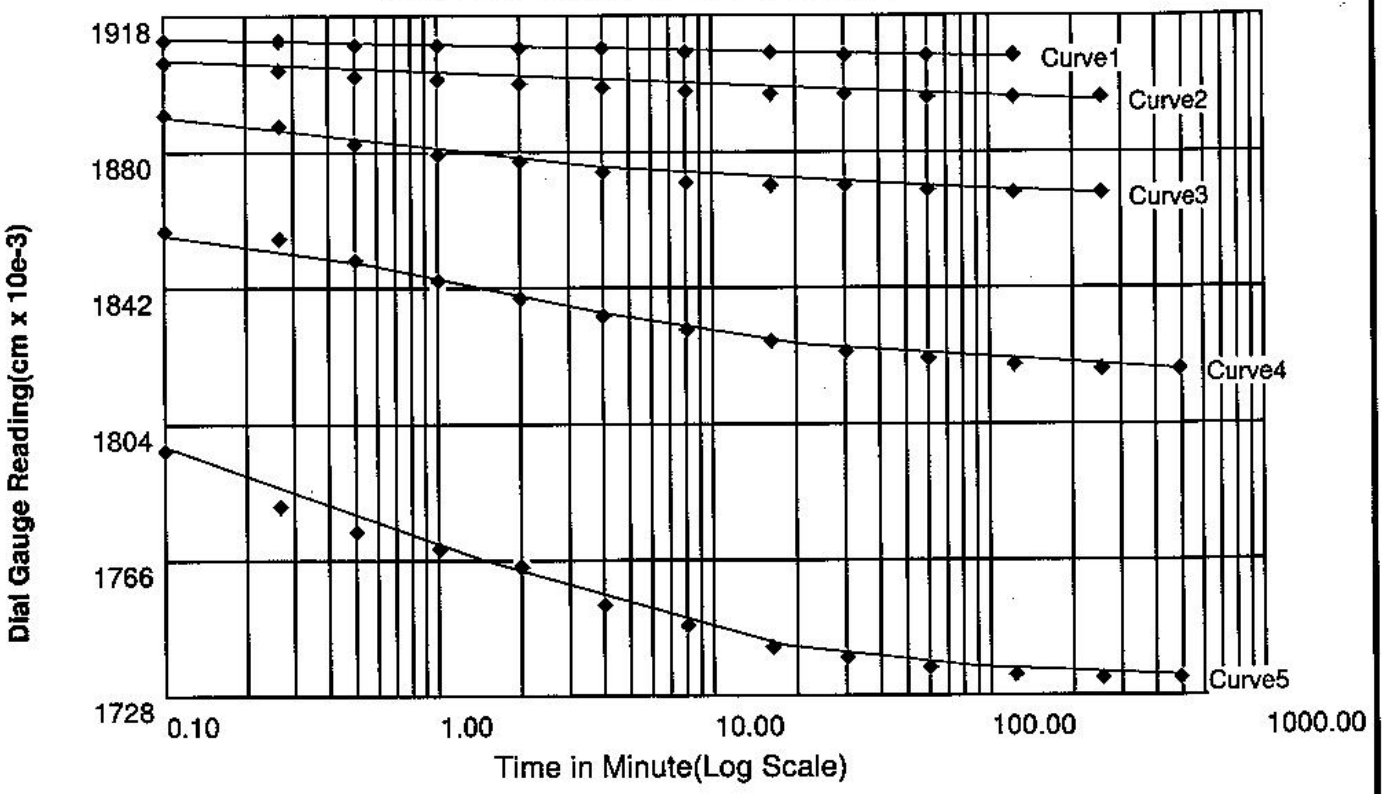
CONSOLIDATION TEST CURVES

Job No. :30796

SKM Geosurvey

Borehole No :10 Depth(m) :3.00-3.45 Sample No. :100476

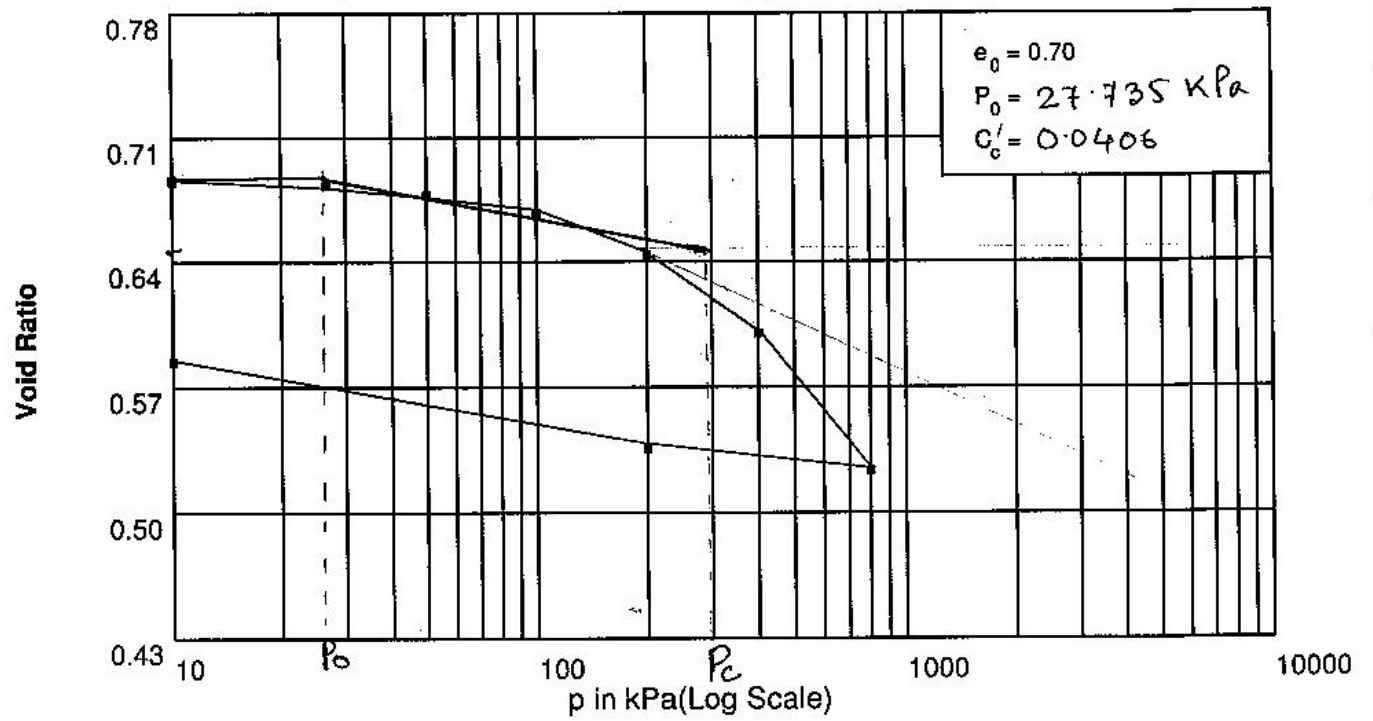
LOG TIME VS SETTLEMENT CURVE



◆ Curve1 :25 - 50 kPa ◆ Curve2 :50 - 100 kPa ◆ Curve3 :100 - 200 kPa

◆ Curve4 :200 - 400 kPa ◆ Curve5 :400 - 800 kPa

e Vs LOG(P)



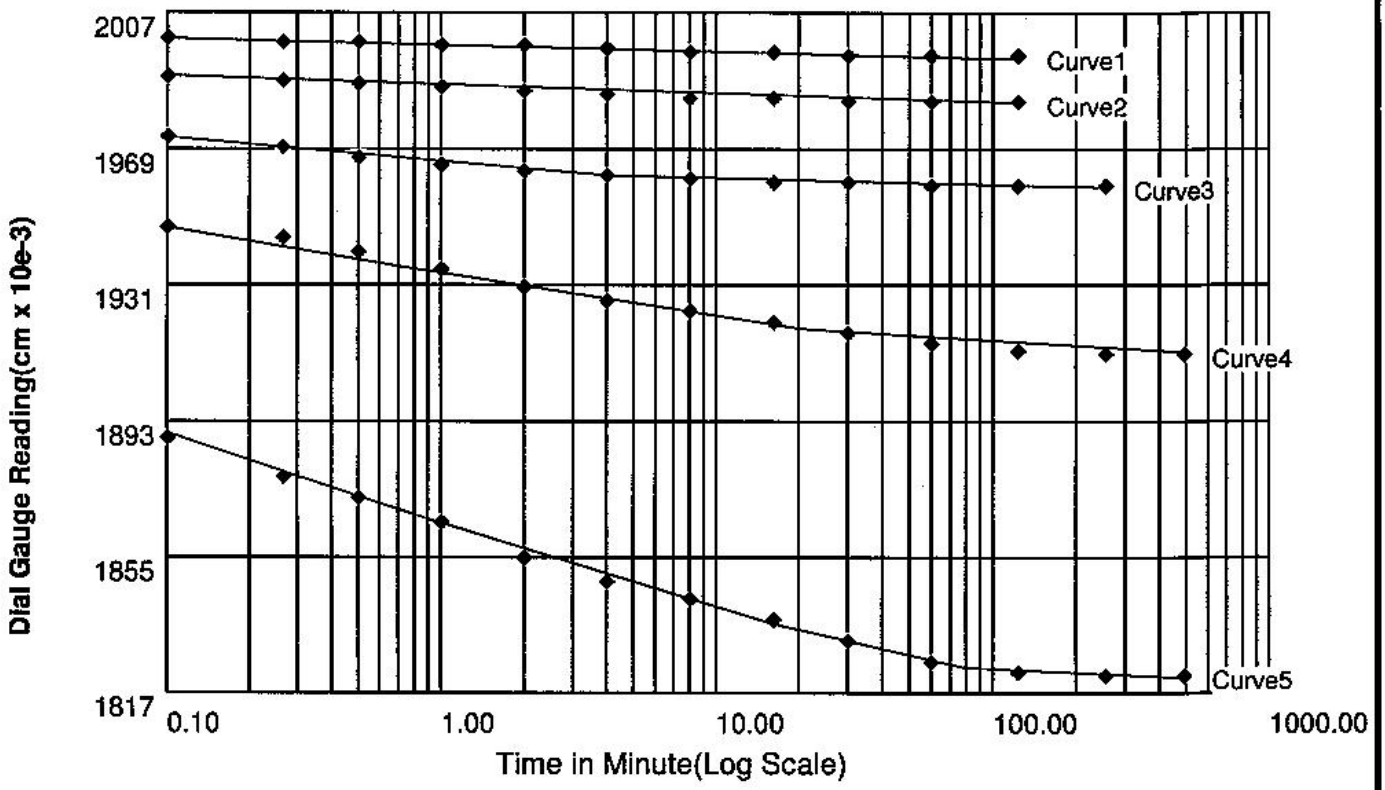
CONSOLIDATION TEST CURVES

Job No. :30796

SKM Geosurvey

Borehole No :11 Depth(m) :1.00-1.45 Sample No. :100852

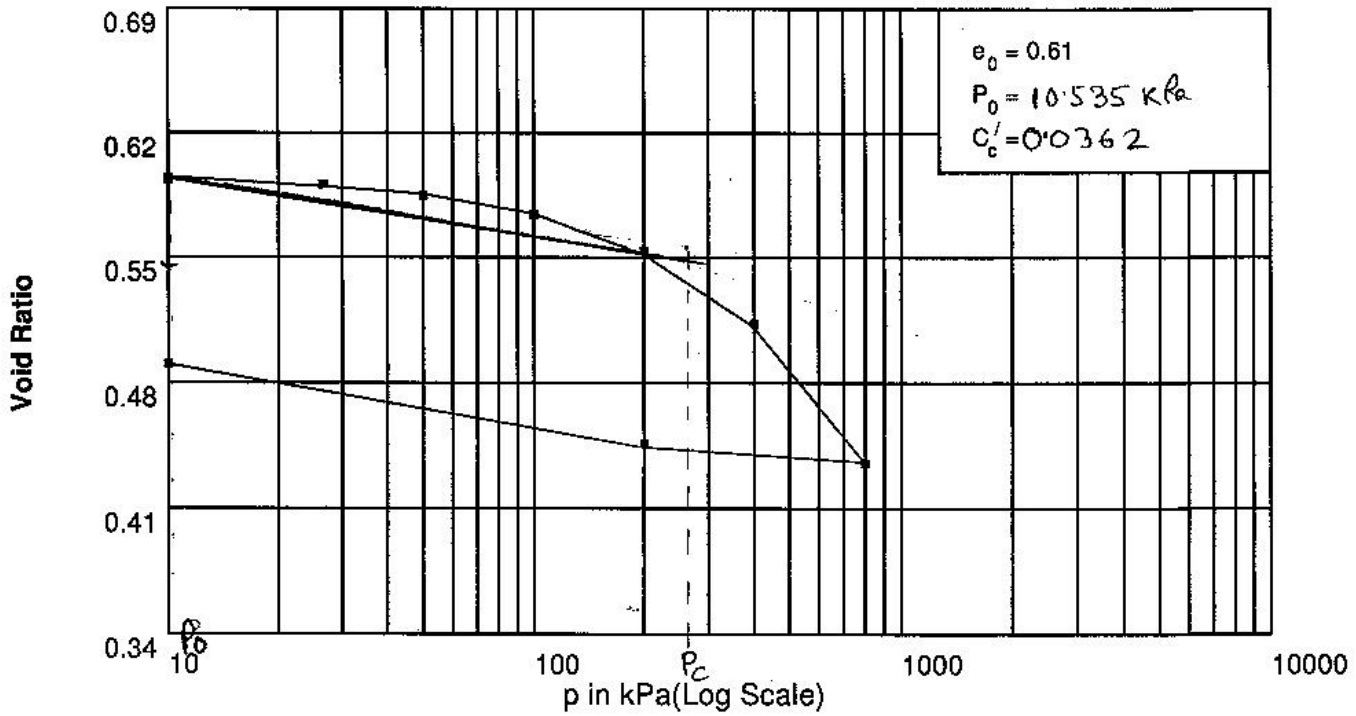
LOG TIME VS SETTLEMENT CURVE



◆ Curve1 :25 - 50 kPa ◆ Curve2 :50 - 100 kPa ◆ Curve3 :100 - 200 kPa

◆ Curve4 :200 - 400 kPa ◆ Curve5 :400 - 800 kPa

e Vs LOG(P)



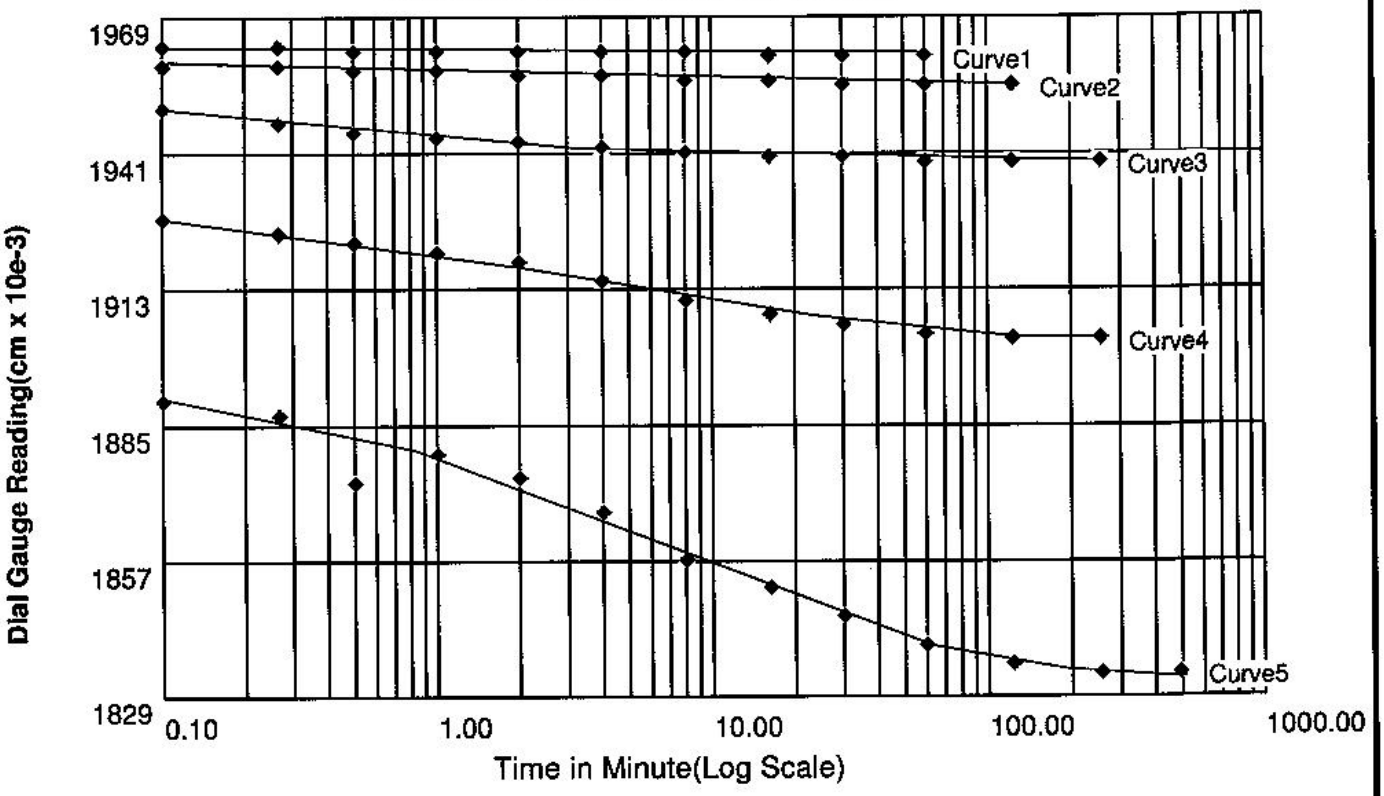
CONSOLIDATION TEST CURVES

Job No. :30796

SKM Geosurvey

Borehole No :11 Depth(m) :3.00-3.45 Sample No. :100856

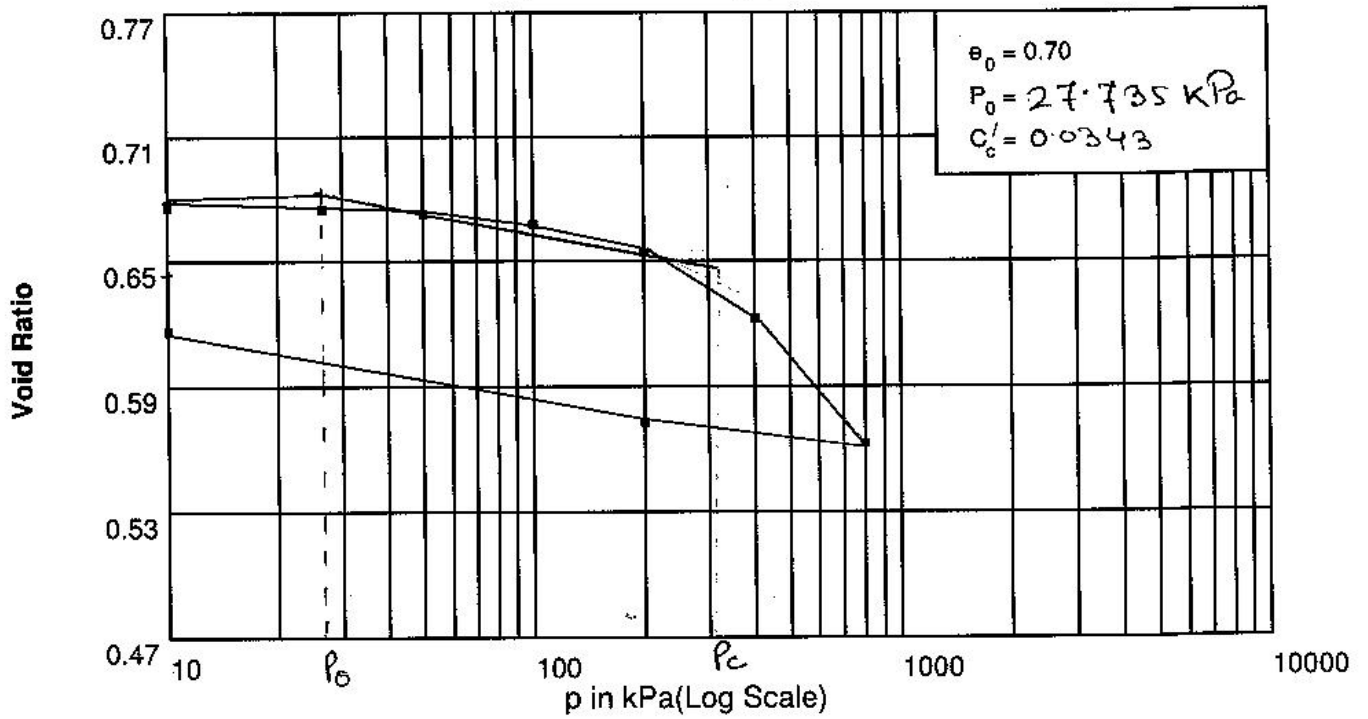
LOG TIME VS SETTLEMENT CURVE



◆ Curve1 :25 - 50 kPa ◆ Curve2 :50 - 100 kPa ◆ Curve3 :100 - 200 kPa

◆ Curve4 :200 - 400 kPa ◆ Curve5 :400 - 800 kPa

e Vs LOG(P)



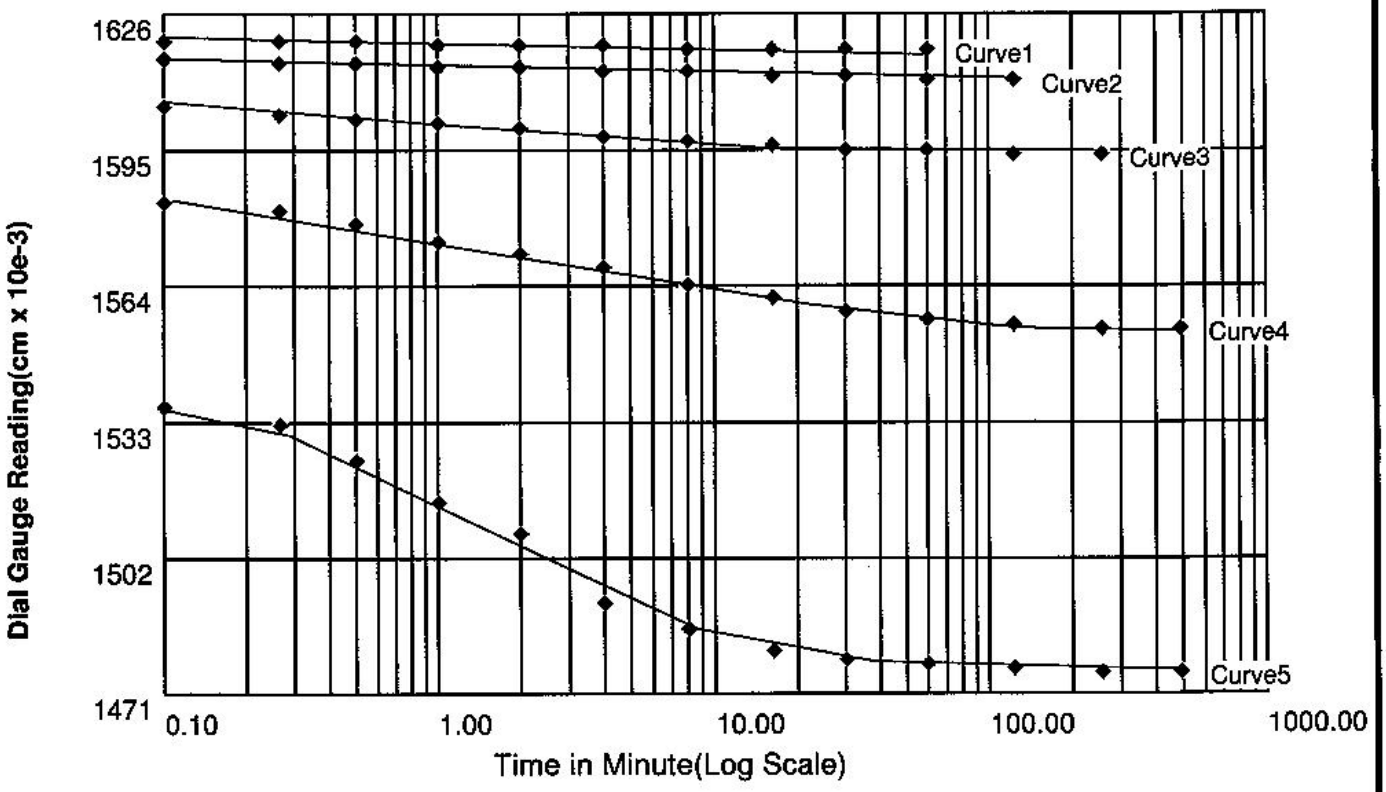
CONSOLIDATION TEST CURVES

Job No. :30796

SKM Geosurvey

Borehole No :12 Depth(m) :1.00-1.45 Sample No. :100978

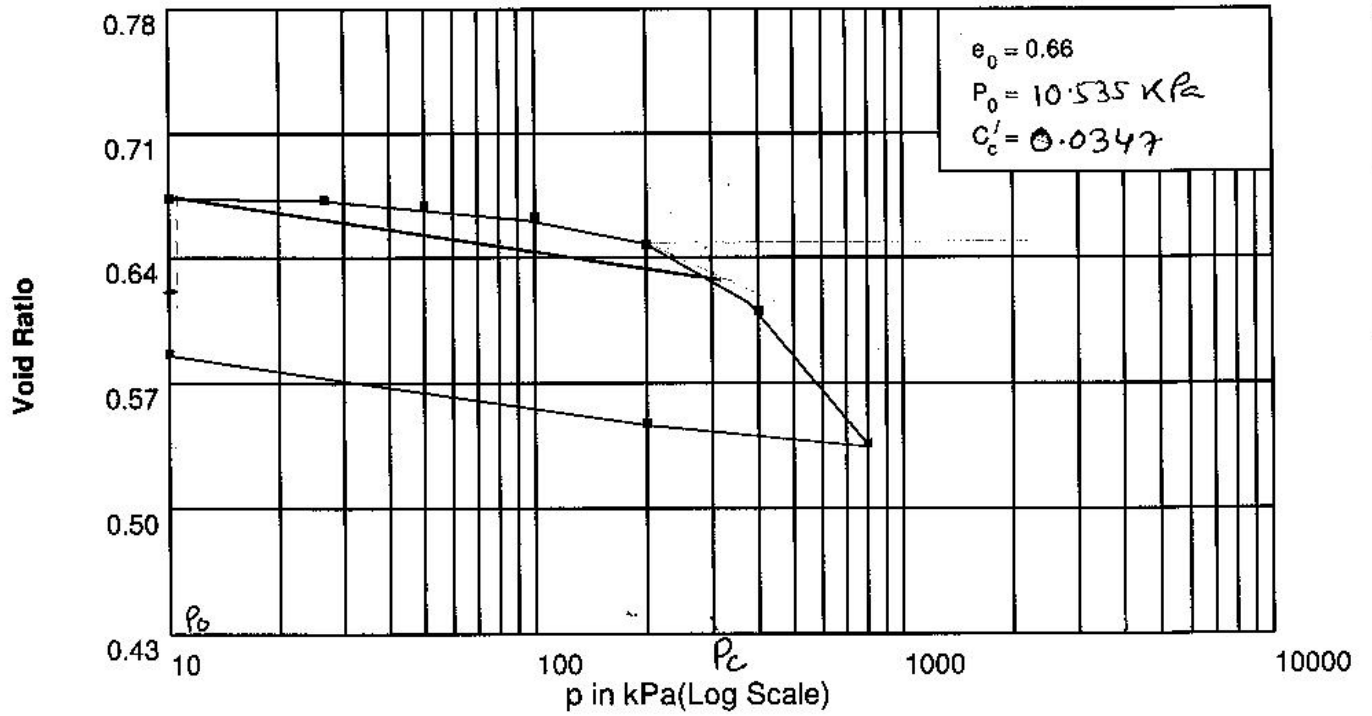
LOG TIME VS SETTLEMENT CURVE



◆ Curve1 :25 - 50 kPa ◆ Curve2 :50 - 100 kPa ◆ Curve3 :100 - 200 kPa

◆ Curve4 :200 - 400 kPa ◆ Curve5 :400 - 800 kPa

e Vs LOG(P)



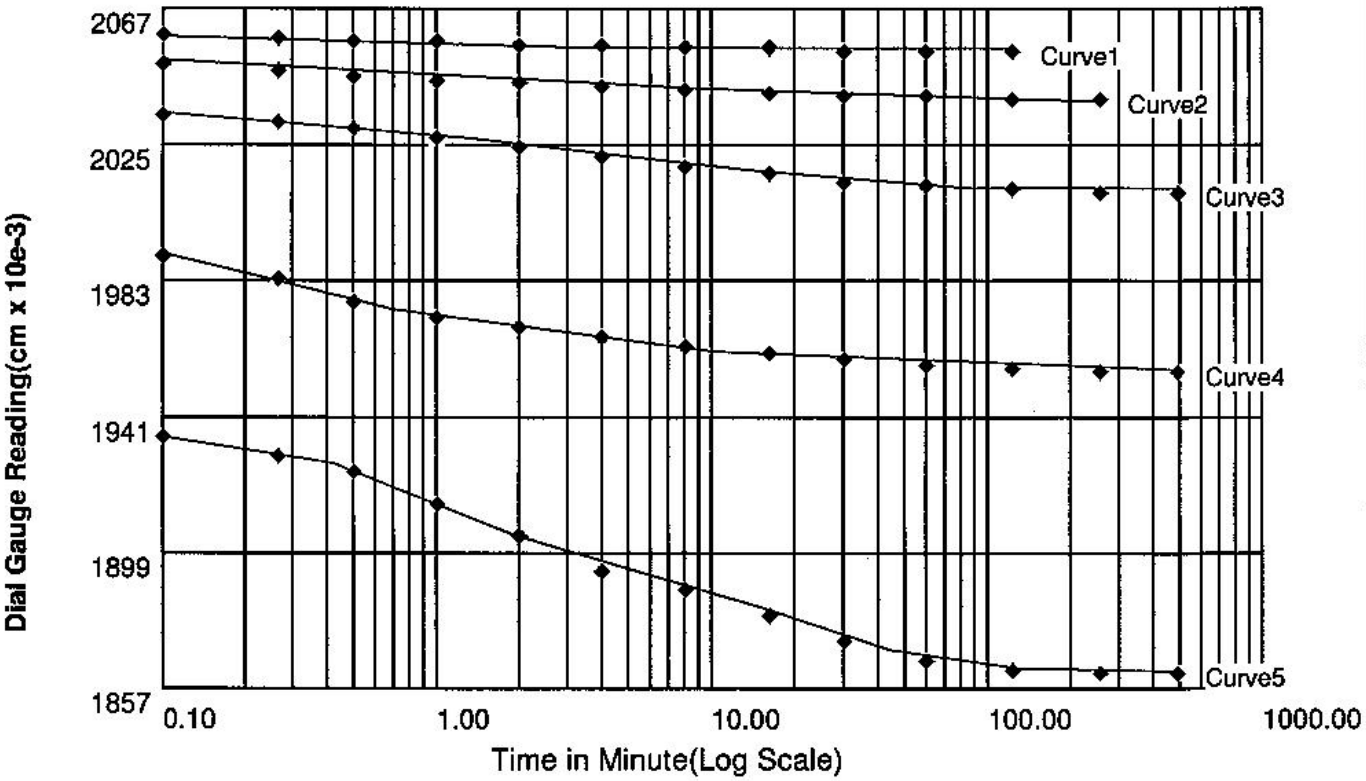
CONSOLIDATION TEST CURVES

Job No. :30796

SKM Geosurvey

Borehole No :14 Depth(m) :2.00-2.45 Sample No. :100554

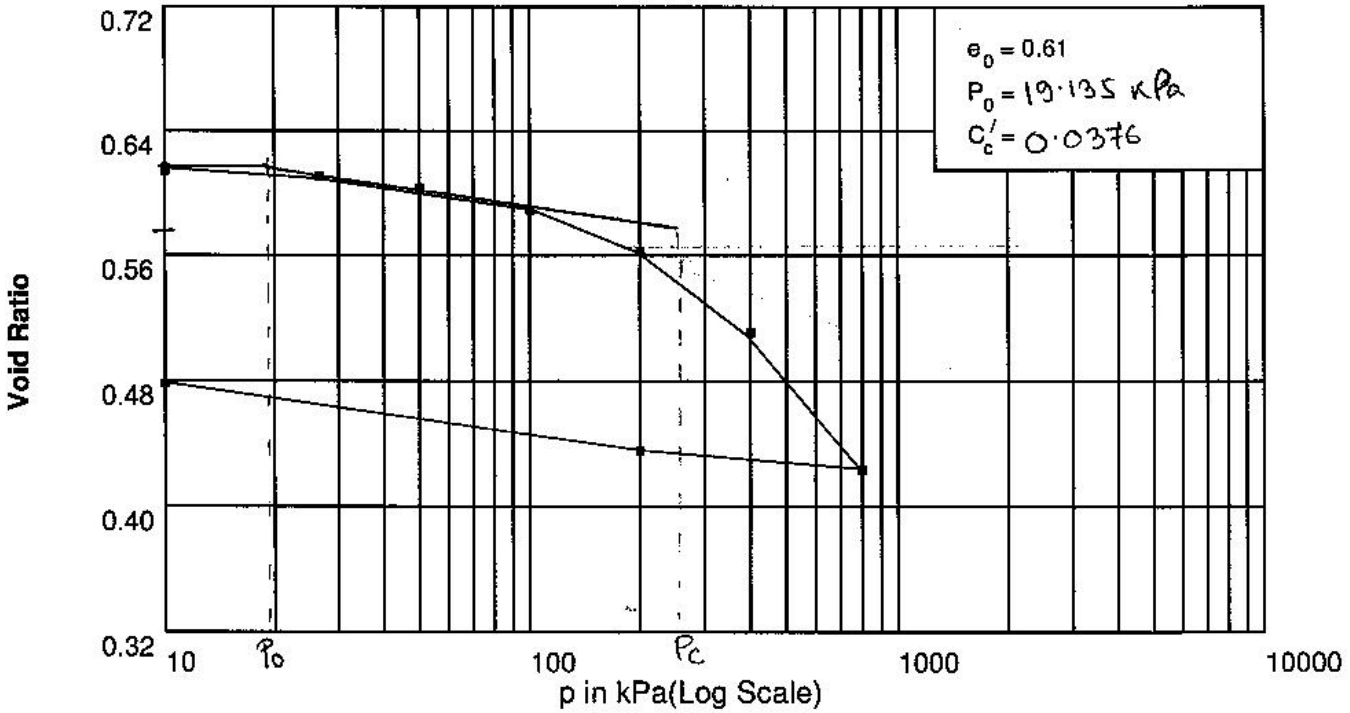
LOG TIME VS SETTLEMENT CURVE



◆ Curve1 :25 - 50 kPa ◆ Curve2 :50 - 100 kPa ◆ Curve3 :100 - 200 kPa

◆ Curve4 :200 - 400 kPa ◆ Curve5 :400 - 800 kPa

e Vs LOG(P)



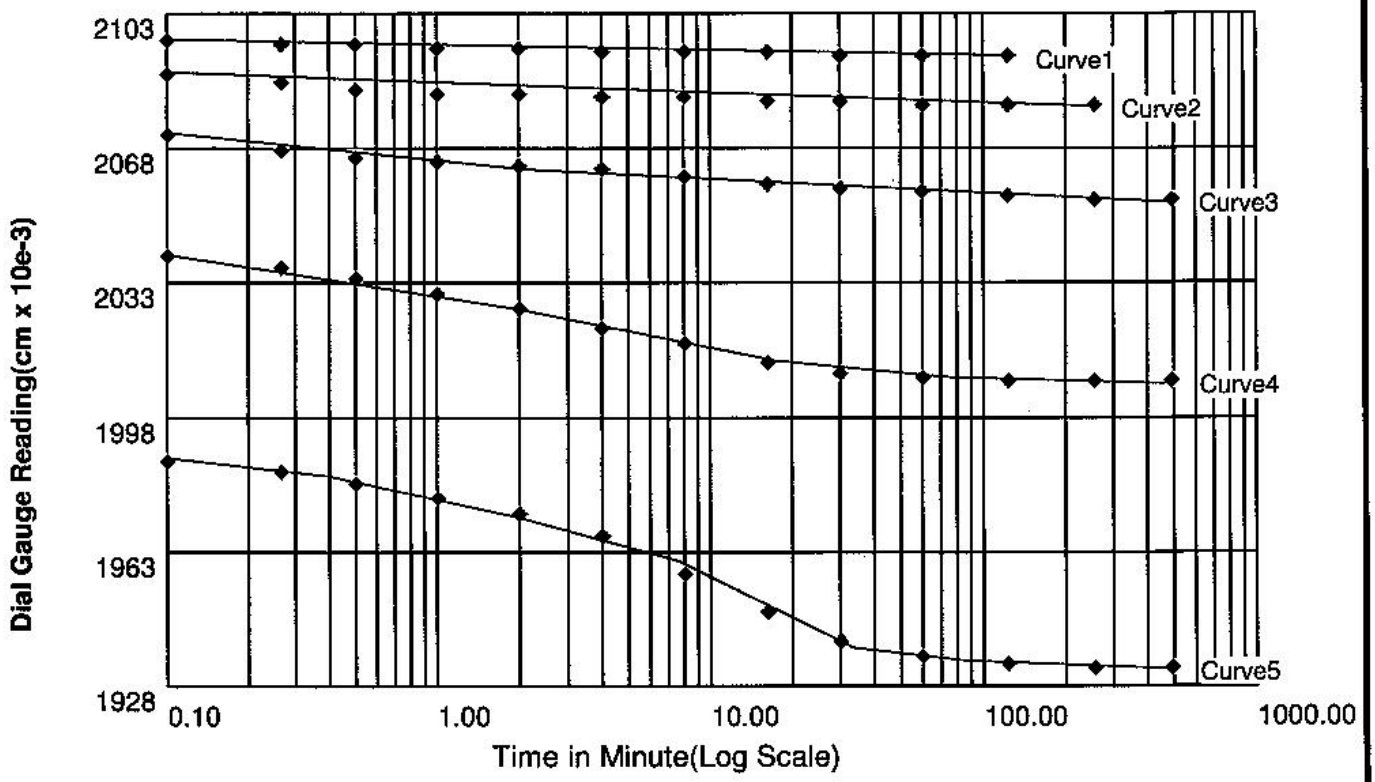
CONSOLIDATION TEST CURVES

Job No. :30796

SKM Geosurvey

Borehole No :16 Depth(m) :2.00-2.45 Sample No. :100954

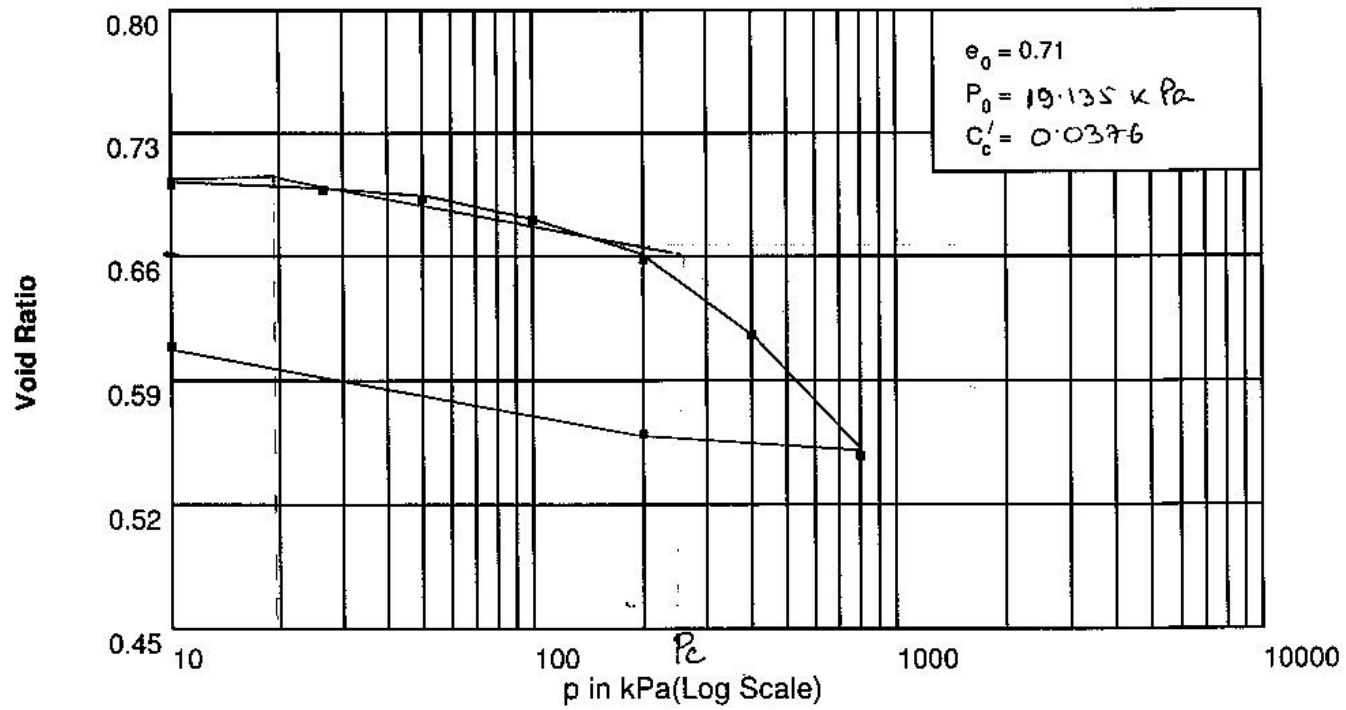
LOG TIME VS SETTLEMENT CURVE



◆ Curve1 :25 - 50 kPa ◆ Curve2 :50 - 100 kPa ◆ Curve3 :100 - 200 kPa

◆ Curve4 :200 - 400 kPa ◆ Curve5 :400 - 800 kPa

e Vs LOG(P)



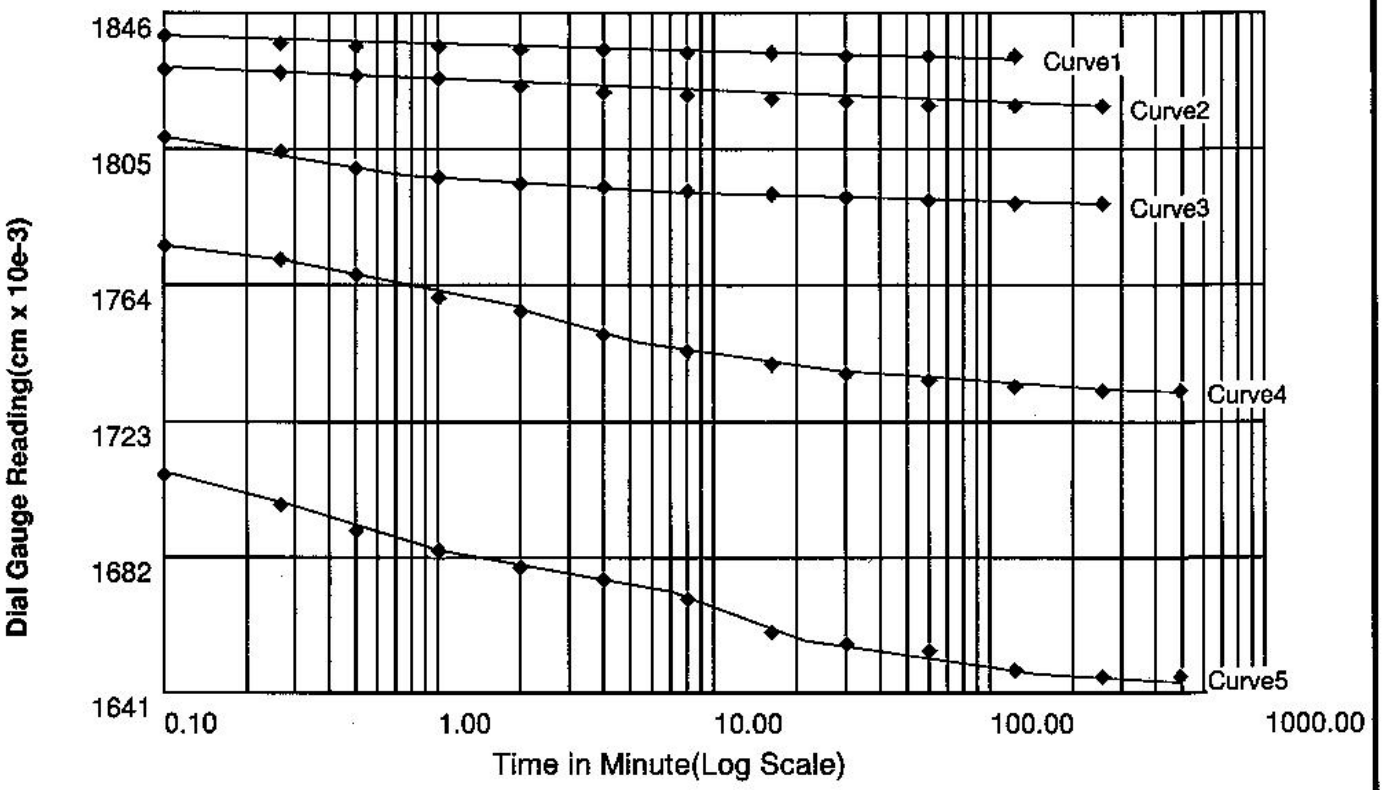
CONSOLIDATION TEST CURVES

Job No. :30796

SKM Geosurvey

Borehole No :17 Depth(m) :2.00-2.45 Sample No. :100517

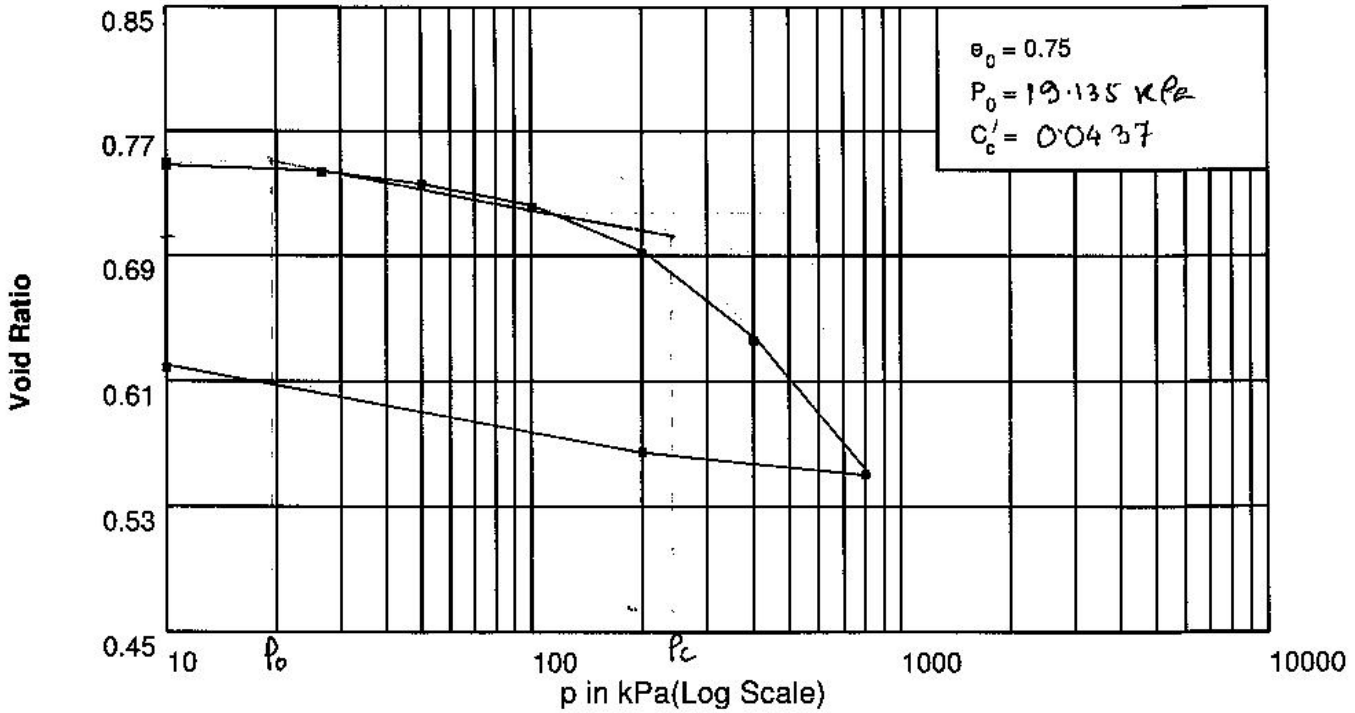
LOG TIME VS SETTLEMENT CURVE



◆ Curve1 :25 - 50 kPa ◆ Curve2 :50 - 100 kPa ◆ Curve3 :100 - 200 kPa

◆ Curve4 :200 - 400 kPa ◆ Curve5 :400 - 800 kPa

e Vs LOG(P)



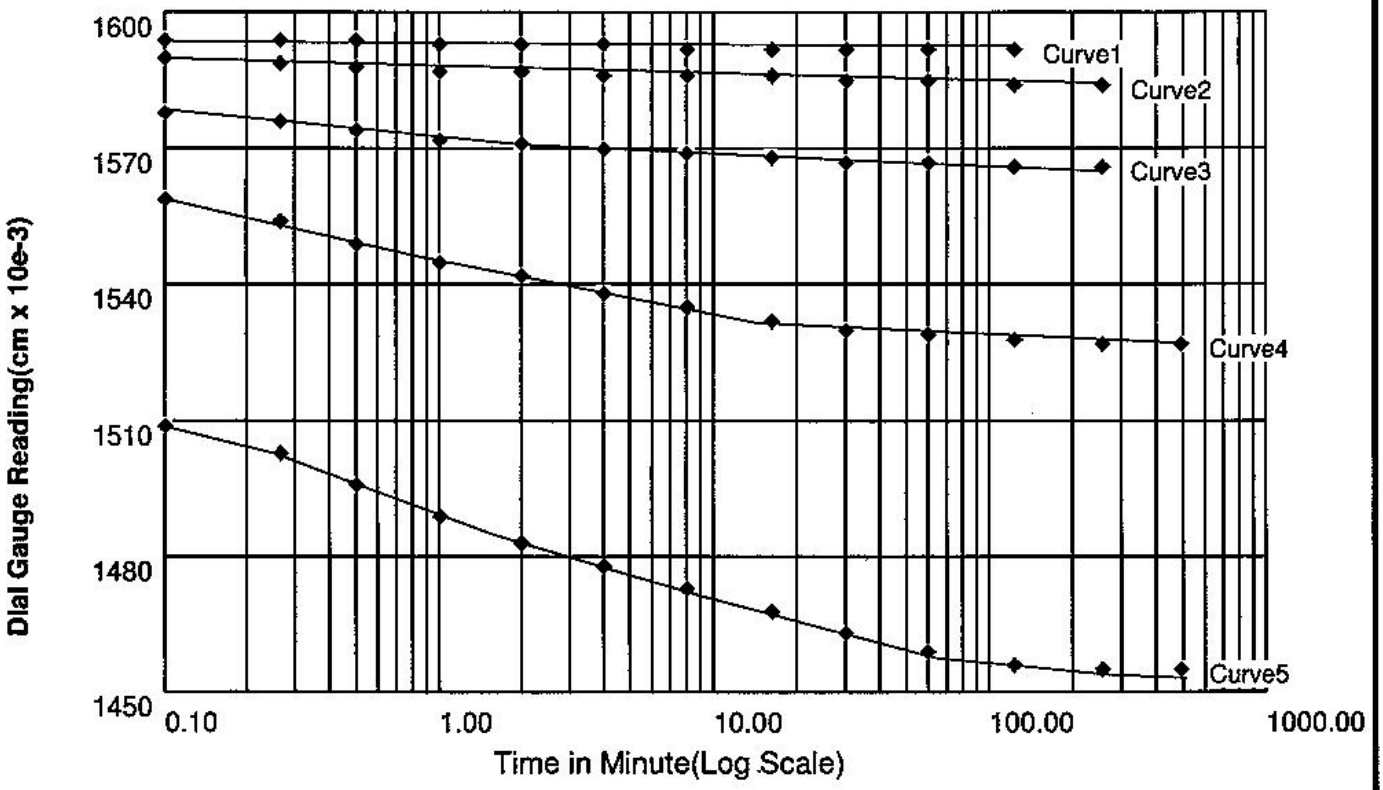
CONSOLIDATION TEST CURVES

Job No. :30796

SKM Geosurvey

Borehole No :17 Depth(m) :7.50-7.95 Sample No. :100524

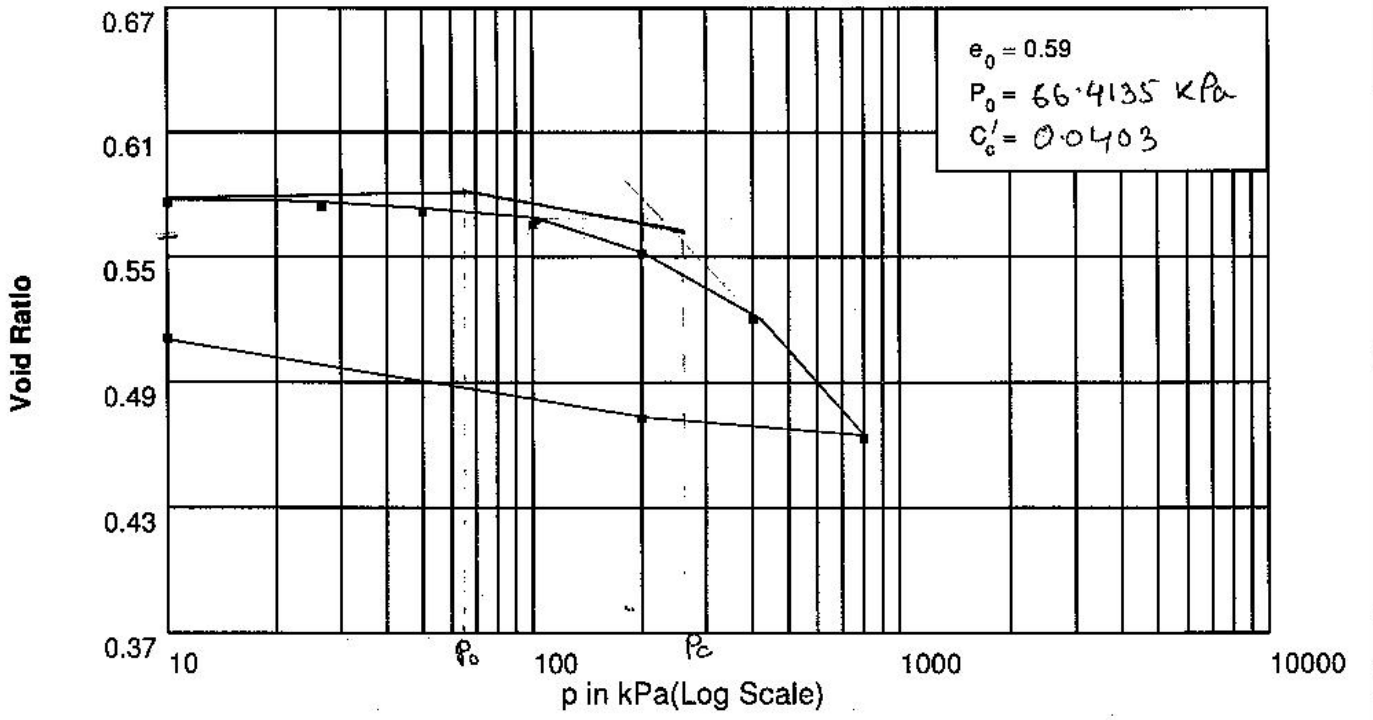
LOG TIME VS SETTLEMENT CURVE



◆ Curve1 :25 - 50 kPa ◆ Curve2 :50 - 100 kPa ◆ Curve3 :100 - 200 kPa

◆ Curve4 :200 - 400 kPa ◆ Curve5 :400 - 800 kPa

e Vs LOG(P)



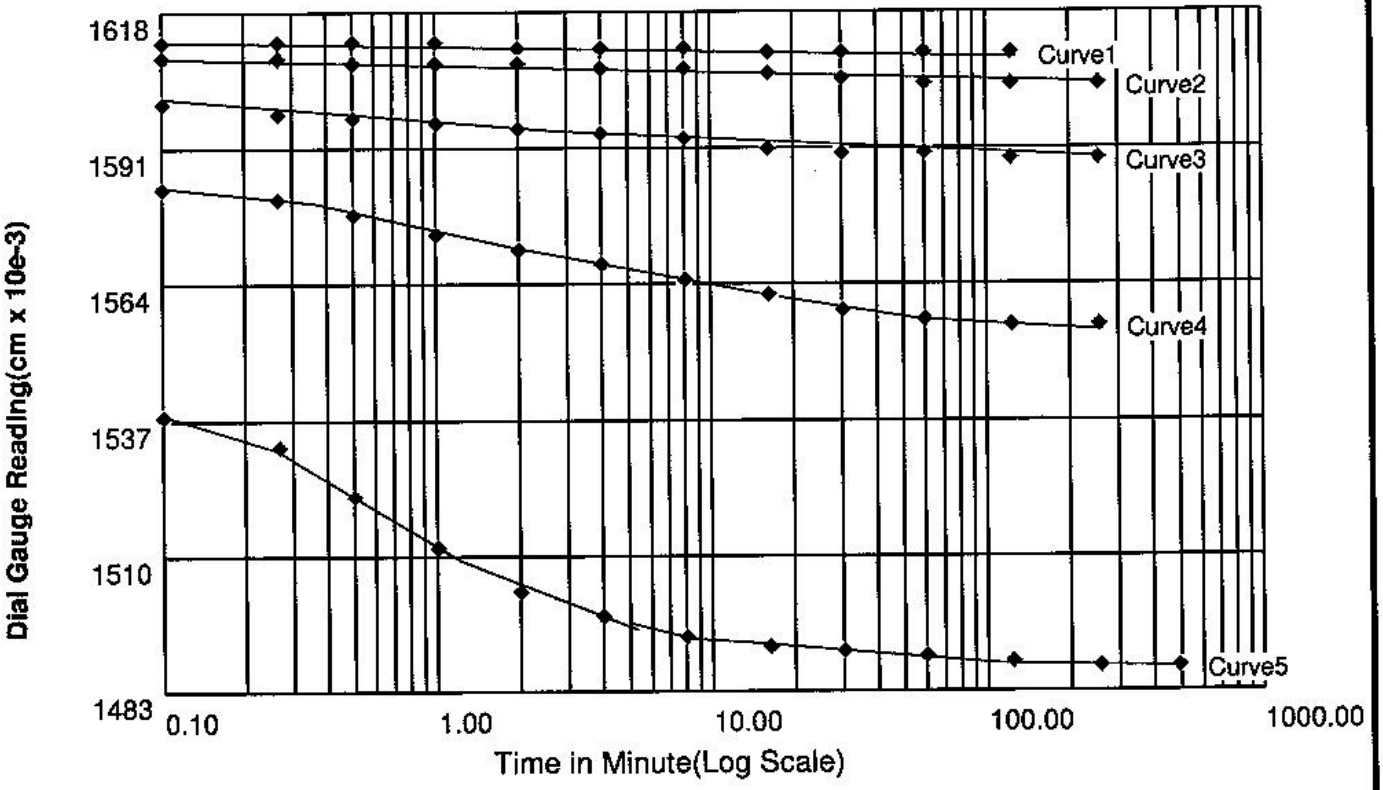
CONSOLIDATION TEST CURVES

Job No. :30796

SKM Geosurvey

Borehole No :18 Depth(m) :3.00-3.45 Sample No. :100535

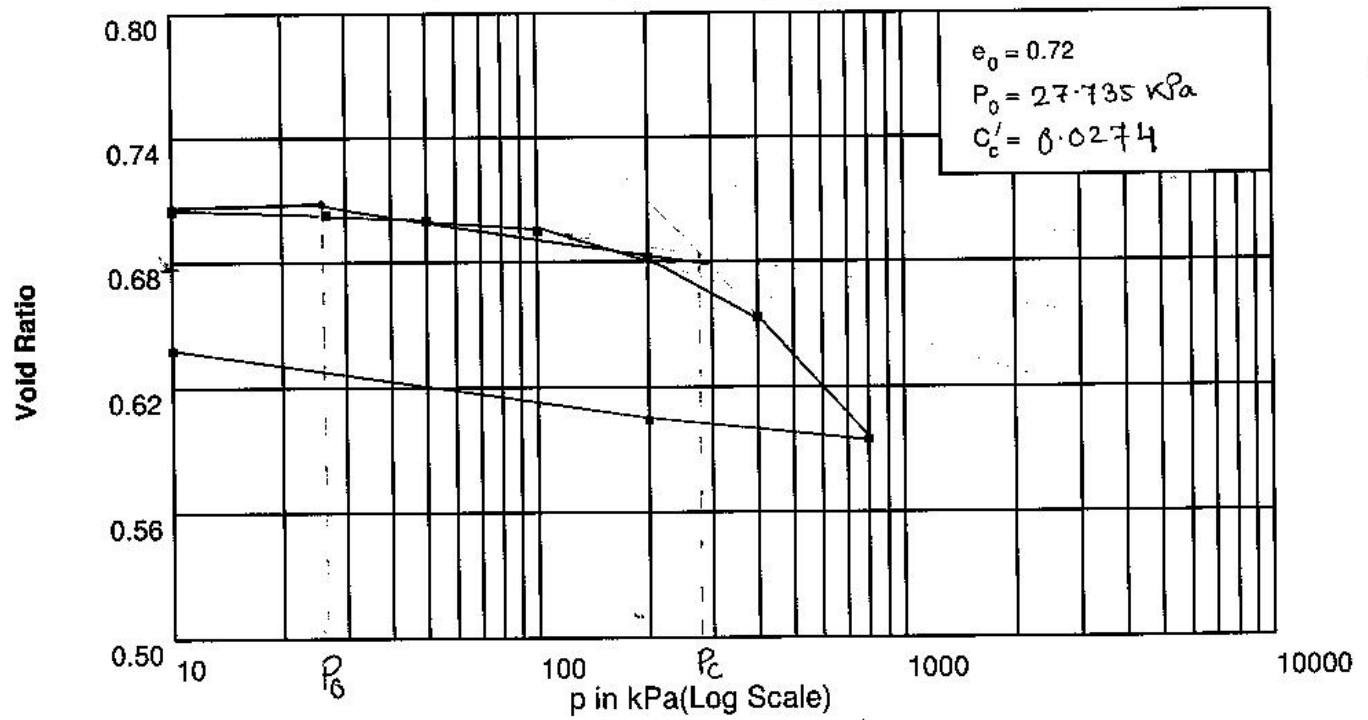
LOG TIME VS SETTLEMENT CURVE



◆ Curve1 :25 - 50 kPa ◆ Curve2 :50 - 100 kPa ◆ Curve3 :100 - 200 kPa

◆ Curve4 :200 - 400 kPa ◆ Curve5 :400 - 800 kPa

e Vs LOG(P)



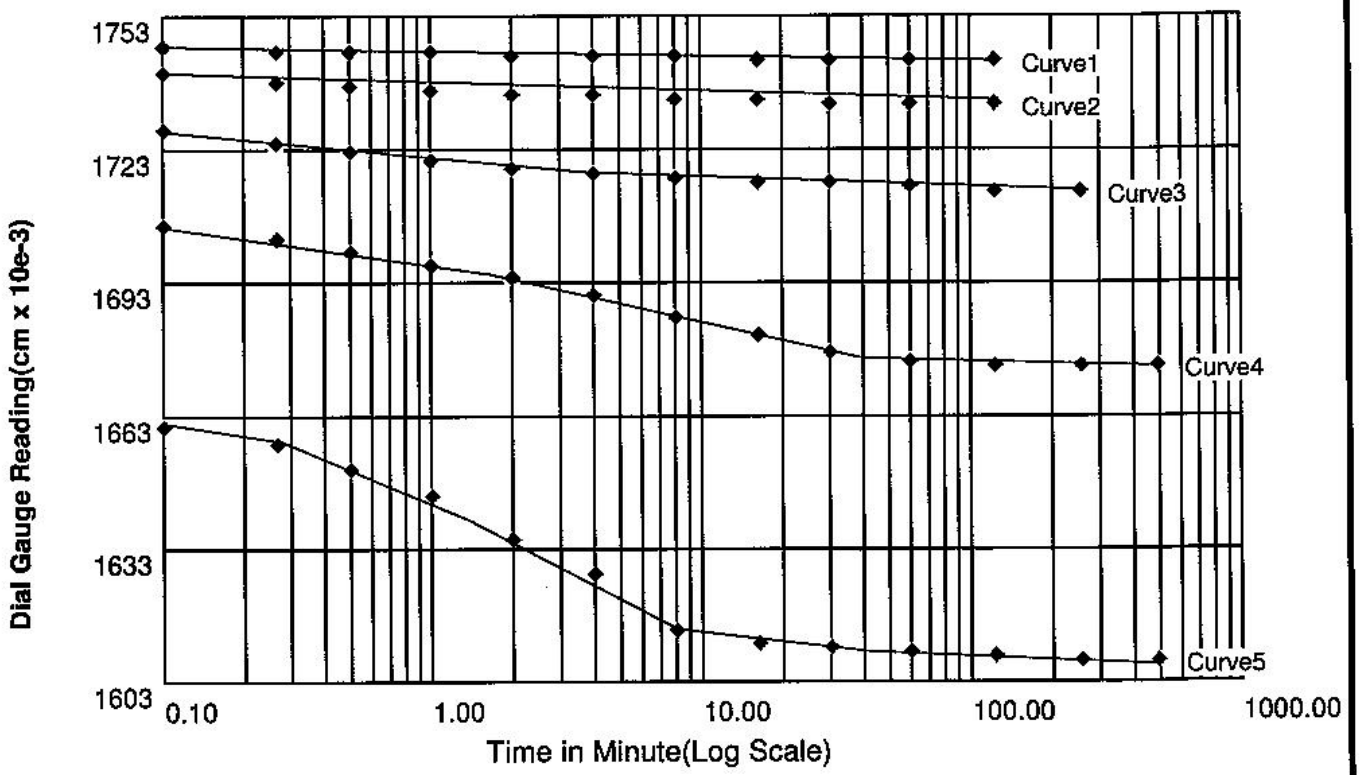
CONSOLIDATION TEST CURVES

Job No. :30796

SKM Geosurvey

Borehole No :19 Depth(m) :4.00-4.45 Sample No. :100507

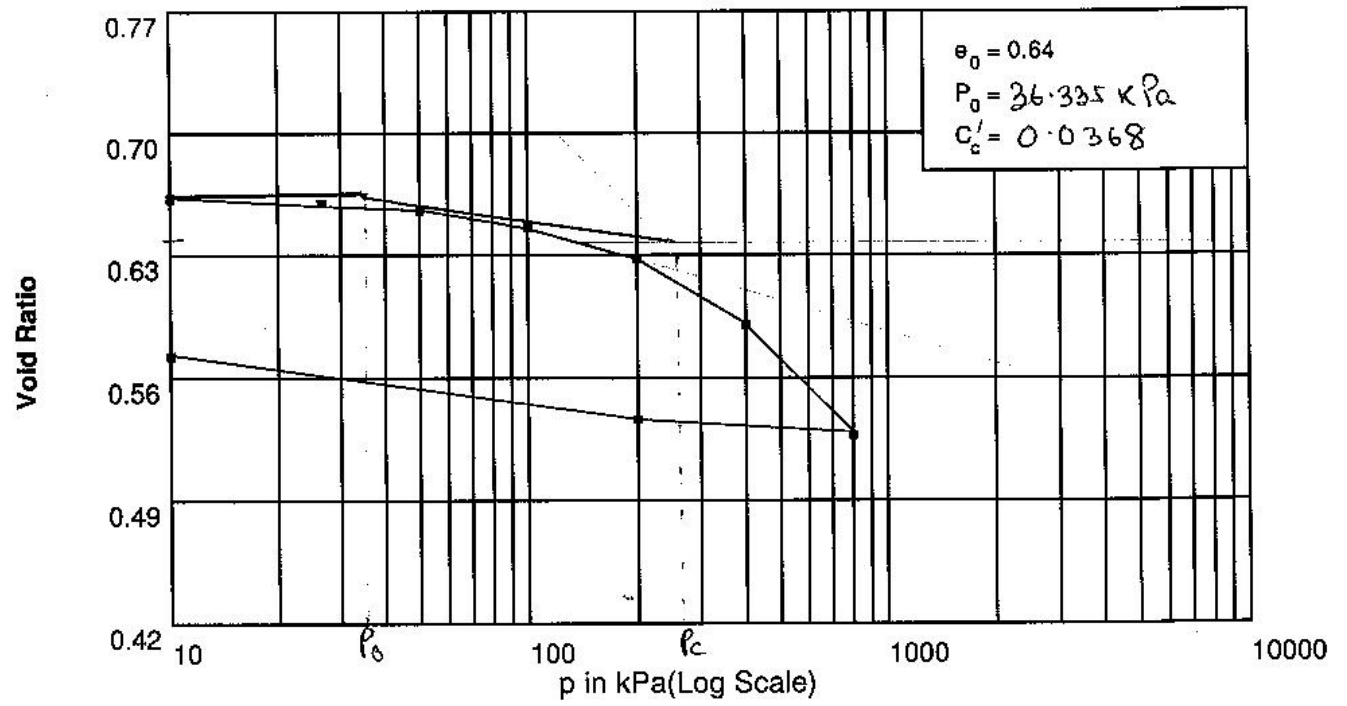
LOG TIME VS SETTLEMENT CURVE



◆ Curve1 :25 - 50 kPa ◆ Curve2 :50 - 100 kPa ◆ Curve3 :100 - 200 kPa

◆ Curve4 :200 - 400 kPa ◆ Curve5 :400 - 800 kPa

e Vs LOG(P)



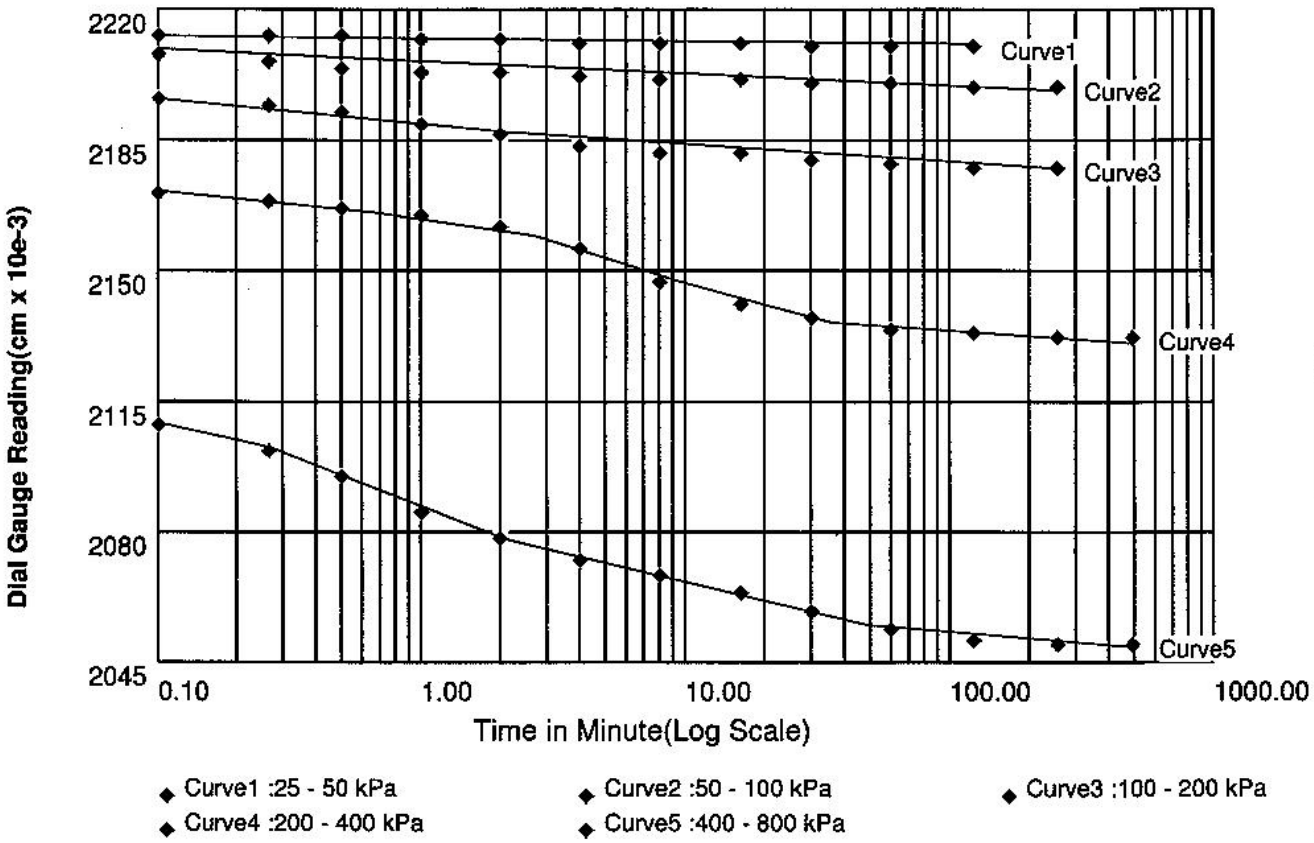
CONSOLIDATION TEST CURVES

Job No. :30796

SKM Geosurvey

Borehole No :20 Depth(m) :2.00-2.45 Sample No. :120103

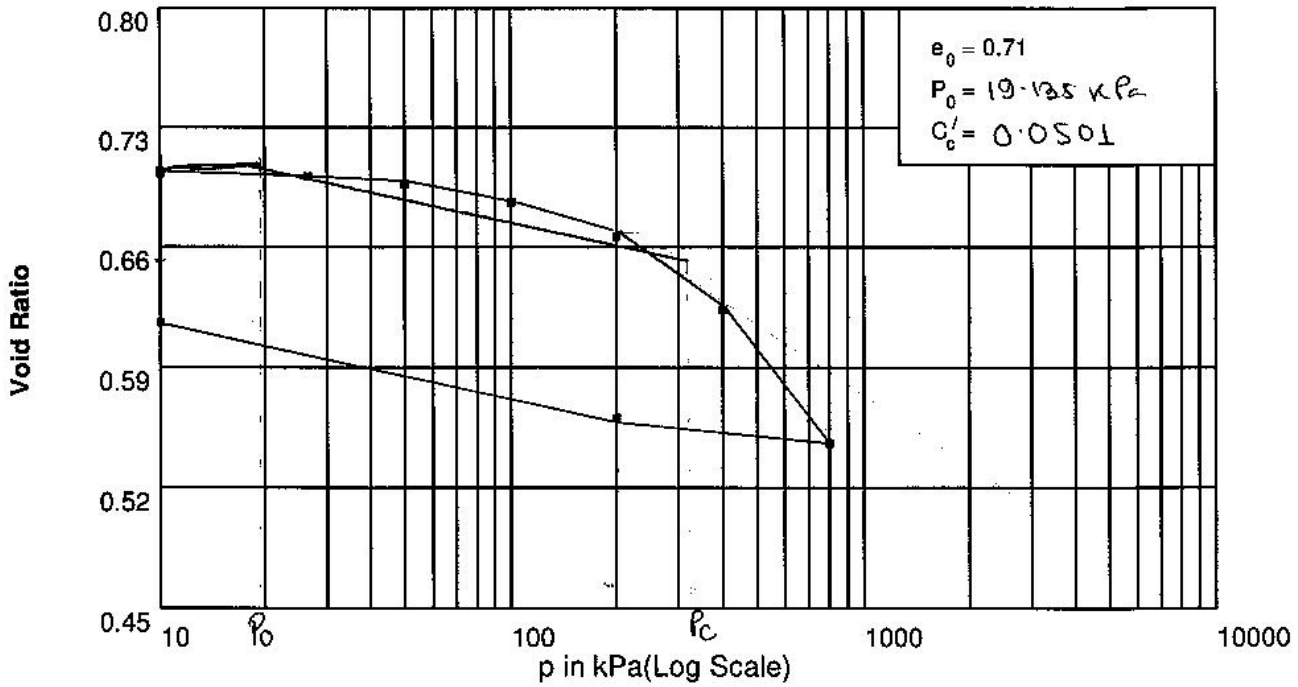
LOG TIME VS SETTLEMENT CURVE



◆ Curve1 :25 - 50 kPa ◆ Curve2 :50 - 100 kPa ◆ Curve3 :100 - 200 kPa

◆ Curve4 :200 - 400 kPa ◆ Curve5 :400 - 800 kPa

e Vs LOG(P)



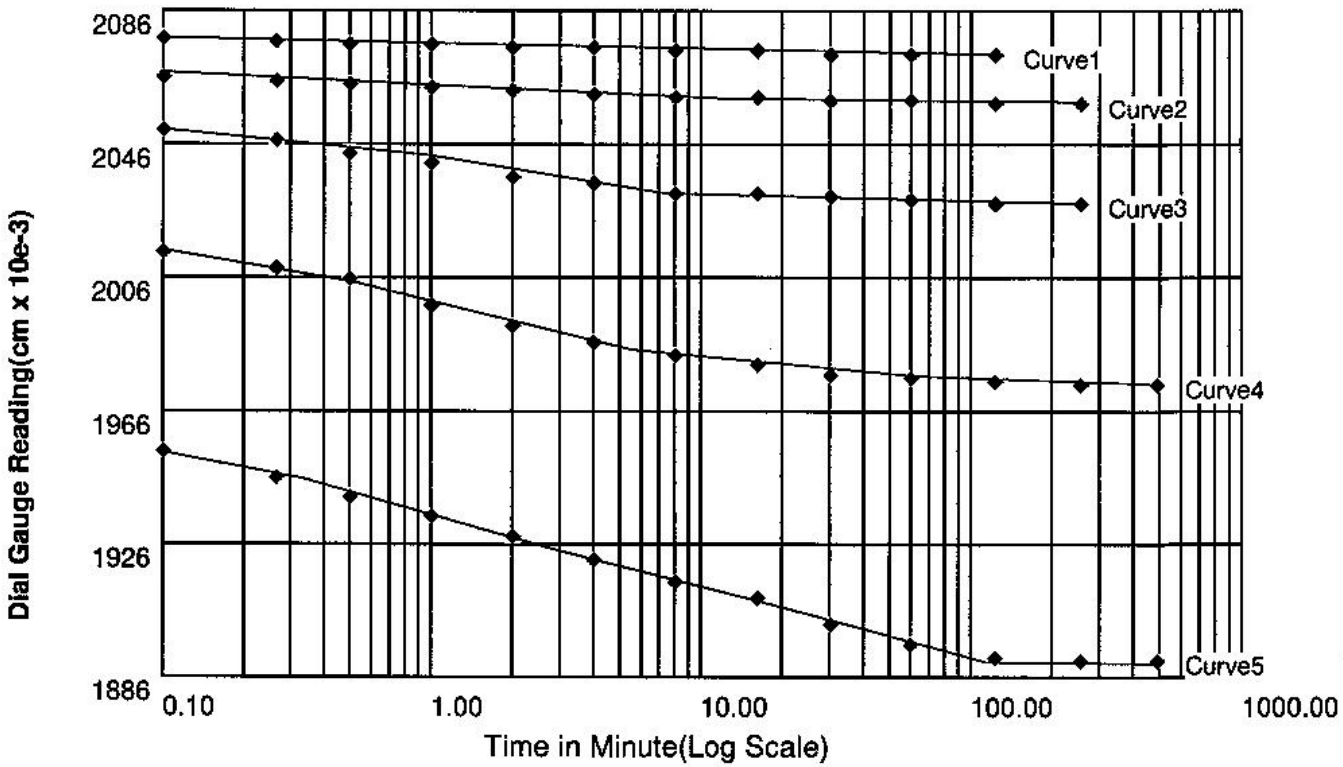
CONSOLIDATION TEST CURVES

Job No. :30796

SKM Geosurvey

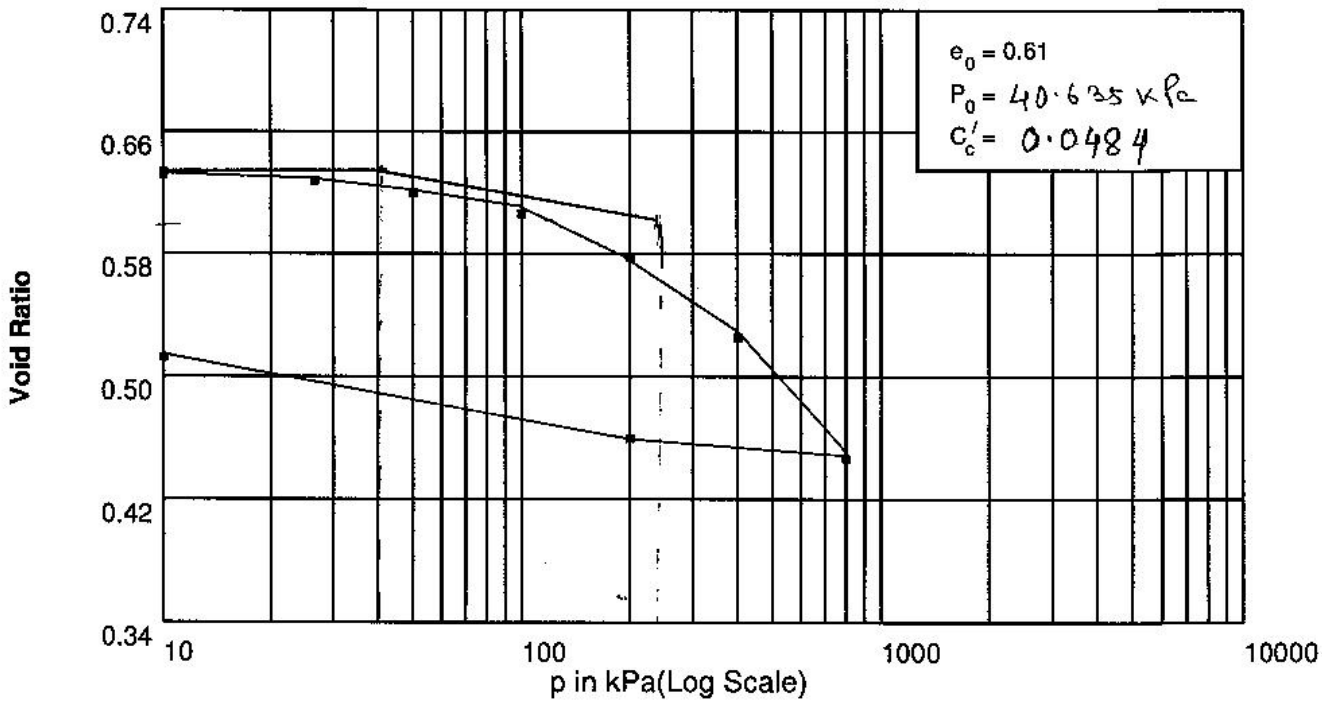
Borehole No :21 Depth(m) :4.50-4.95 Sample No. :120117

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)



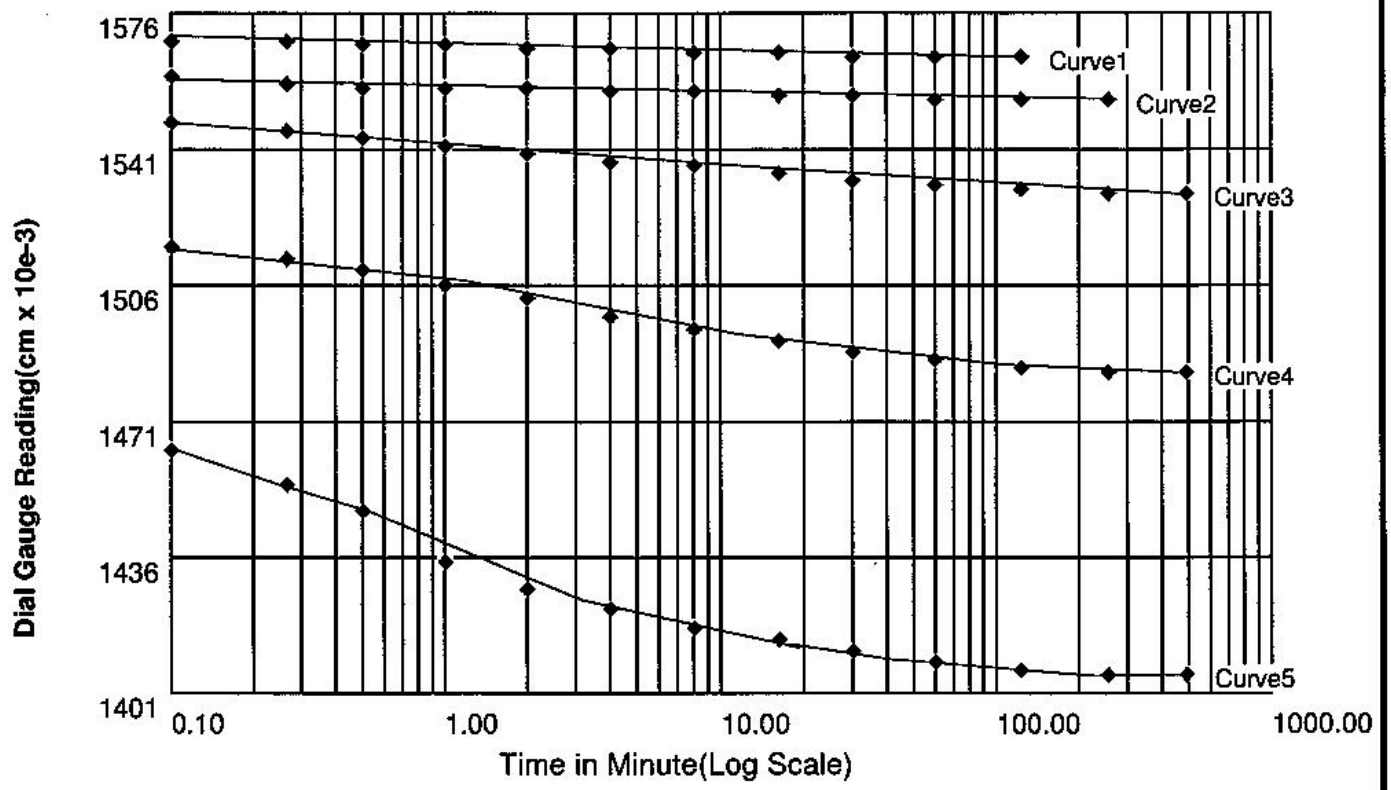
CONSOLIDATION TEST CURVES

Job No. :30796

SKM Geosurvey

Borehole No :22 Depth(m) :1.00-1.45 Sample No. :165101

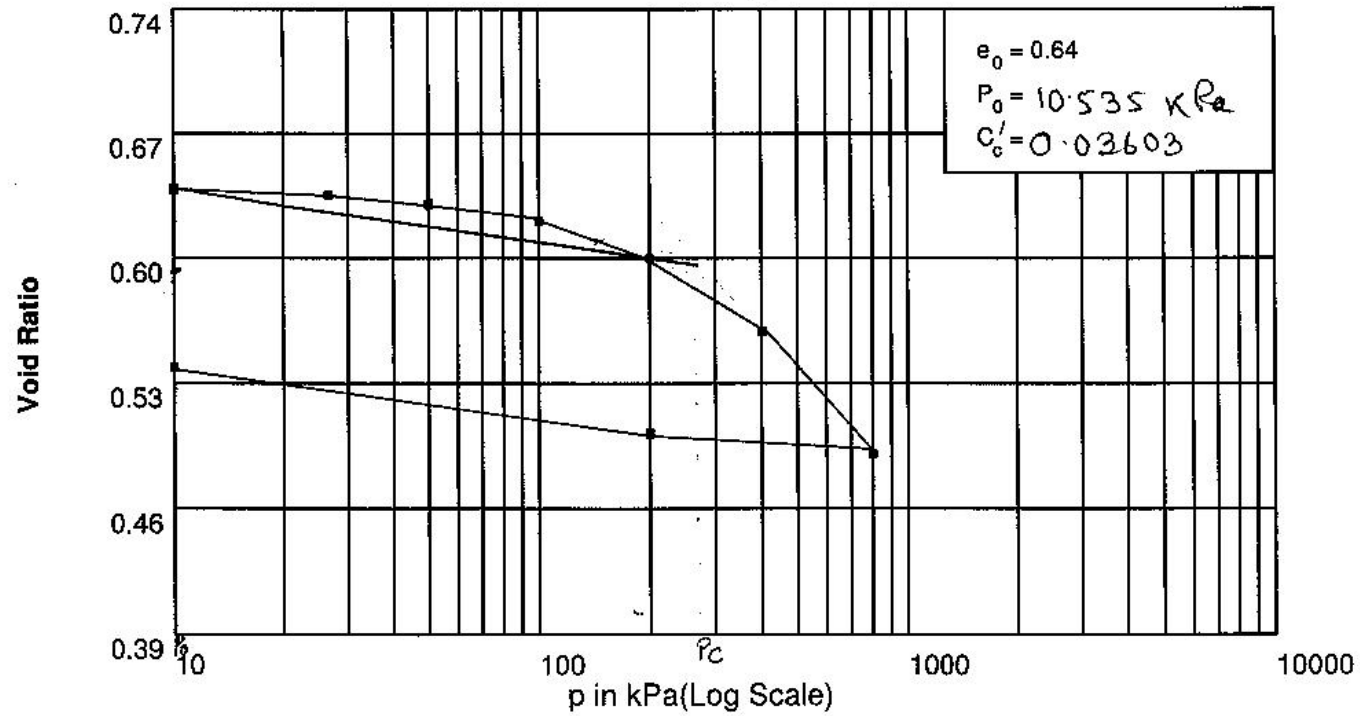
LOG TIME VS SETTLEMENT CURVE



◆ Curve1 :25 - 50 kPa ◆ Curve2 :50 - 100 kPa ◆ Curve3 :100 - 200 kPa

◆ Curve4 :200 - 400 kPa ◆ Curve5 :400 - 800 kPa

e Vs LOG(P)



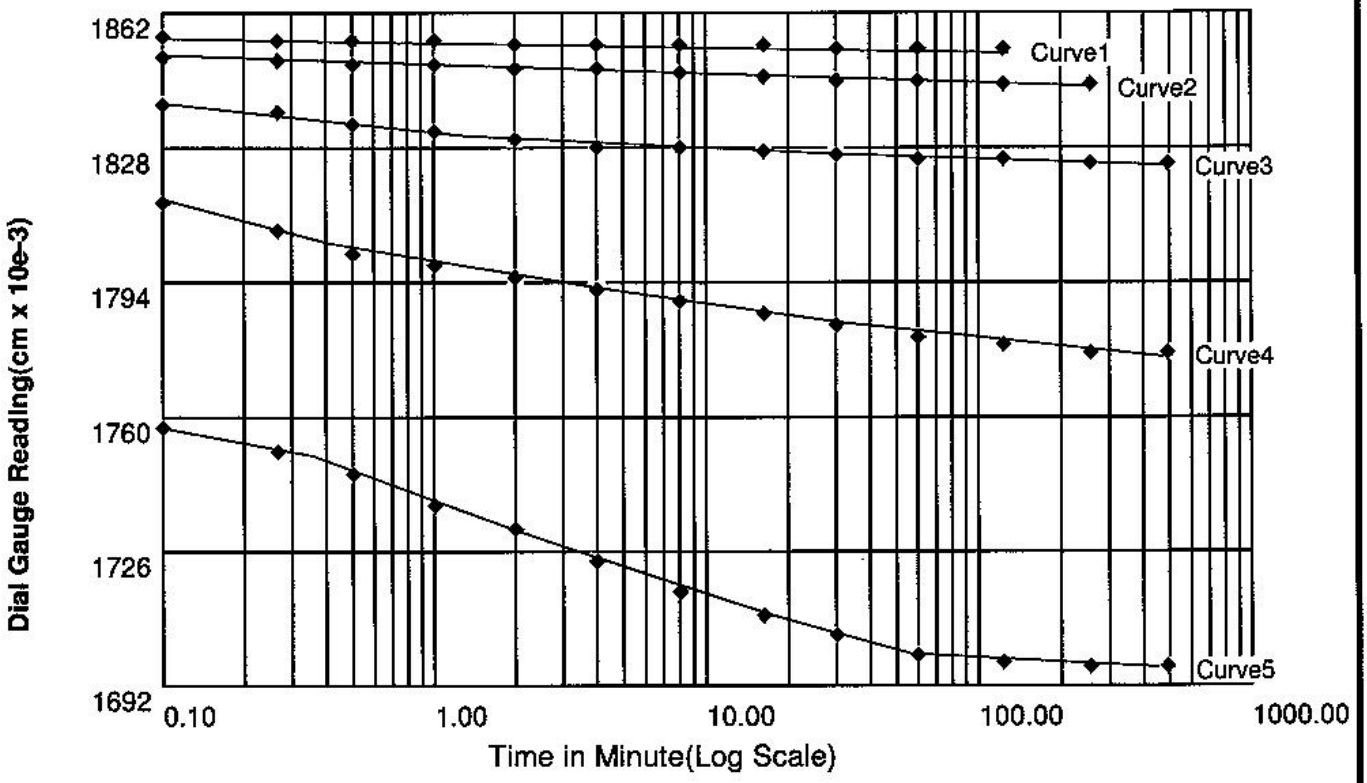
CONSOLIDATION TEST CURVES

Job No. :30796

SKM Geosurvey

Borehole No :23 Depth(m) :1.00-1.45 Sample No. :100251

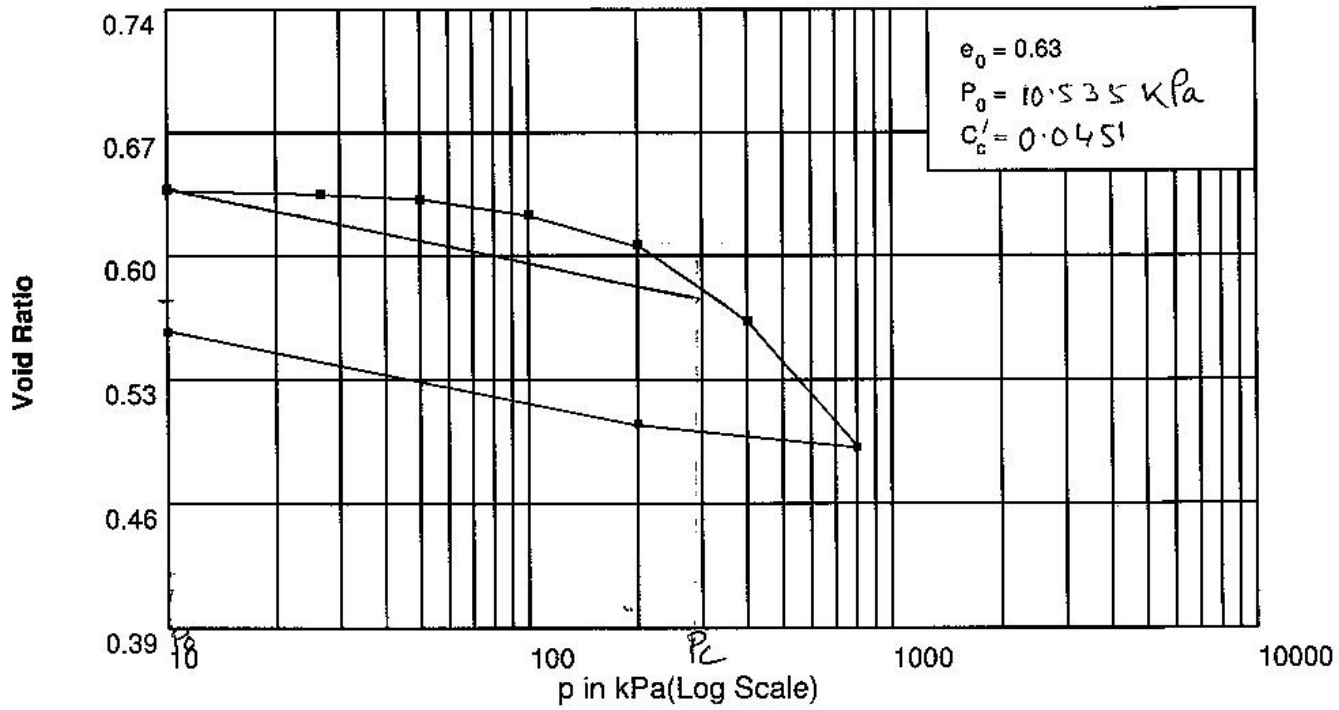
LOG TIME VS SETTLEMENT CURVE



◆ Curve1 :25 - 50 kPa ◆ Curve2 :50 - 100 kPa ◆ Curve3 :100 - 200 kPa

◆ Curve4 :200 - 400 kPa ◆ Curve5 :400 - 800 kPa

e Vs LOG(P)



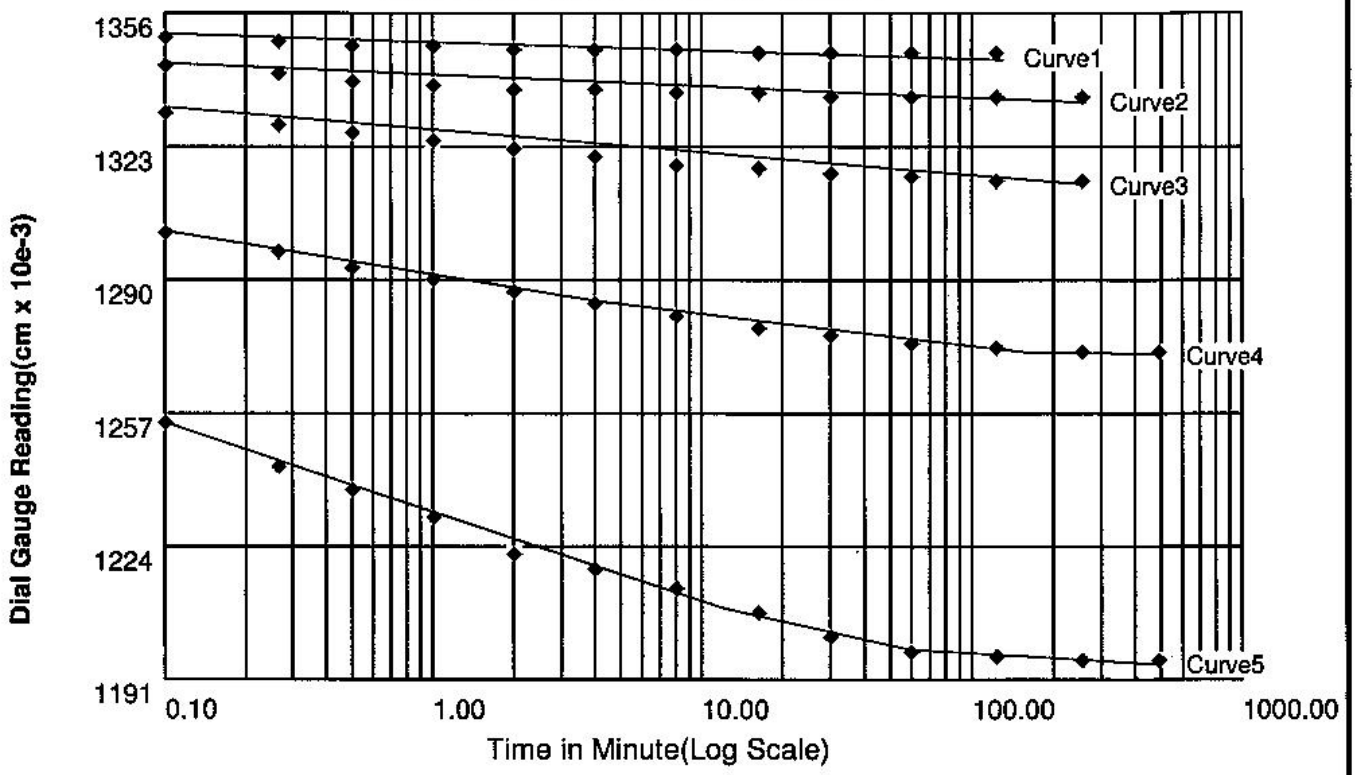
CONSOLIDATION TEST CURVES

Job No. :30796

SKM Geosurvey

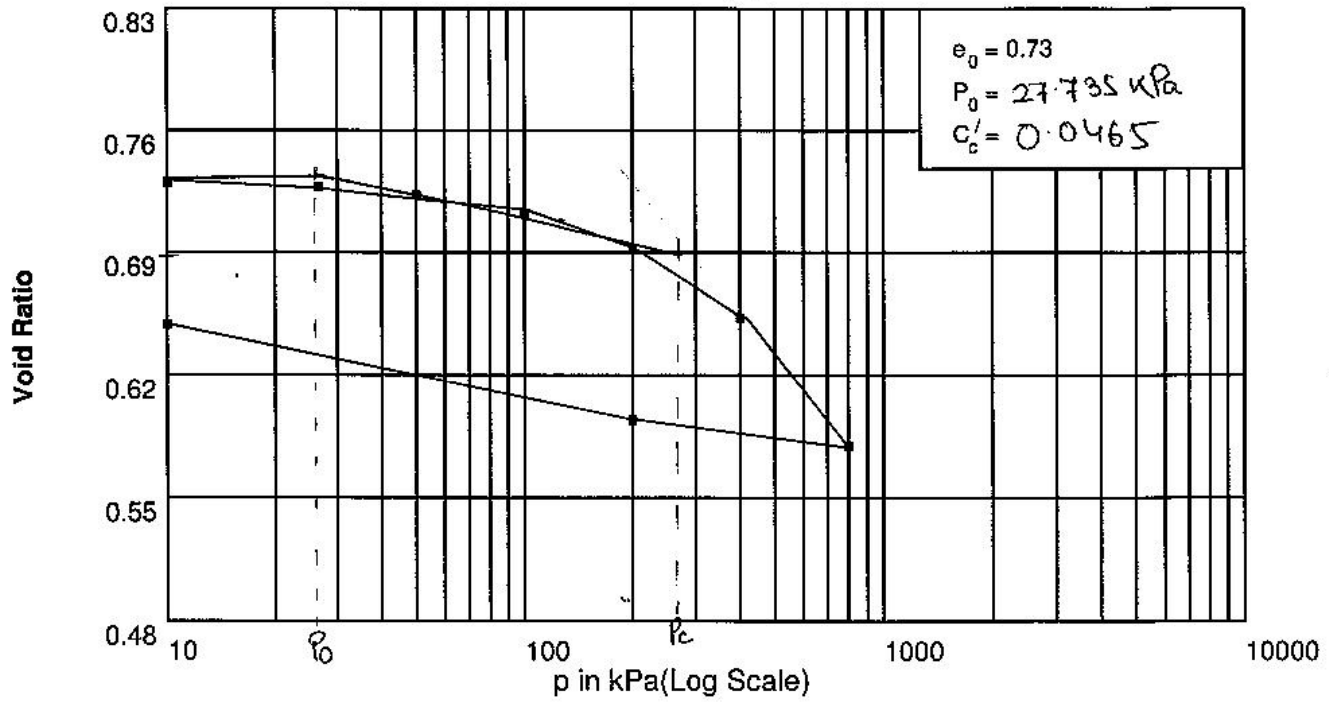
Borehole No :24 Depth(m) :3.00-3.45 Sample No. :100106

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)



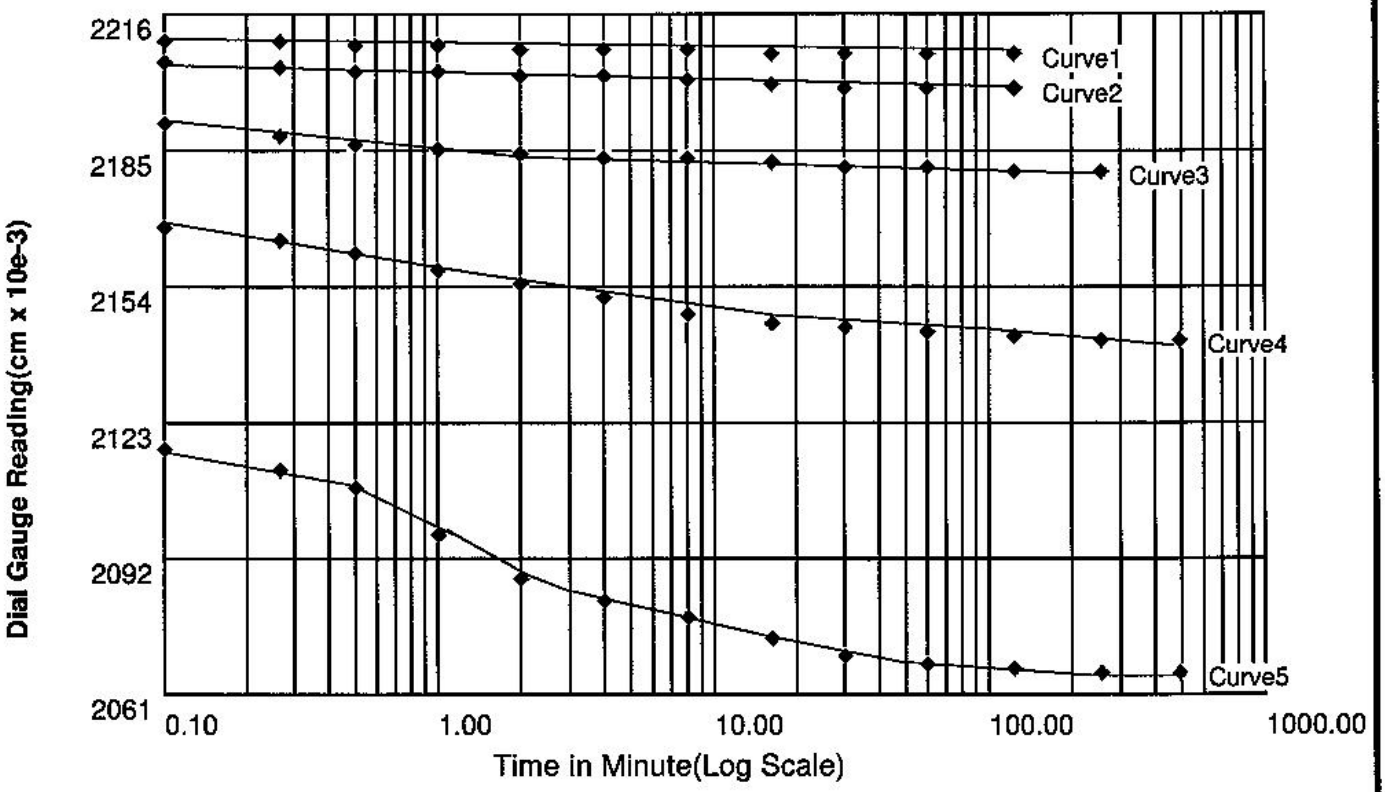
CONSOLIDATION TEST CURVES

Job No. :30796

SKM Geosurvey

Borehole No :25 Depth(m) :6.00-6.45 Sample No. :170027

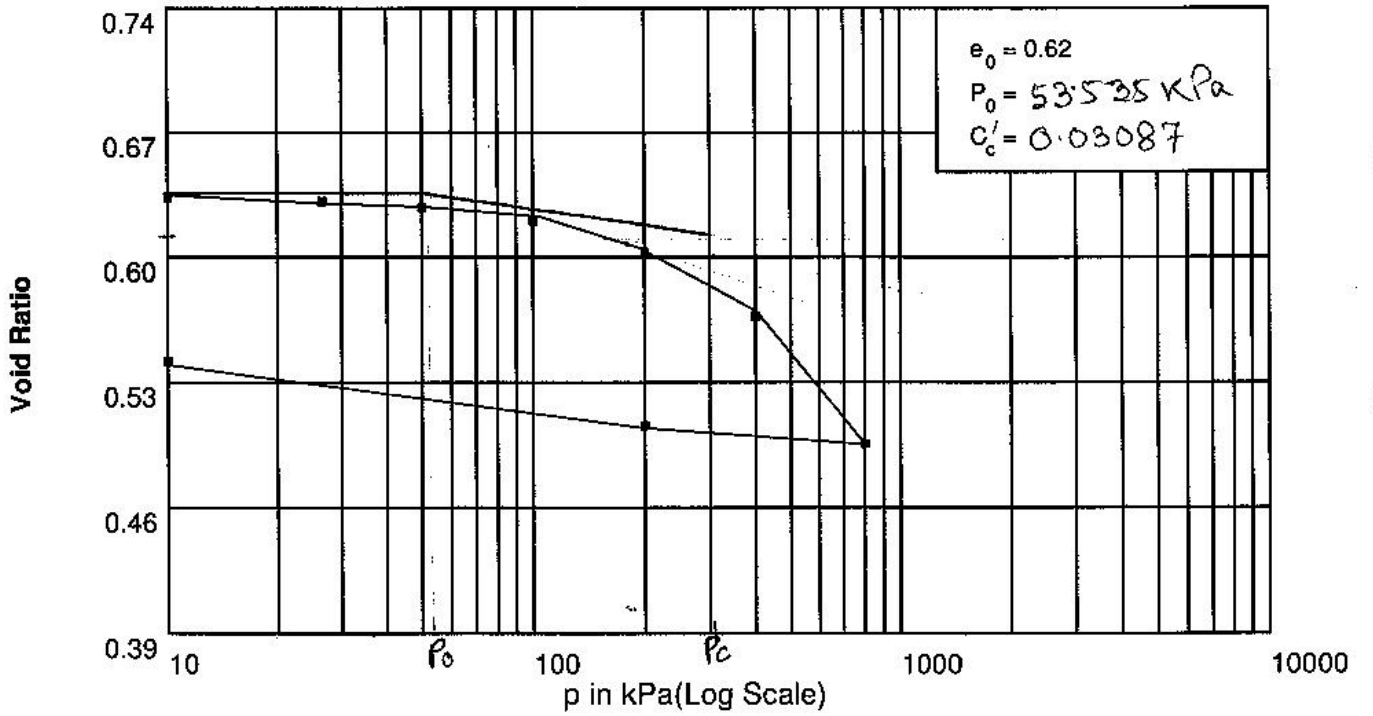
LOG TIME VS SETTLEMENT CURVE



◆ Curve1 :25 - 50 kPa ◆ Curve2 :50 - 100 kPa ◆ Curve3 :100 - 200 kPa

◆ Curve4 :200 - 400 kPa ◆ Curve5 :400 - 800 kPa

e Vs LOG(P)



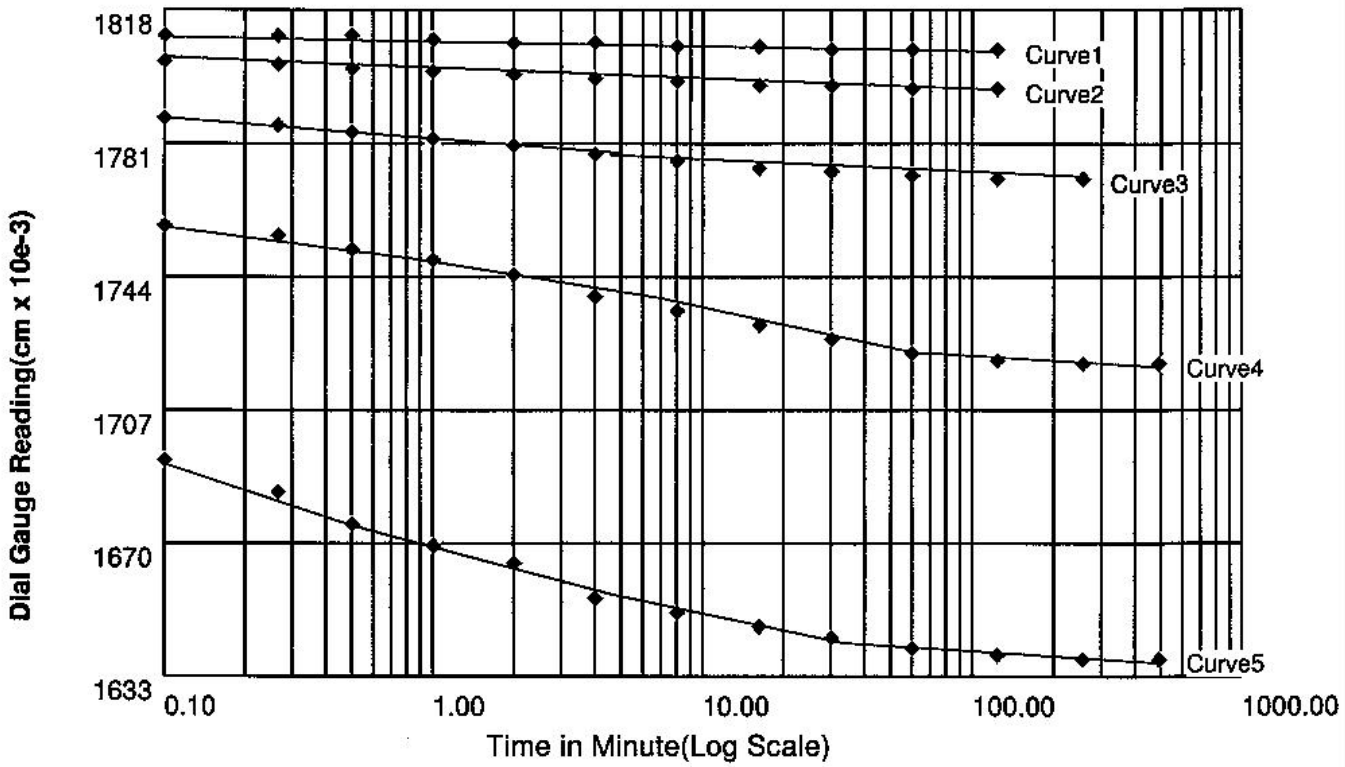
CONSOLIDATION TEST CURVES

Job No. :30796

SKM Geosurvey

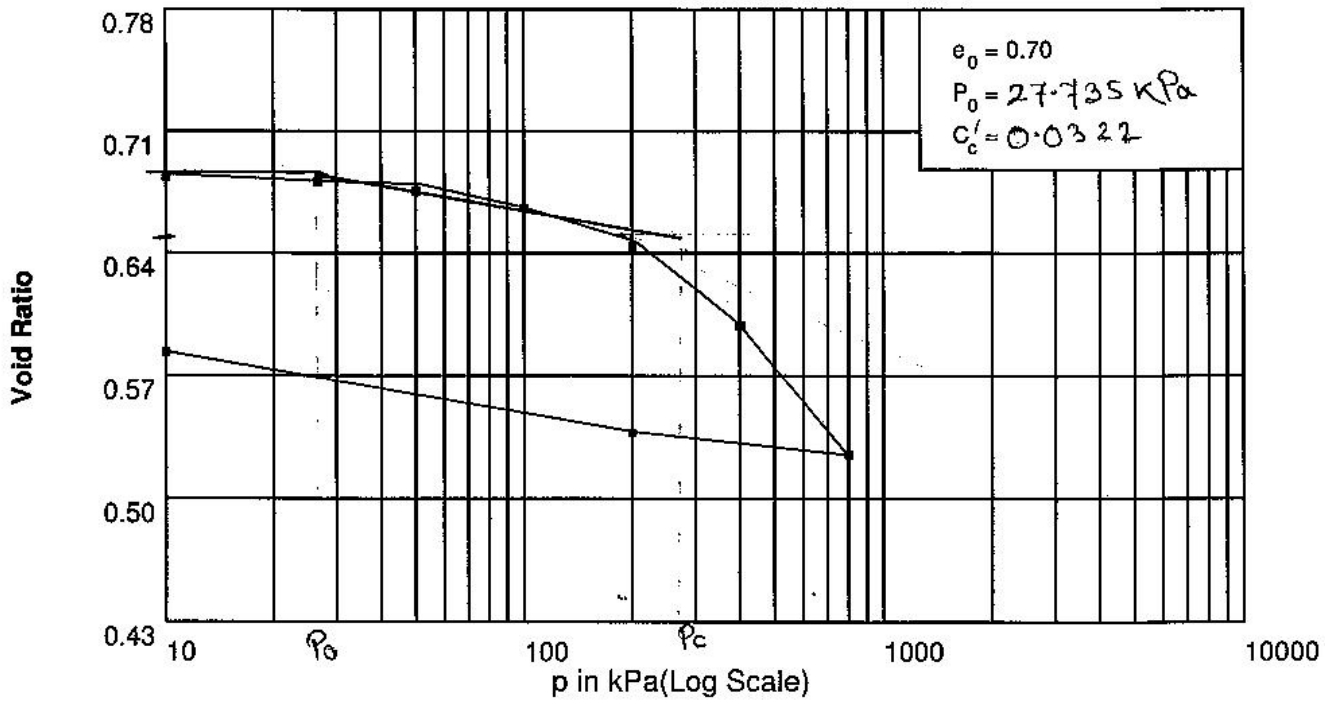
Borehole No :26 Depth(m) :3.00-3.45 Sample No. :182160

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)



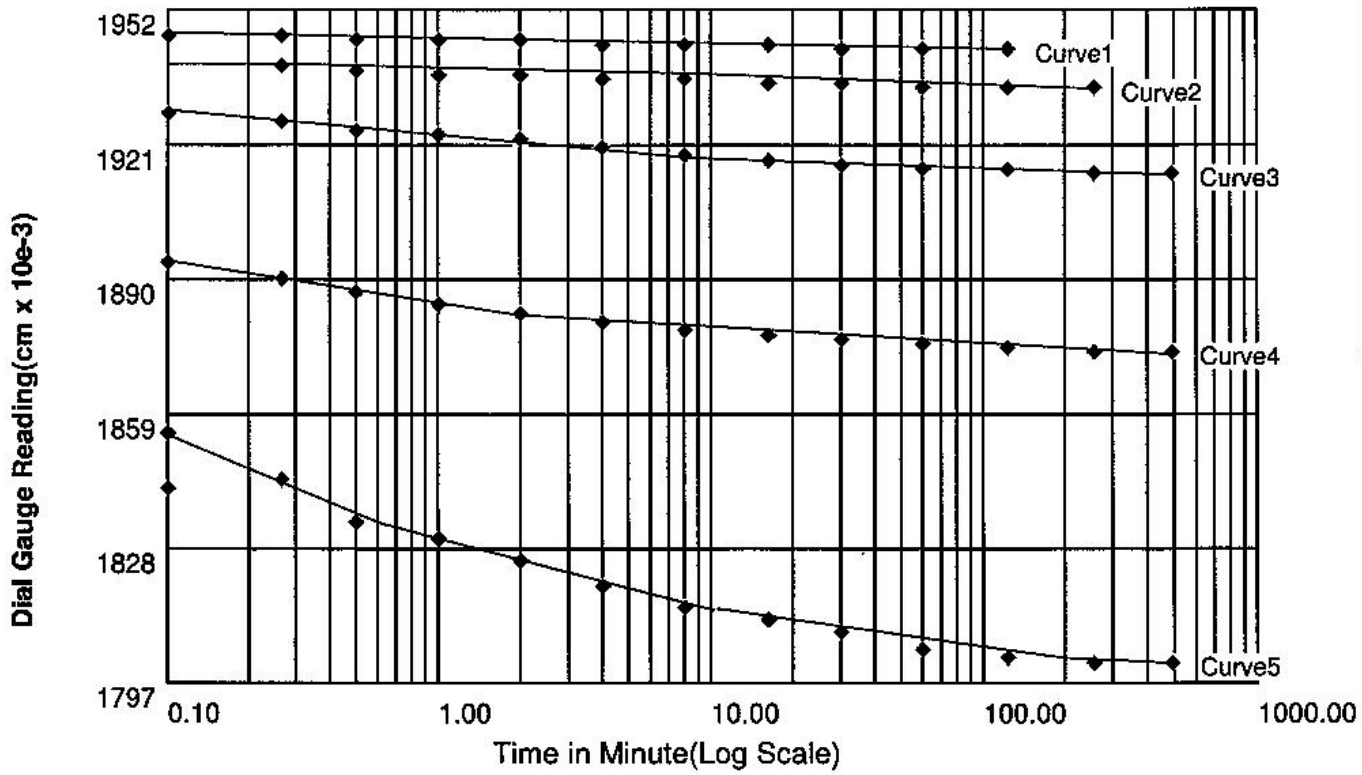
CONSOLIDATION TEST CURVES

Job No. :30796

SKM Geosurvey

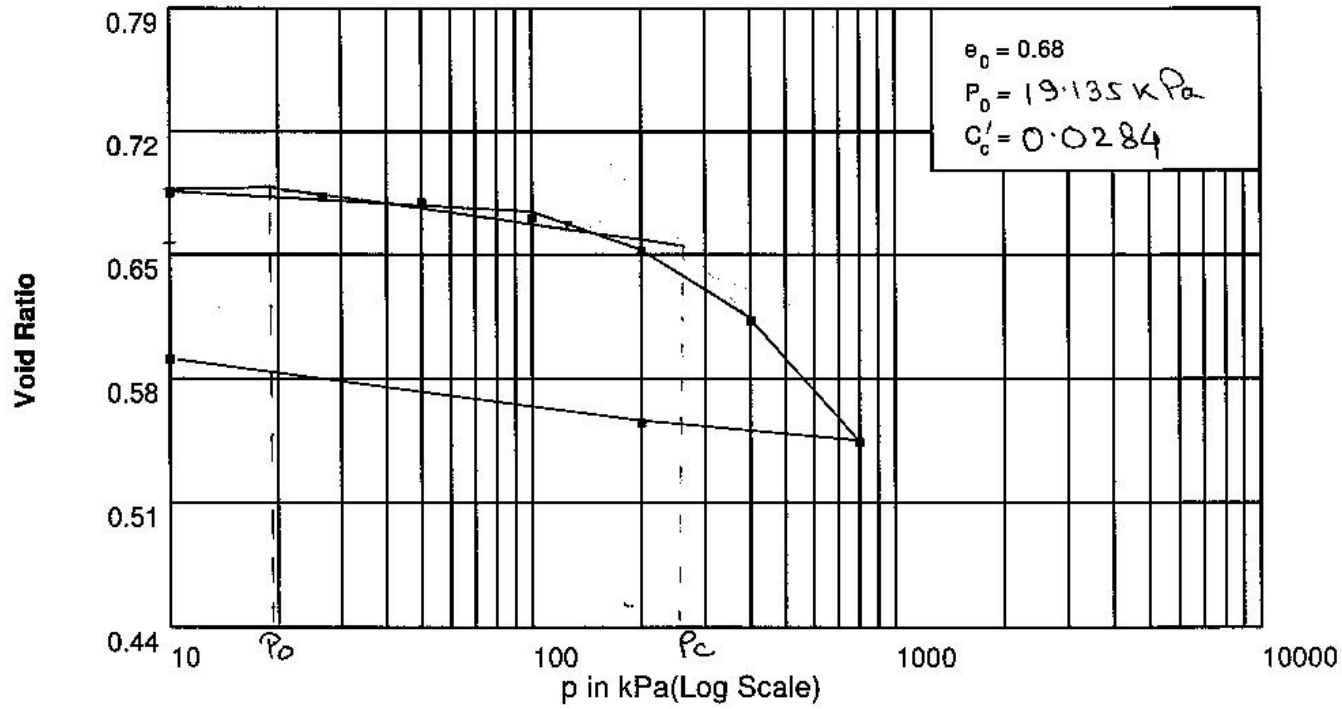
Borehole No :27 Depth(m) :2.00-2.45 Sample No. :170663

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)

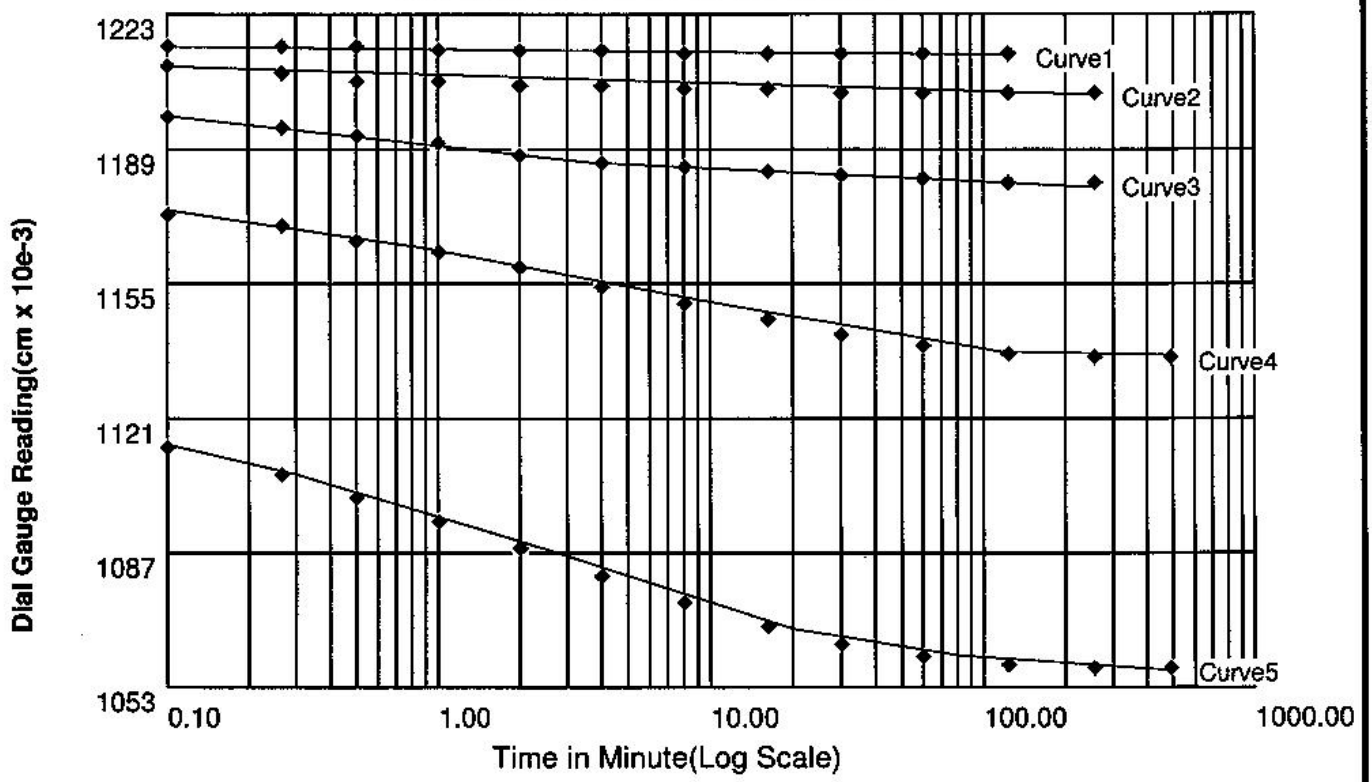


CONSOLIDATION TEST CURVES

Job No. :30796

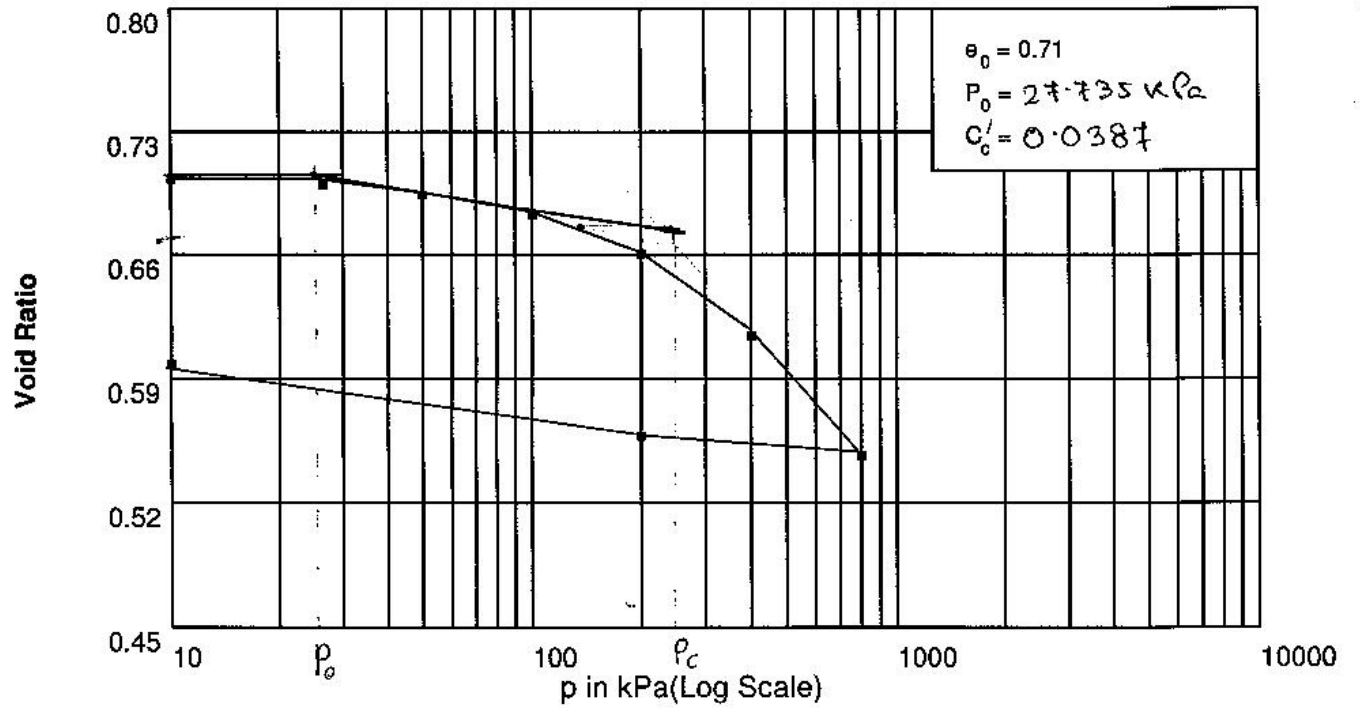
Borehole No :28 Depth(m) :3.00-3.45 Sample No. :160775

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)



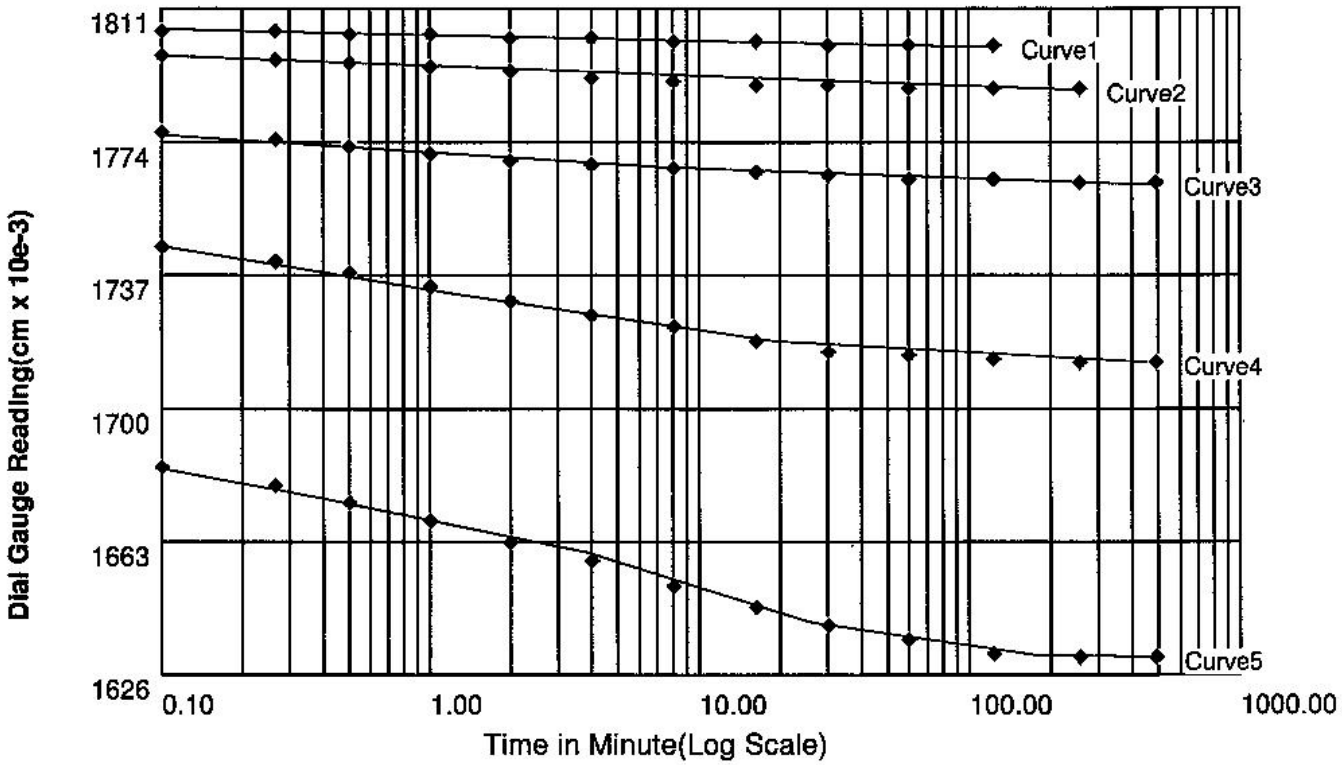
CONSOLIDATION TEST CURVES

Job No. :30796

SKM Geosurvey

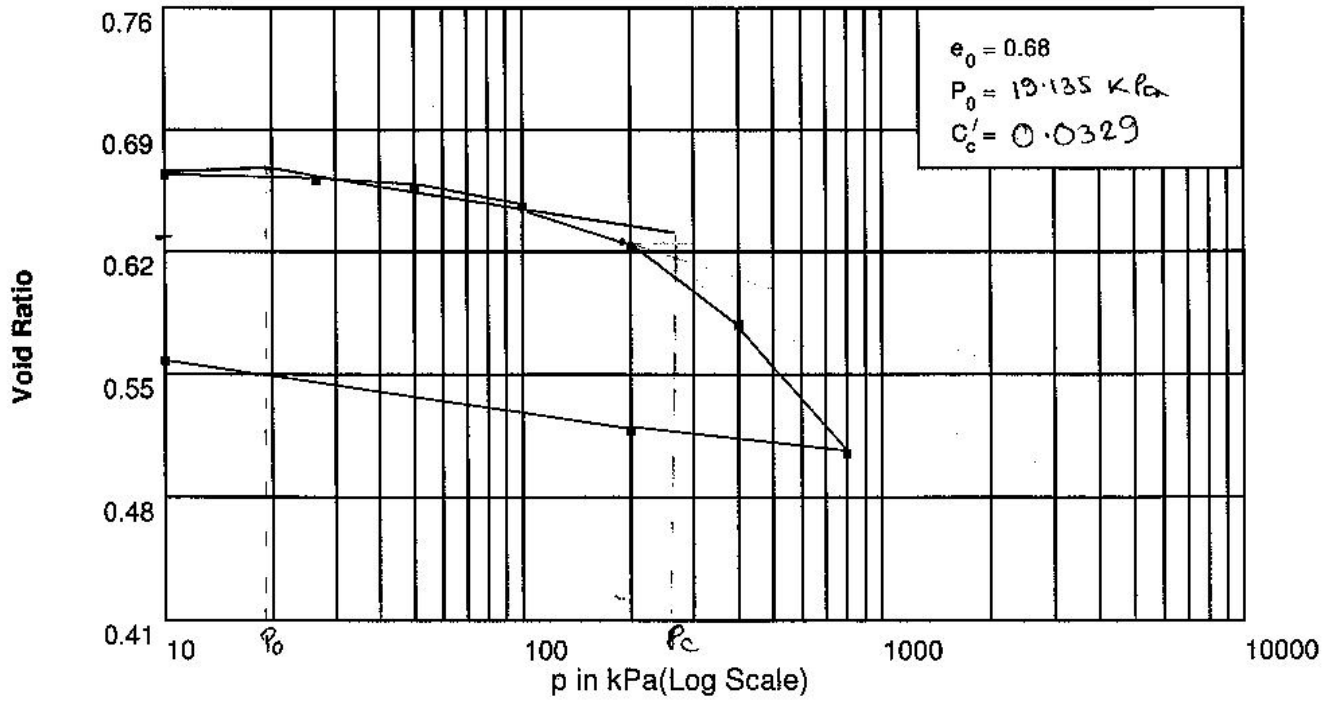
Borehole No :29 | Depth(m) :2.00-2.45 | Sample No. :130154

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)



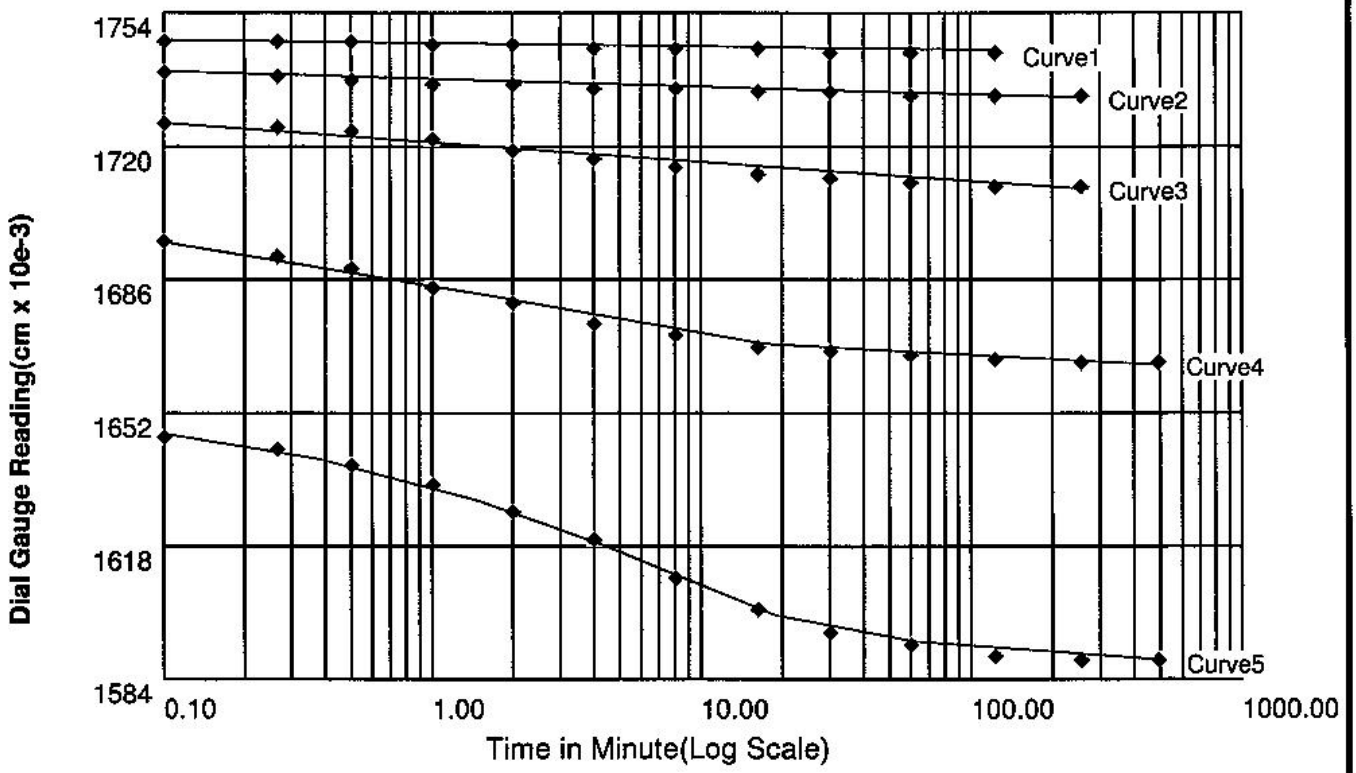
CONSOLIDATION TEST CURVES

Job No. :30796

SKM Geosurvey

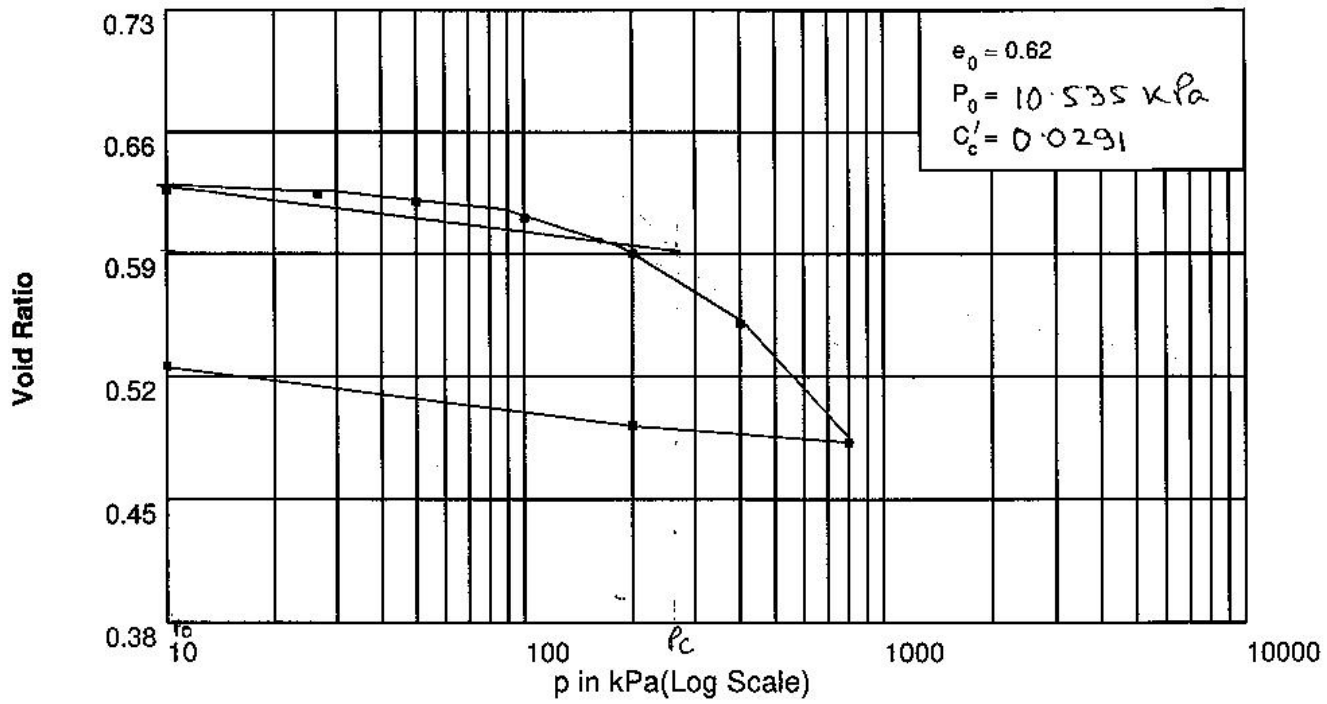
Borehole No :30 Depth(m) :1.00-1.45 Sample No. :180111

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)



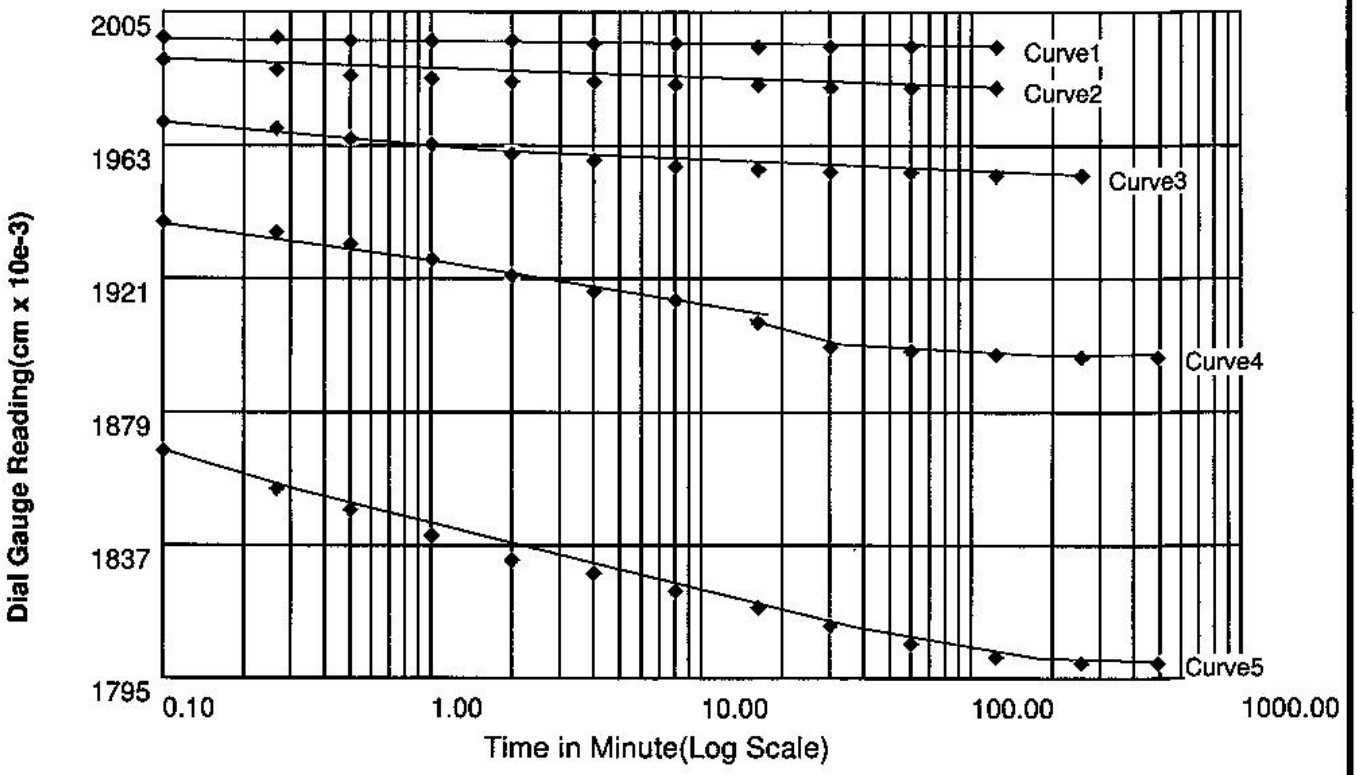
CONSOLIDATION TEST CURVES

Job No. :30796

SKM Geosurvey

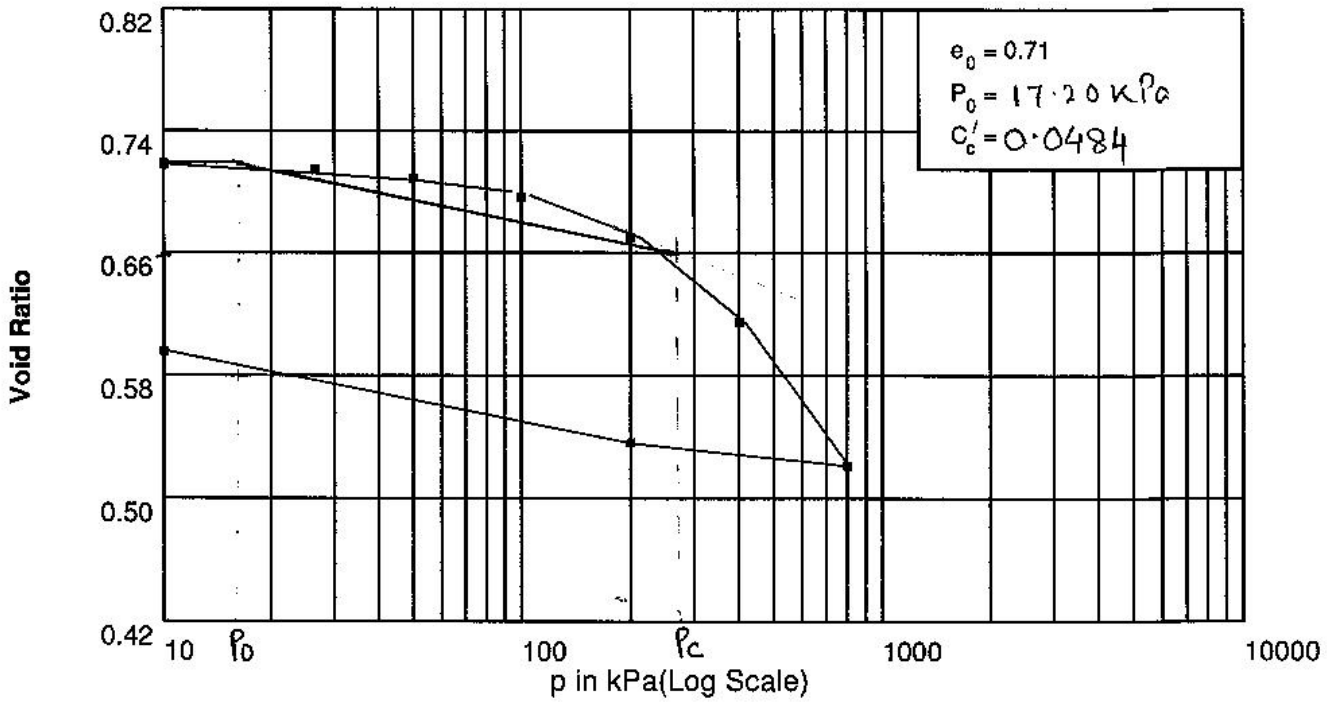
Borehole No :TP-3 Depth(m) :2.00 Sample No. :106101

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)



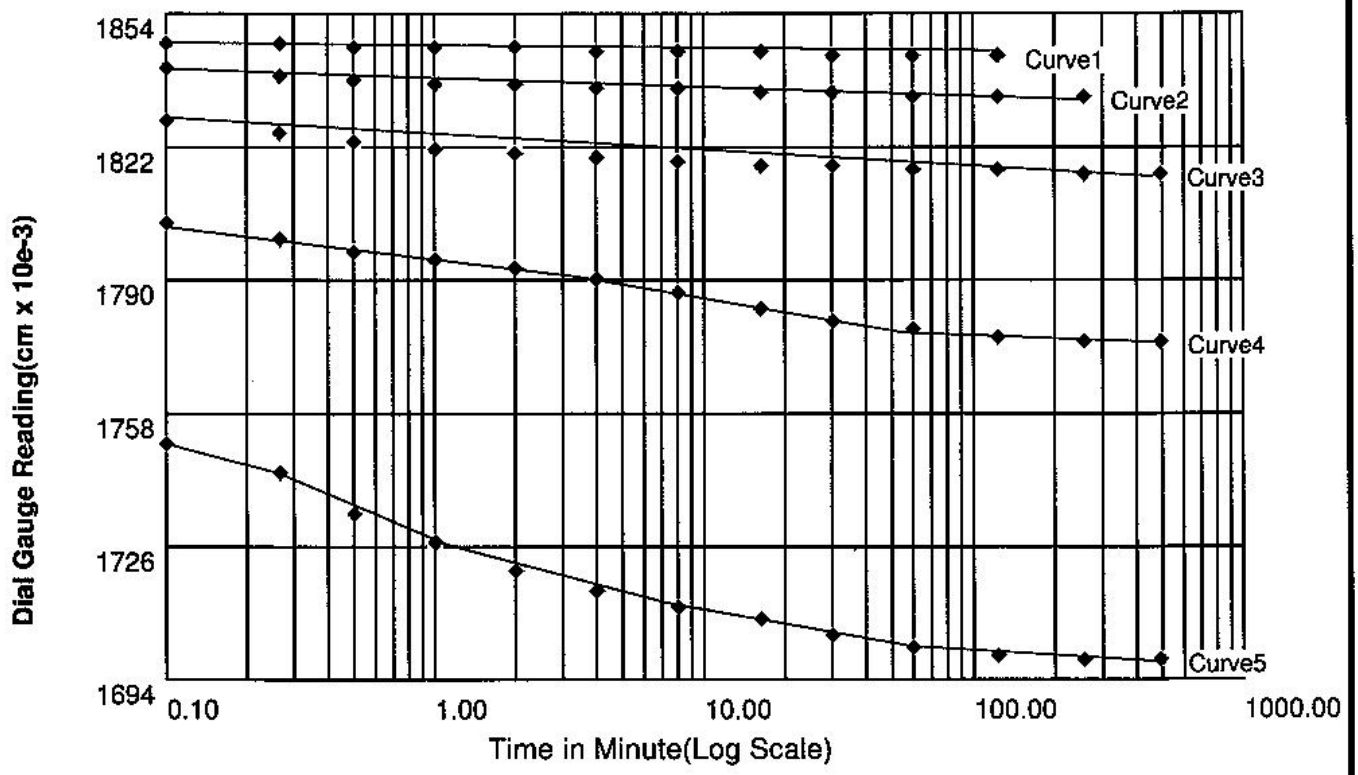
CONSOLIDATION TEST CURVES

Job No. :30796-

SKM Geosurvey

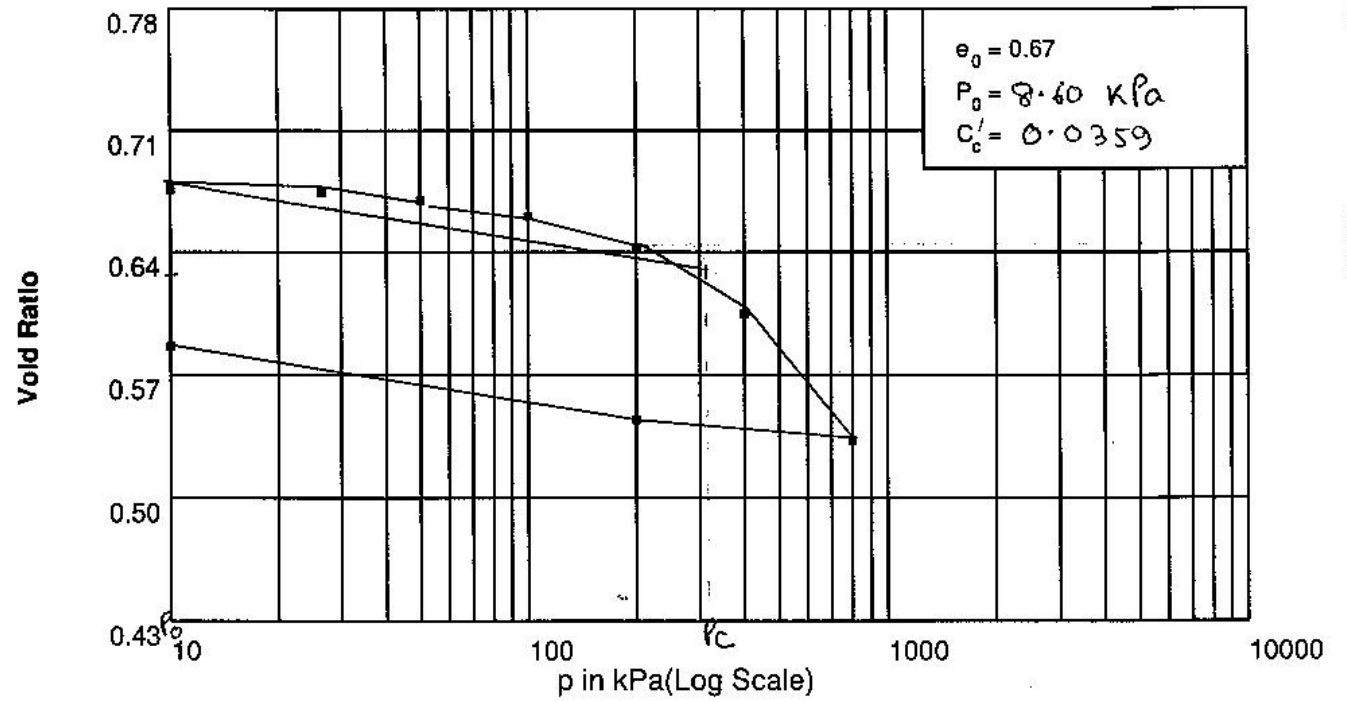
Borehole No :TP-6 Depth(m) :1.00 Sample No. :171620

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)



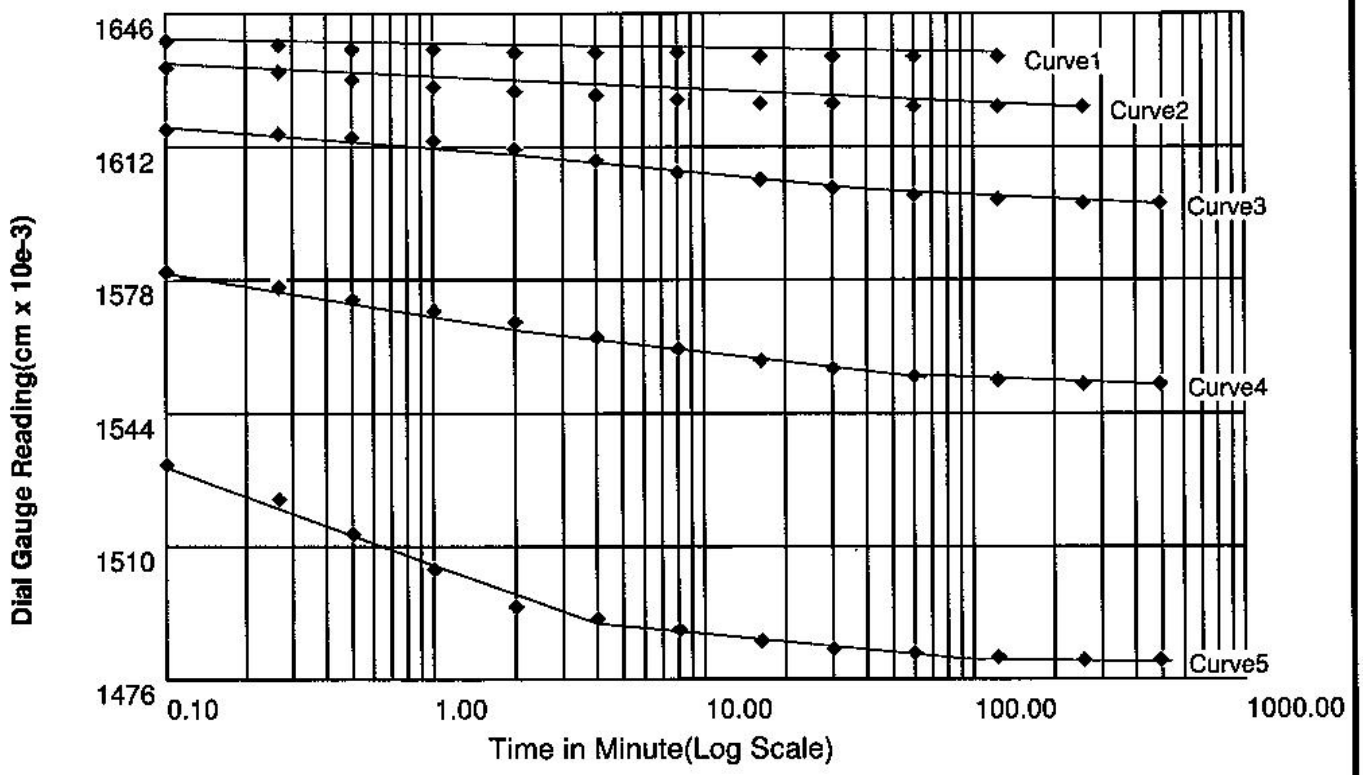
CONSOLIDATION TEST CURVES

Job No. :30796-

SKM Geosurvey

Borehole No :TP-9 Depth(m) :3.00 Sample No. :120152

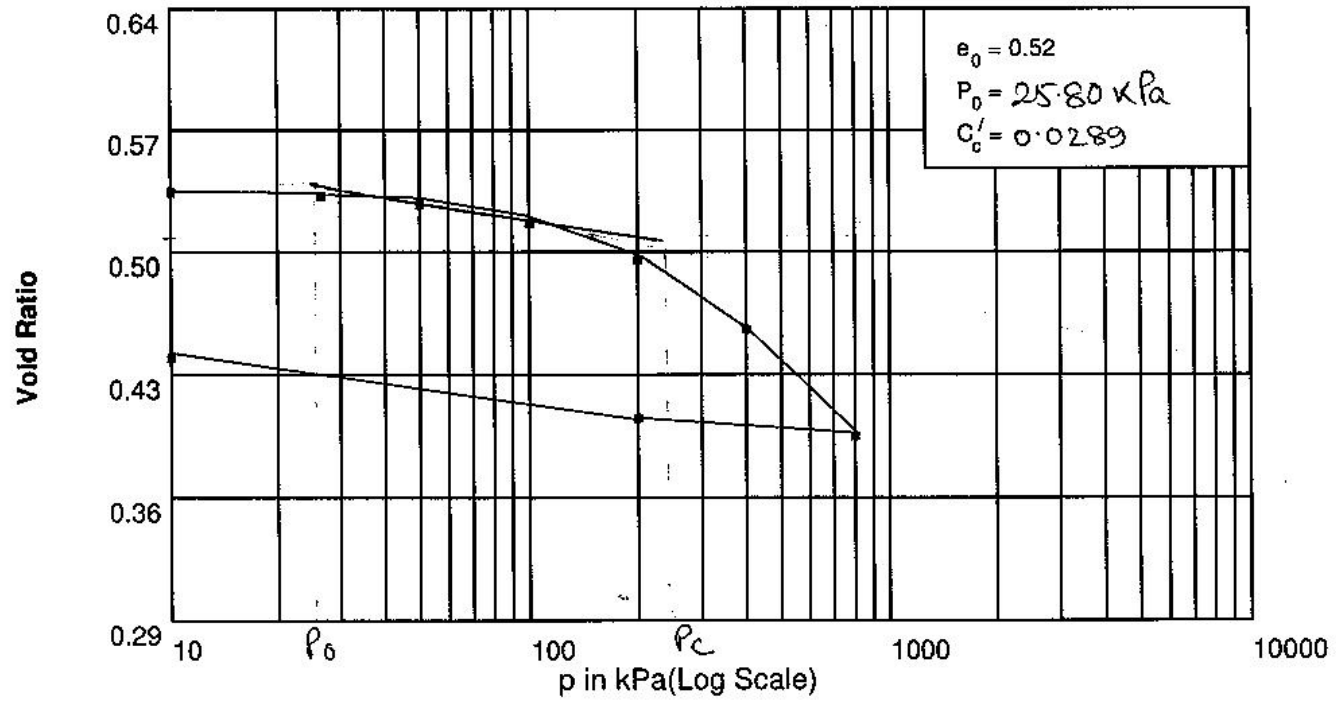
LOG TIME VS SETTLEMENT CURVE



◆ Curve1 :25 - 50 kPa ◆ Curve2 :50 - 100 kPa ◆ Curve3 :100 - 200 kPa

◆ Curve4 :200 - 400 kPa ◆ Curve5 :400 - 800 kPa

e Vs LOG(P)



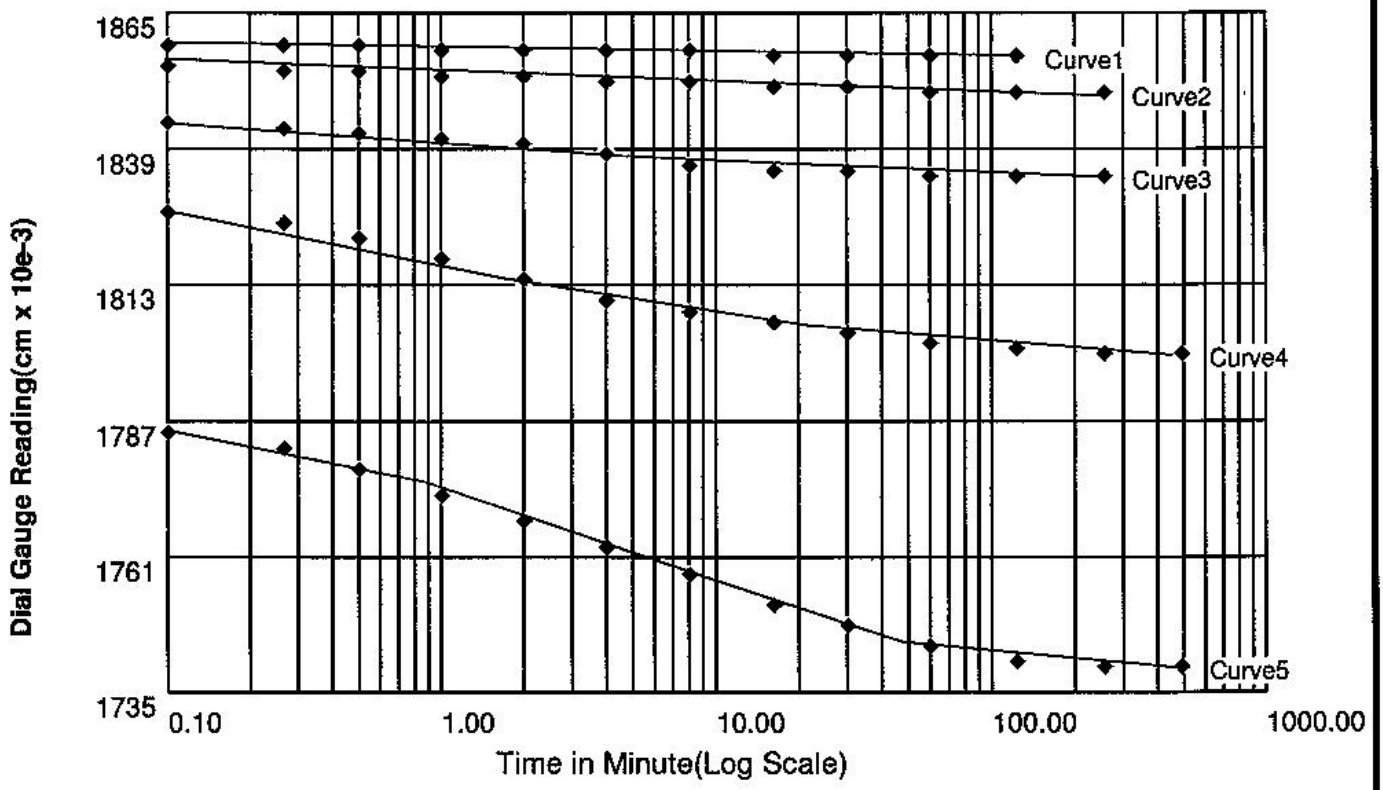
CONSOLIDATION TEST CURVES

Job No. :30796-

SKM Geosurvey

Borehole No :TP-12 Depth(m) :3.00 Sample No. :106114

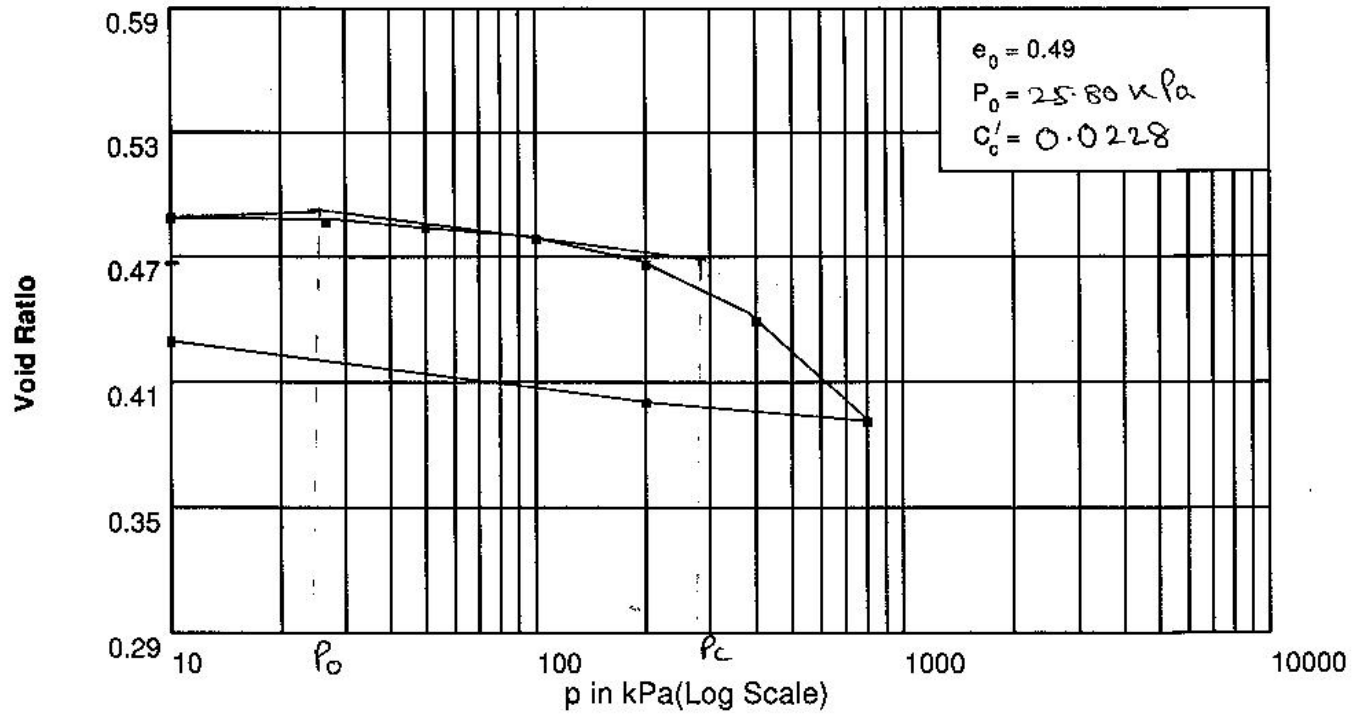
LOG TIME VS SETTLEMENT CURVE



◆ Curve1 :25 - 50 kPa ◆ Curve2 :50 - 100 kPa ◆ Curve3 :100 - 200 kPa

◆ Curve4 :200 - 400 kPa ◆ Curve5 :400 - 800 kPa

e Vs LOG(P)



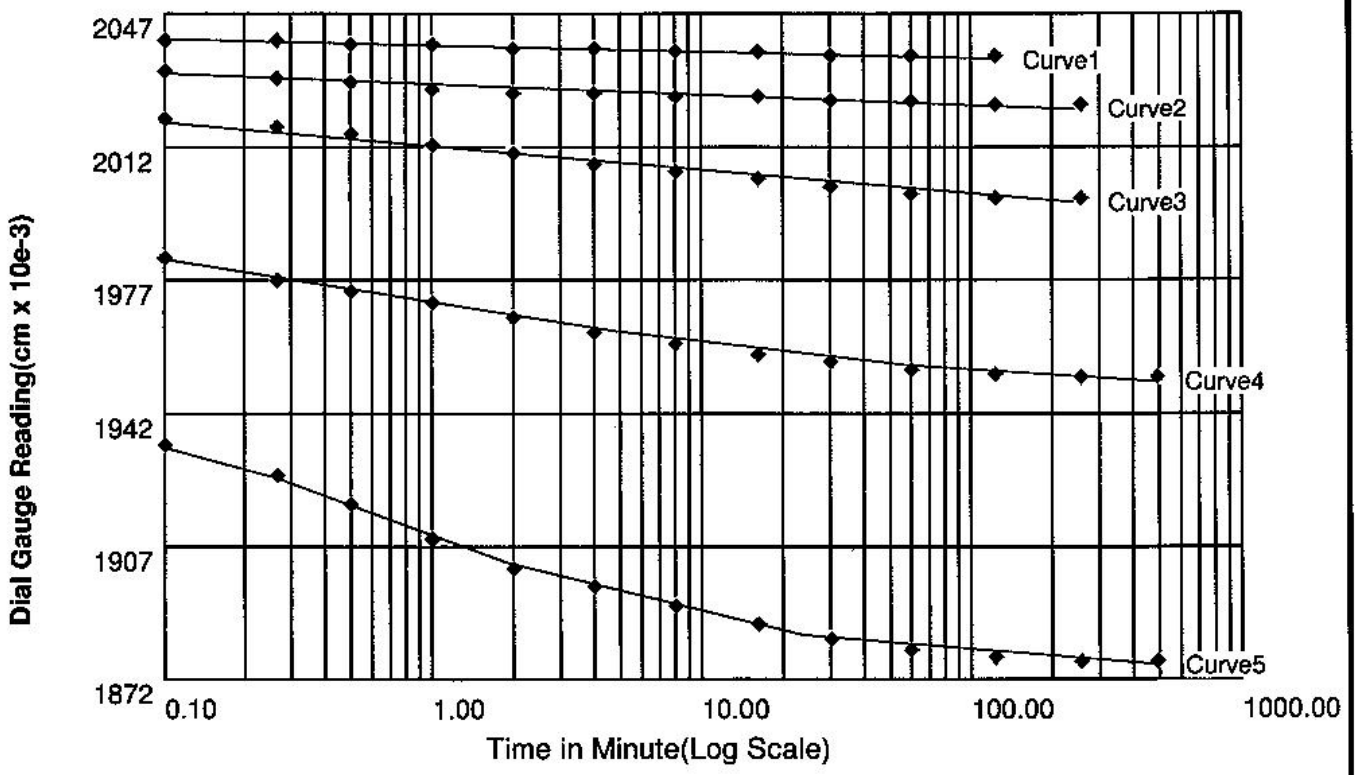
CONSOLIDATION TEST CURVES

Job No. :30796-

SKM Geosurvey

Borehole No :TP-15 Depth(m) :1.00 Sample No. :106108

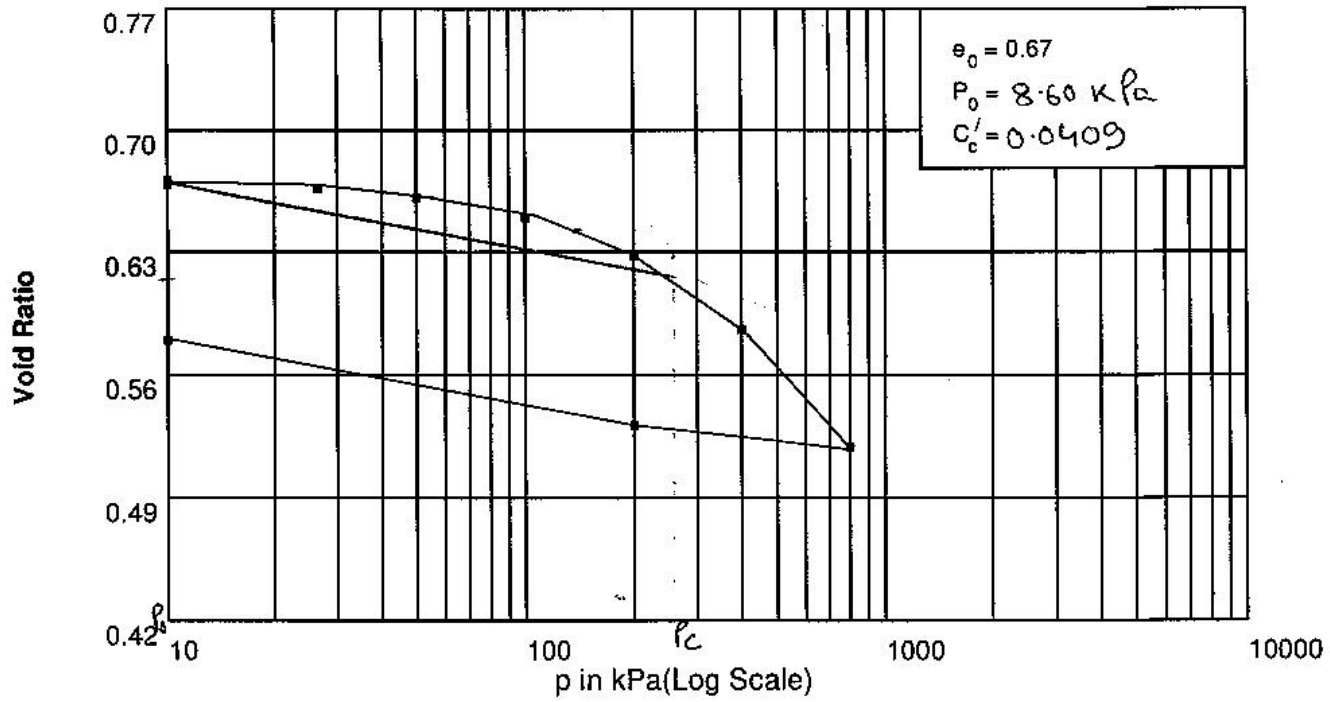
LOG TIME VS SETTLEMENT CURVE



◆ Curve1 :25 - 50 kPa ◆ Curve2 :50 - 100 kPa ◆ Curve3 :100 - 200 kPa

◆ Curve4 :200 - 400 kPa ◆ Curve5 :400 - 800 kPa

e Vs LOG(P)

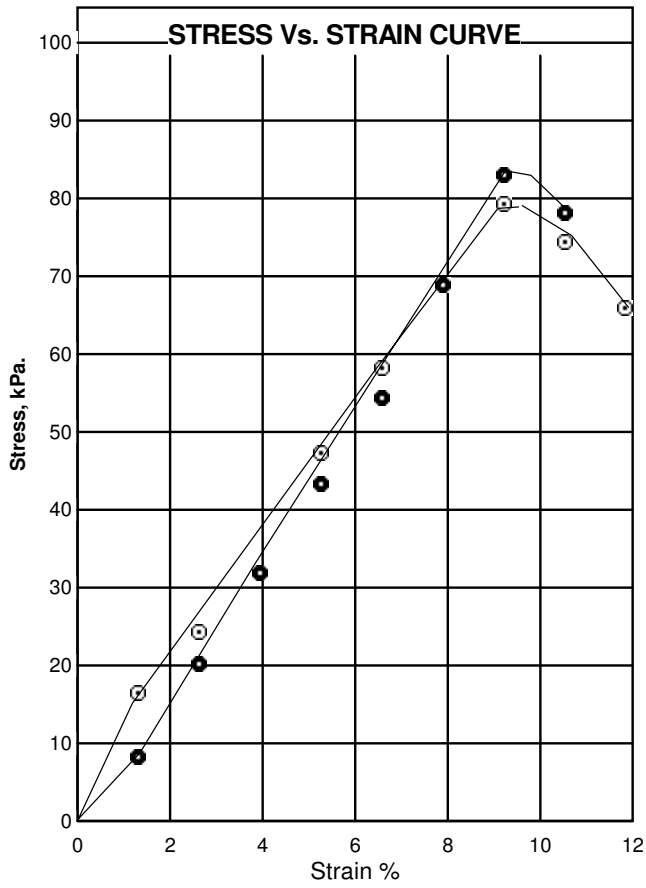


CONSOLIDATION TEST CURVES

Job No. :30796-

Sample Number : 177121
Sample Depth : 1.00 - 1.45m.
Bore Hole Number : 1

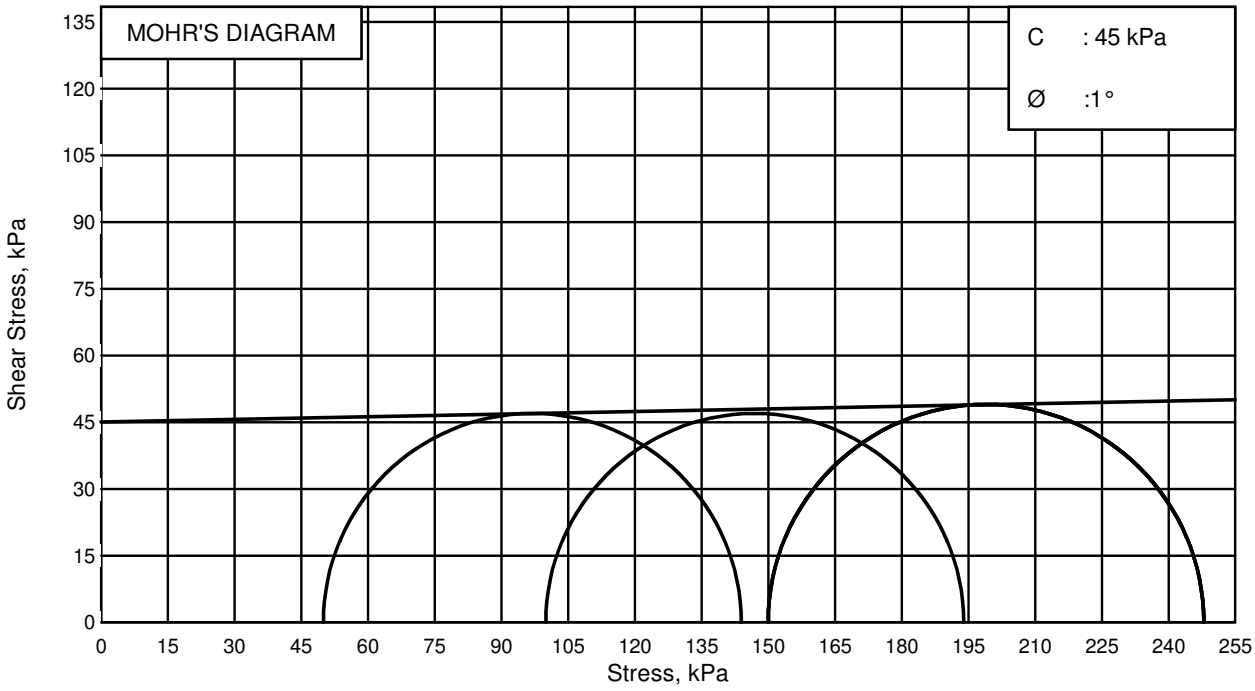
Site :
Type of Test : uu



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

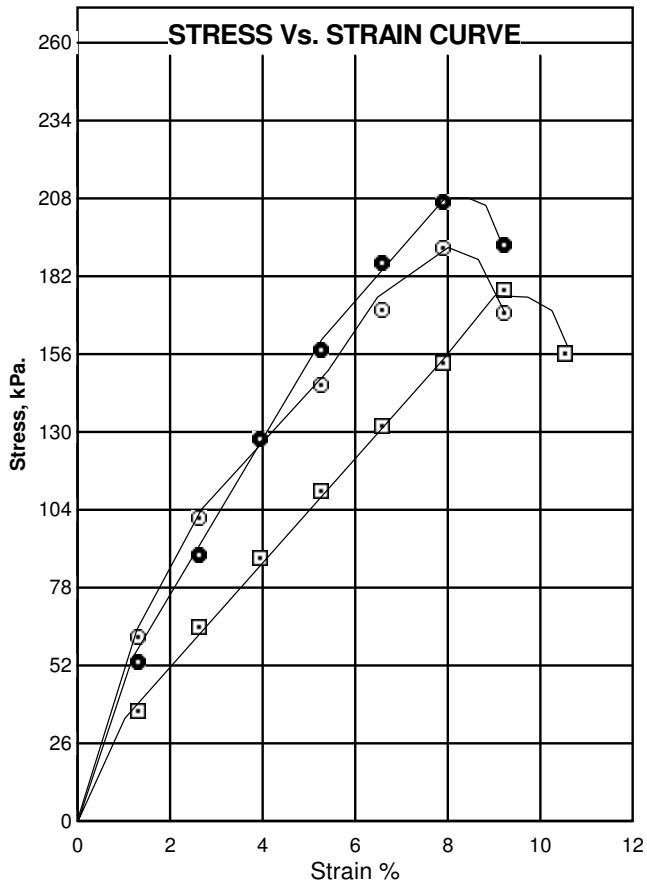


TRIAXIAL TEST CURVES

Job No. : 30796

Sample Number : 177128
Sample Depth : 6.00 - 6.45m.
Bore Hole Number : 1

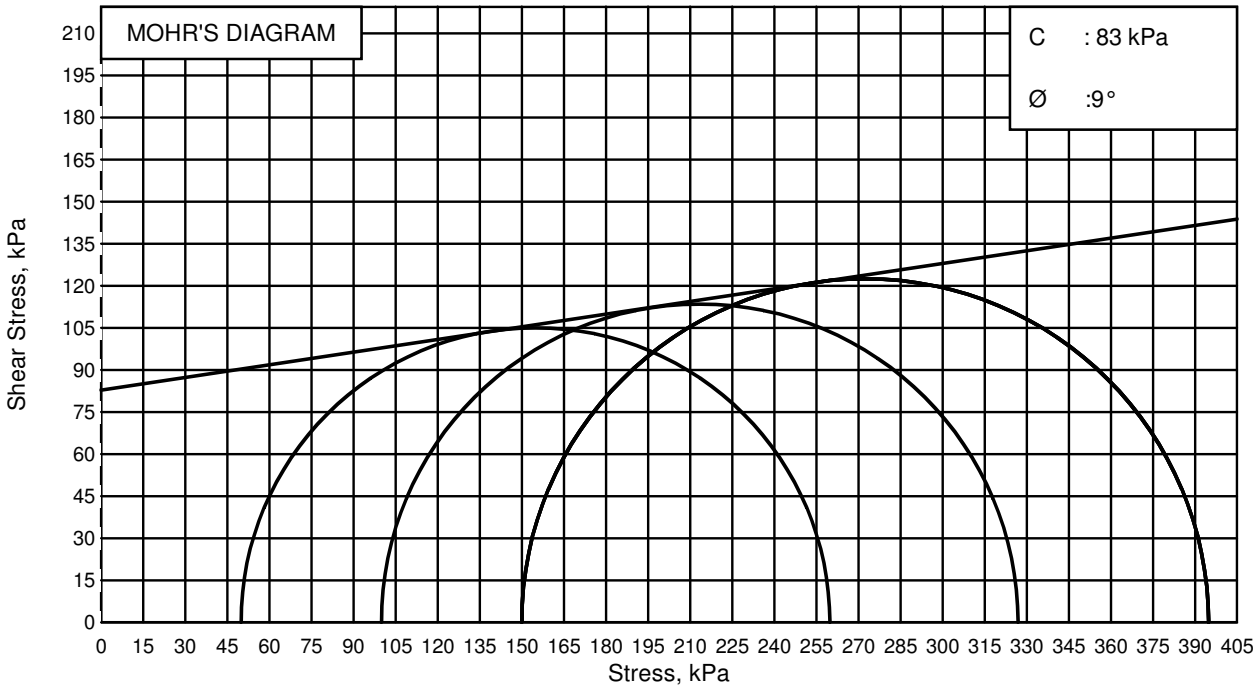
Site :
Type of Test : uu



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

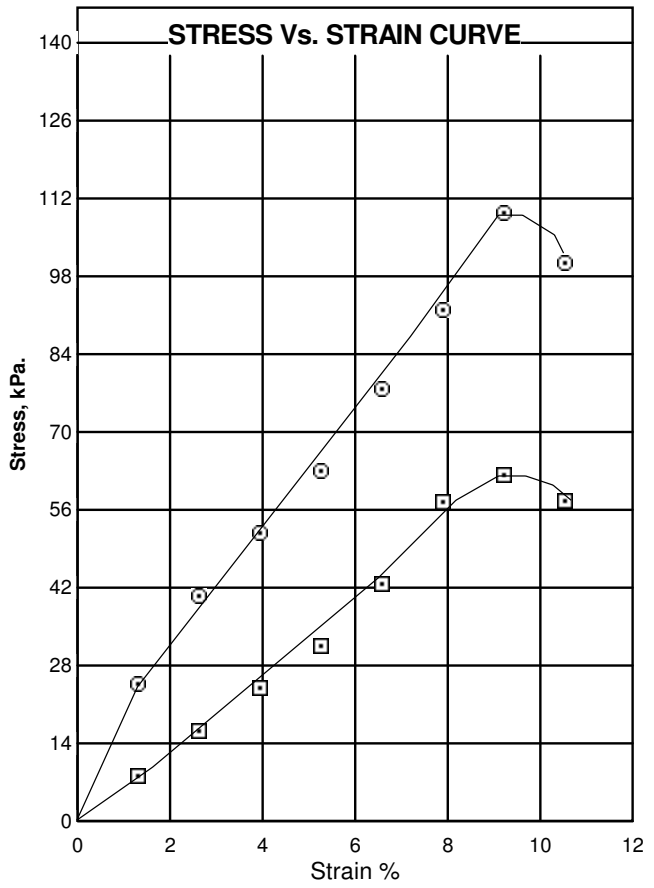


TRIAXIAL TEST CURVES

Job No. : 30796

Sample Number : 160128
Sample Depth : 4.50 - 4.95m.
Bore Hole Number : 2

Site :
Type of Test : cd



Mode of Failure :

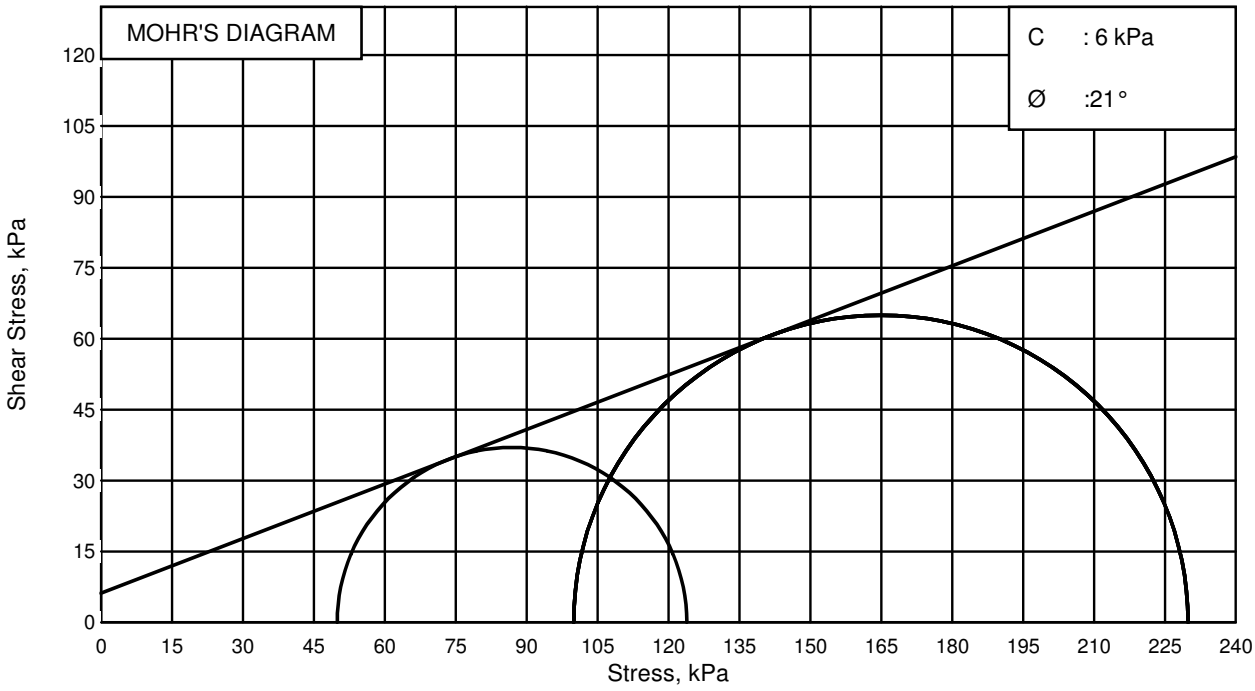
Specimen : 1 ⊡

Cell Pressure : 50 kPa

Mode of Failure :

Specimen : 2 ⊙

Cell Pressure : 100 kPa

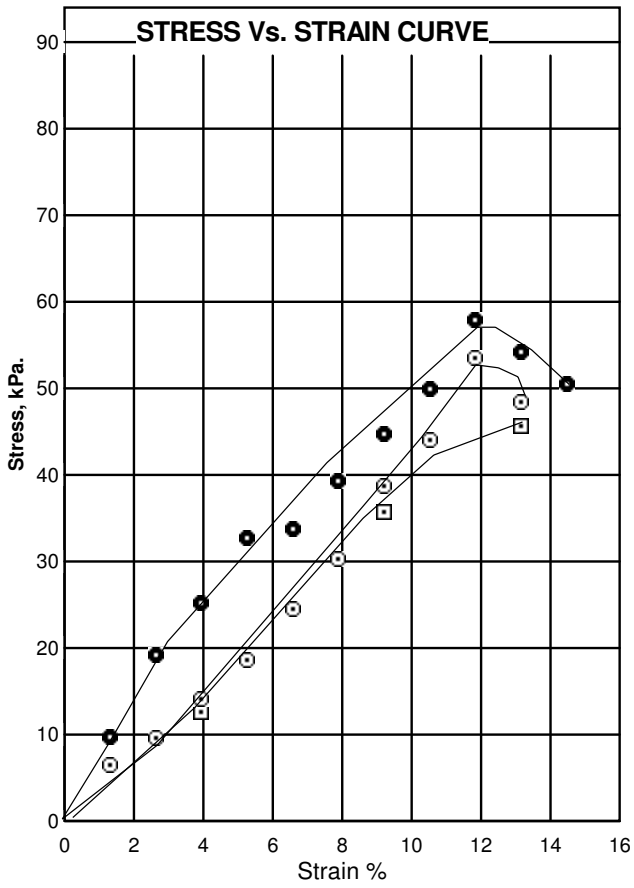


TRIAXIAL TEST CURVES

Job No. : 30796

Sample Number : 100869
Sample Depth : 1.00 - 1.45m.
Bore Hole Number : 3

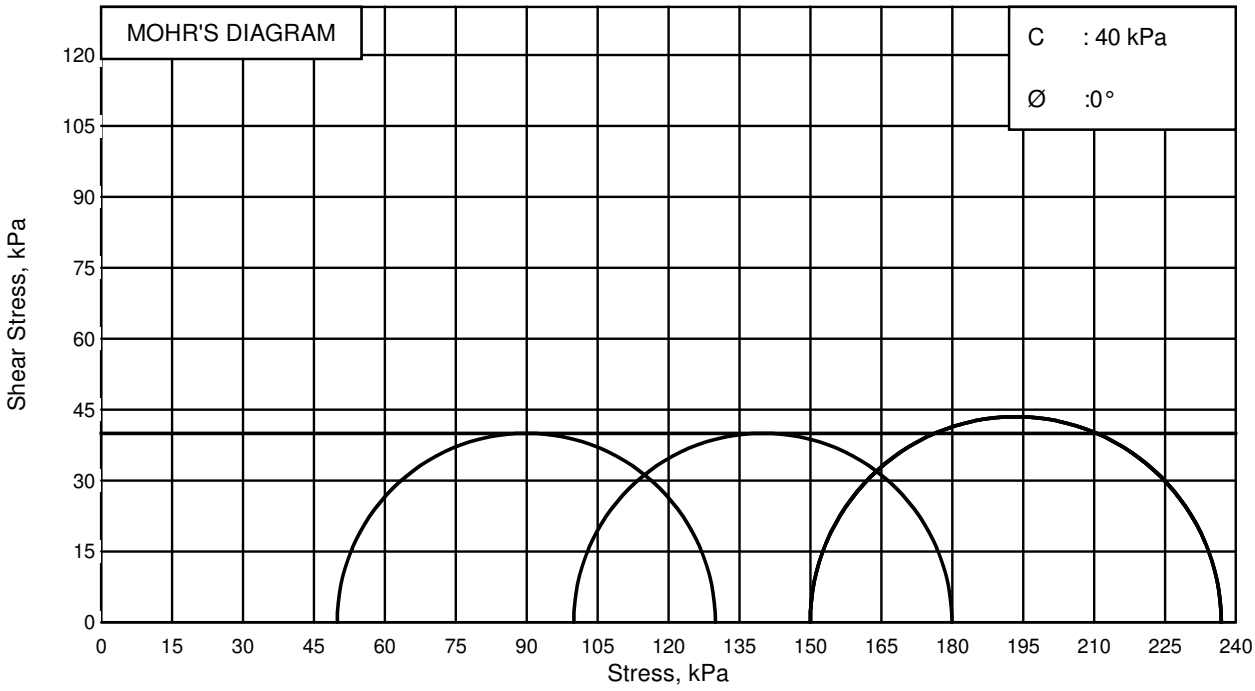
Site :
Type of Test : UU



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

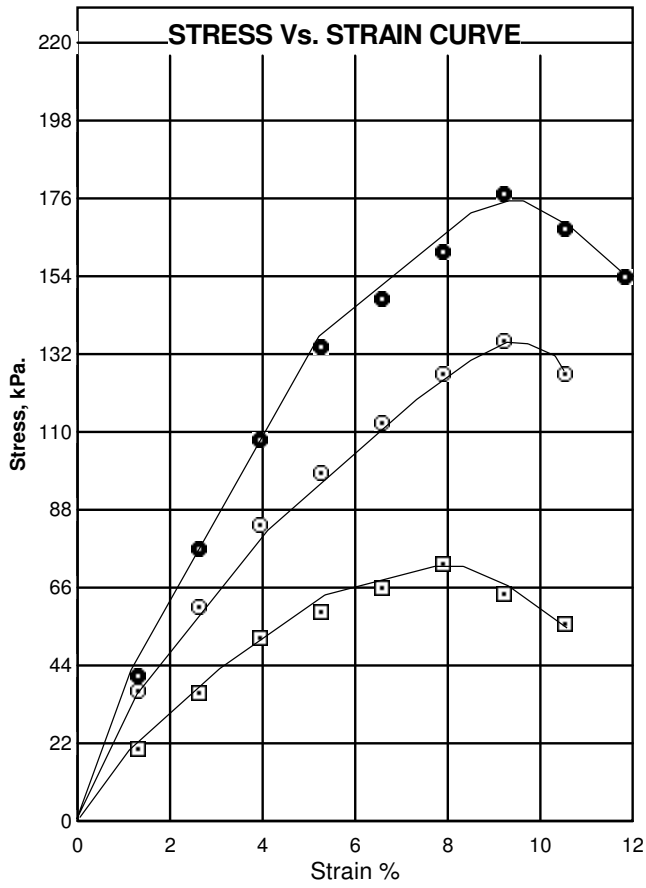


TRIAXIAL TEST CURVES

Job No. : 30796

Sample Number : 100879
Sample Depth : 8.00 - 8.45m.
Bore Hole Number : 3

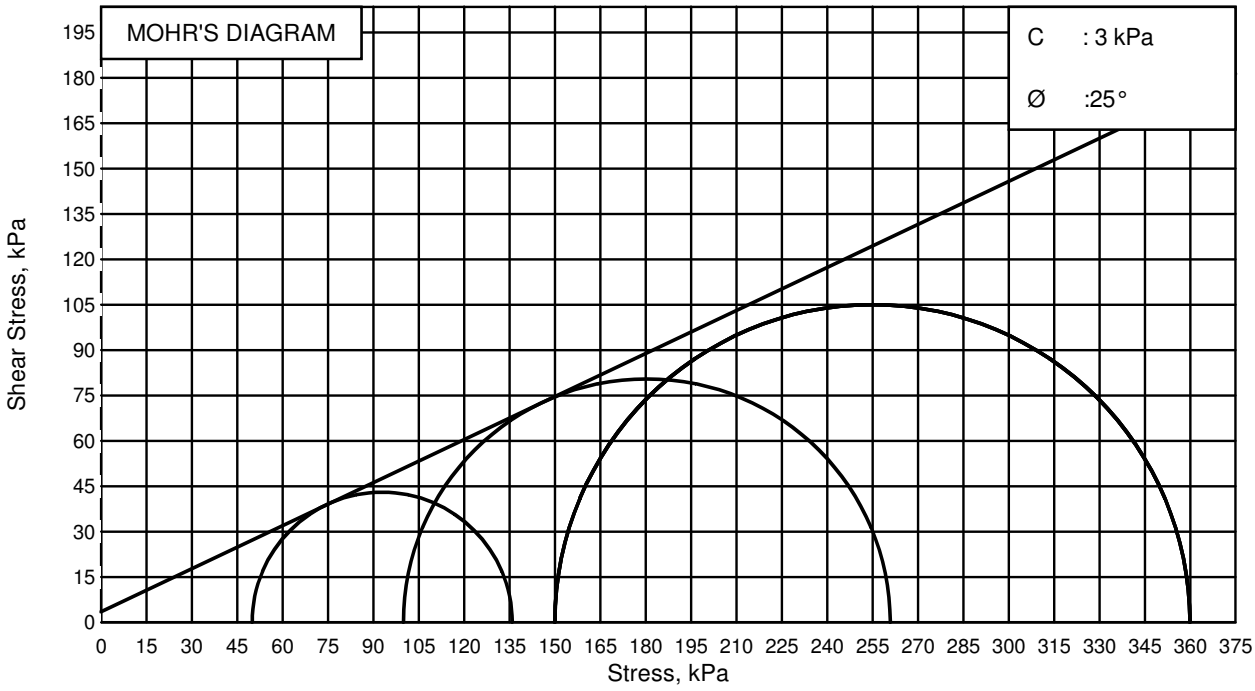
Site :
Type of Test : CD



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

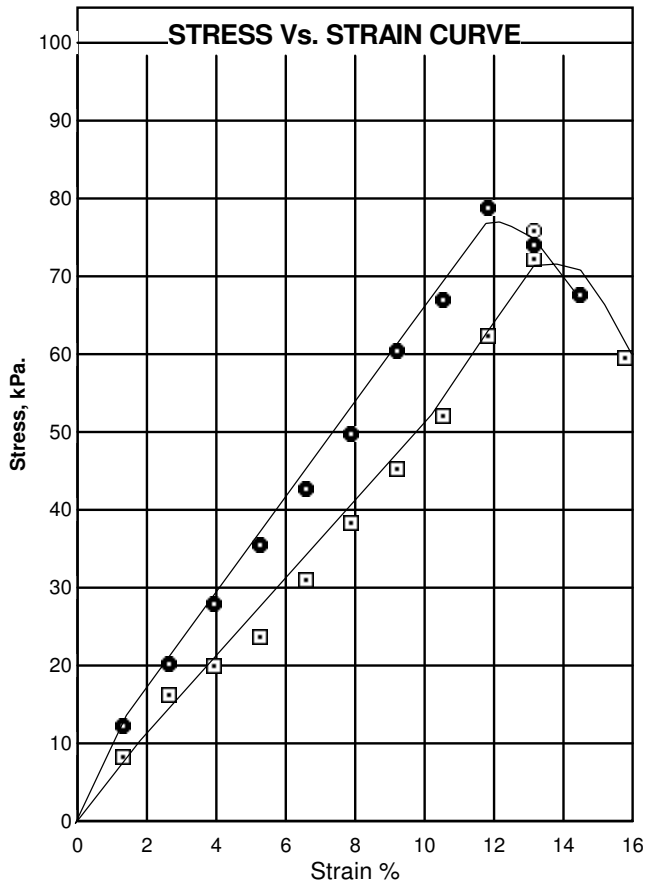


TRIAXIAL TEST CURVES

Job No. : 30796

Sample Number : 100902
Sample Depth : 1.50-1.95
Bore Hole Number : 4

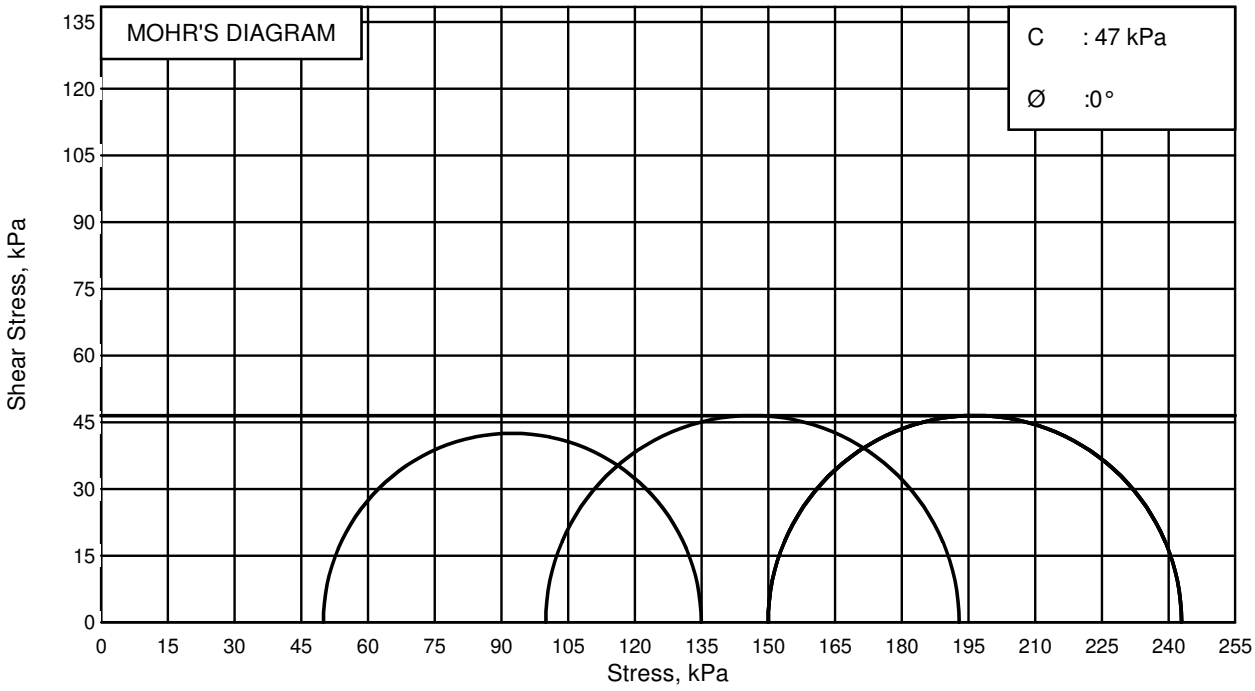
Site :
Type of Test : uu



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

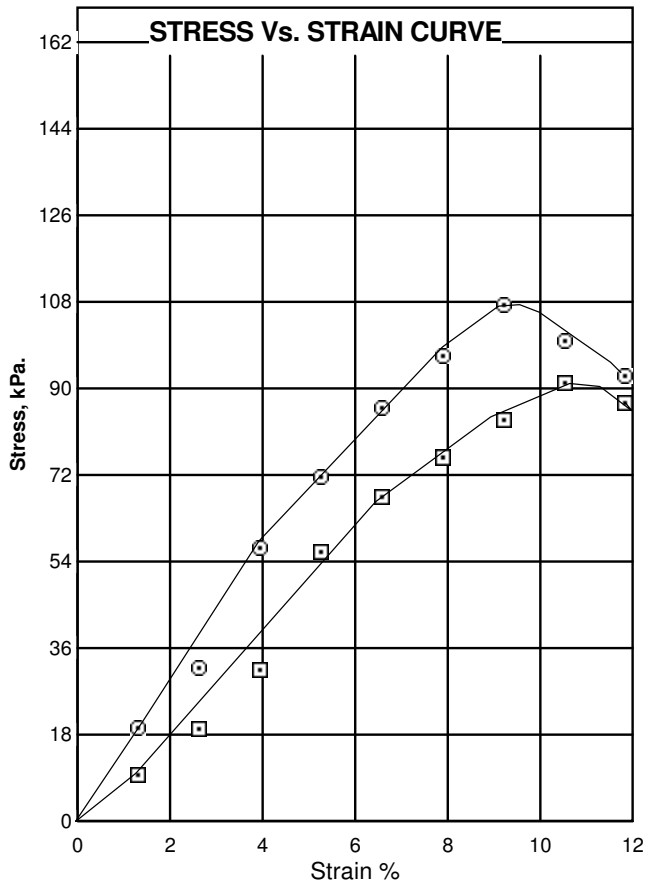


TRIAXIAL TEST CURVES

Job No. : 30796

Sample Number : 105112
Sample Depth : 1.00 - 1.45m.
Bore Hole Number : 6

Site :
Type of Test : cu



Mode of Failure :

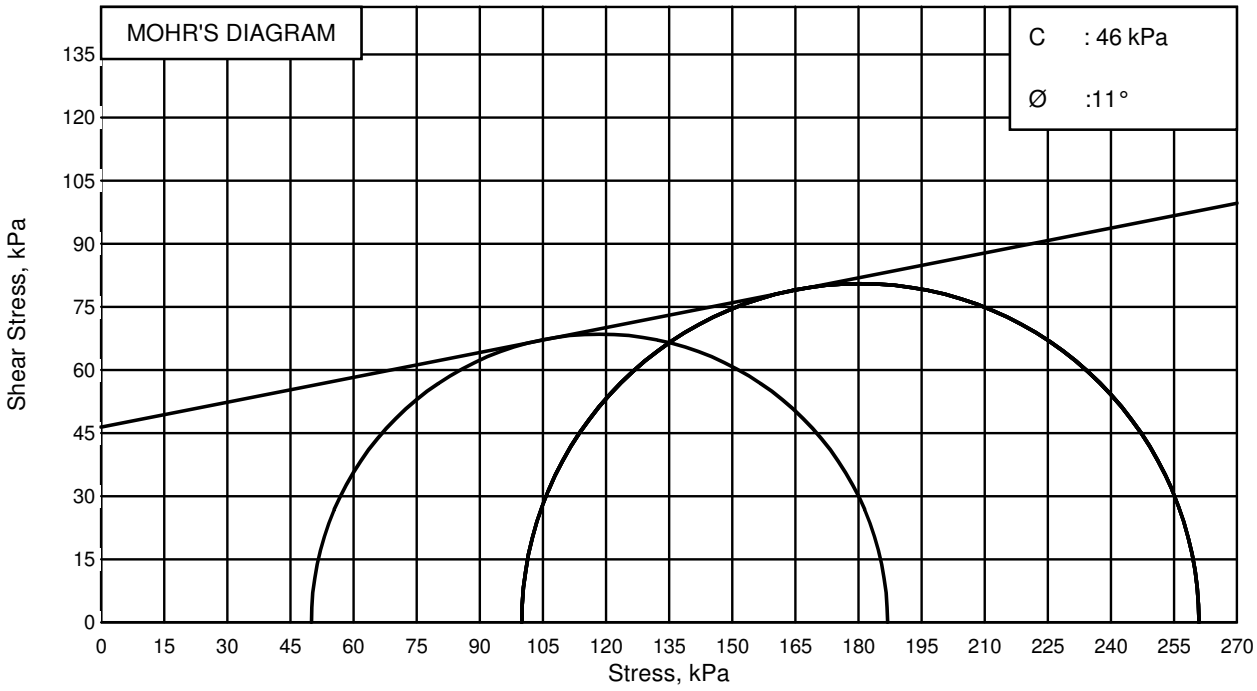
Specimen : 1 ⊡

Cell Pressure : 50 kPa

Mode of Failure :

Specimen : 2 ⊙

Cell Pressure : 100 kPa

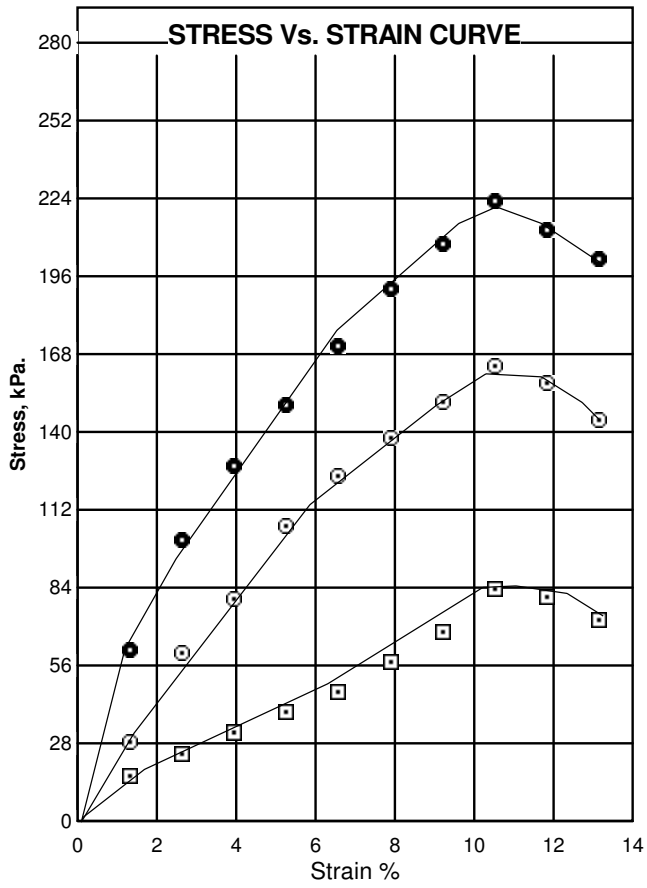


TRIAXIAL TEST CURVES

Job No. : 30796

Sample Number : 100968
Sample Depth : 1.00 - 1.45m.
Bore Hole Number : 8

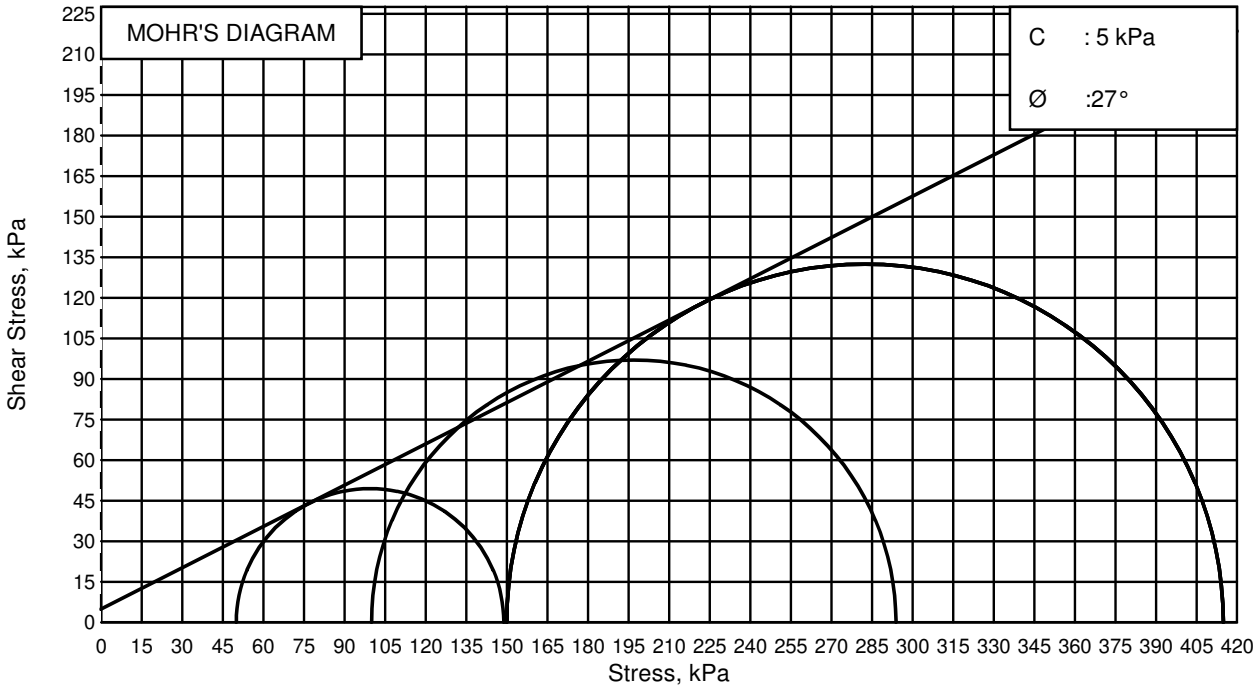
Site :
Type of Test : CD



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

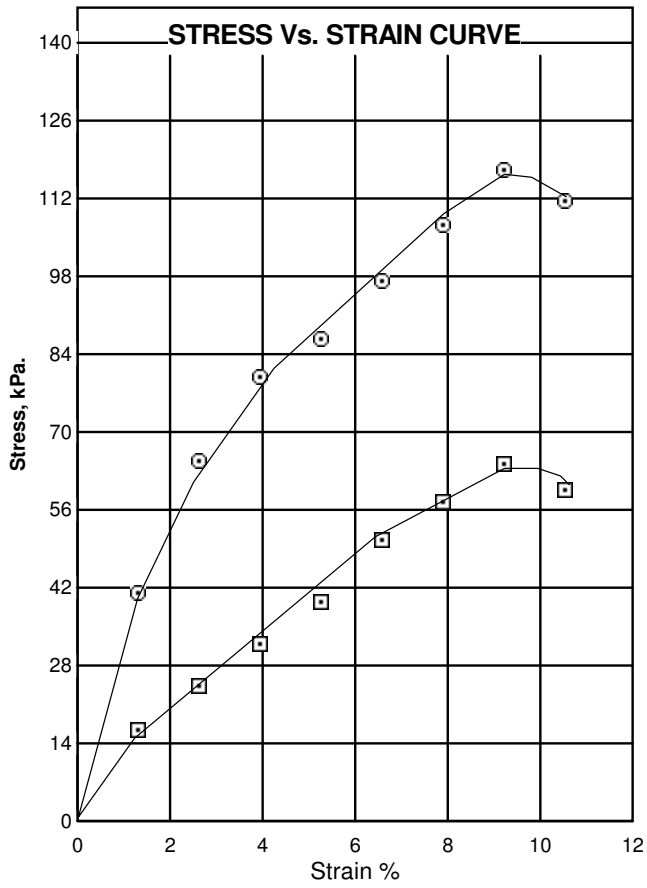


TRIAXIAL TEST CURVES

Job No. : 30796

Sample Number : 100972
Sample Depth : 3.00 - 3.45m.
Bore Hole Number : 8

Site :
Type of Test : cd



Mode of Failure :

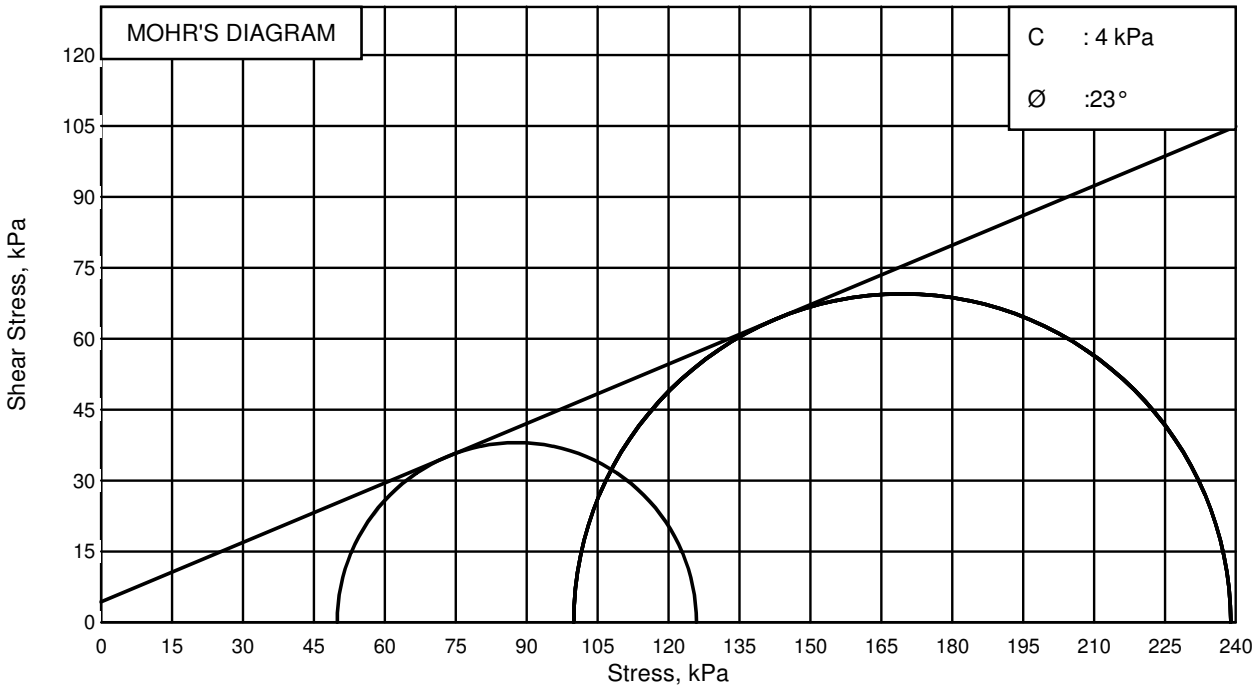
Specimen : 1 ⊡

Cell Pressure : 50 kPa

Mode of Failure :

Specimen : 2 ⊙

Cell Pressure : 100 kPa

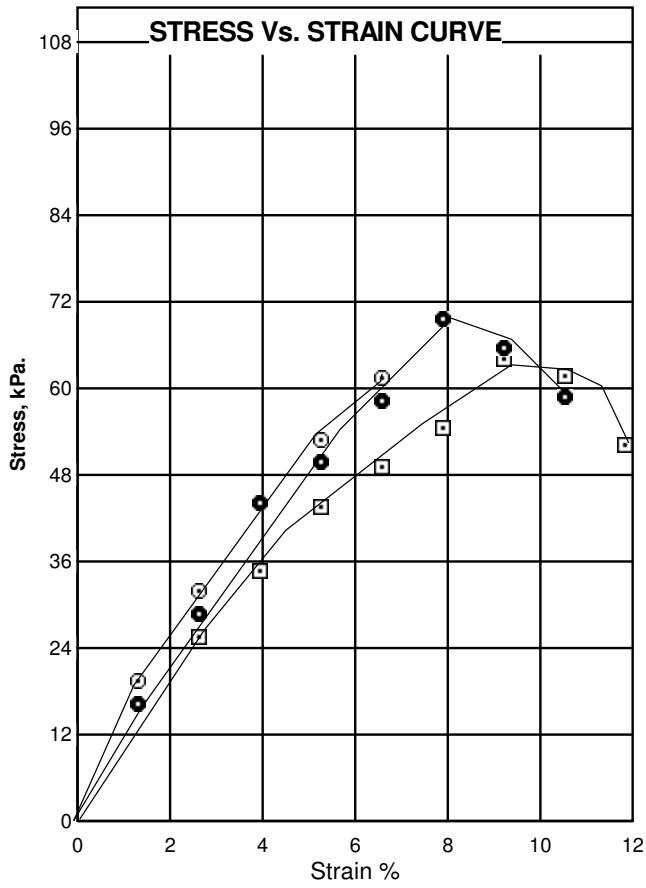


TRIAXIAL TEST CURVES

Job No. : 30796

Sample Number : 100878
Sample Depth : 2.00 - 2.45m.
Bore Hole Number : 9

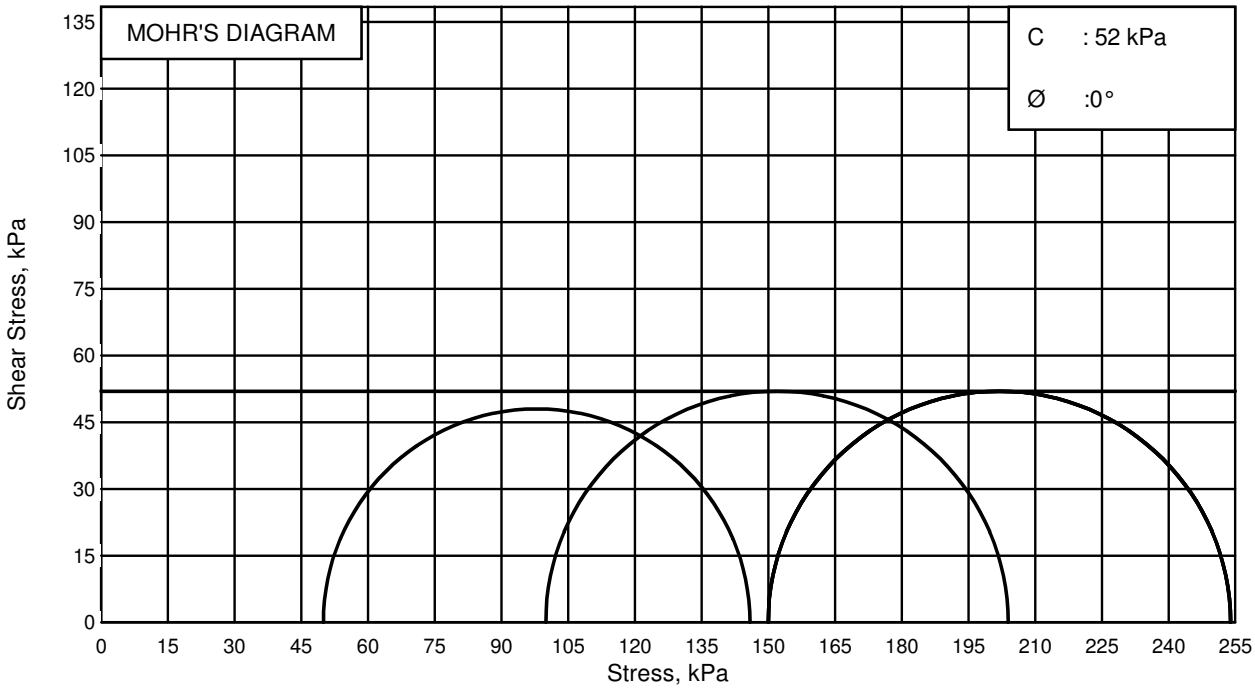
Site :
Type of Test : uu



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

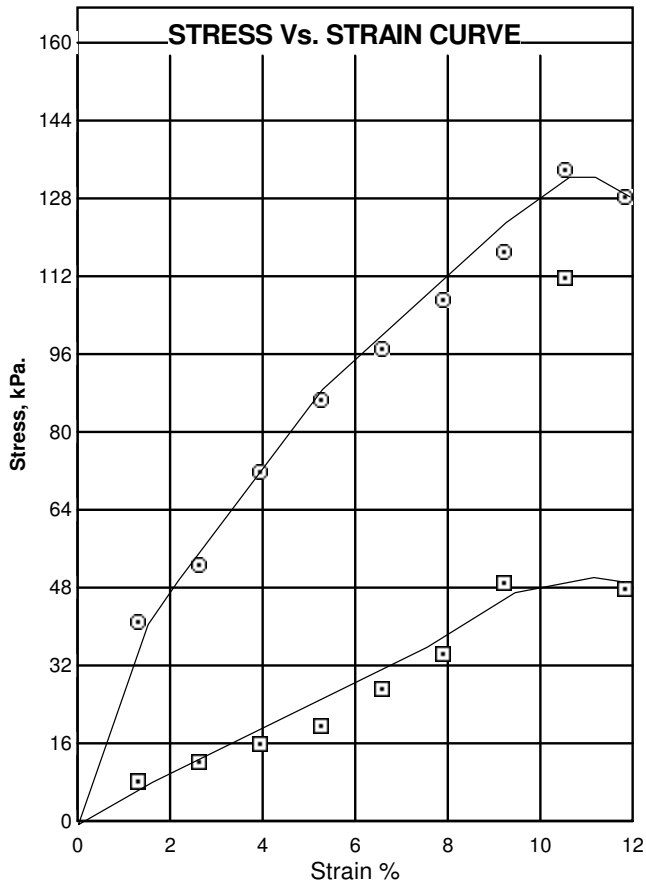


TRIAXIAL TEST CURVES

Job No. : 30796

Sample Number : 100882
Sample Depth : 4.50 - 4.95m.
Bore Hole Number : 9

Site :
Type of Test : cu



Mode of Failure :

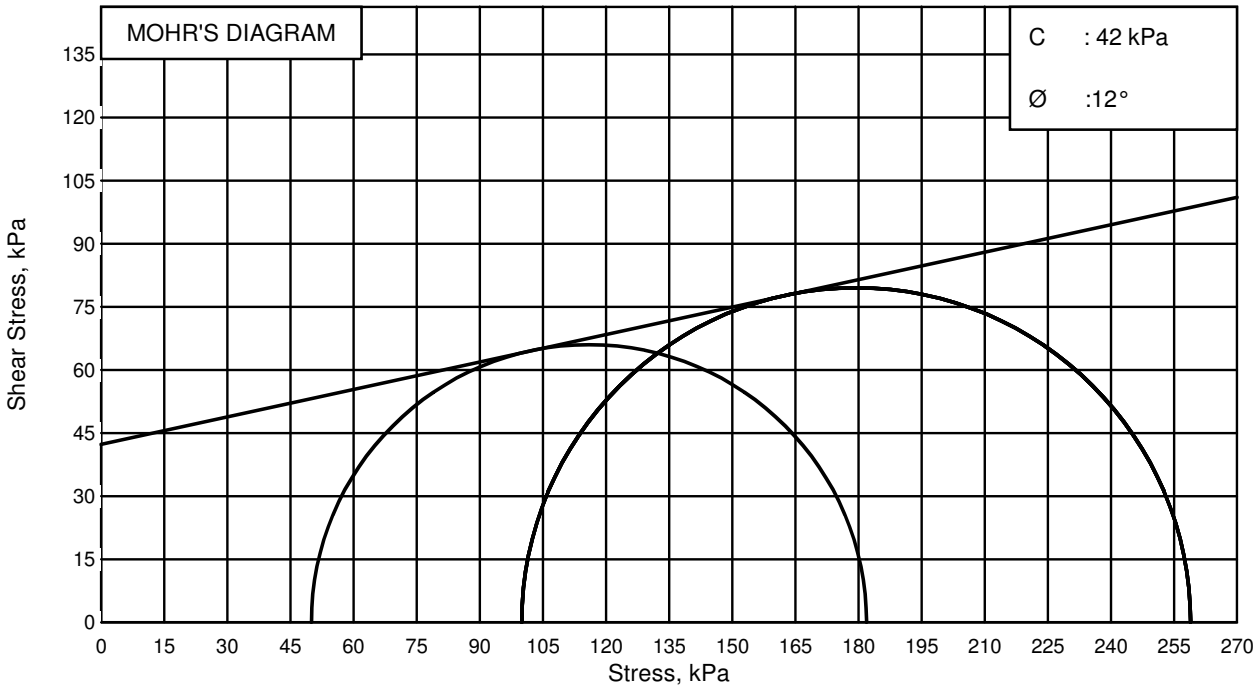
Specimen : 1 ⊡

Cell Pressure : 50 kPa

Mode of Failure :

Specimen : 2 ⊙

Cell Pressure : 100 kPa

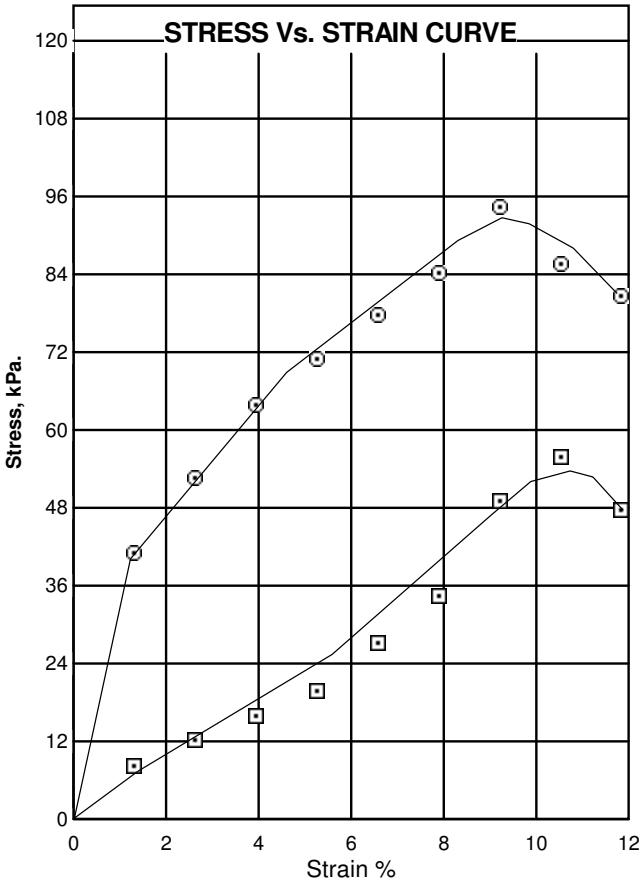


TRIAXIAL TEST CURVES

Job No. : 30796

Sample Number : 100882
Sample Depth : 4.50 - 4.95m.
Bore Hole Number : 9

Site :
Type of Test : cu



Mode of Failure :

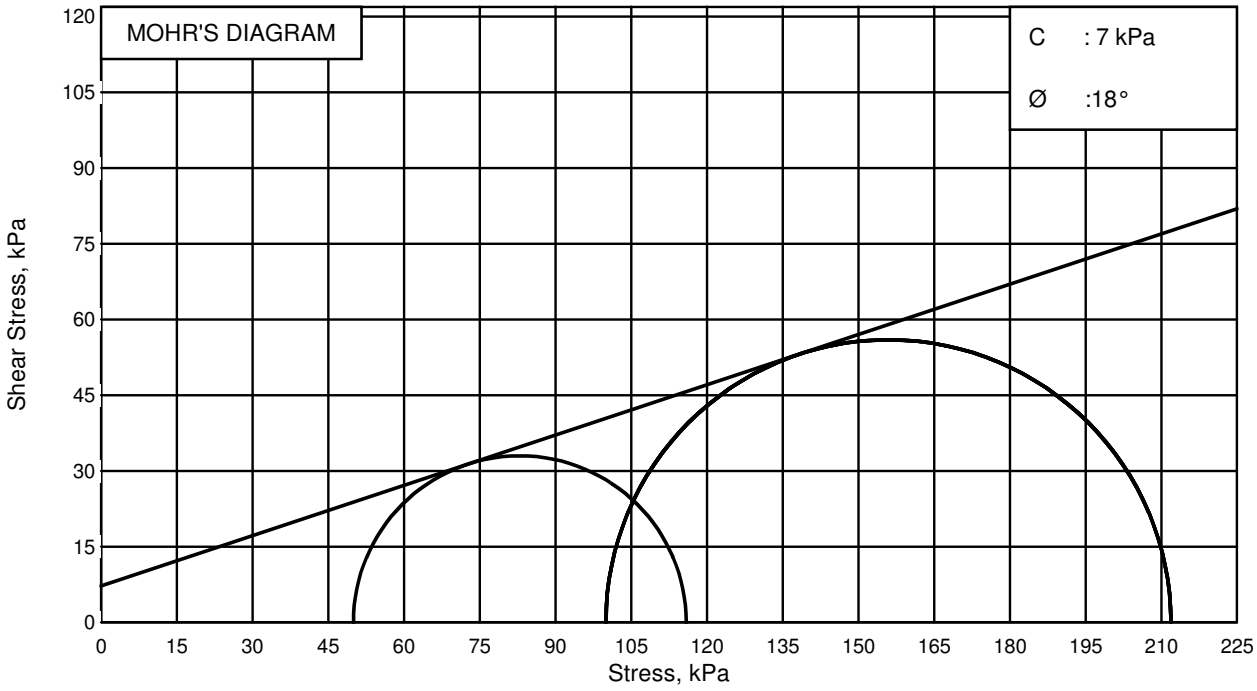
Specimen : 1 ⊡

Cell Pressure : 50 kPa

Mode of Failure :

Specimen : 2 ⊙

Cell Pressure : 100 kPa

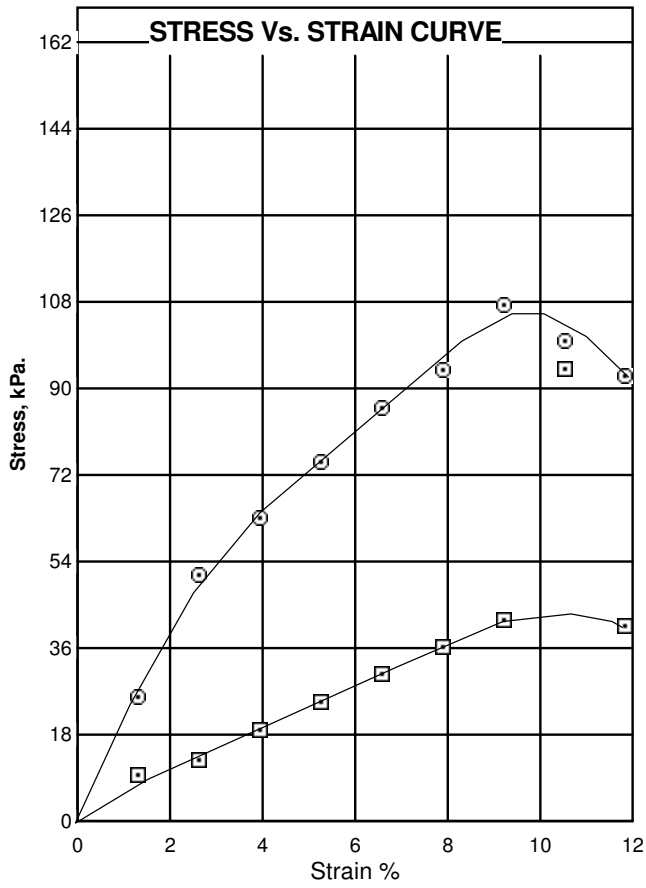


TRIAXIAL TEST CURVES

Job No. : 30796

Sample Number : 100852
Sample Depth : 1.00 - 1.45m.
Bore Hole Number : 11

Site :
Type of Test : cu



Mode of Failure :

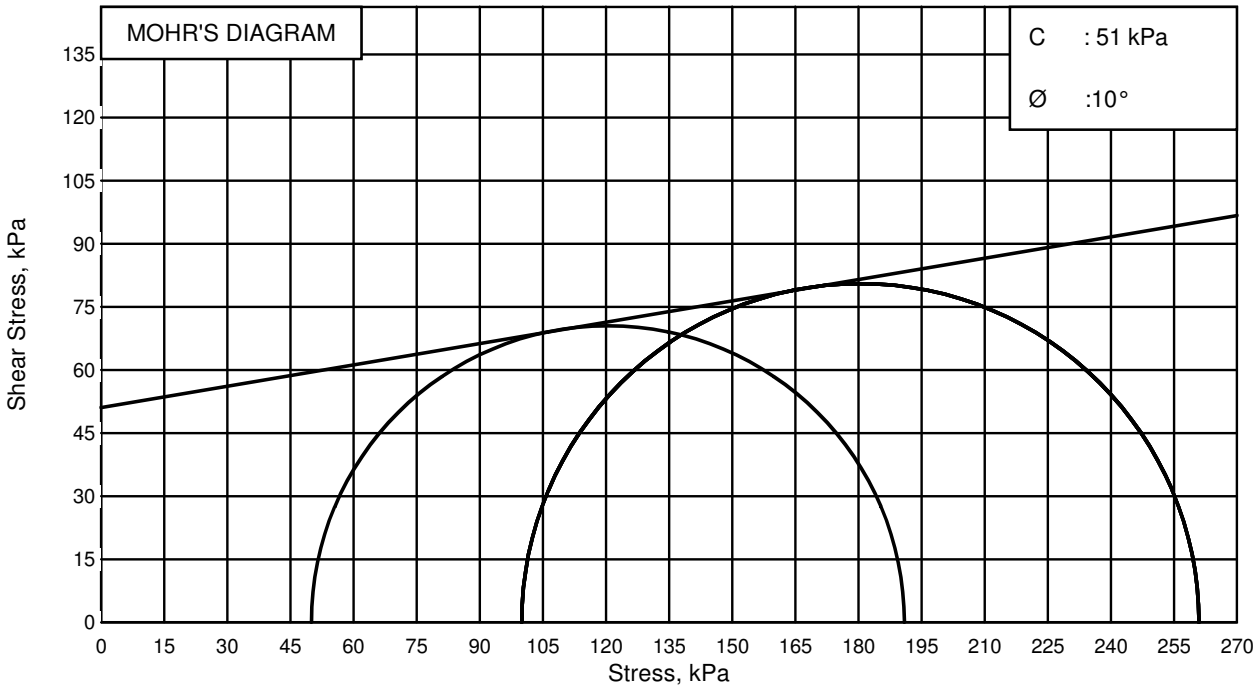
Specimen : 1 ⊡

Cell Pressure : 50 kPa

Mode of Failure :

Specimen : 2 ⊙

Cell Pressure : 100 kPa

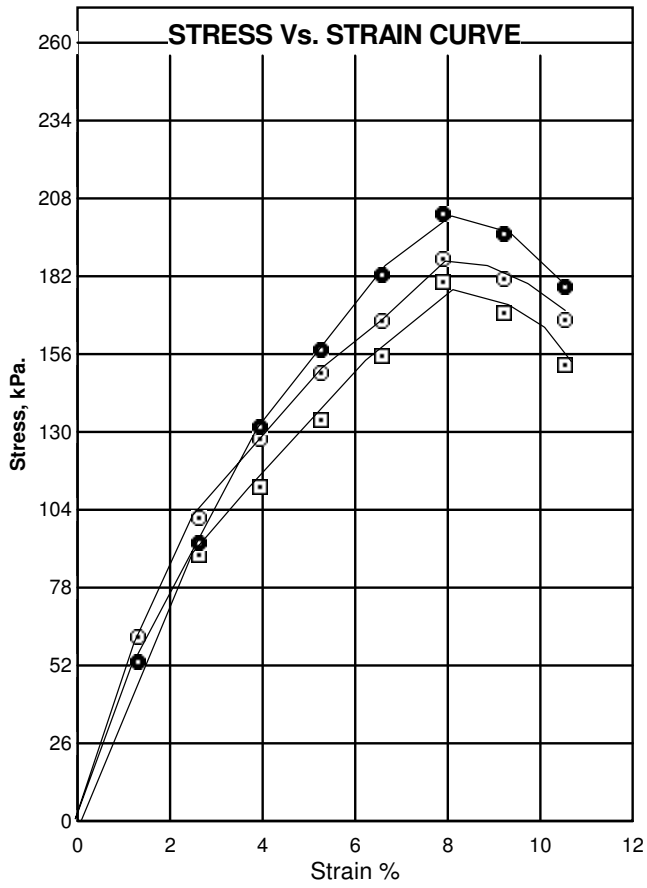


TRIAXIAL TEST CURVES

Job No. : 30796

Sample Number : 100856
Sample Depth : 3.00 - 3.45m.
Bore Hole Number : 11

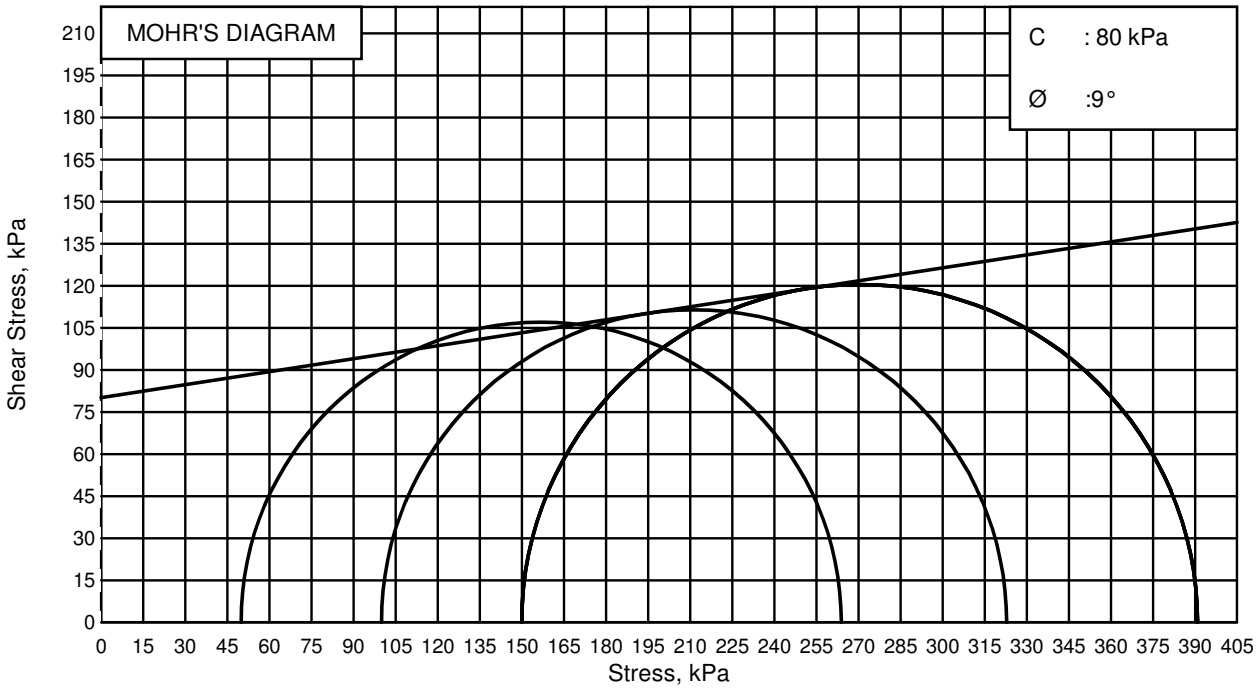
Site :
Type of Test : uu



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

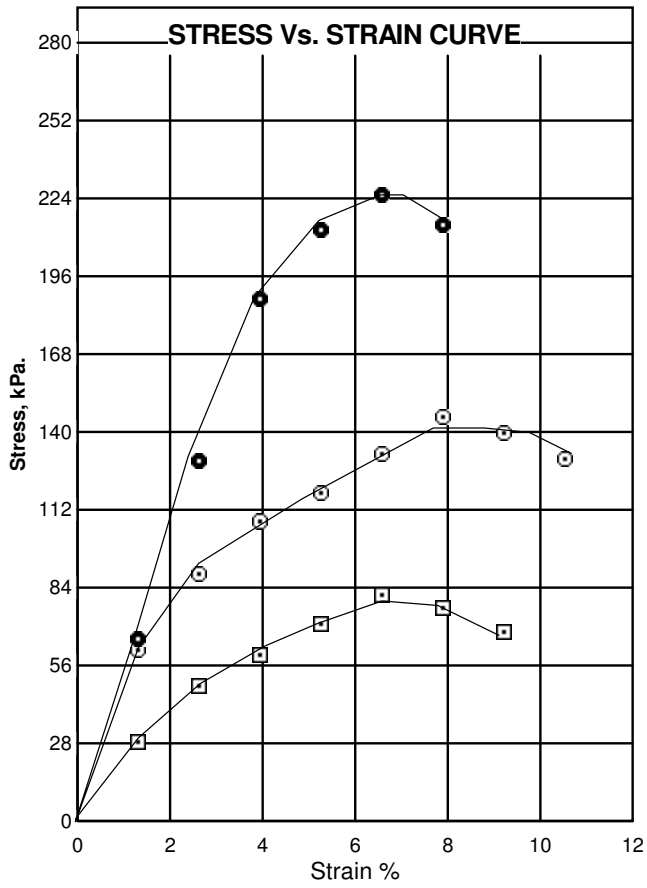


TRIAXIAL TEST CURVES

Job No. : 30796

Sample Number : 100978
Sample Depth : 1.00 - 1.45m.
Bore Hole Number : 12

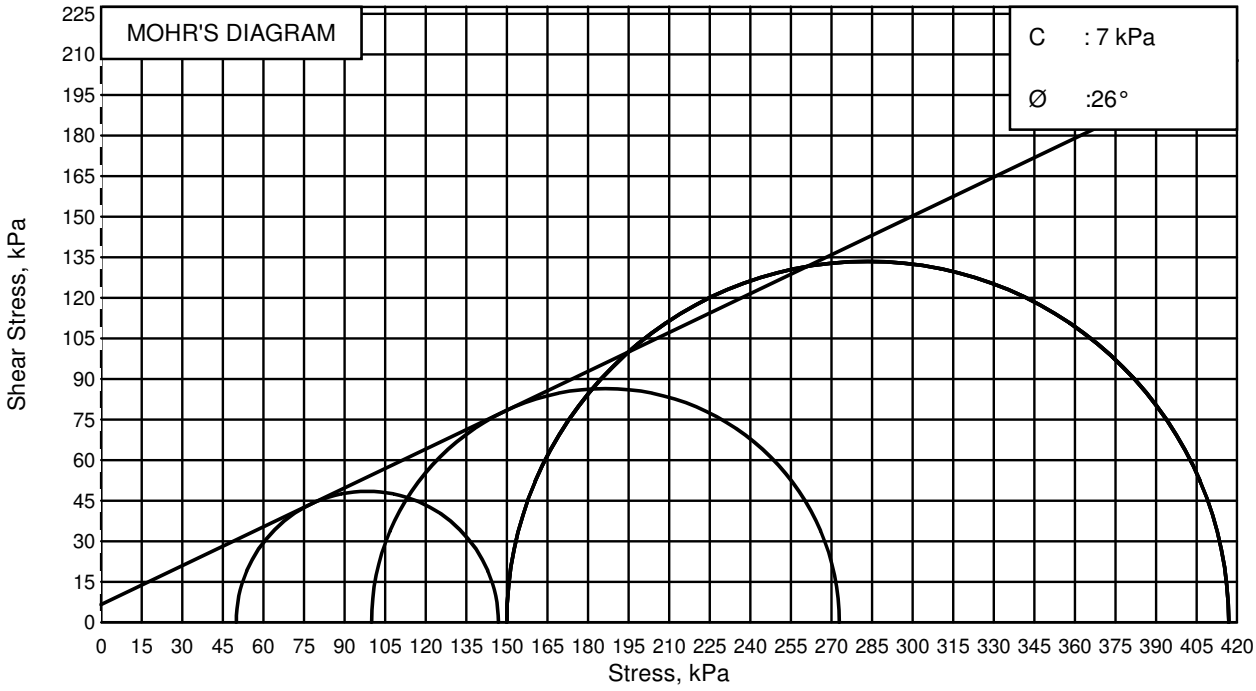
Site :
Type of Test : CD



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

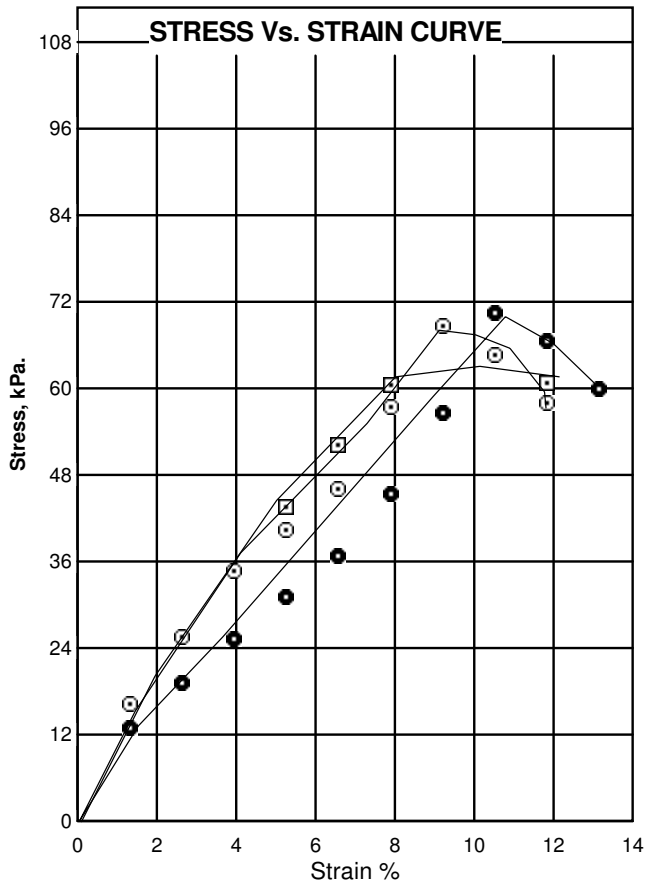


TRIAXIAL TEST CURVES

Job No. : 30796

Sample Number : 100954
Sample Depth : 2.00 - 2.45m.
Bore Hole Number : 16

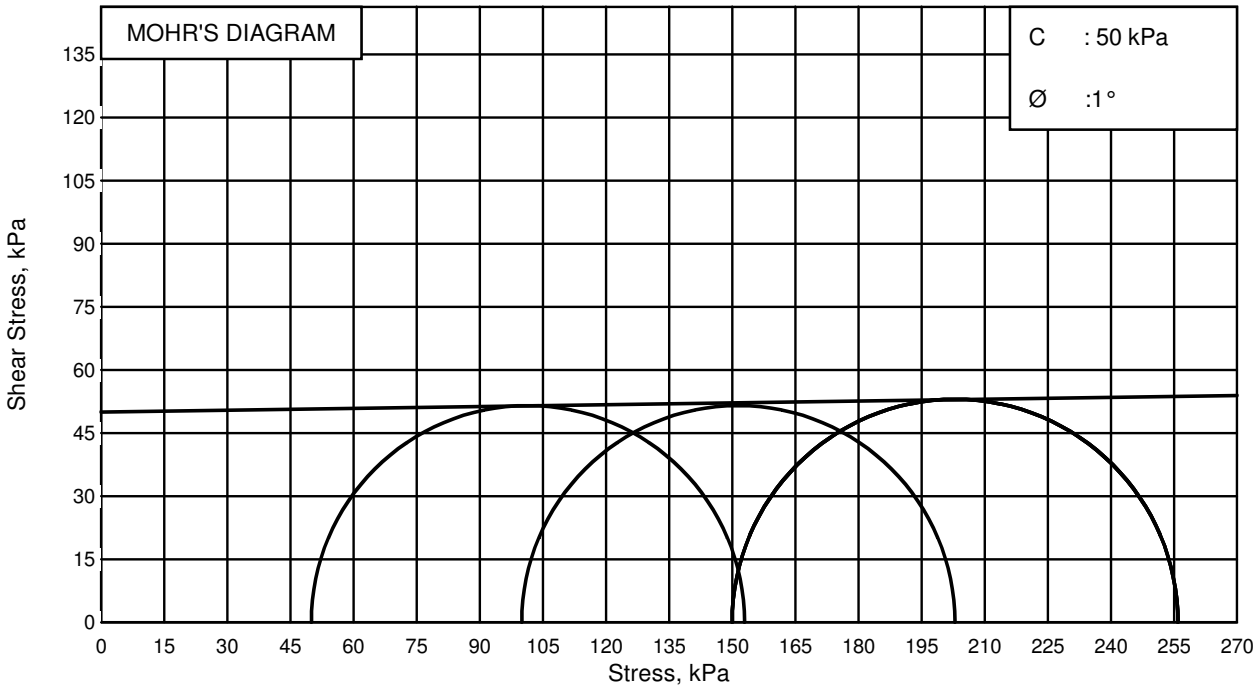
Site :
Type of Test : uu



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

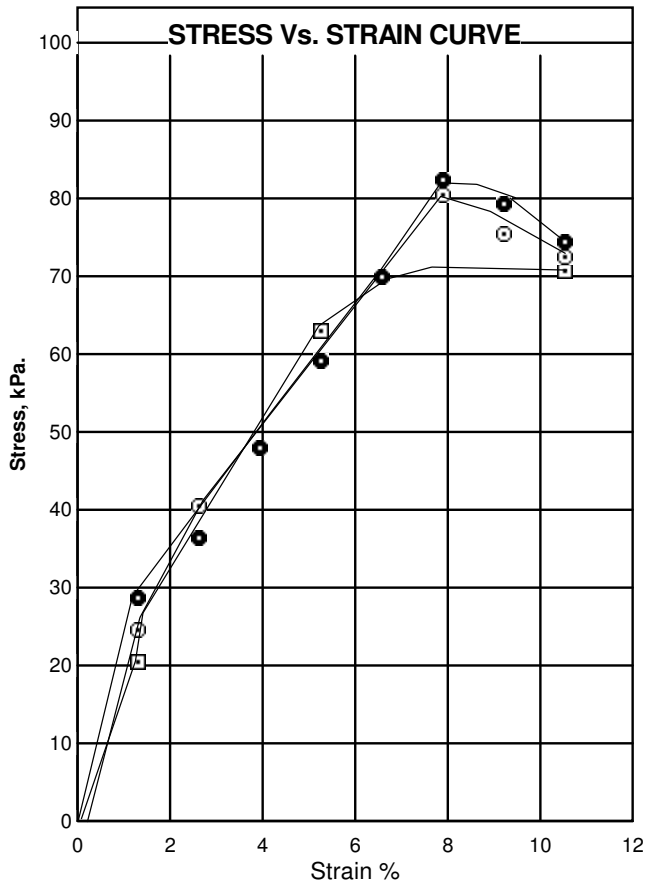


TRIAXIAL TEST CURVES

Job No. : 30796

Sample Number : 100517
Sample Depth : 2.00 - 2.45m.
Bore Hole Number : 17

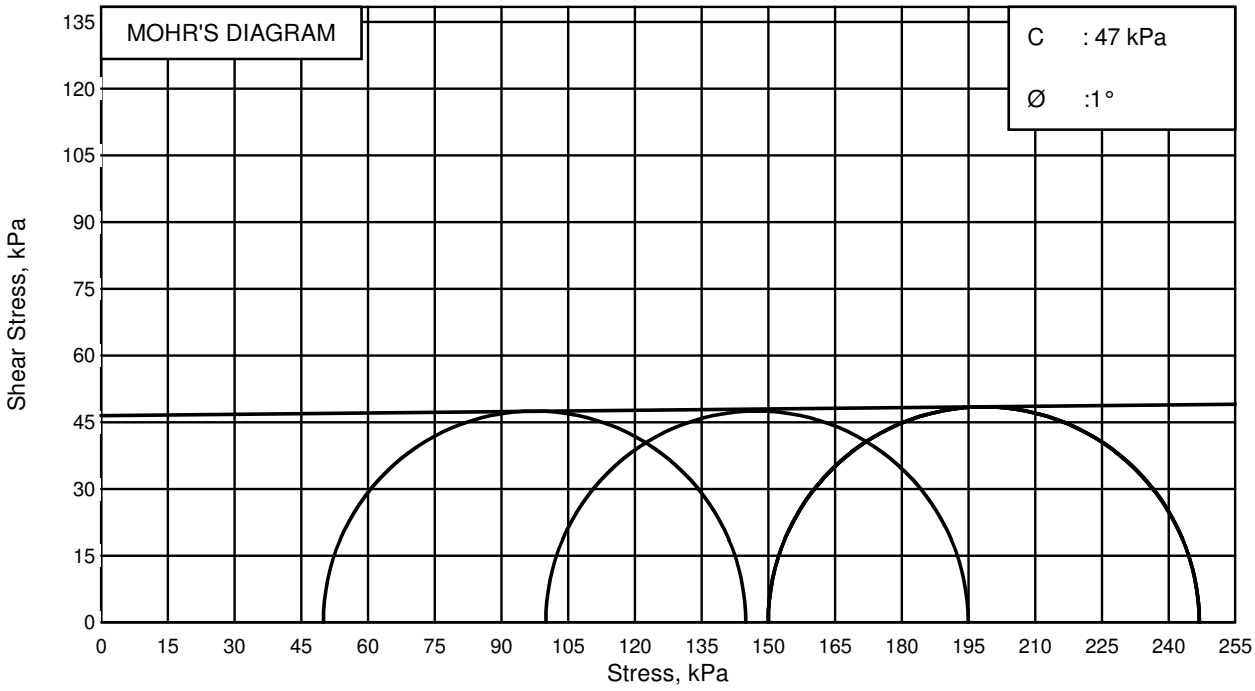
Site :
Type of Test : UU



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

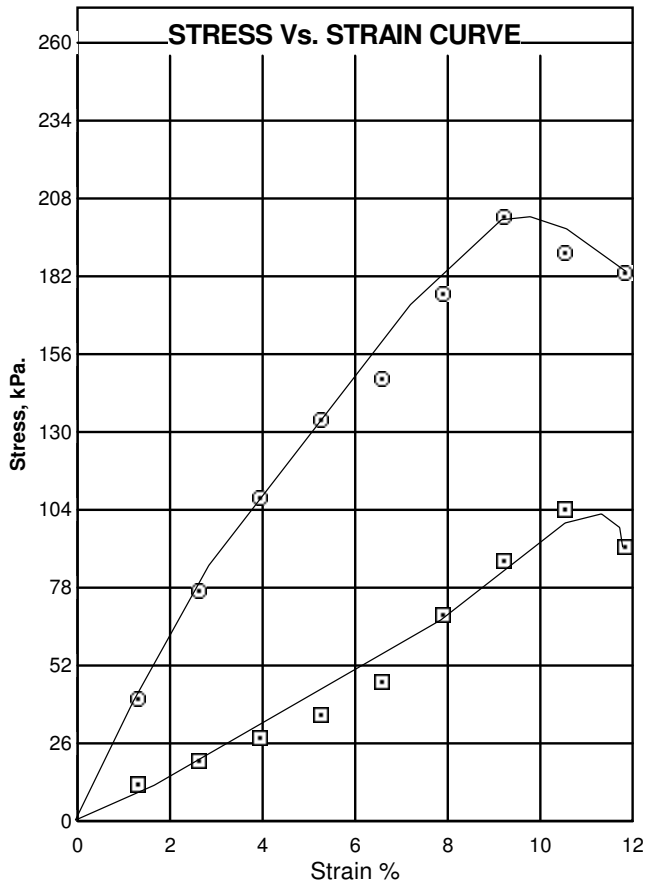


TRIAXIAL TEST CURVES

Job No. : 30796

Sample Number : 100524
Sample Depth : 7.50 - 7.95m.
Bore Hole Number : 17

Site :
Type of Test : cu



Mode of Failure :

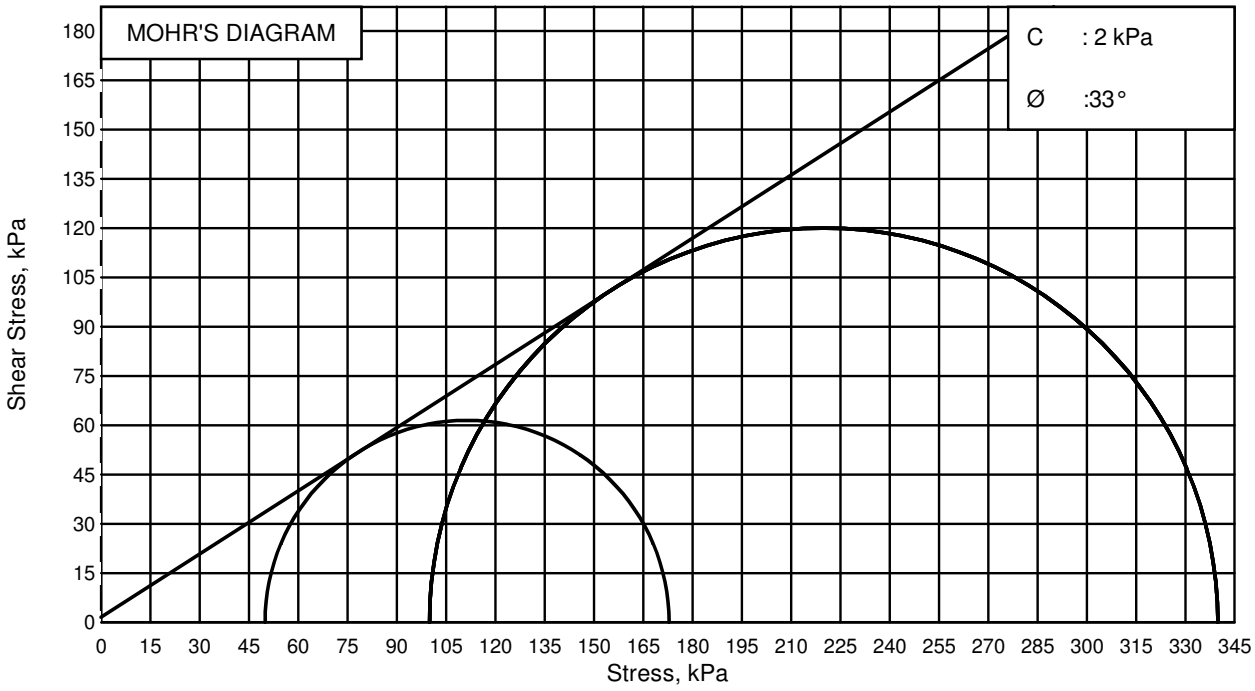
Specimen : 1 ⊡

Cell Pressure : 50 kPa

Mode of Failure :

Specimen : 2 ⊙

Cell Pressure : 100 kPa

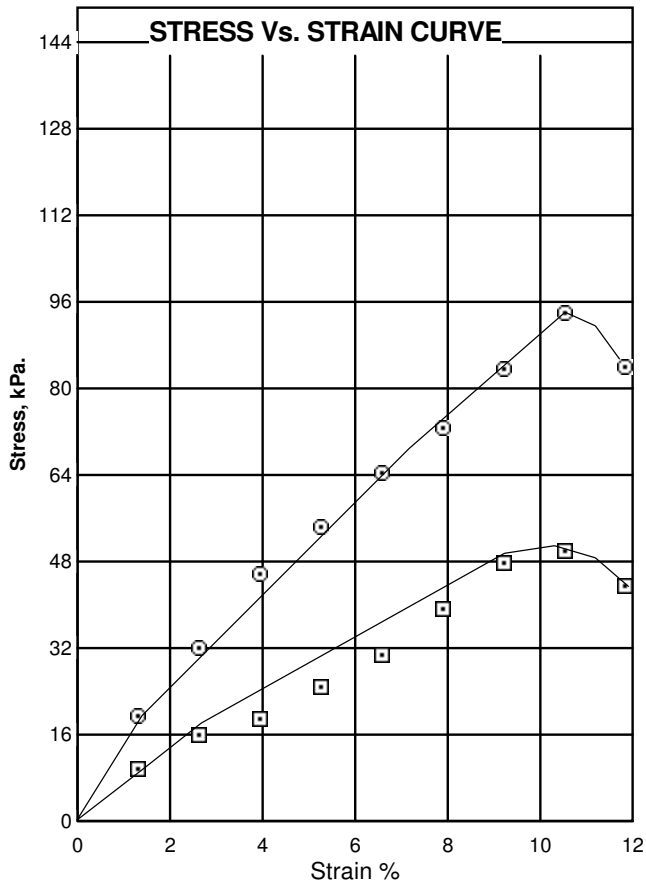


TRIAXIAL TEST CURVES

Job No. : 30796

Sample Number : 100535
Sample Depth : 3.00 - 3.45m.
Bore Hole Number : 18

Site :
Type of Test : CD



Mode of Failure :

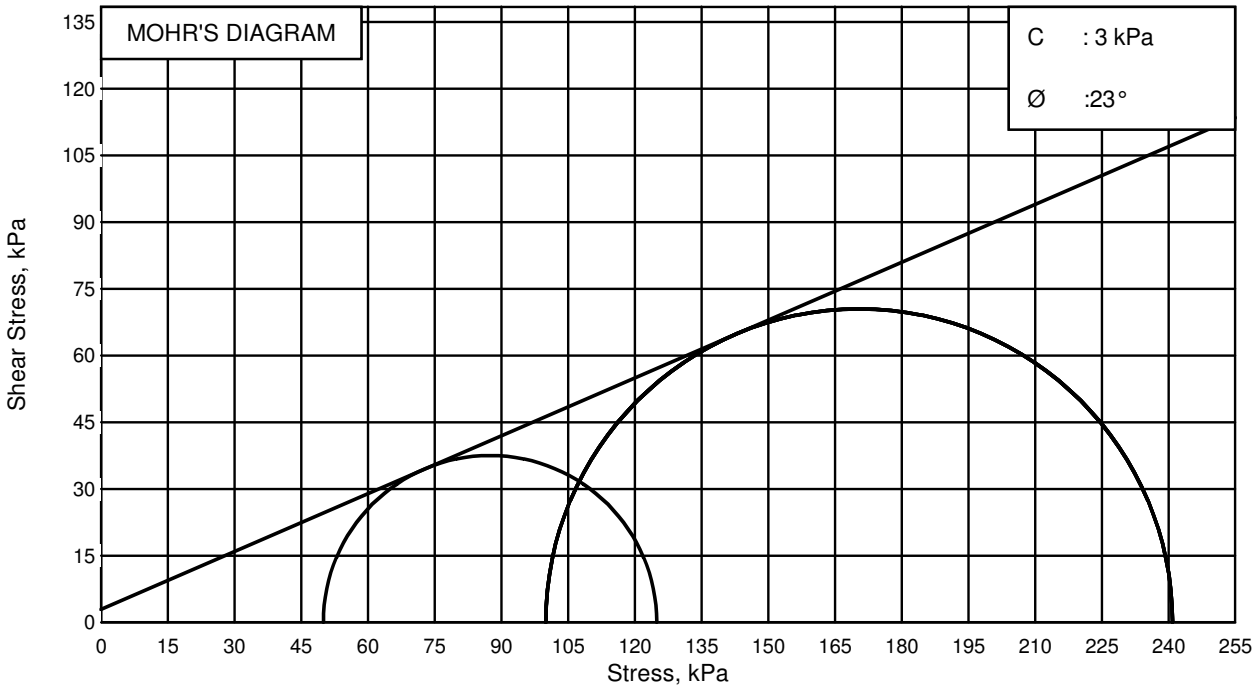
Specimen : 1 ⊡

Cell Pressure : 50 kPa

Mode of Failure :

Specimen : 2 ⊙

Cell Pressure : 100 kPa

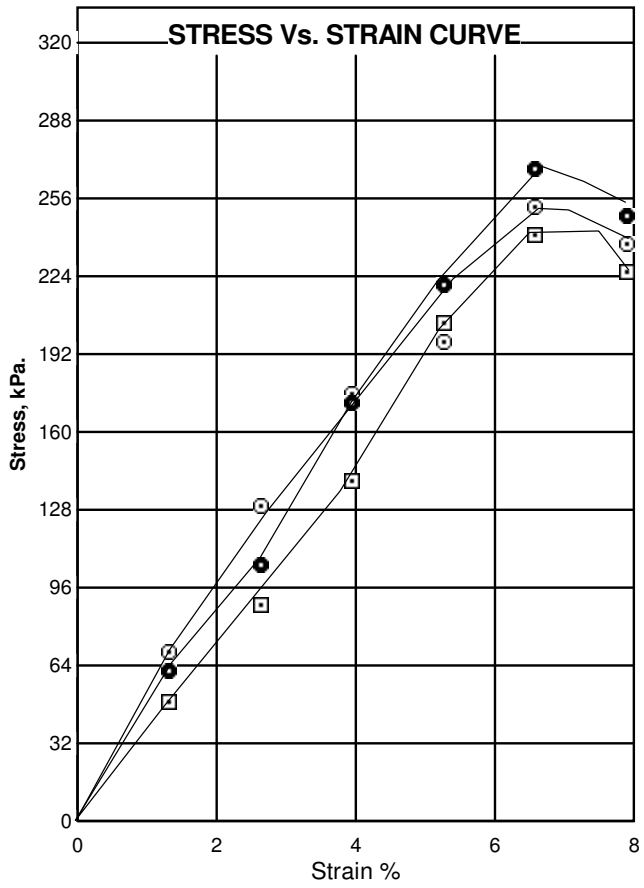


TRIAXIAL TEST CURVES

Job No. : 30796

Sample Number : 100507
Sample Depth : 4.00 - 4.45m.
Bore Hole Number : 19

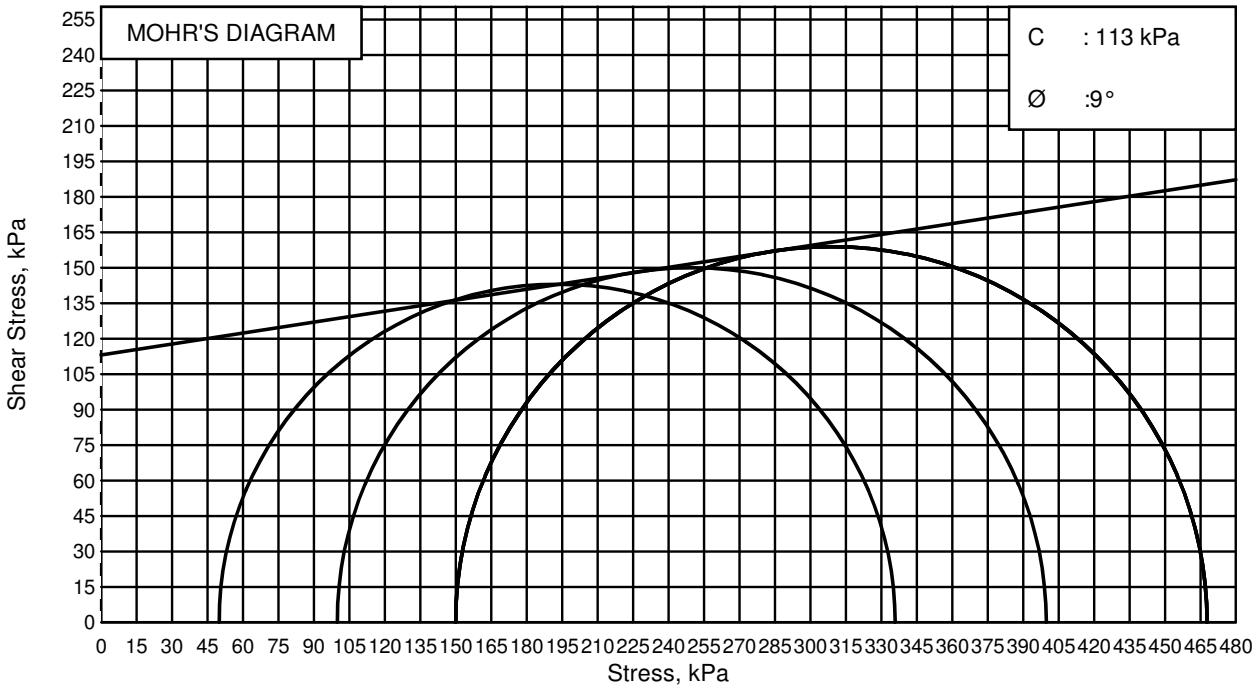
Site :
Type of Test : uu



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

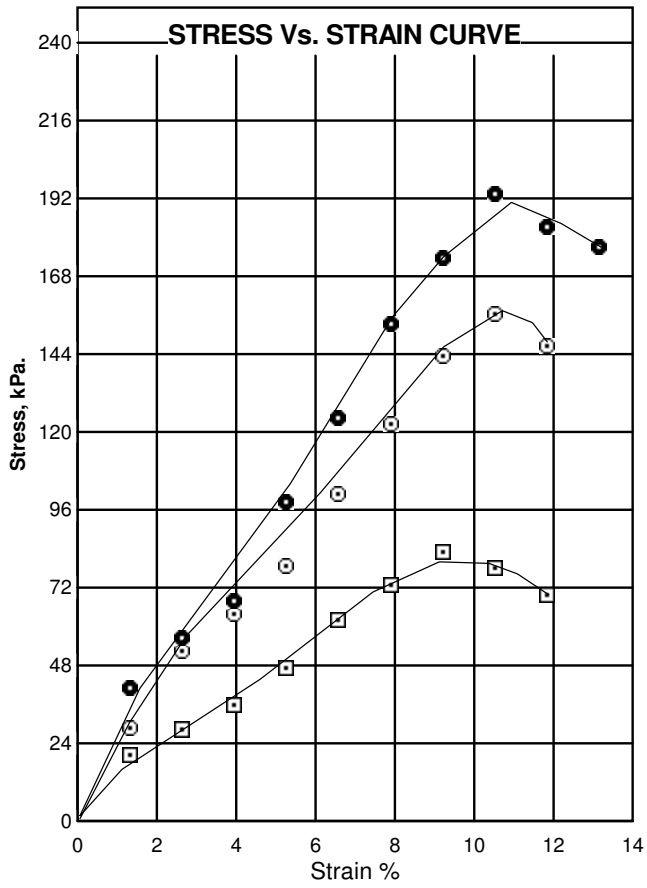


TRIAXIAL TEST CURVES

Job No. : 30796

Sample Number : 120103
Sample Depth : 2.00 -2.45m.
Bore Hole Number : 20

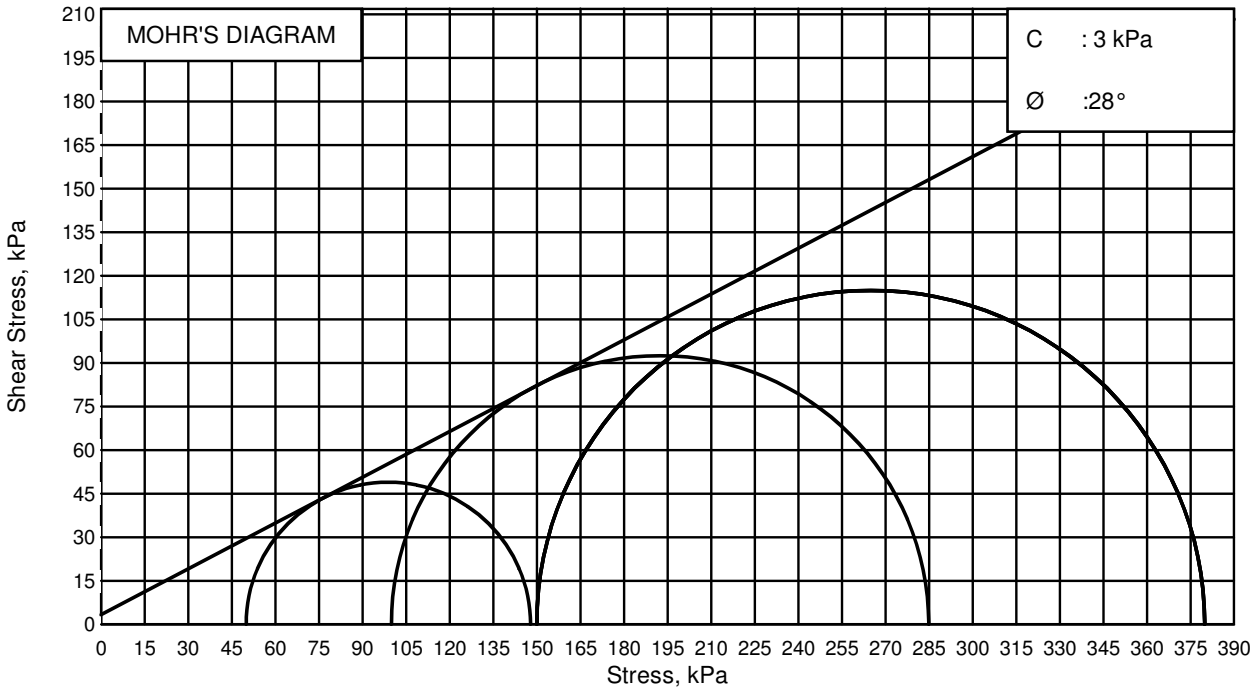
Site :
Type of Test : CD



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

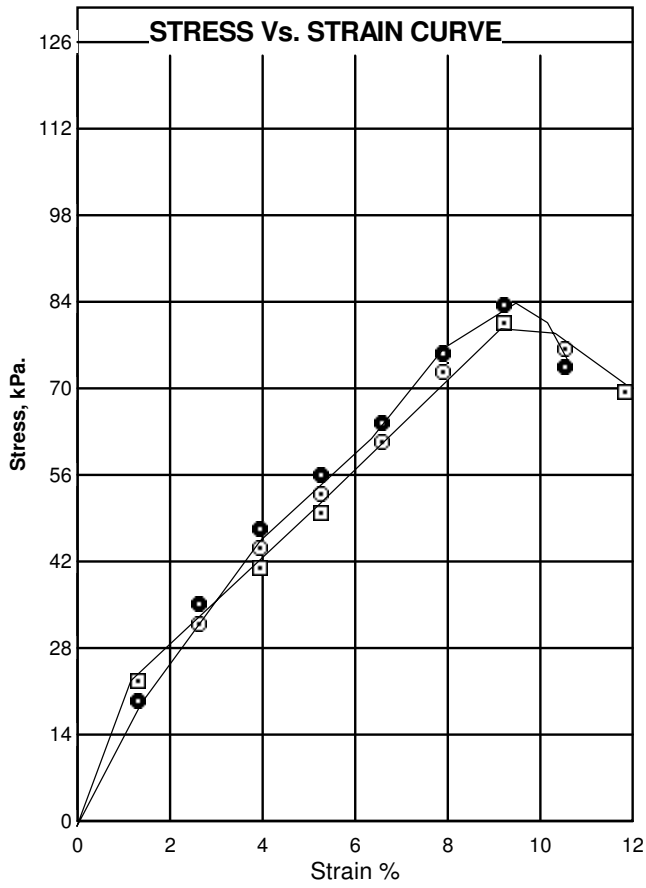


TRIAXIAL TEST CURVES

Job No. : 30796

Sample Number : 165105
Sample Depth : 3.00 - 3.45m.
Bore Hole Number : 22

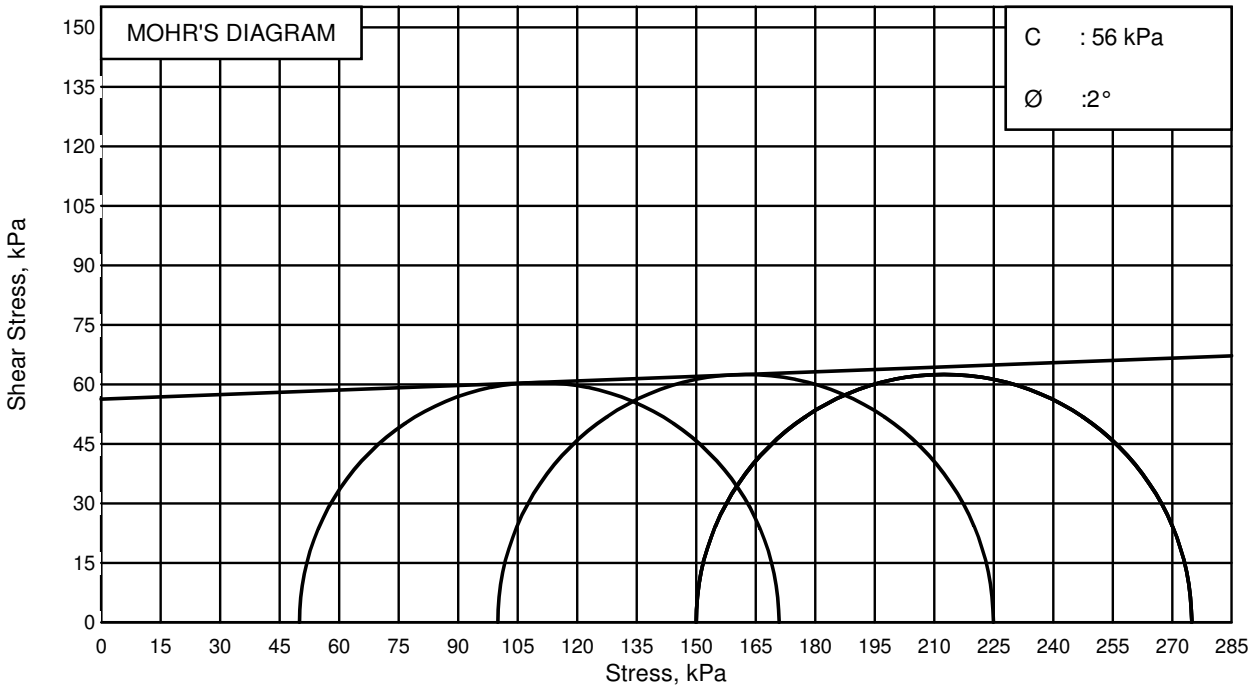
Site :
Type of Test : uu



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

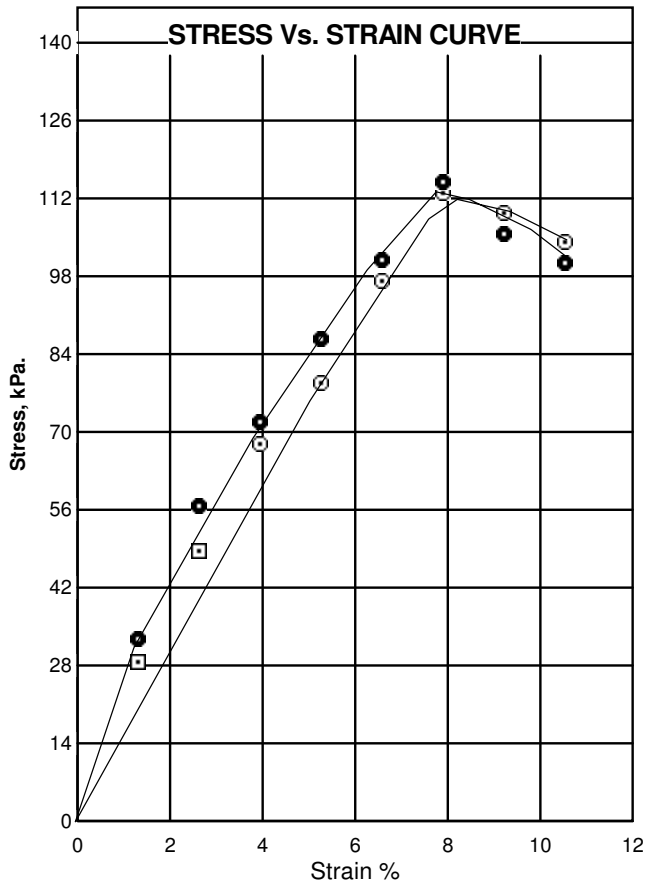


TRIAXIAL TEST CURVES

Job No. : 30796

Sample Number : 100251
Sample Depth : 1.00 - 1.45m.
Bore Hole Number : 23

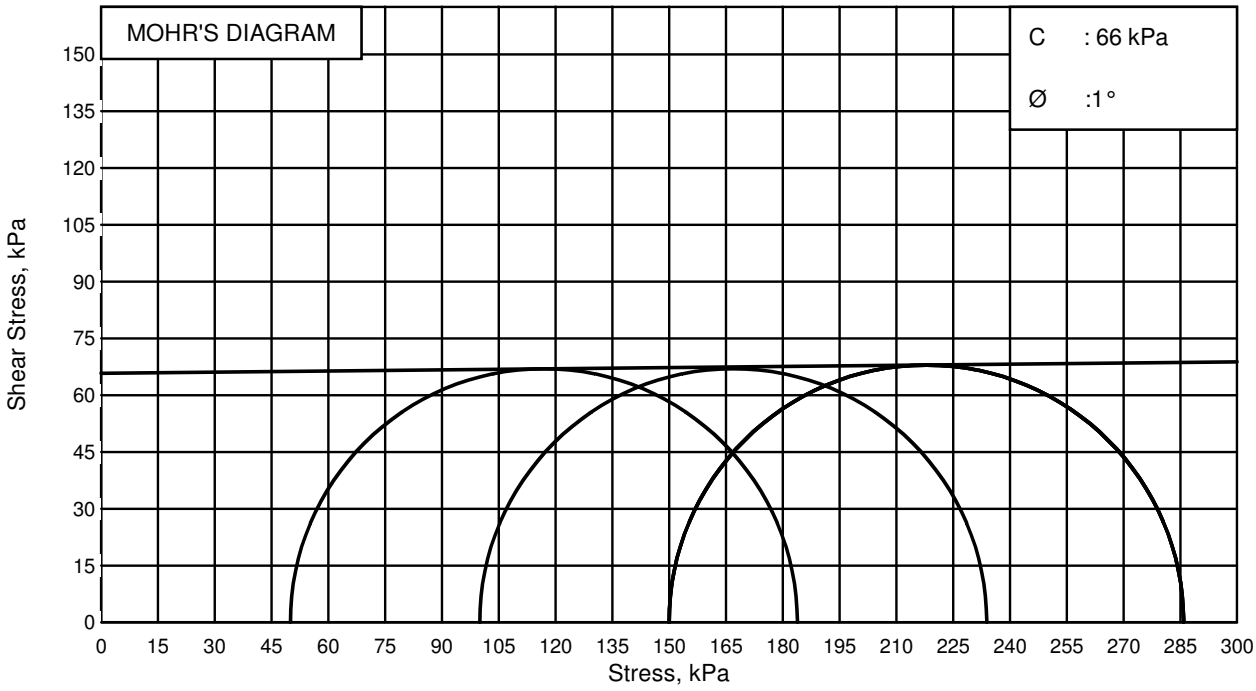
Site :
Type of Test : UU



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

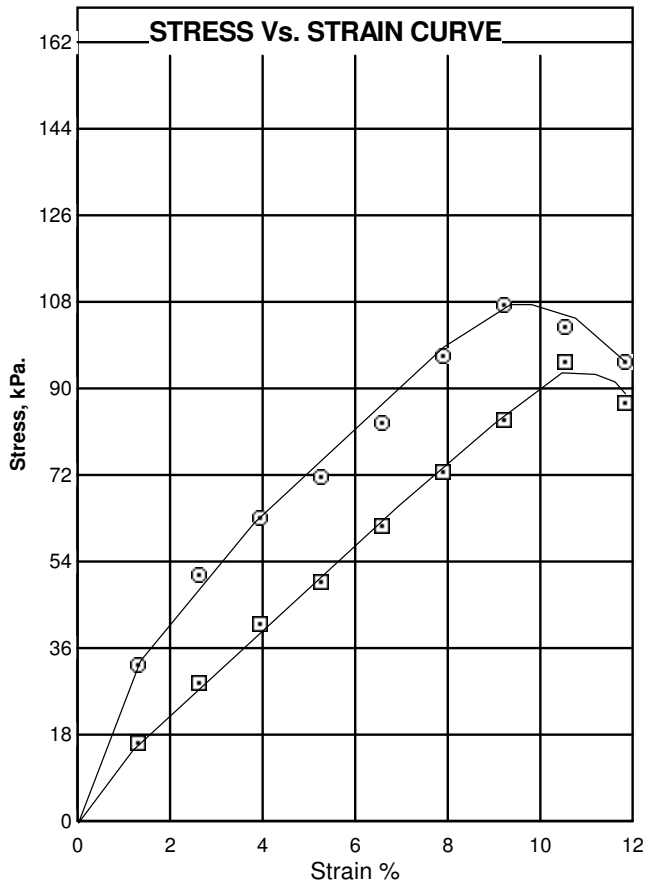


TRIAXIAL TEST CURVES

Job No. : 30796

Sample Number : 100254
Sample Depth : 3.00 - 3.45m.
Bore Hole Number : 23

Site :
Type of Test : cu



Mode of Failure :

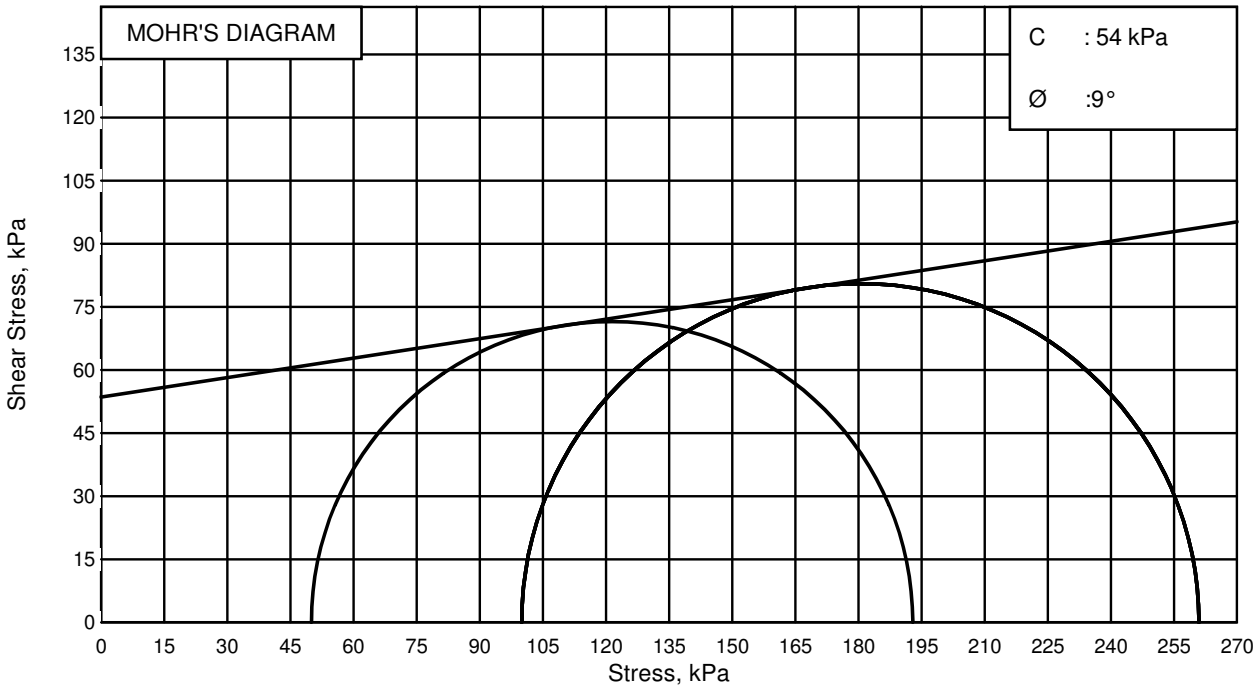
Specimen : 1 ⊡

Cell Pressure : 50 kPa

Mode of Failure :

Specimen : 2 ⊙

Cell Pressure : 100 kPa

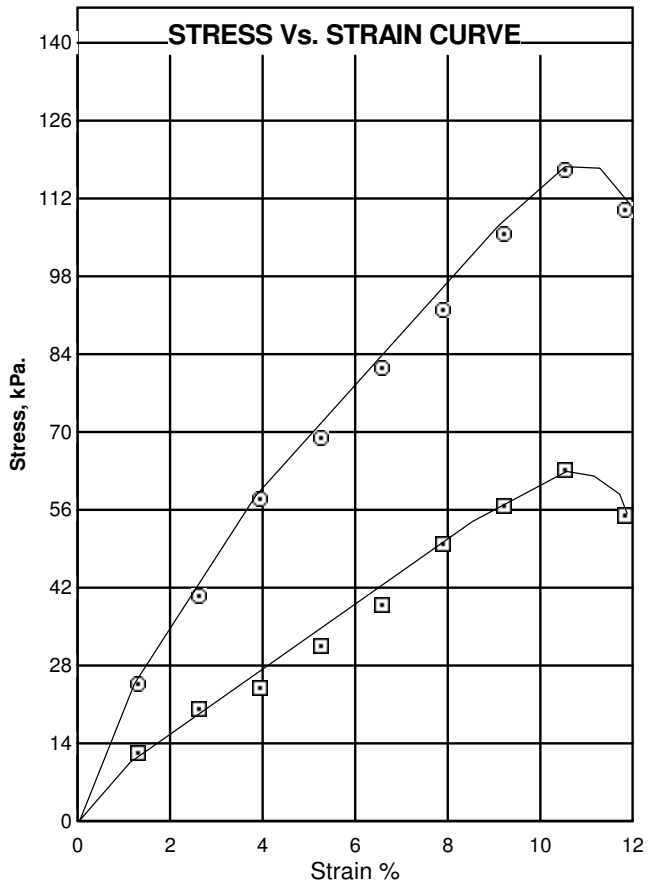


TRIAXIAL TEST CURVES

Job No. : 30796

Sample Number : 100102
Sample Depth : 1.00 - 1.45m.
Bore Hole Number : 24

Site :
Type of Test : CD



Mode of Failure :

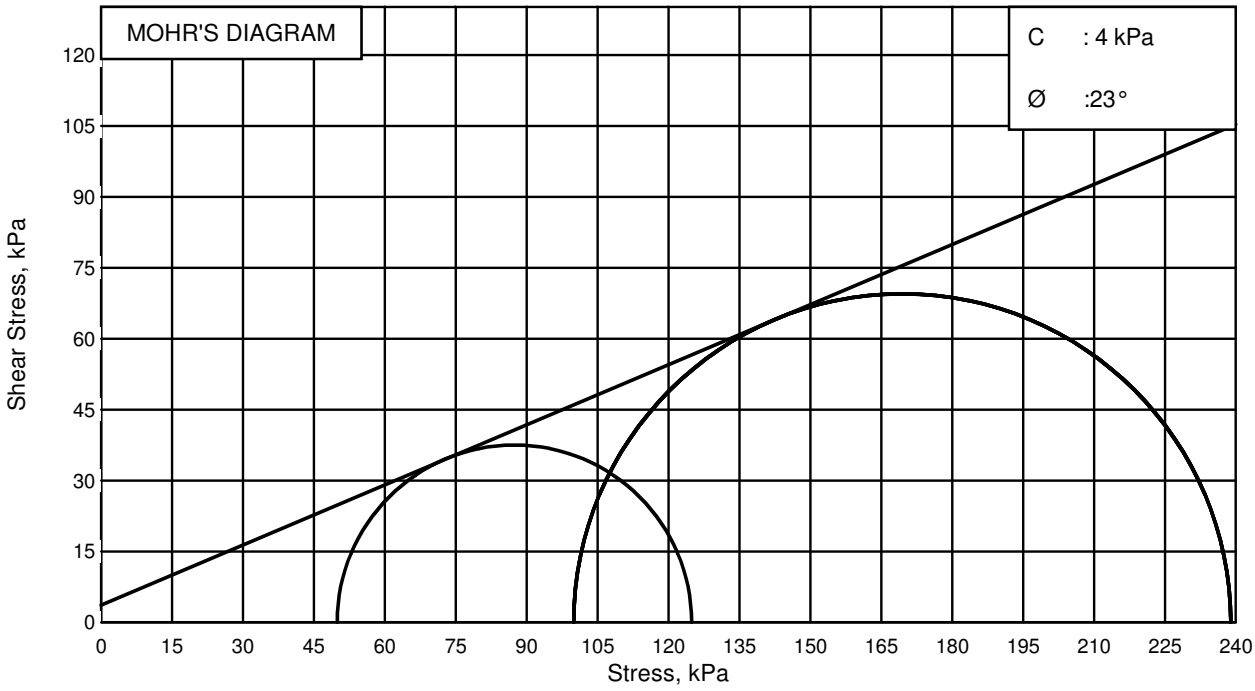
Specimen : 1 ⊡

Cell Pressure : 50 kPa

Mode of Failure :

Specimen : 2 ⊙

Cell Pressure : 100 kPa

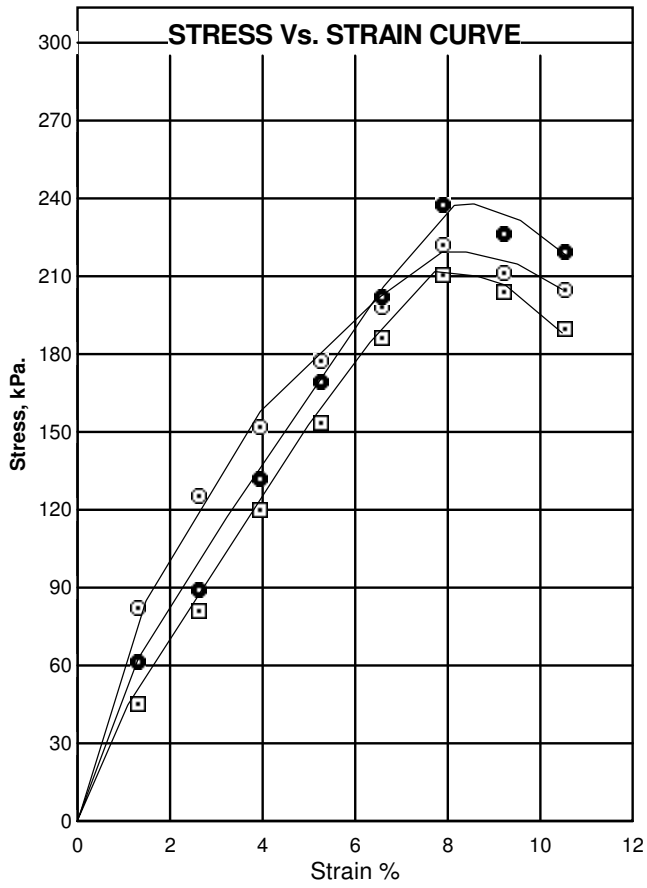


TRIAXIAL TEST CURVES

Job No. : 30796

Sample Number : 100106
Sample Depth : 3.00 - 3.45m.
Bore Hole Number : 24

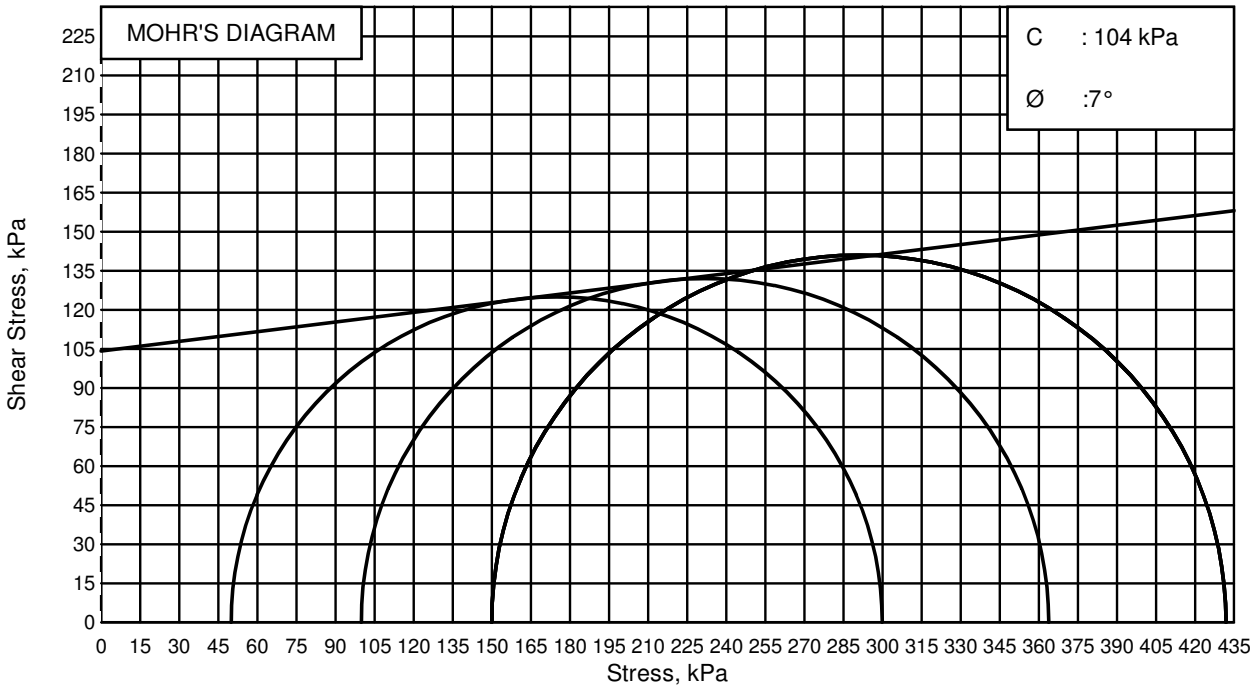
Site :
Type of Test : UU



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

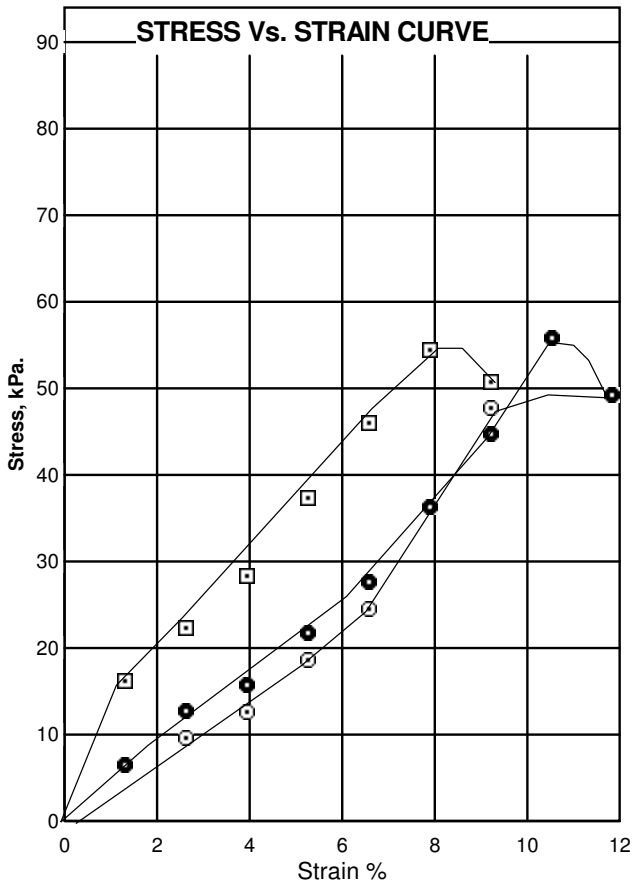


TRIAXIAL TEST CURVES

Job No. : 30796

Sample Number : 170020
Sample Depth : 1.00 - 1.45m.
Bore Hole Number : 25

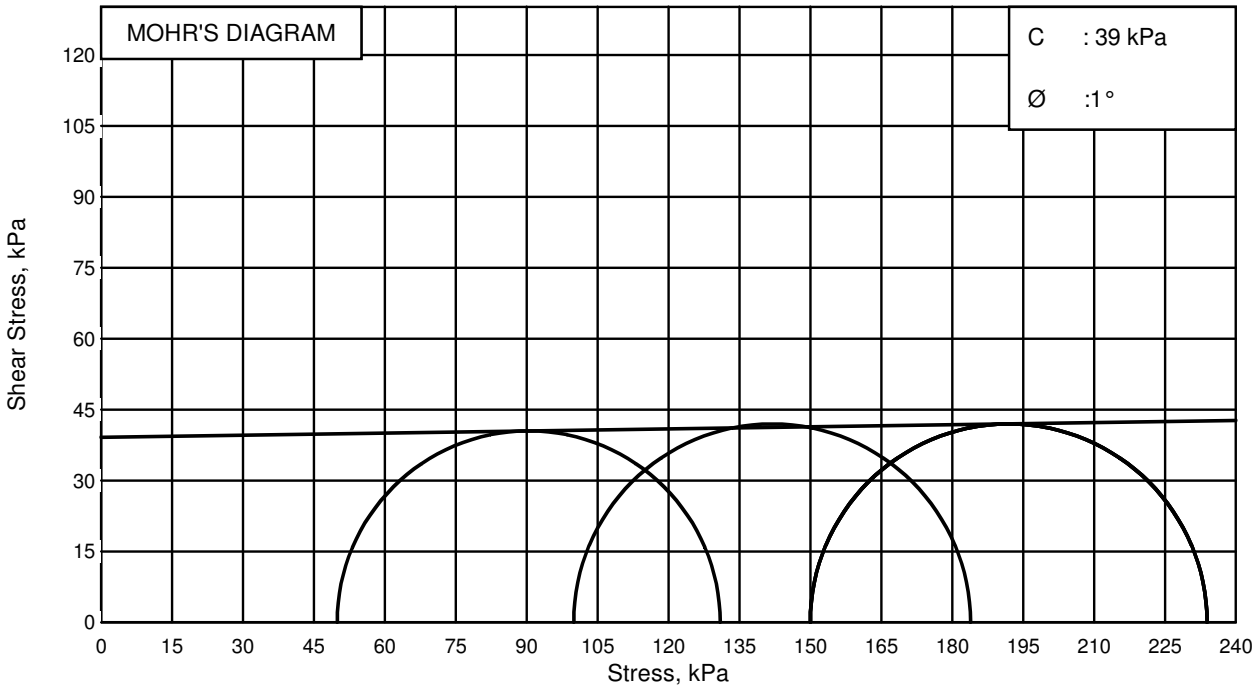
Site :
Type of Test : uu



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

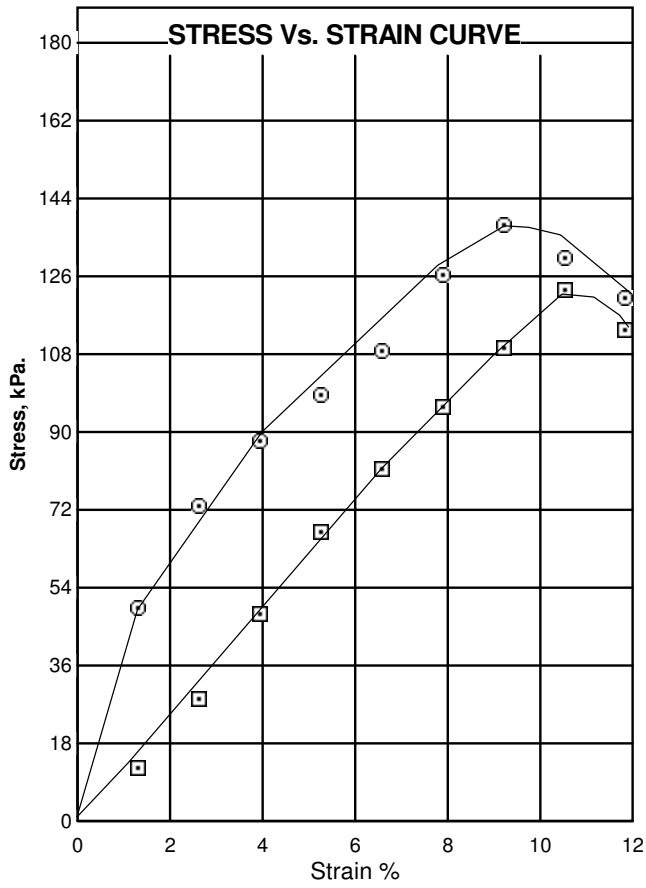


TRIAXIAL TEST CURVES

Job No. : 30796

Sample Number : 170027
Sample Depth : 6.00 - 6.45m.
Bore Hole Number : 25

Site :
Type of Test : cu



Mode of Failure :

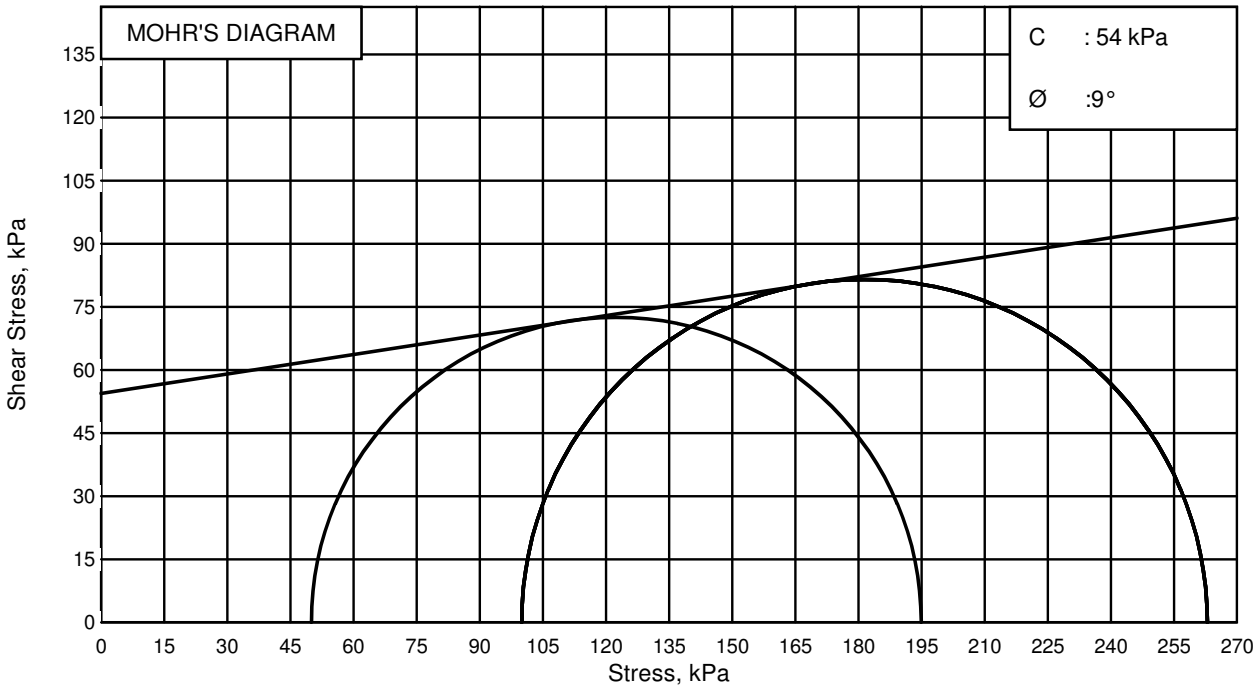
Specimen : 1 ⊡

Cell Pressure : 50 kPa

Mode of Failure :

Specimen : 2 ⊙

Cell Pressure : 100 kPa

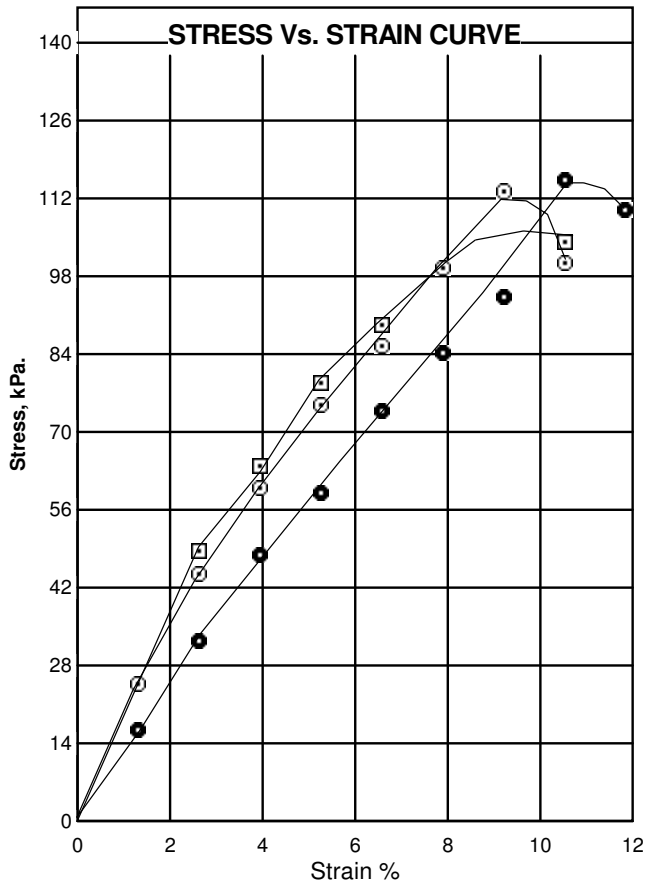


TRIAXIAL TEST CURVES

Job No. : 30796

Sample Number : 182160
Sample Depth : 3.00 - 3.45m.
Bore Hole Number : 26

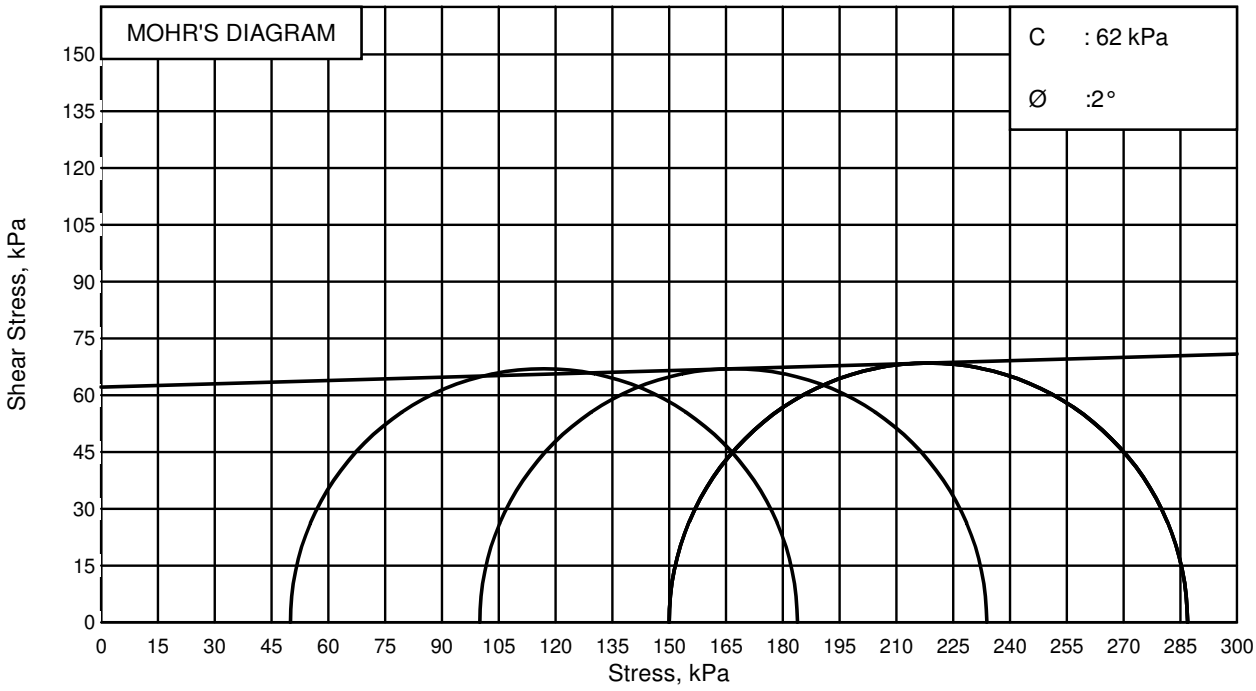
Site :
Type of Test : uu



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

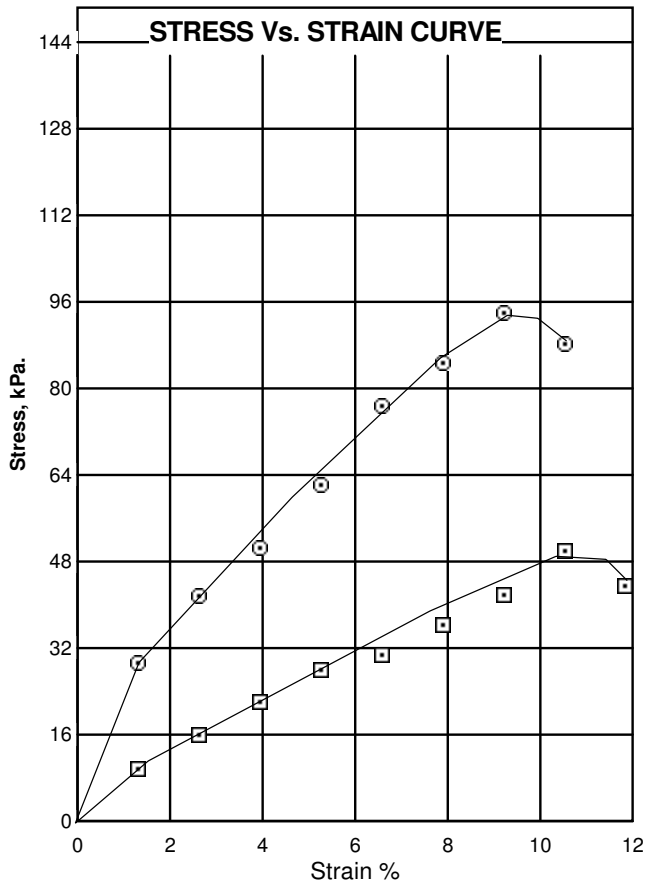


TRIAXIAL TEST CURVES

Job No. : 30796

Sample Number : 170667
Sample Depth : 4.50 - 4.95m.
Bore Hole Number : 27

Site :
Type of Test : cd



Mode of Failure :

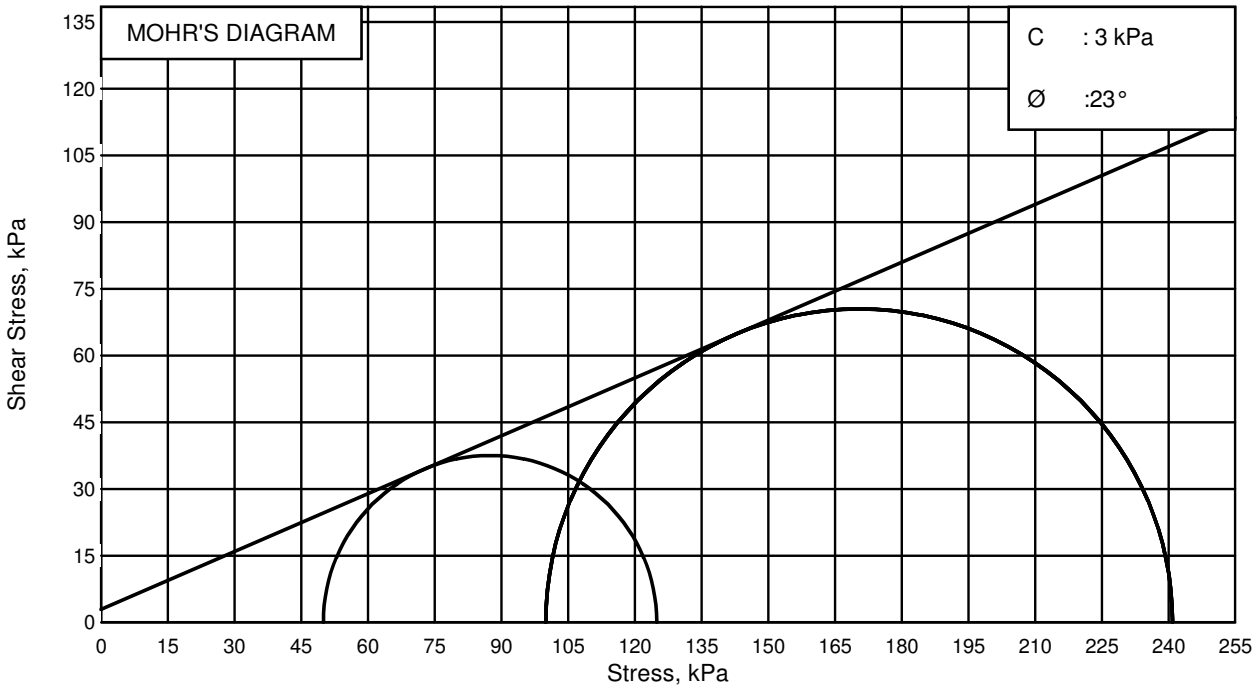
Specimen : 1 ⊡

Cell Pressure : 50 kPa

Mode of Failure :

Specimen : 2 ⊙

Cell Pressure : 100 kPa

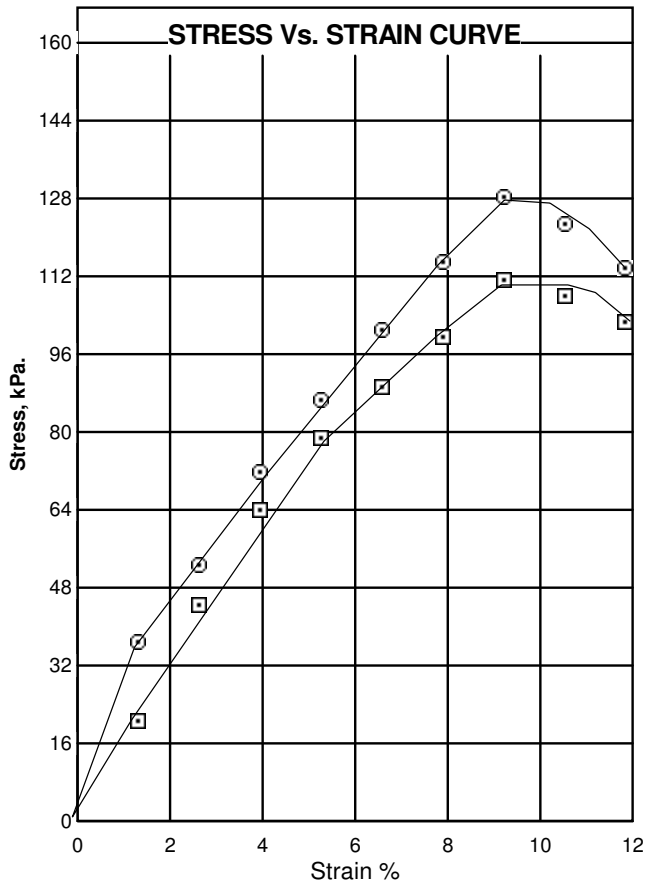


TRIAXIAL TEST CURVES

Job No. : 30796

Sample Number : 160775
Sample Depth : 3.00 - 3.45m.
Bore Hole Number : 28

Site :
Type of Test : cu



Mode of Failure :

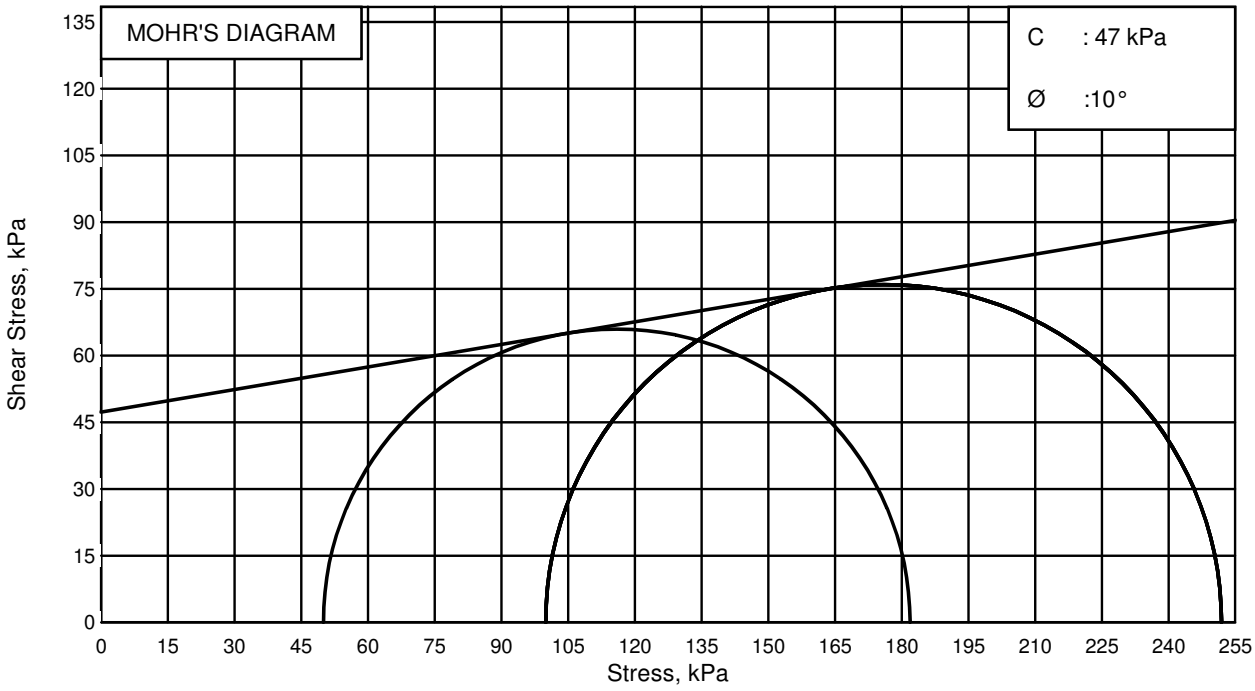
Specimen : 1 ⊡

Cell Pressure : 50 kPa

Mode of Failure :

Specimen : 2 ⊙

Cell Pressure : 100 kPa

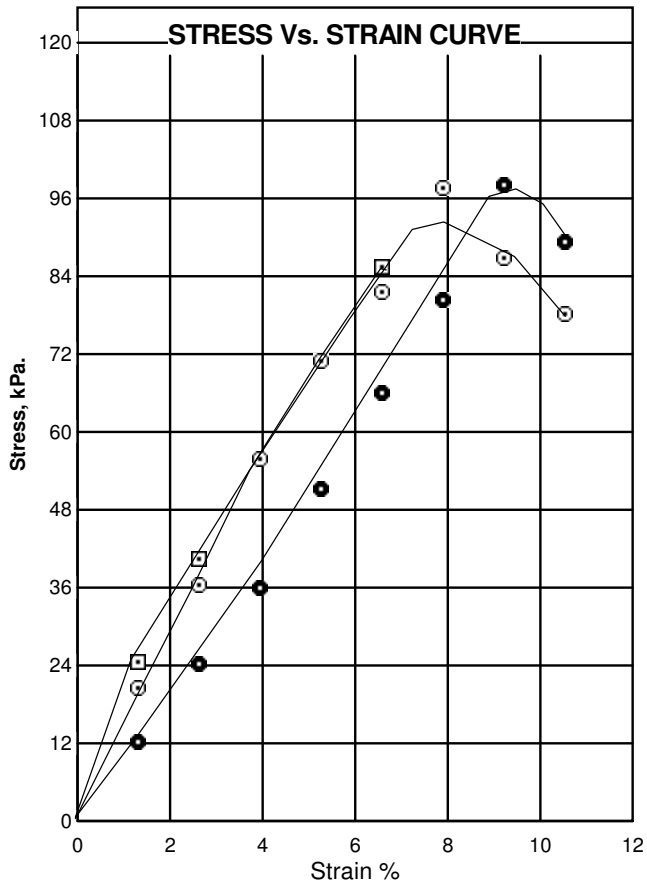


TRIAXIAL TEST CURVES

Job No. : 30796

Sample Number : 130154
Sample Depth : 2.00 - 2.45m.
Bore Hole Number : 29

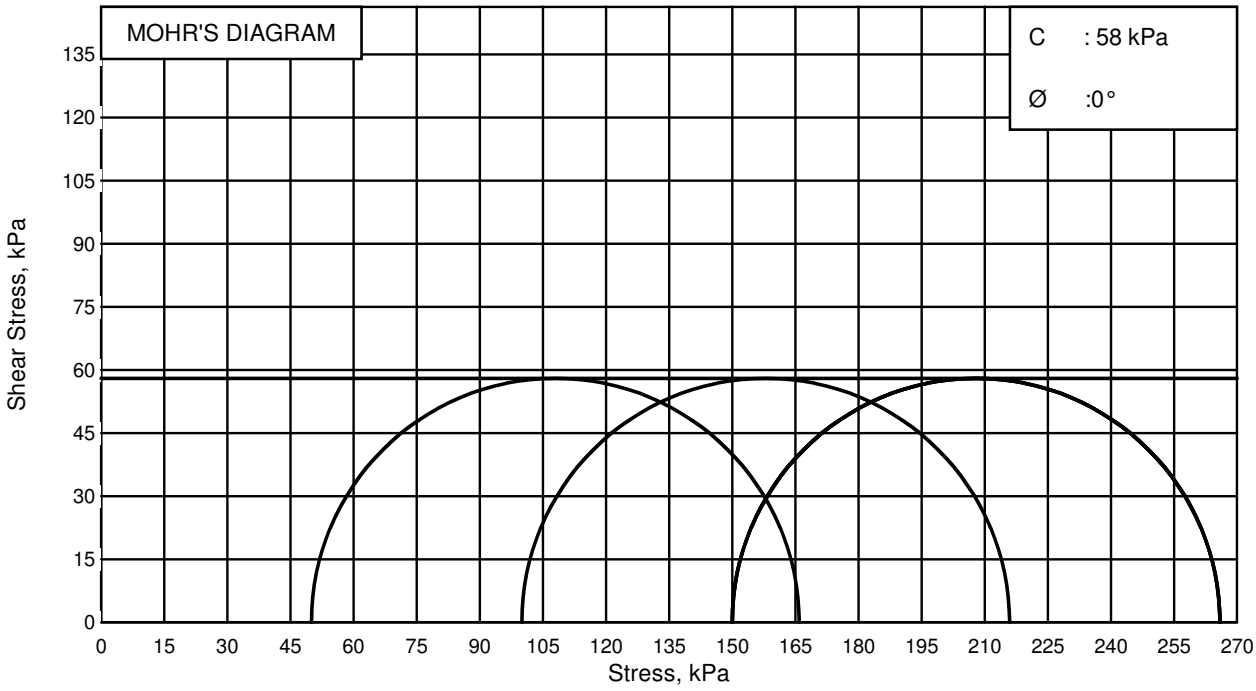
Site :
Type of Test : uu



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

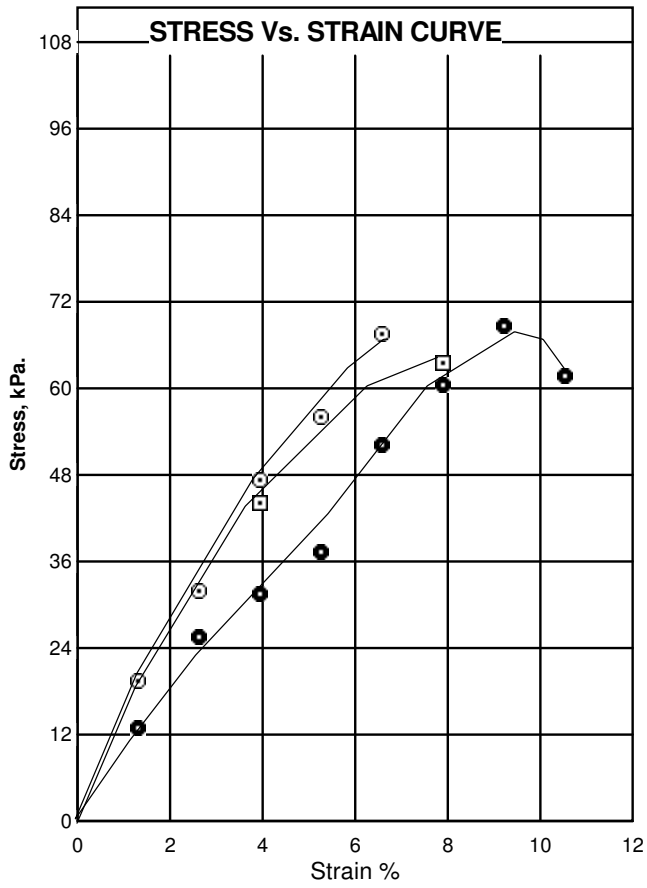


TRIAXIAL TEST CURVES

Job No. : 30796

Sample Number : 180111
Sample Depth : 1.00 - 1.45m.
Bore Hole Number : 30

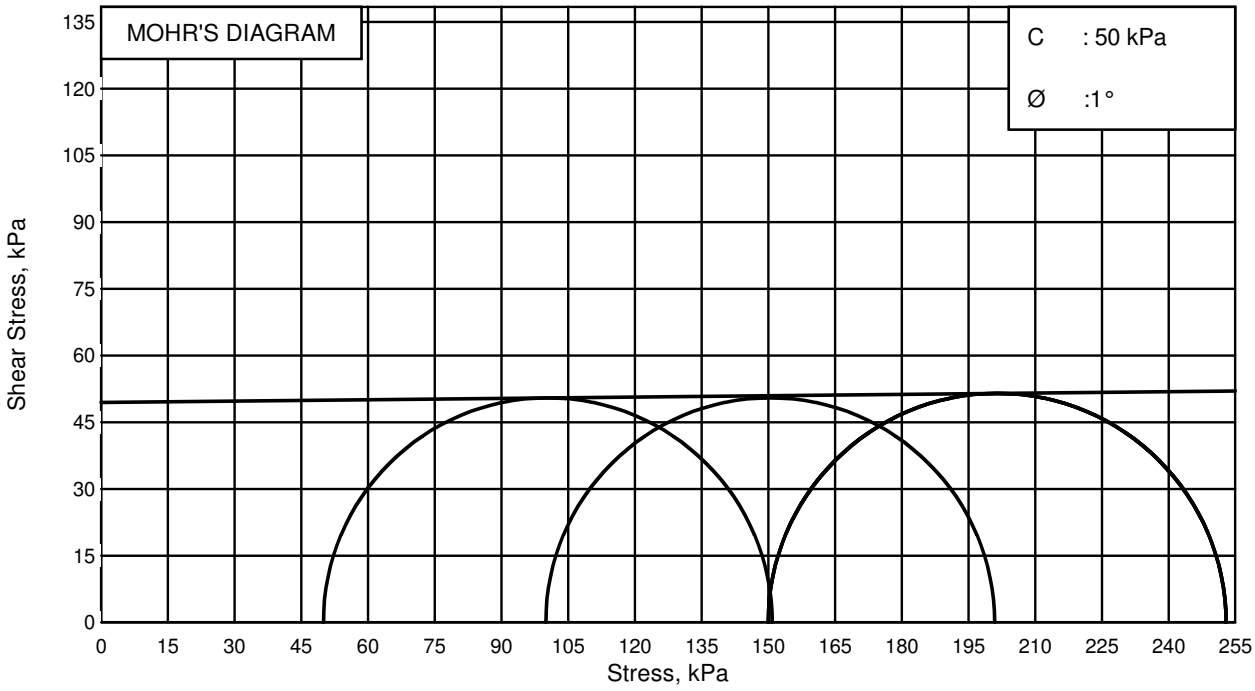
Site :
Type of Test : uu



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

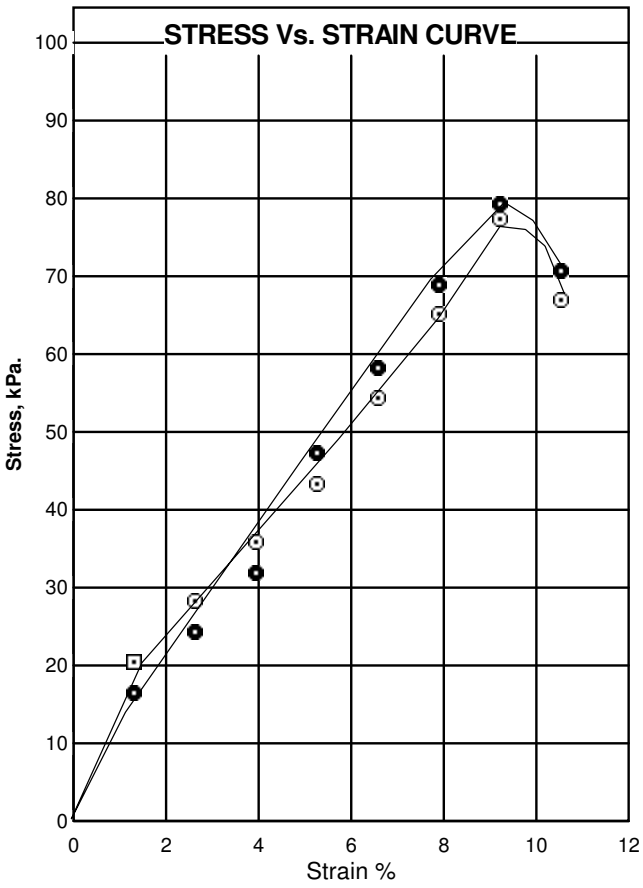


TRIAXIAL TEST CURVES

Job No. : 30796

Sample Number : 162192
Sample Depth : 2.00m.
Bore Hole Number : TP-1

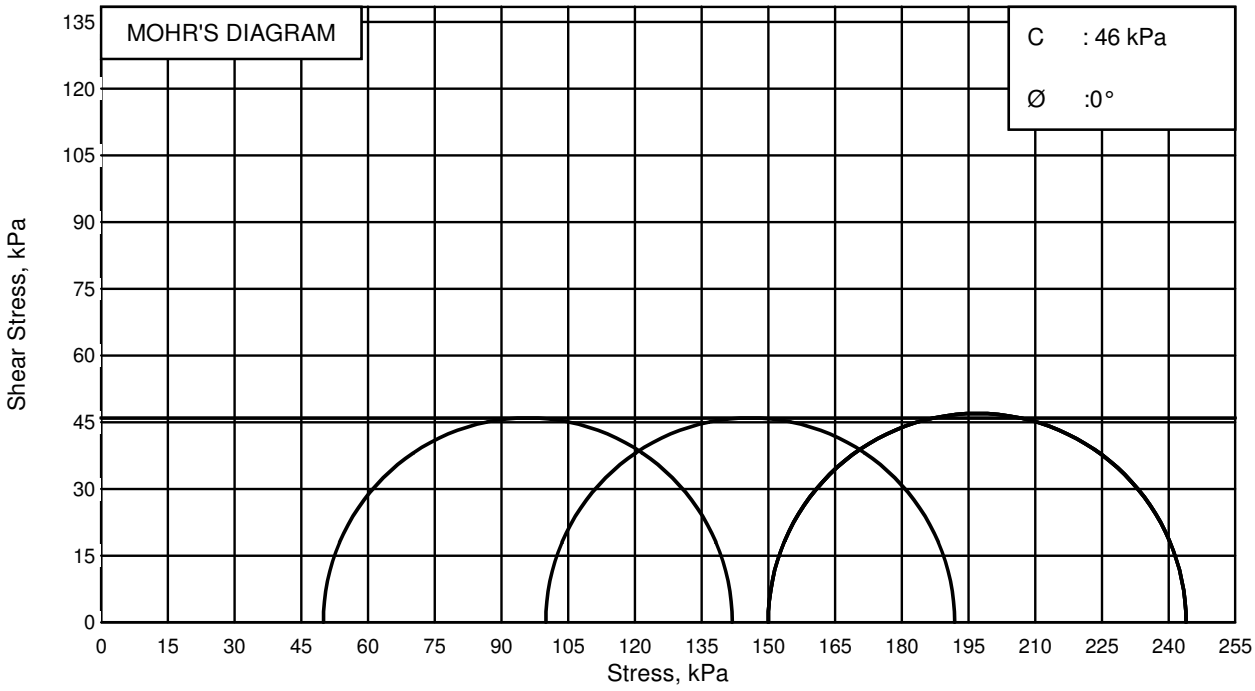
Site :
Type of Test : uu



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

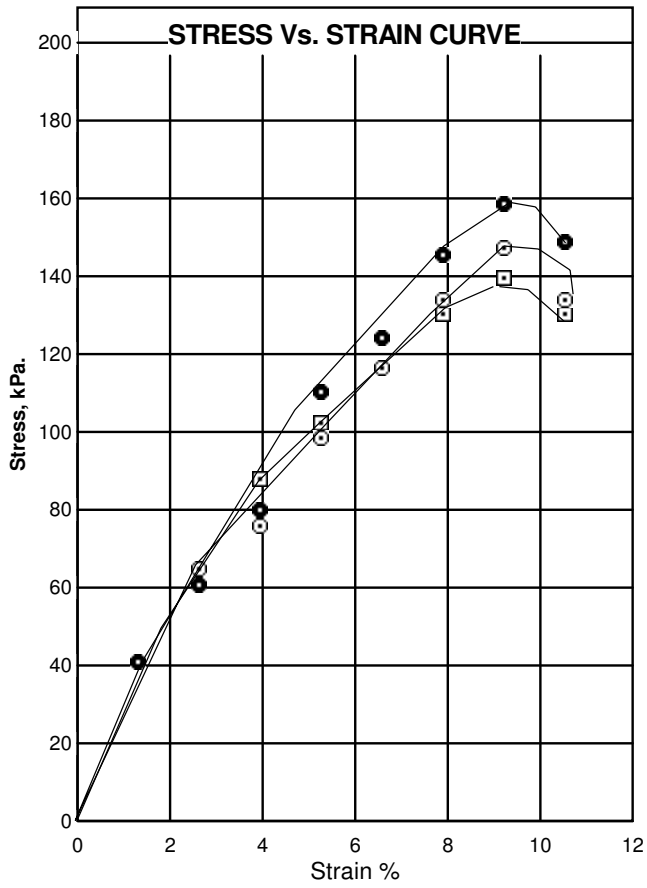


TRIAXIAL TEST CURVES

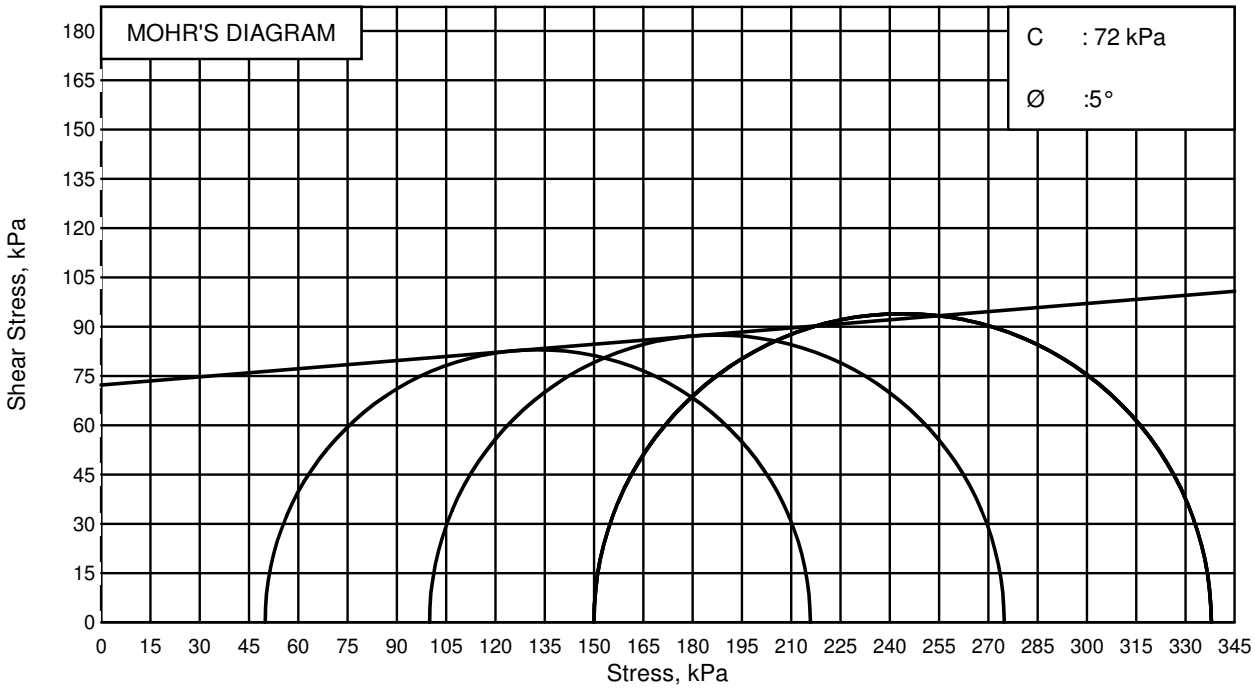
Job No. : 30796-TP

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	

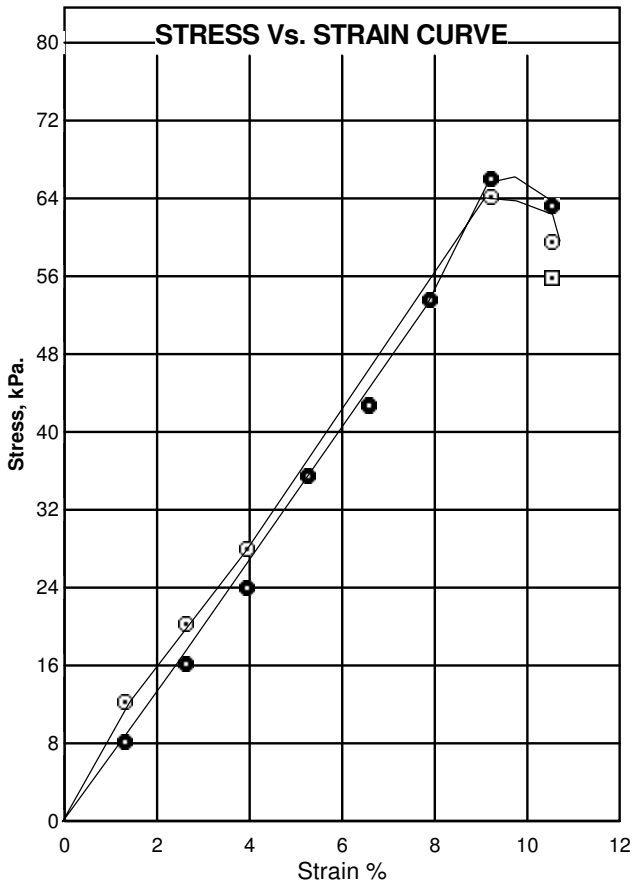


TRIAXIAL TEST CURVES

Job No. : 30796-TP

Sample Number : 100676
Sample Depth : 2.00m.
Bore Hole Number : TP-2

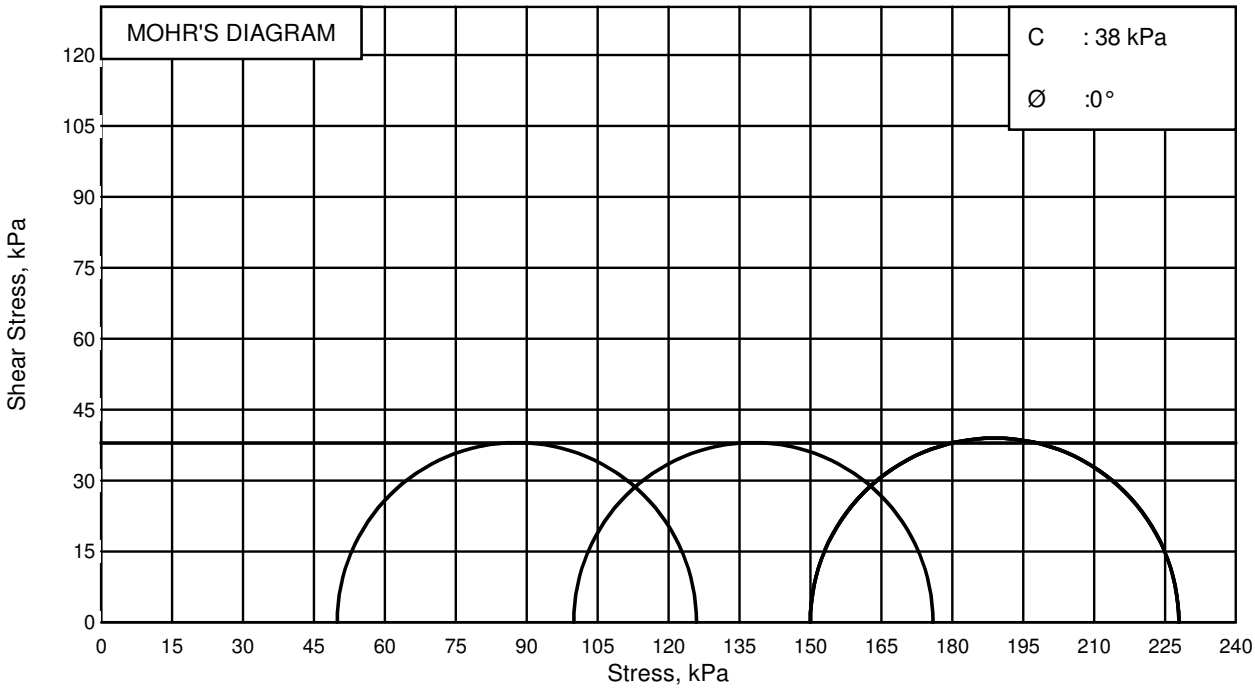
Site :
Type of Test : uu



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

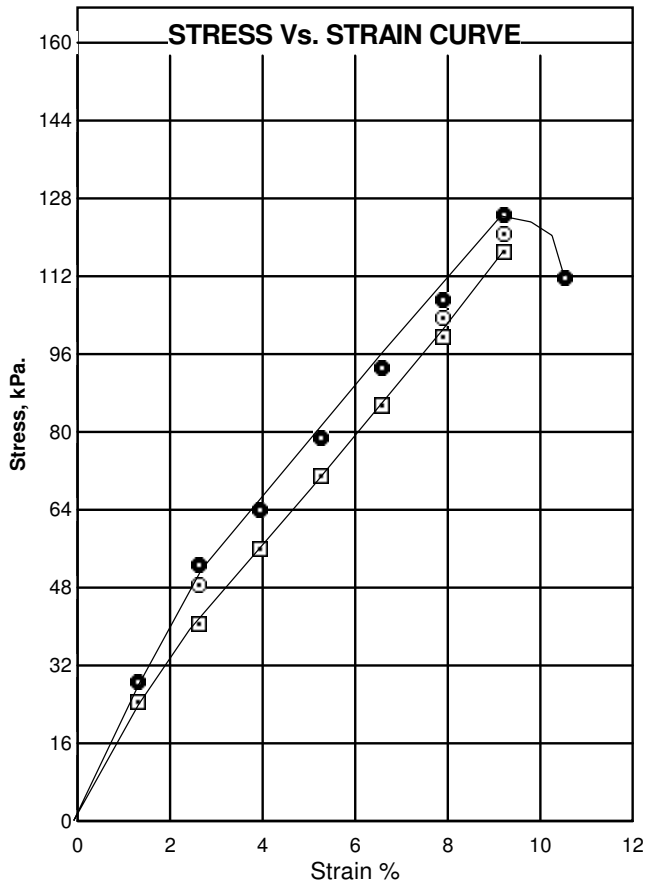


TRIAXIAL TEST CURVES

Job No. : 30796-TP

Sample Number : 100678
Sample Depth : 4.00m.
Bore Hole Number : TP-2

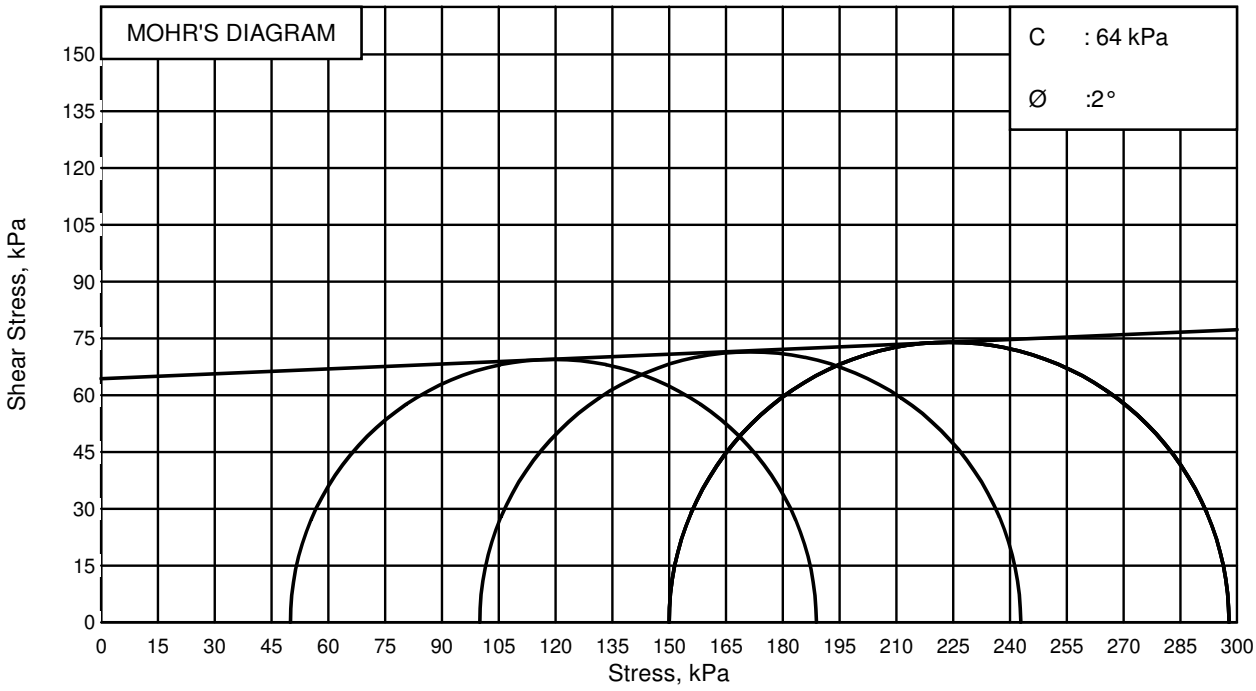
Site :
Type of Test : uu



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

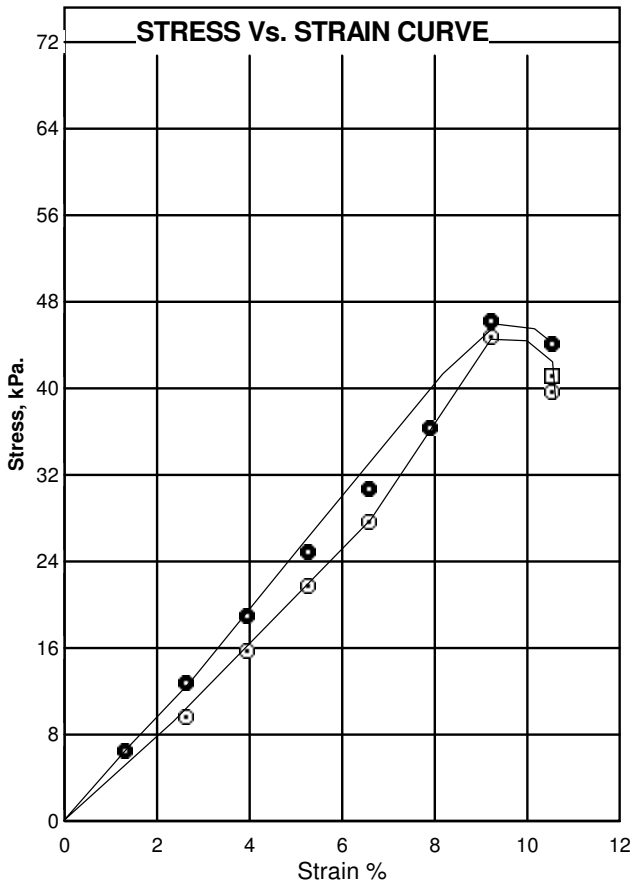


TRIAXIAL TEST CURVES

Job No. : 30796-TP

Sample Number : 106101
Sample Depth : 2.00m.
Bore Hole Number : TP-3

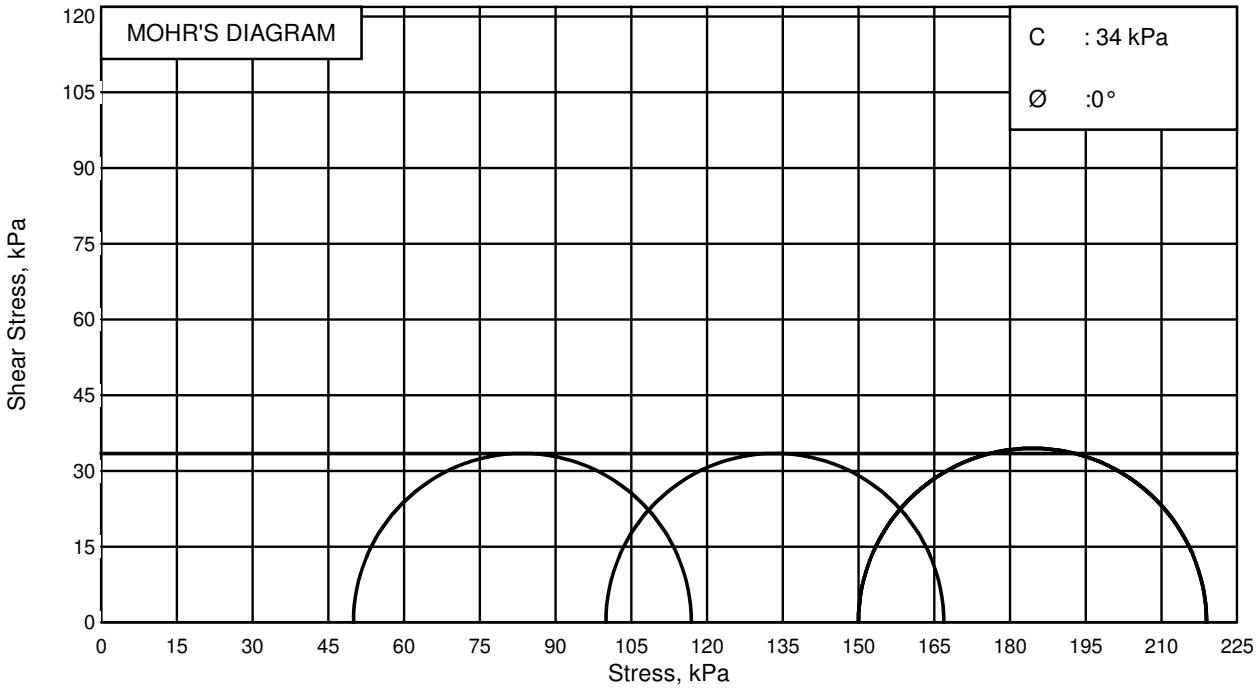
Site :
Type of Test : uu



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

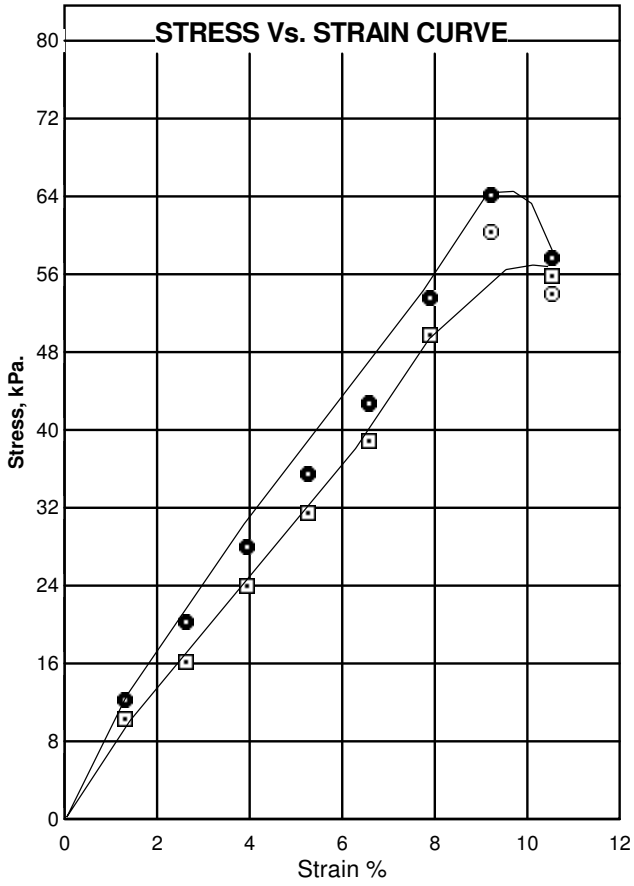


TRIAXIAL TEST CURVES

Job No. : 30796-TP

Sample Number : 106103
Sample Depth : 4.00m.
Bore Hole Number : TP-3

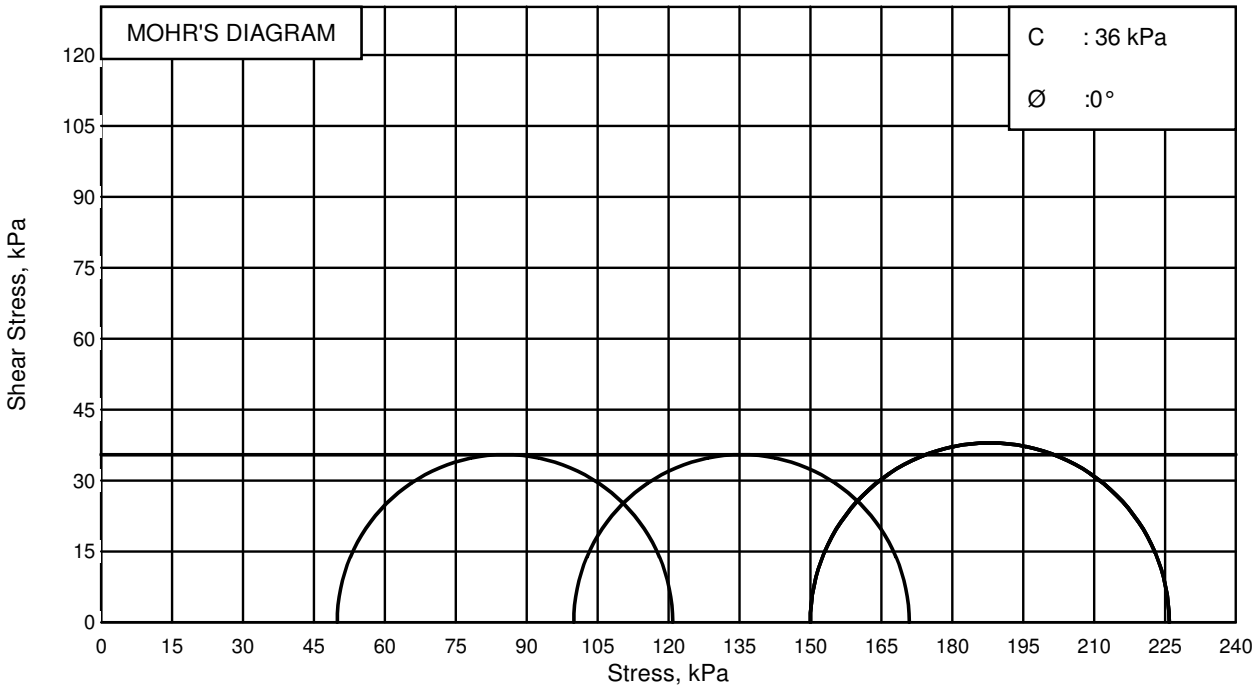
Site :
Type of Test : uu



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

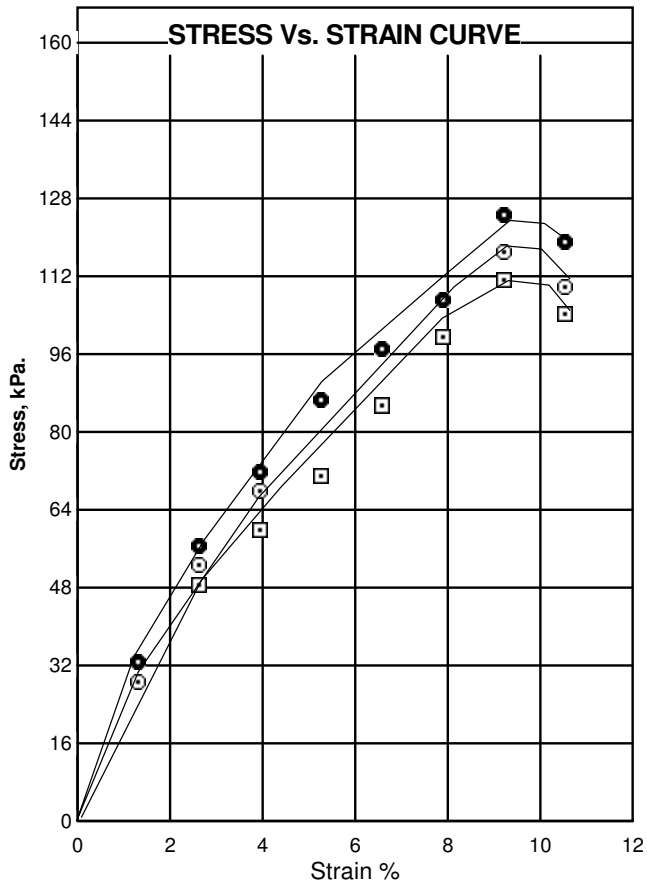


TRIAXIAL TEST CURVES

Job No. : 30796-TP

Sample Number : 106105
Sample Depth : 2.00m.
Bore Hole Number : TP-4

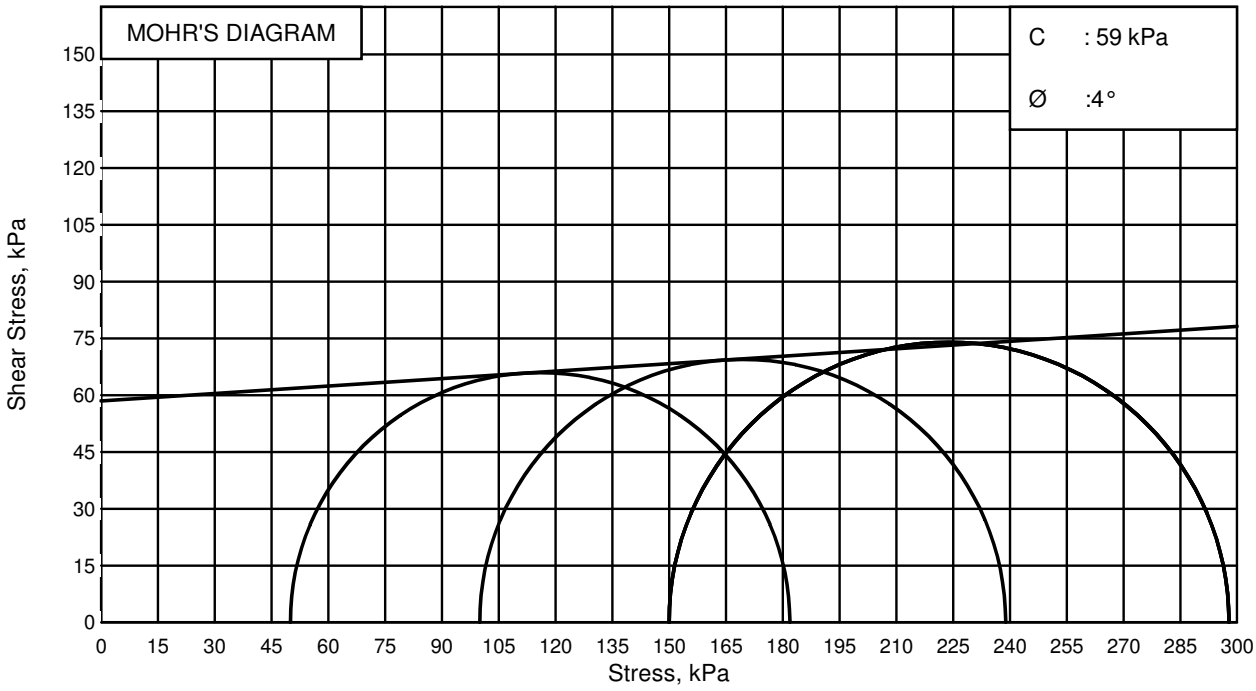
Site :
Type of Test : uu



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

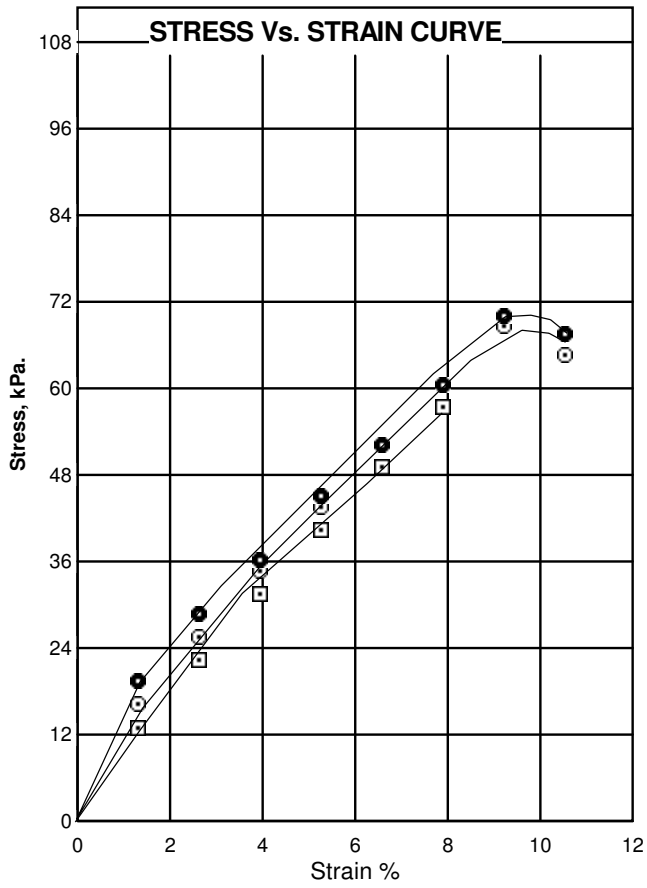


TRIAXIAL TEST CURVES

Job No. : 30796-TP

Sample Number : 151251
Sample Depth : 1.00m.
Bore Hole Number : TP-5

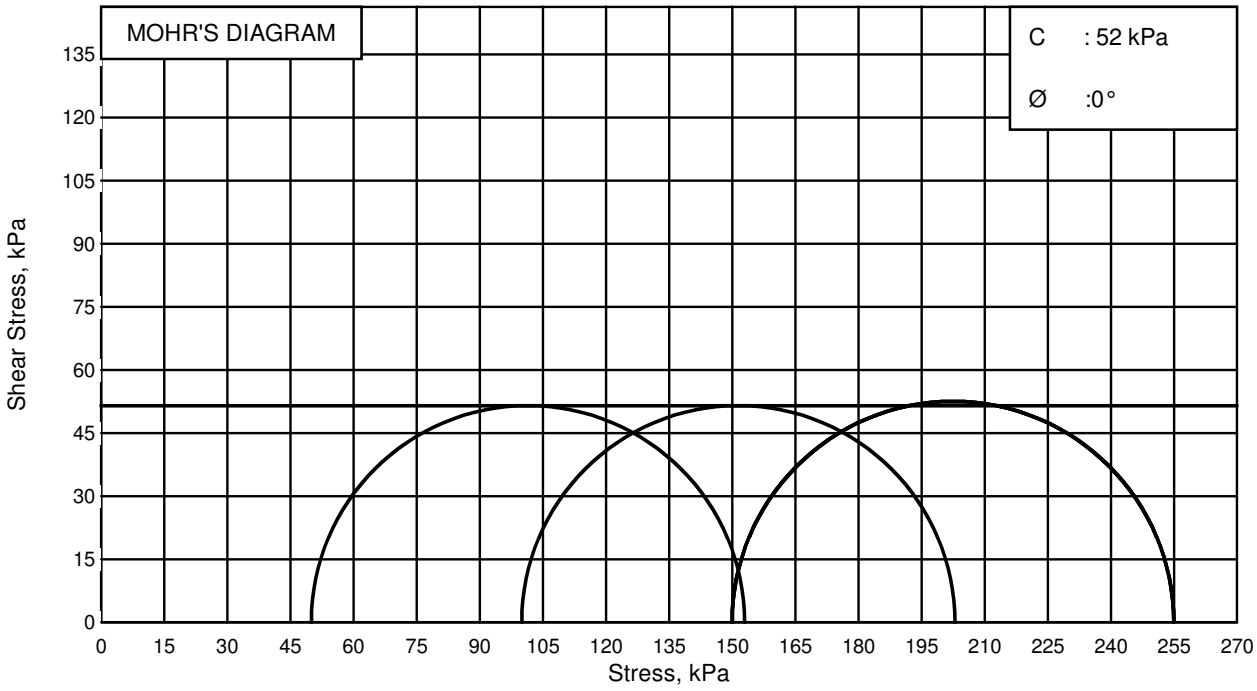
Site :
Type of Test : uu



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

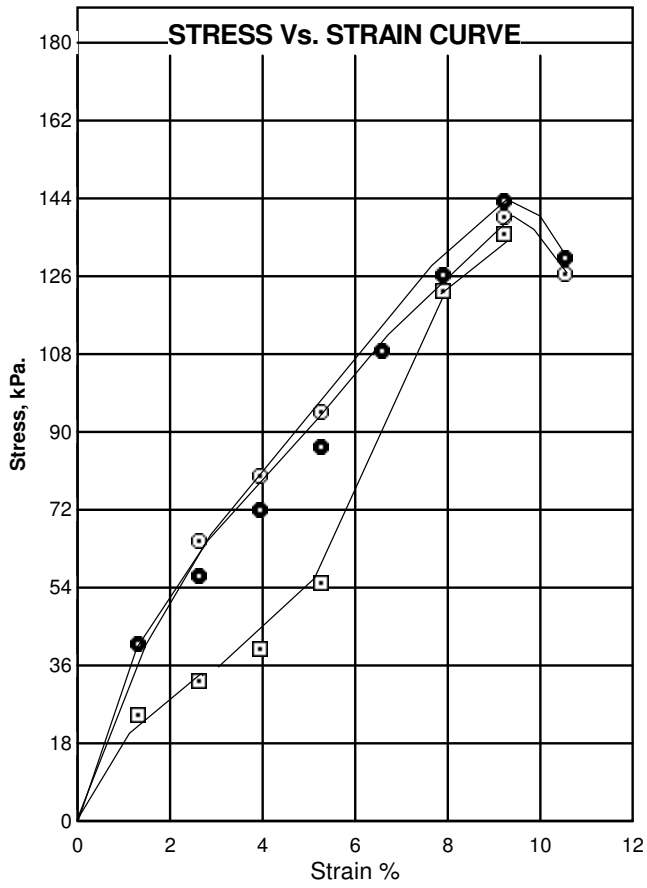


TRIAXIAL TEST CURVES

Job No. : 30796-TP

Sample Number : 151253
Sample Depth : 3.00 m.
Bore Hole Number : TP-5

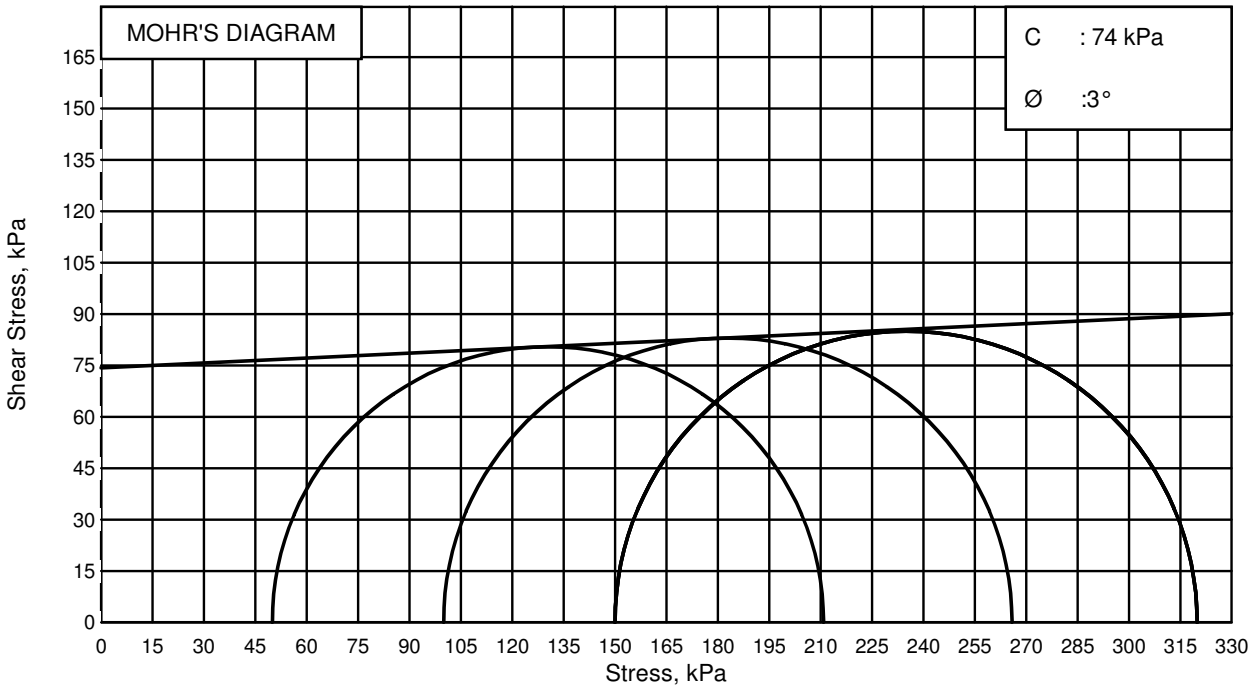
Site :
Type of Test : uu



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

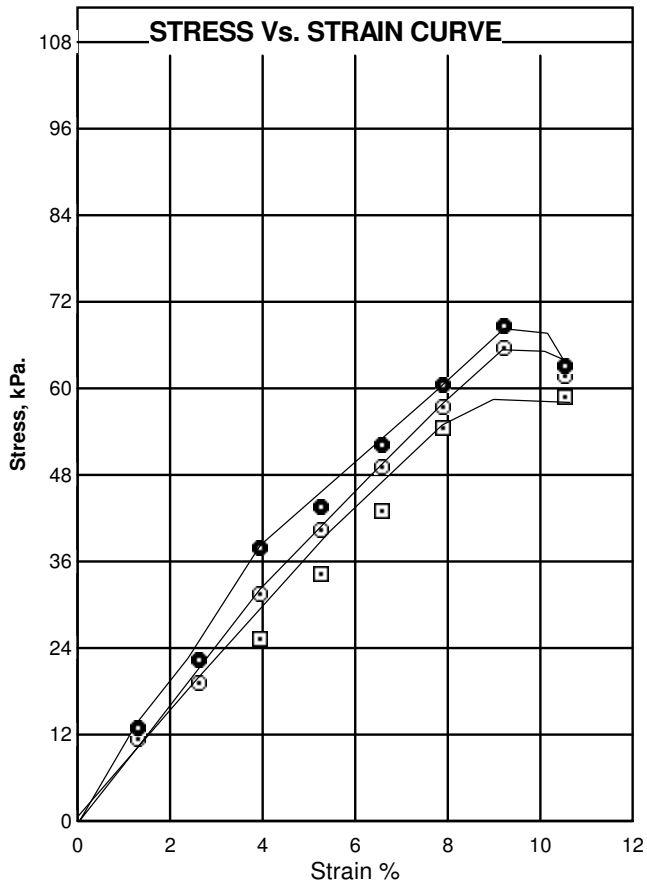


TRIAXIAL TEST CURVES

Job No. : 30796-TP

Sample Number : 171620
Sample Depth : 1.00m.
Bore Hole Number : TP-6

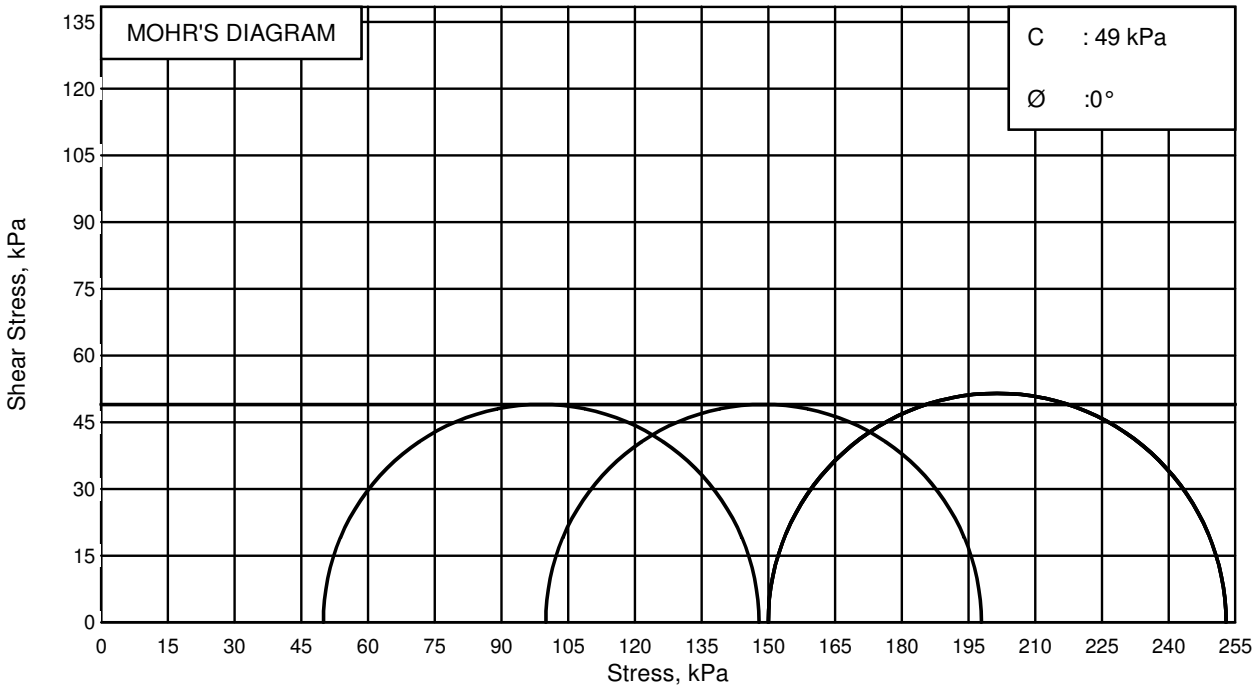
Site :
Type of Test : uu



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

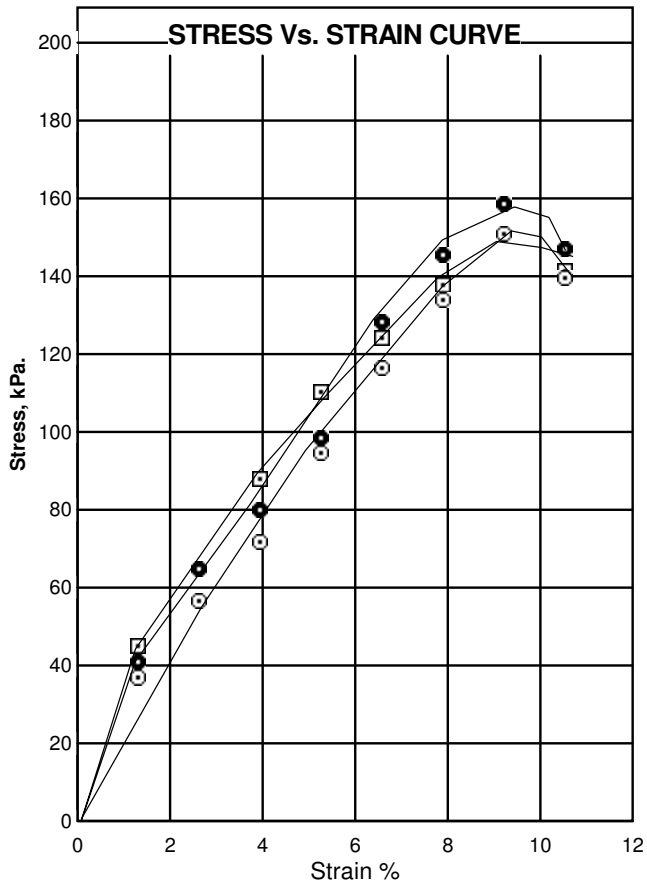


TRIAXIAL TEST CURVES

Job No. : 30796-TP

Sample Number : 171622
Sample Depth : 3.00m.
Bore Hole Number : TP-6

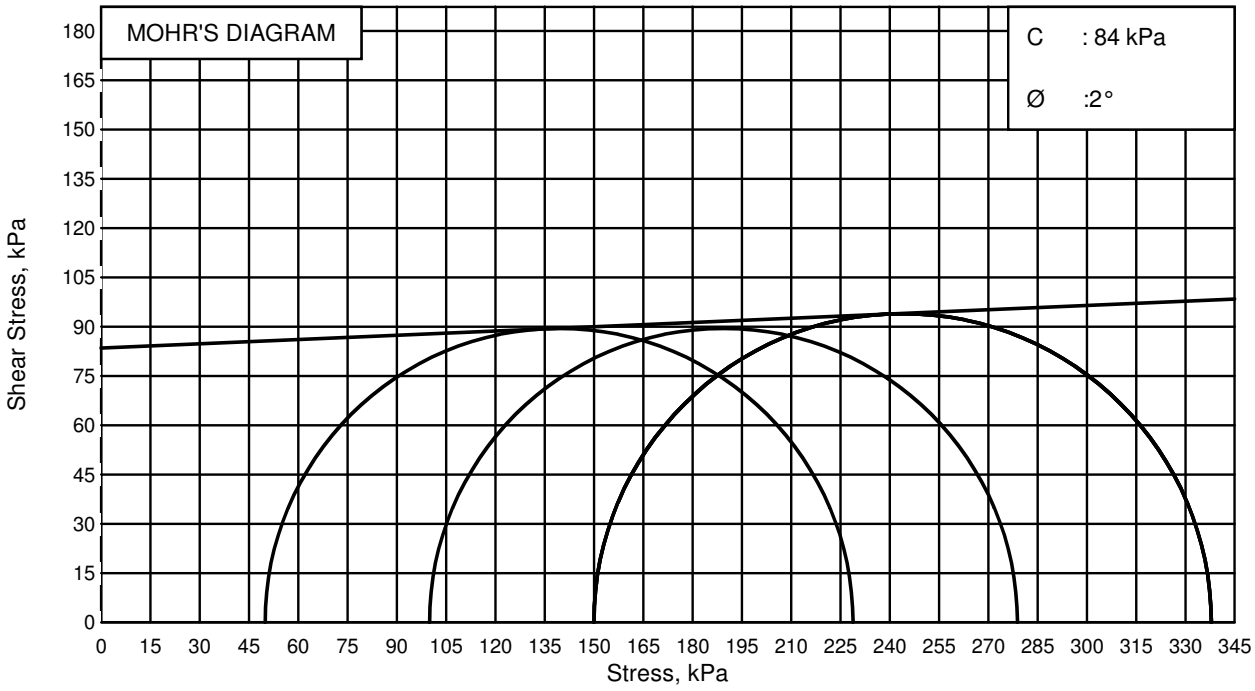
Site :
Type of Test : uu



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

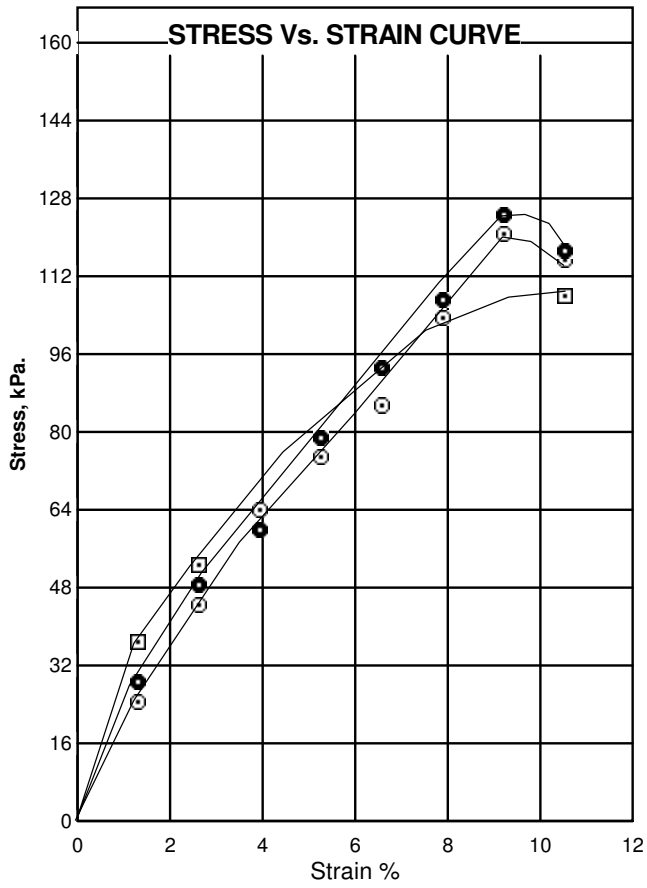


TRIAXIAL TEST CURVES

Job No. : 30796-TP

Sample Number : 100711
Sample Depth : 2.00m.
Bore Hole Number : TP-7

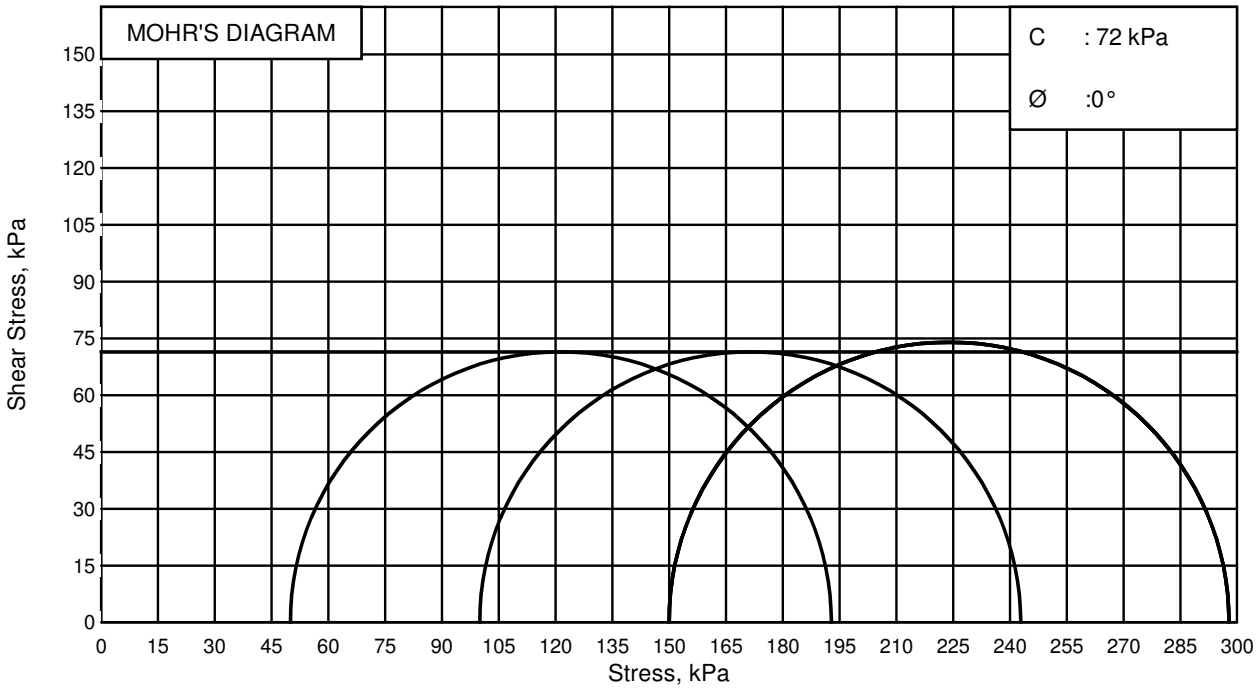
Site :
Type of Test : uu



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

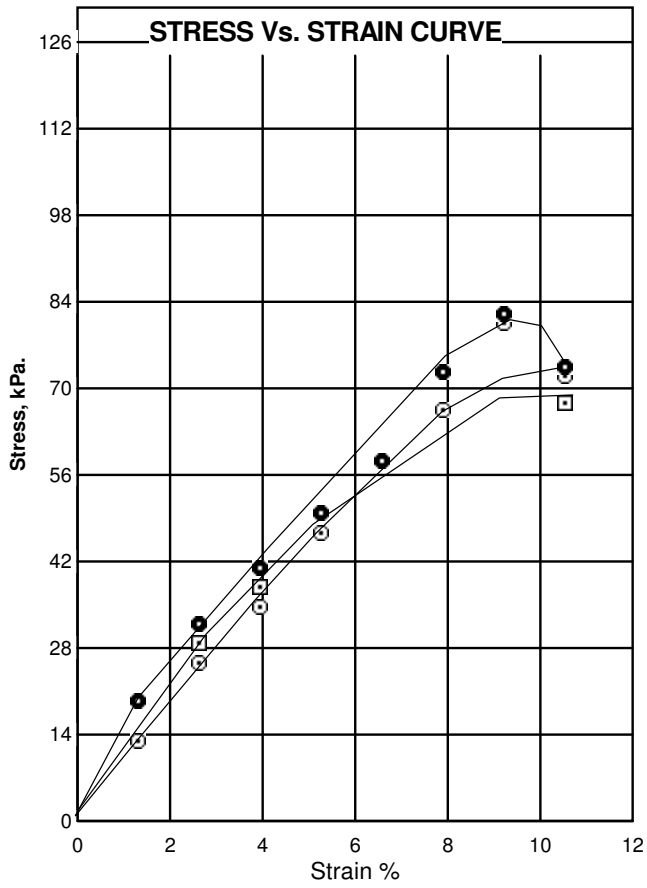


TRIAXIAL TEST CURVES

Job No. : 30796-TP

Sample Number : 105130
Sample Depth : 2.00m.
Bore Hole Number : TP-8

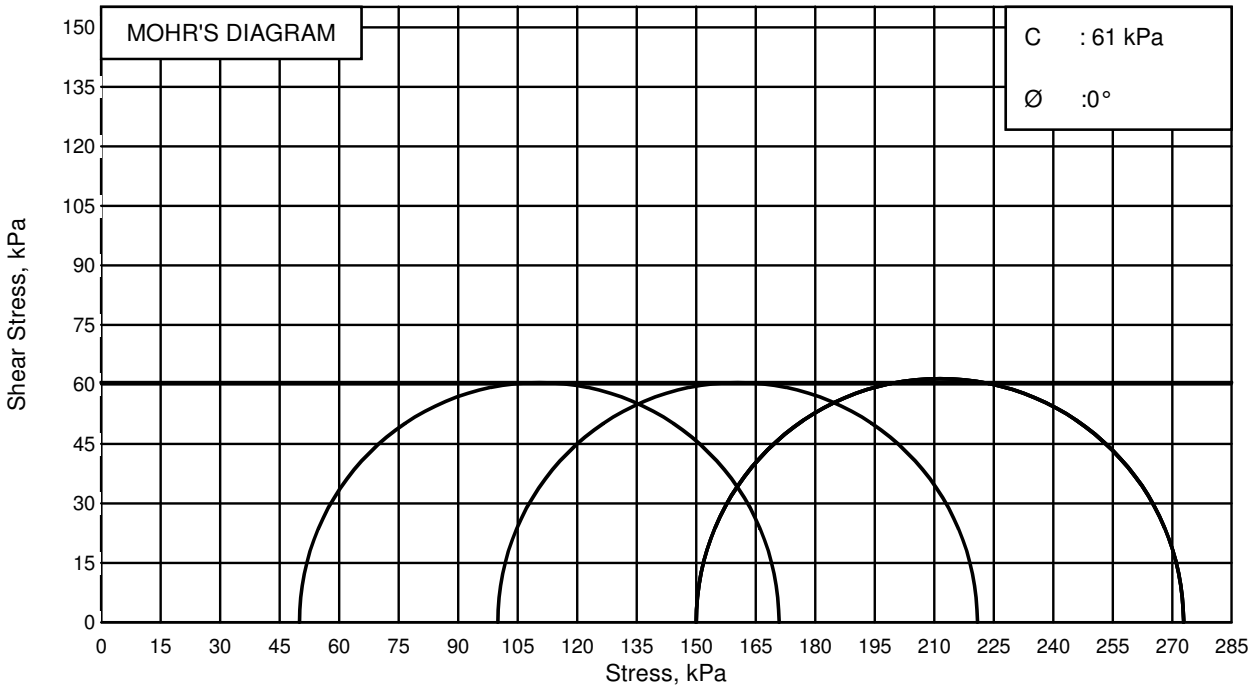
Site :
Type of Test : uu



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

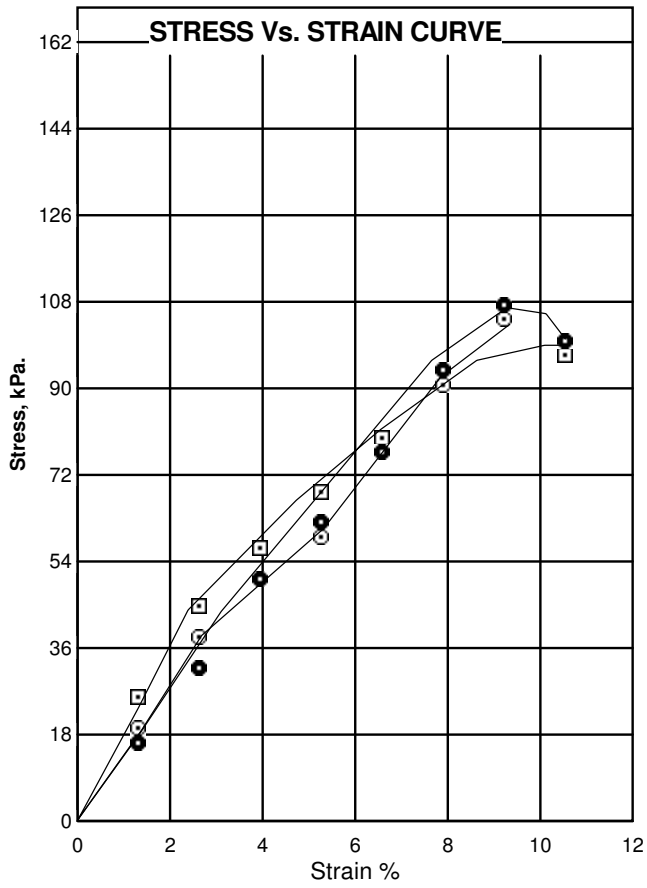


TRIAXIAL TEST CURVES

Job No. : 30796-TP

Sample Number : 105131
Sample Depth : 3.00m.
Bore Hole Number : TP-8

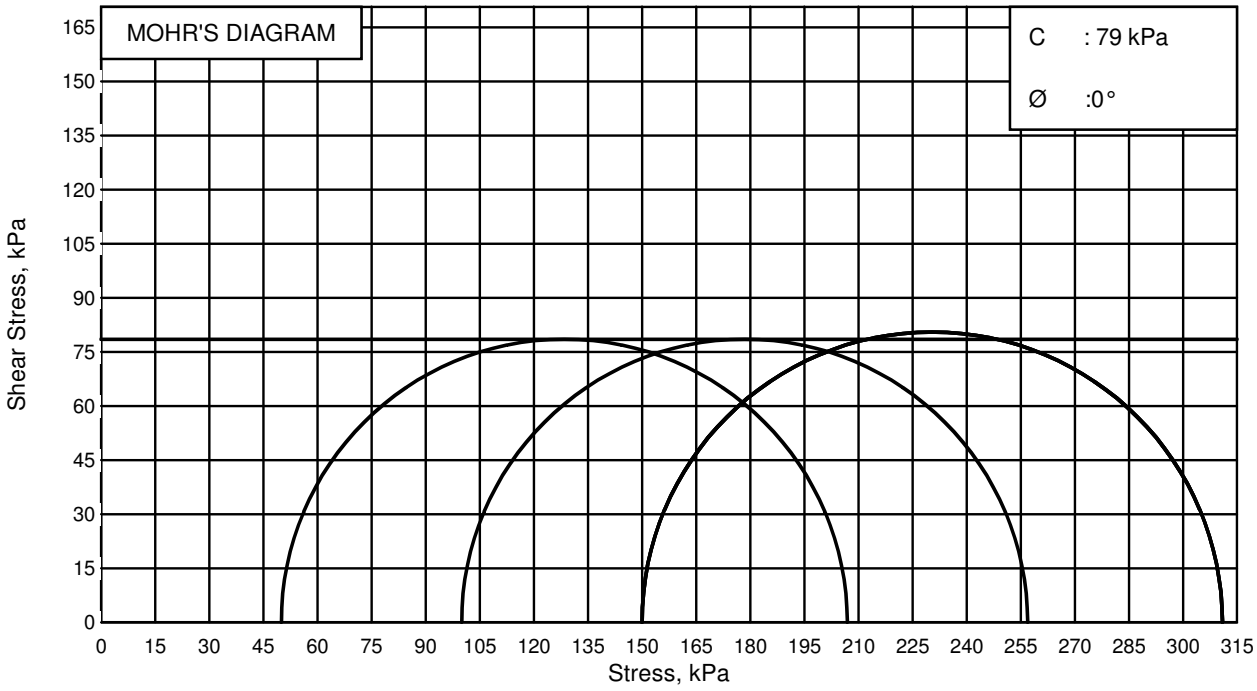
Site :
Type of Test : uu



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

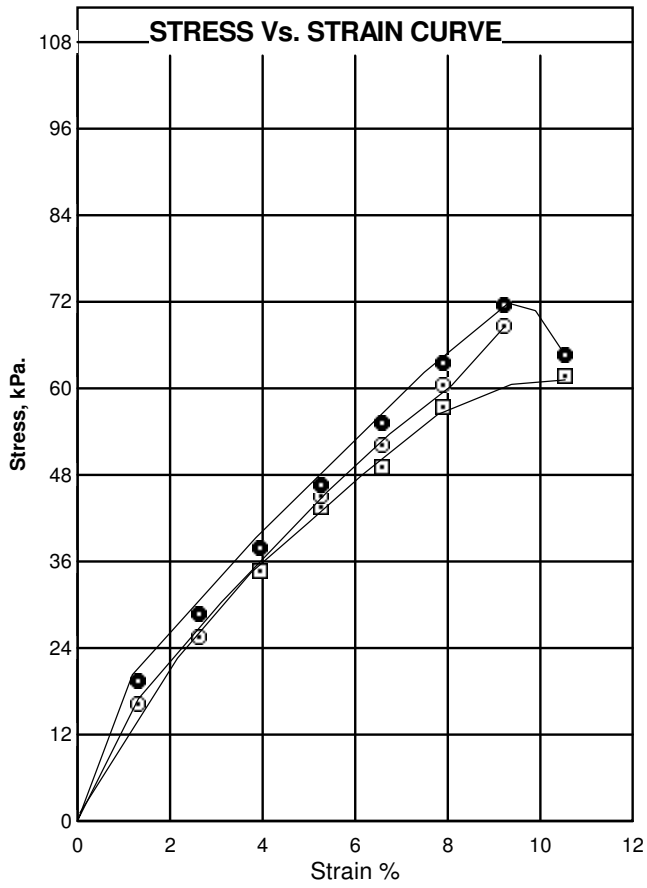


TRIAXIAL TEST CURVES

Job No. : 30796-TP

Sample Number : 120150
Sample Depth : 1.00m.
Bore Hole Number : TP-9

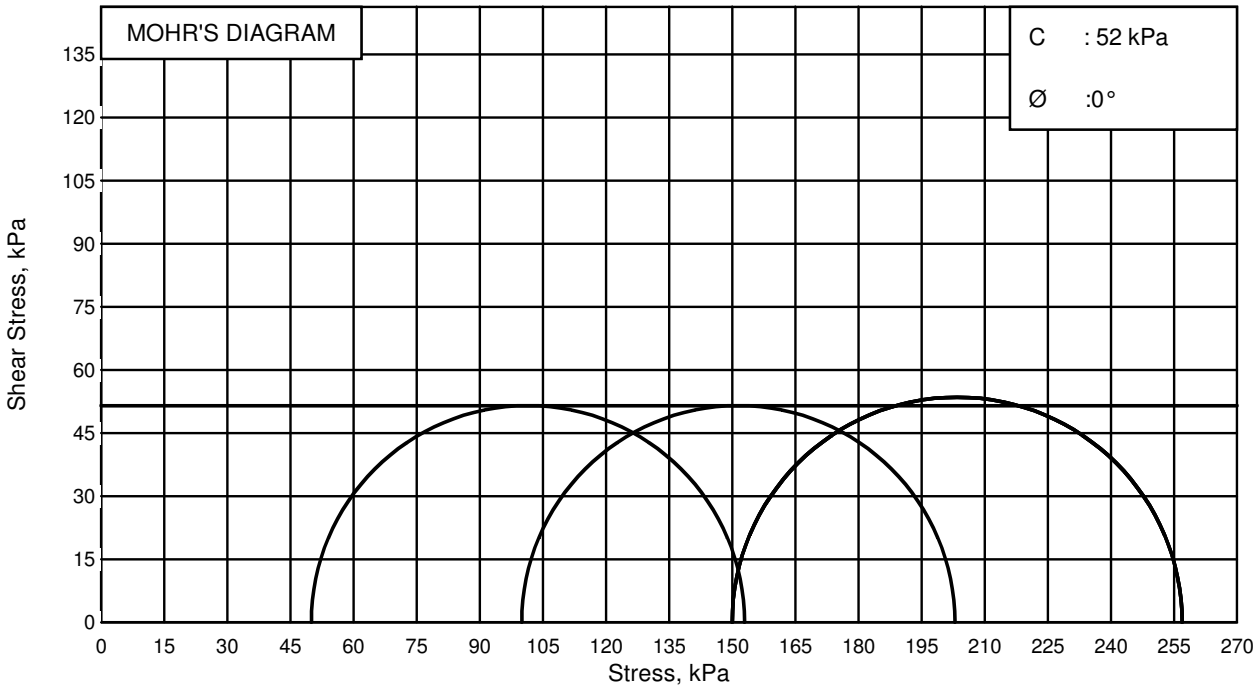
Site :
Type of Test : uu



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

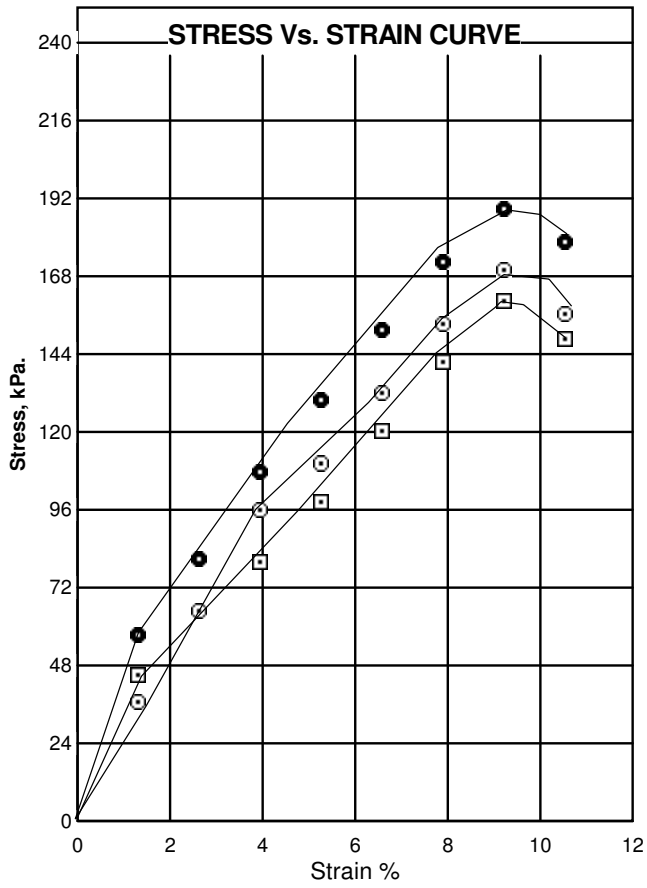


TRIAXIAL TEST CURVES

Job No. : 30796-TP

Sample Number : 120152
Sample Depth : 3.00m.
Bore Hole Number : TP-9

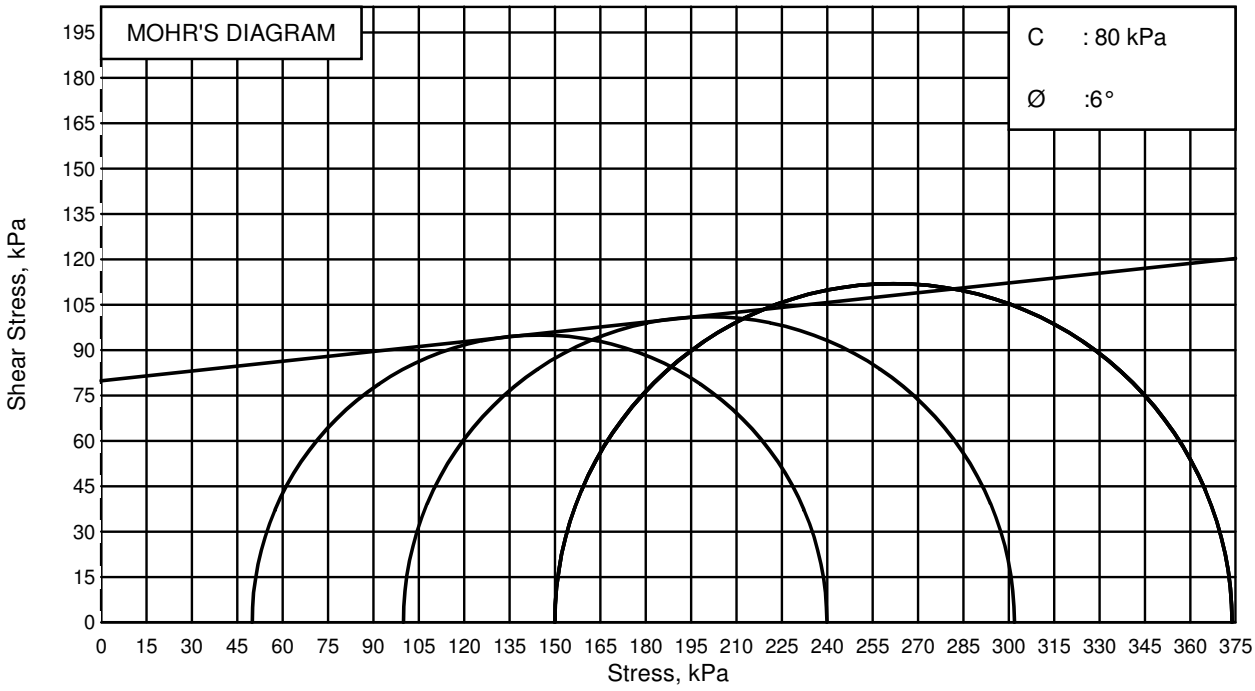
Site :
Type of Test : uu



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

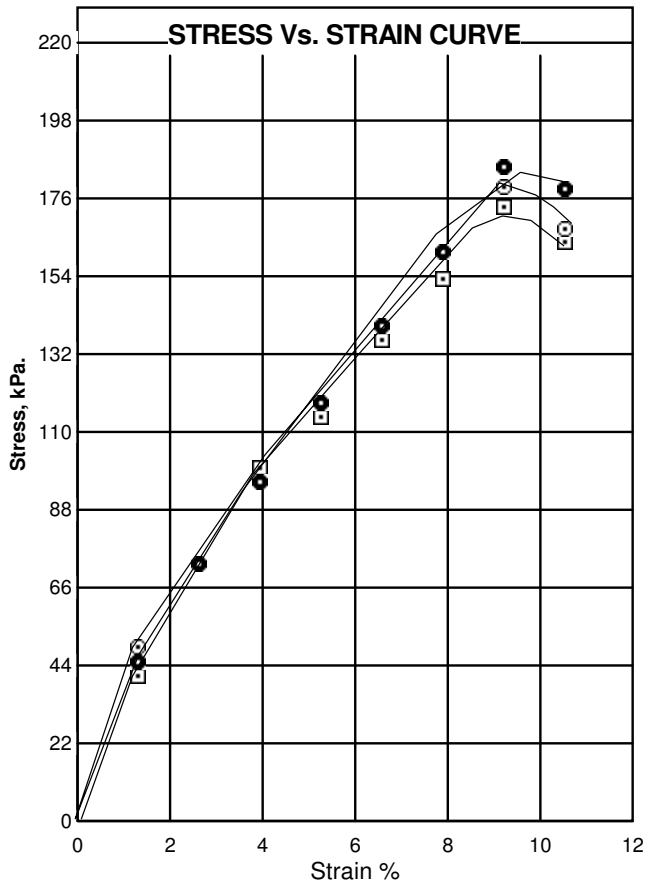


TRIAXIAL TEST CURVES

Job No. : 30796-TP

Sample Number : 105135
Sample Depth : 3.00m.
Bore Hole Number : TP-10

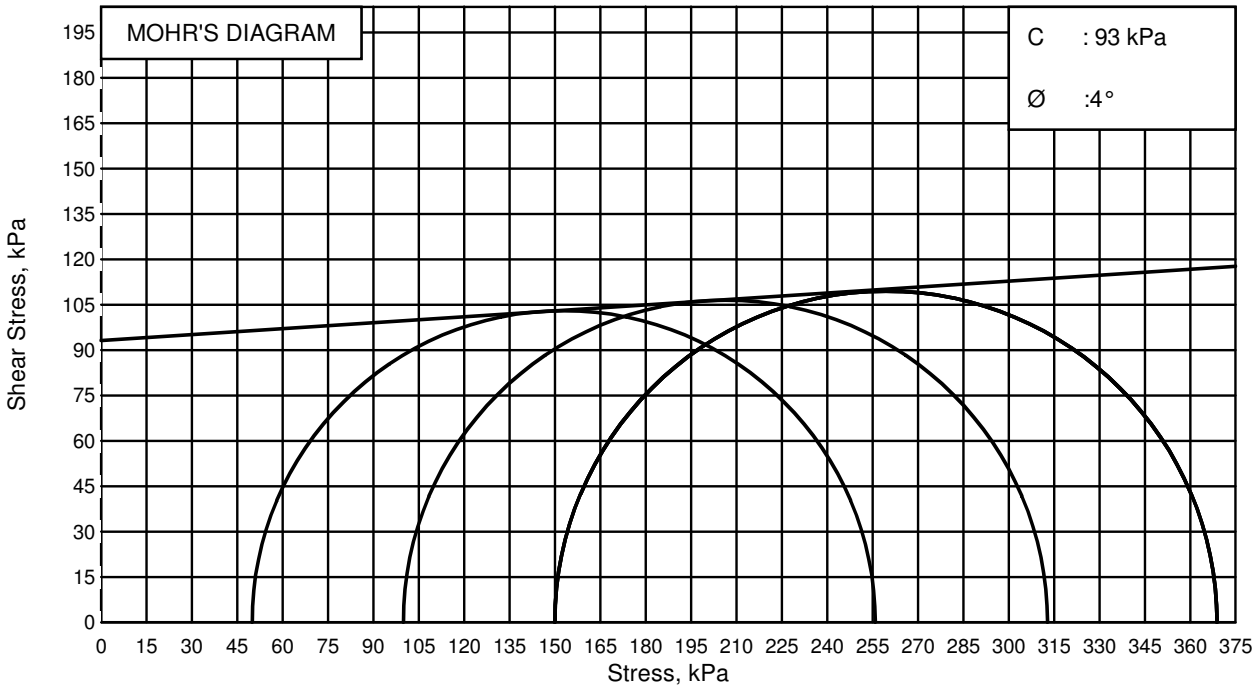
Site :
Type of Test : uu



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

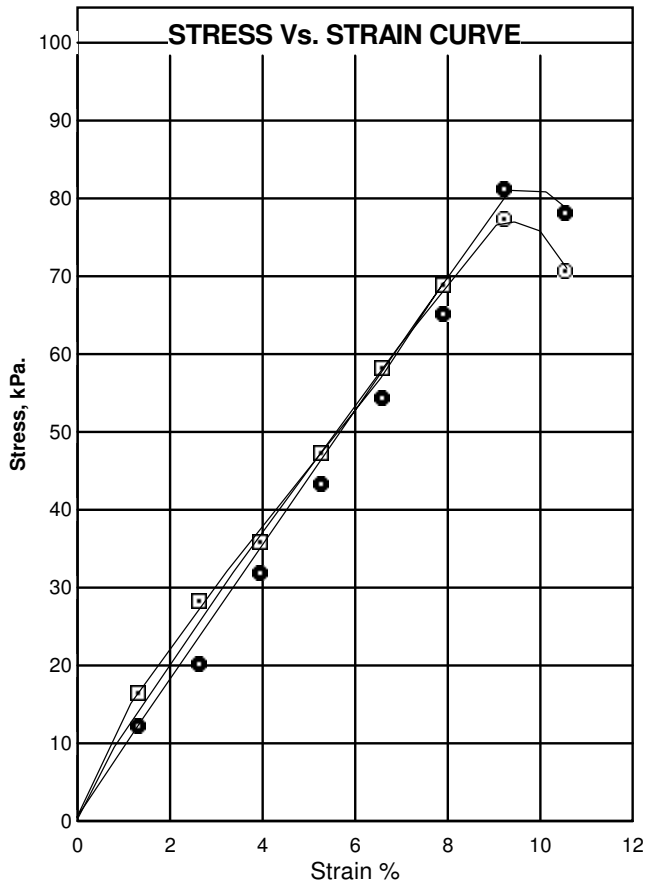


TRIAXIAL TEST CURVES

Job No. : 30796-TP

Sample Number : 150122
Sample Depth : 1.00m.
Bore Hole Number : TP-11

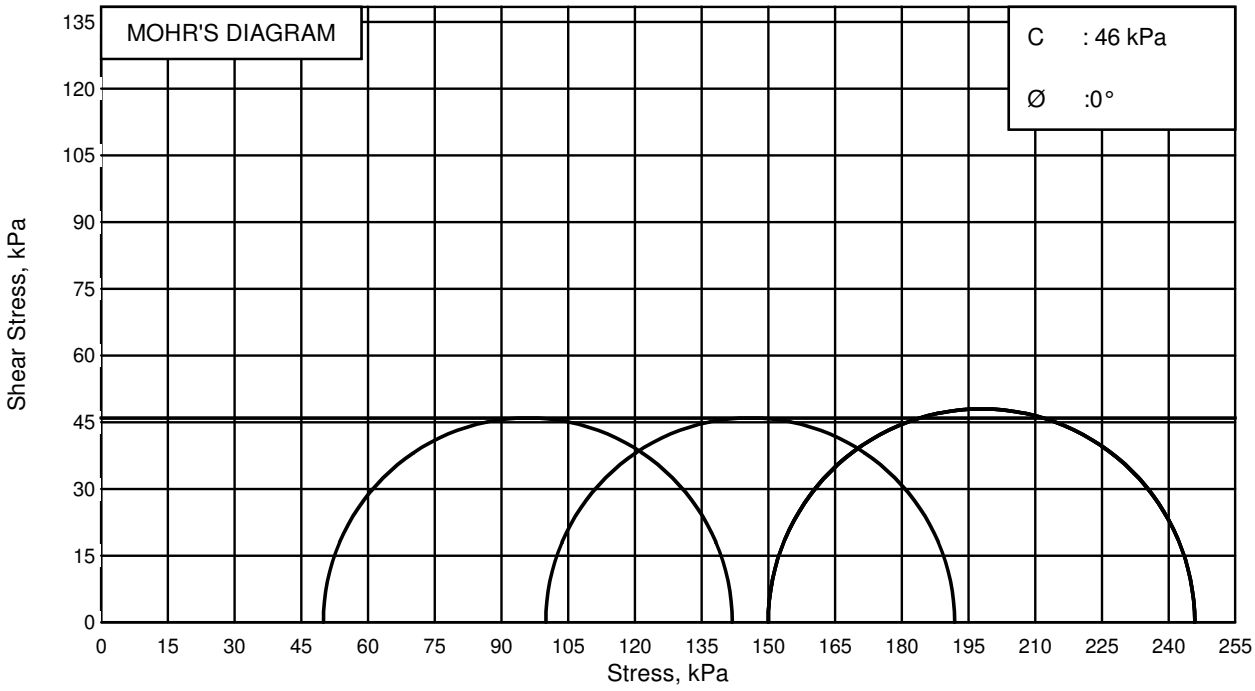
Site :
Type of Test : uu



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

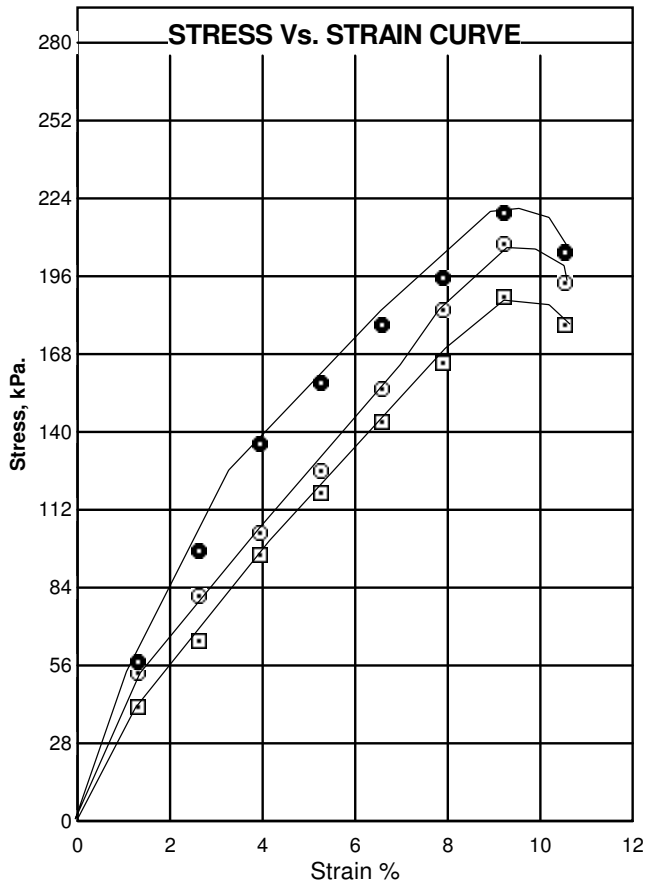


TRIAXIAL TEST CURVES

Job No. : 30796-TP

Sample Number : 150124
Sample Depth : 3.00m.
Bore Hole Number : TP-11

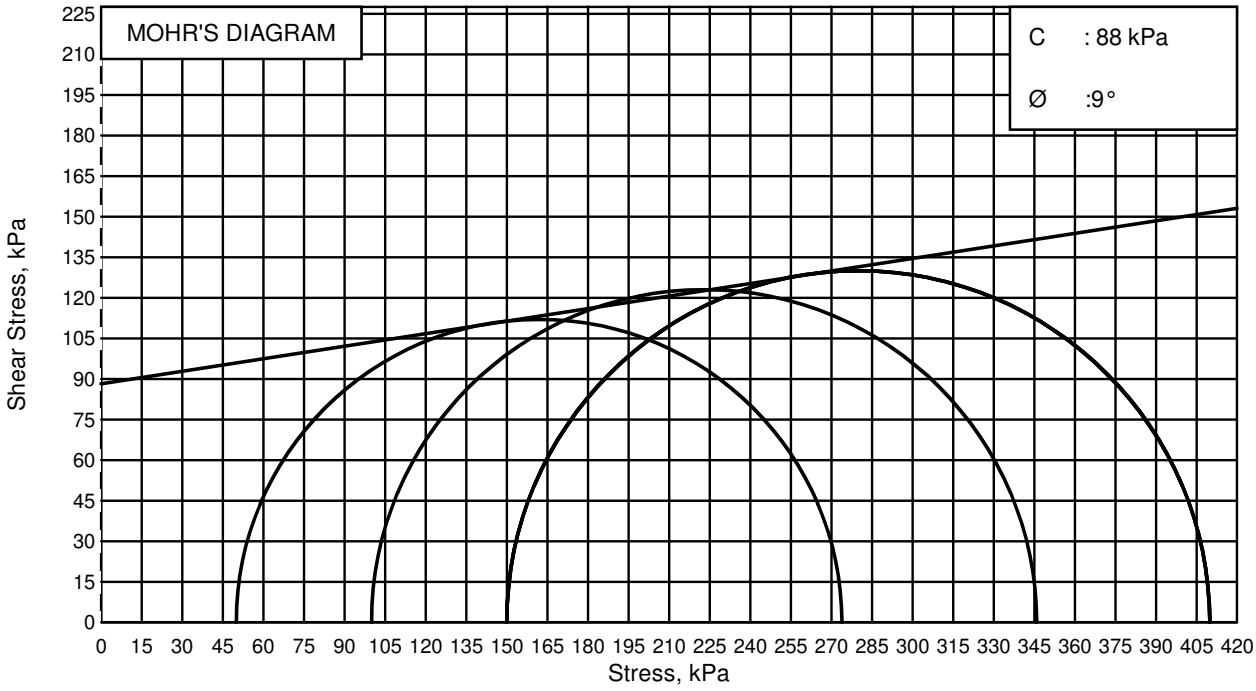
Site :
Type of Test : uu



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

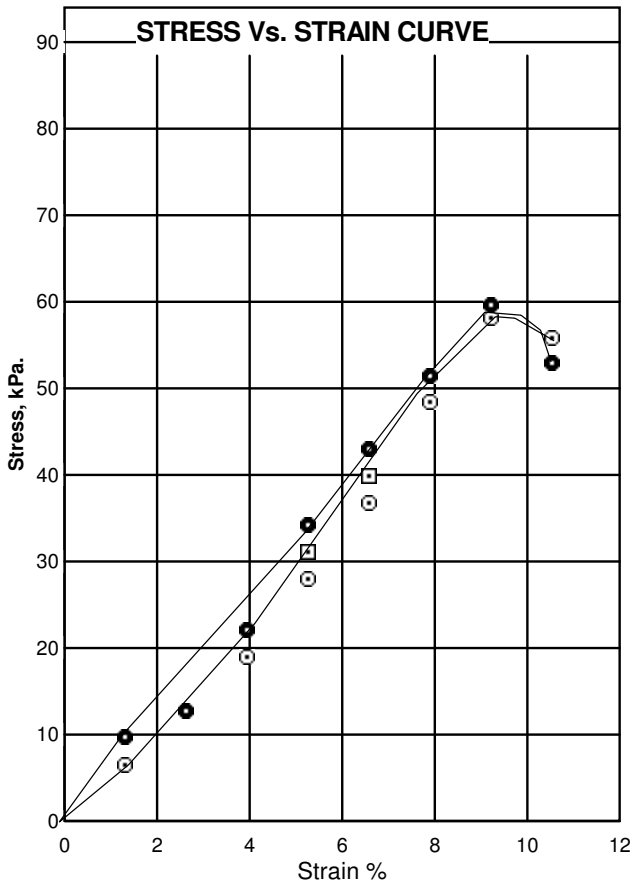


TRIAXIAL TEST CURVES

Job No. : 30796-TP

Sample Number : 106112
Sample Depth : 1.00m.
Bore Hole Number : TP-12

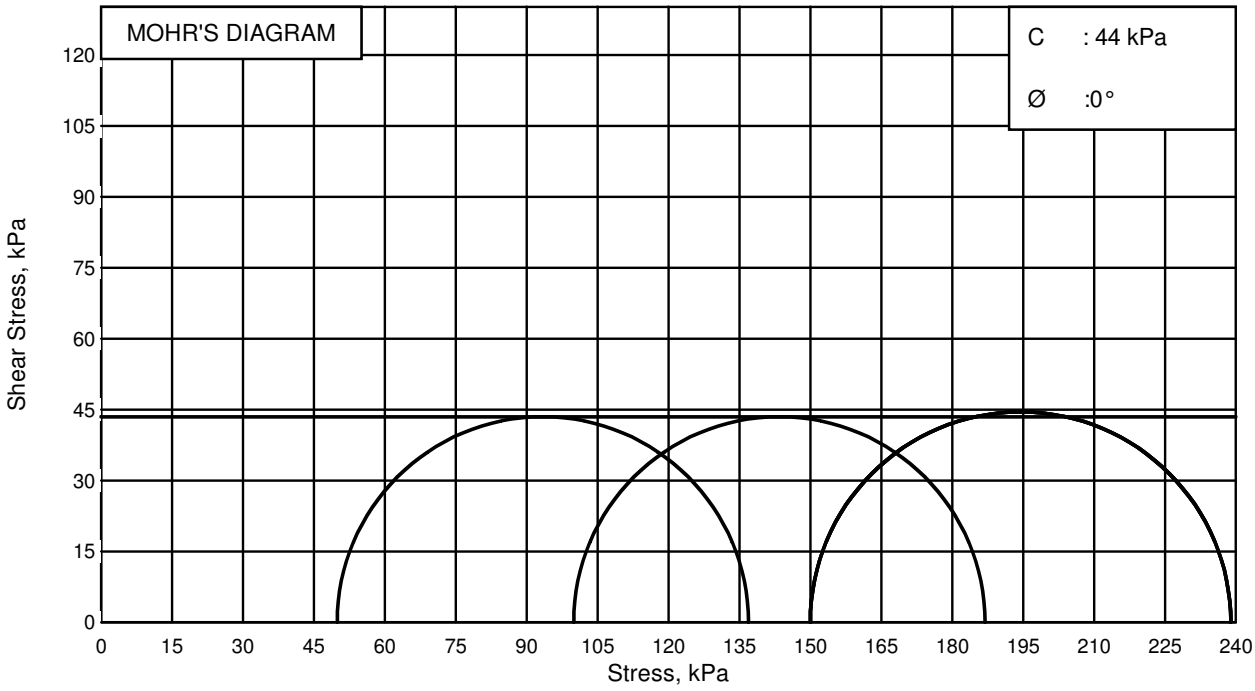
Site :
Type of Test : uu



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

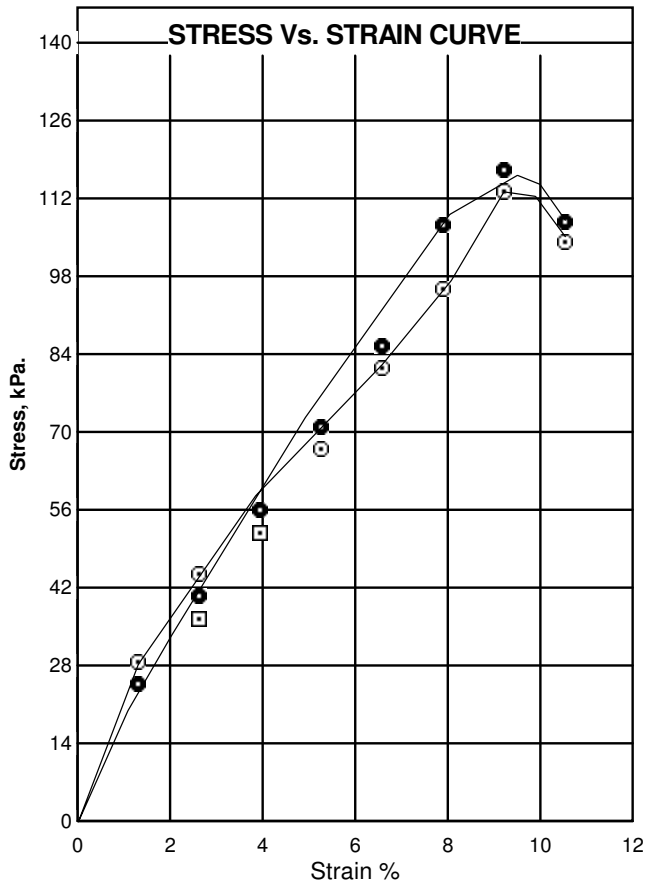


TRIAXIAL TEST CURVES

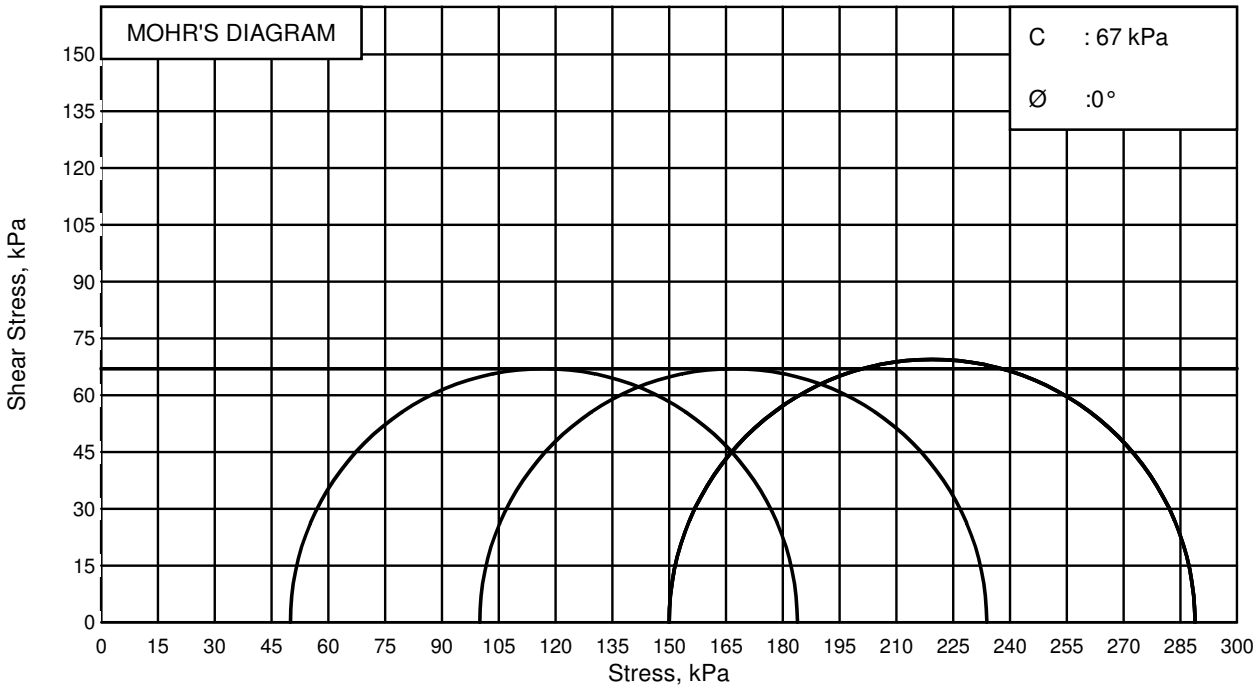
Job No. : 30796-TP

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	

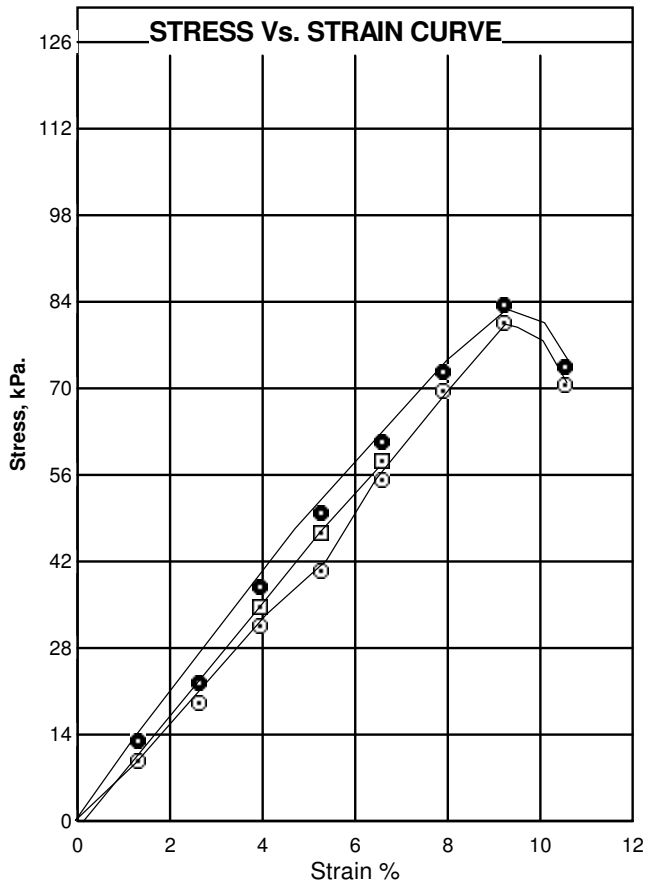


TRIAXIAL TEST CURVES

Job No. : 30796-TP

Sample Number : 105126
Sample Depth : 2.00m.
Bore Hole Number : TP-14

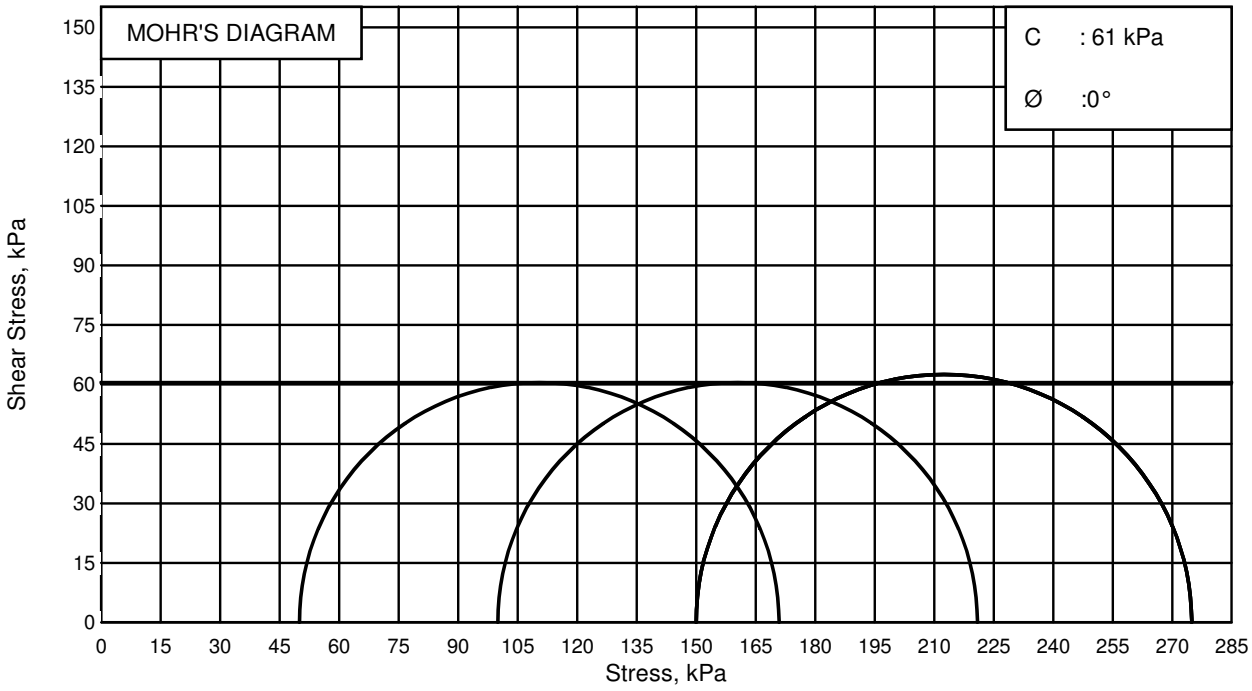
Site :
Type of Test : uu



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

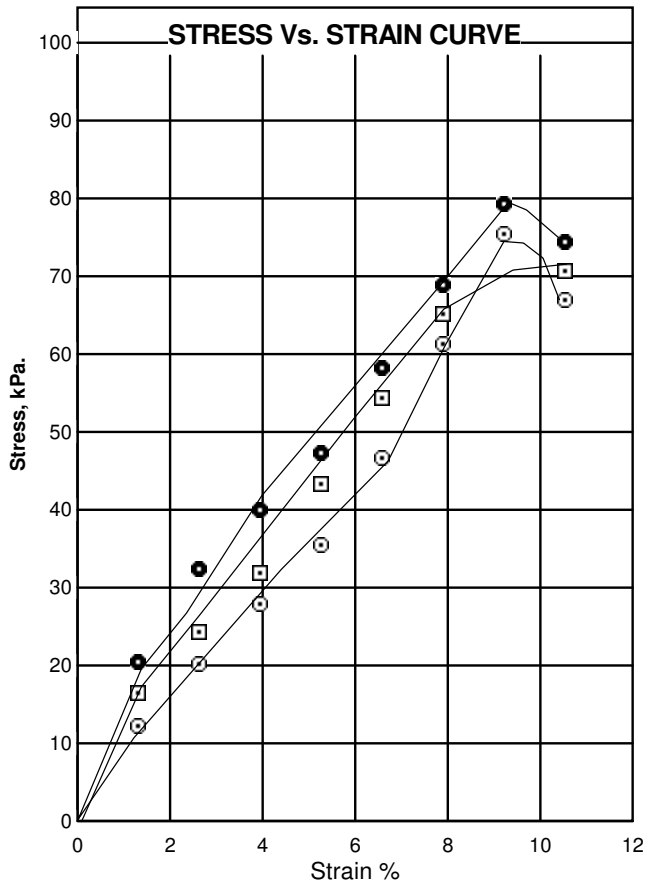


TRIAXIAL TEST CURVES

Job No. : 30796-TP

Sample Number : 106108
Sample Depth : 1.00m.
Bore Hole Number : TP-15

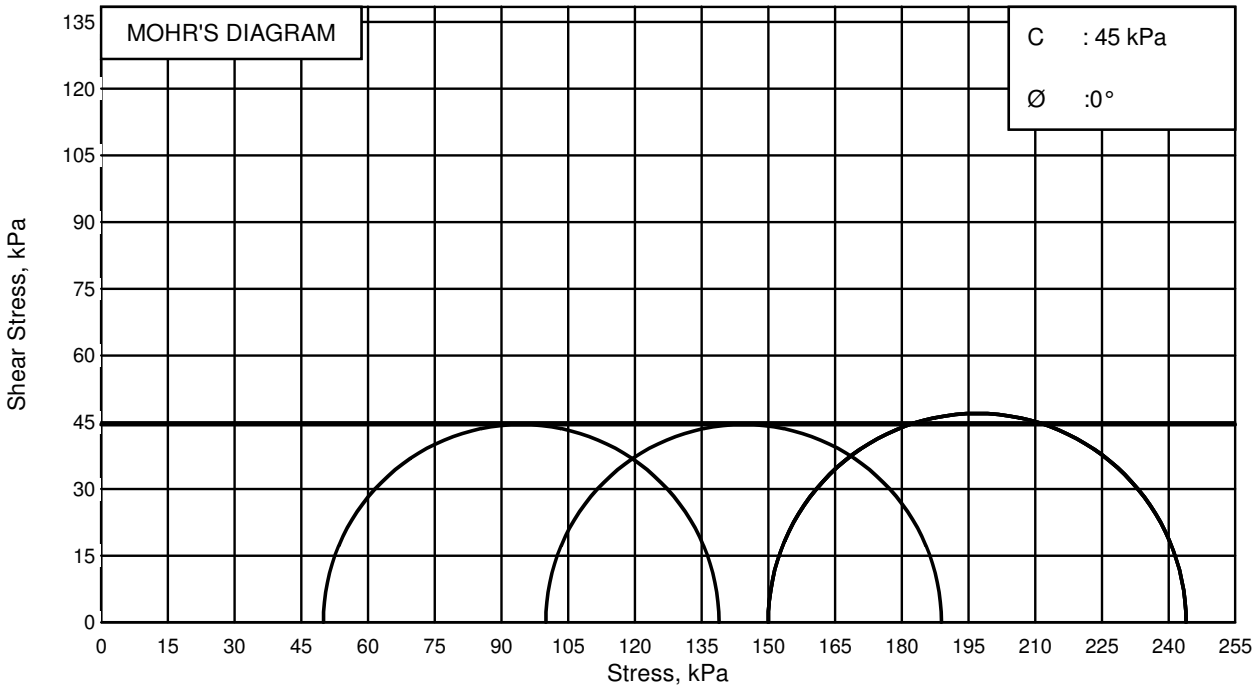
Site :
Type of Test : uu



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

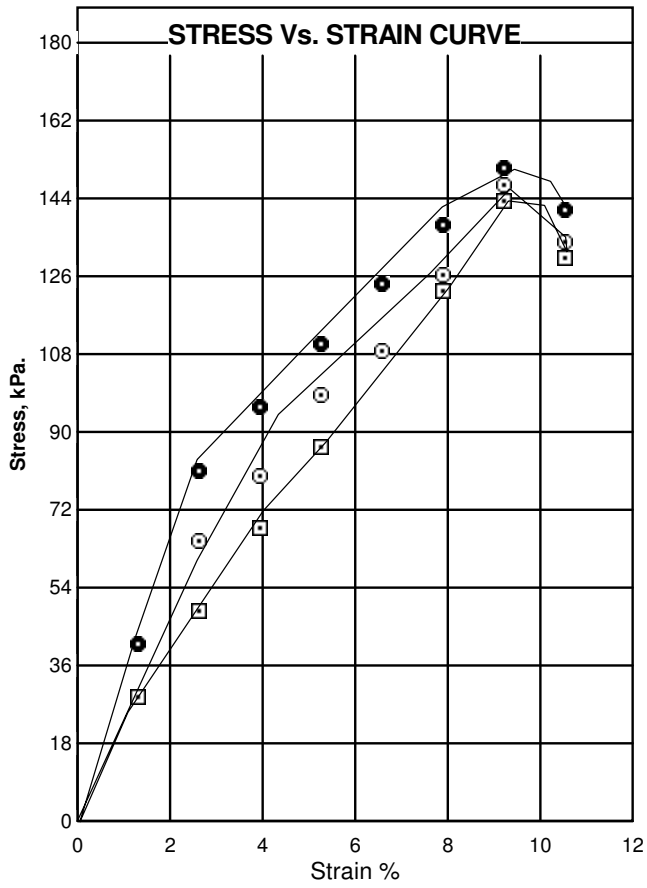


TRIAXIAL TEST CURVES

Job No. : 30796-TP

Sample Number : 106110
Sample Depth : 3.00m.
Bore Hole Number : TP-15

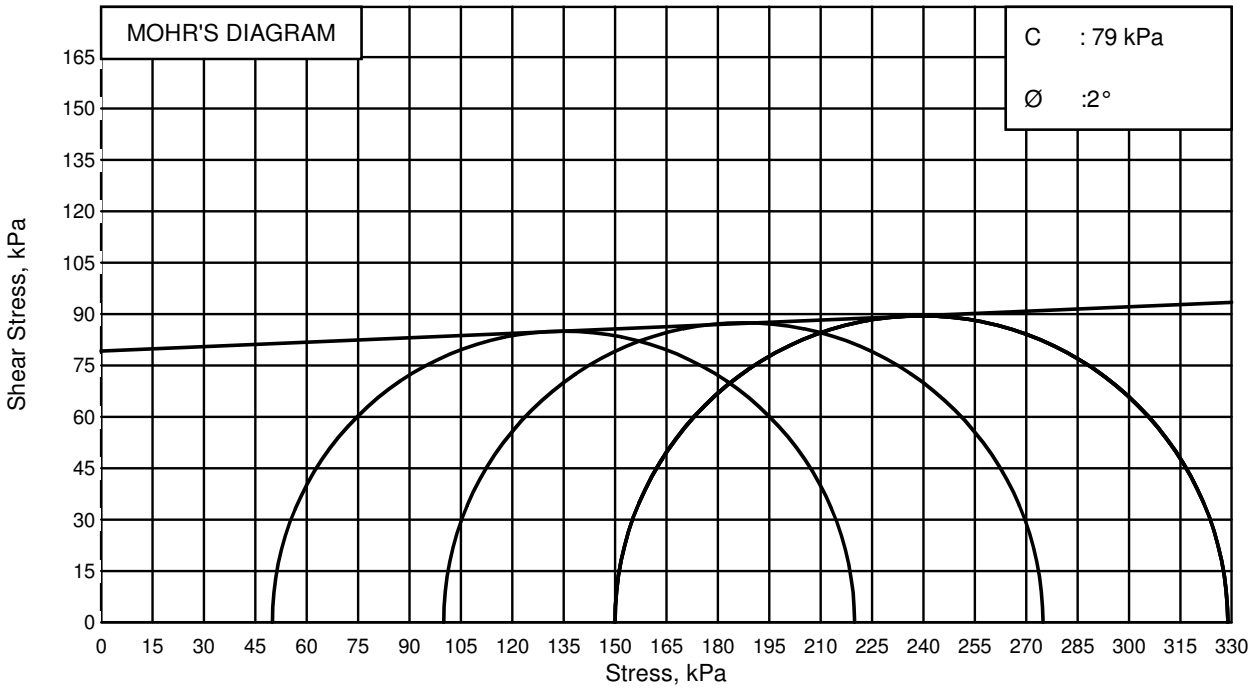
Site :
Type of Test : uu



Mode of Failure :
Specimen : 1
Cell Pressure : 50 kPa

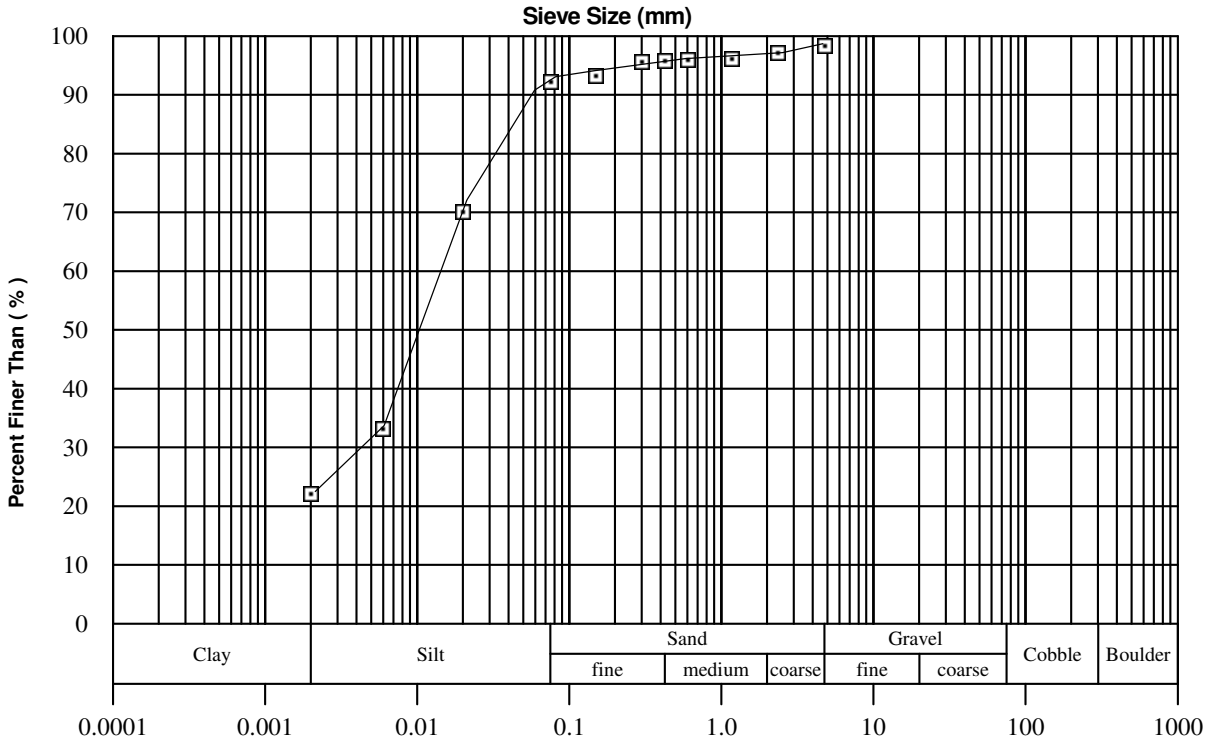
Mode of Failure :
Specimen : 2
Cell Pressure : 100 kPa

Mode of Failure :
Specimen : 3
Cell Pressure : 150 kPa

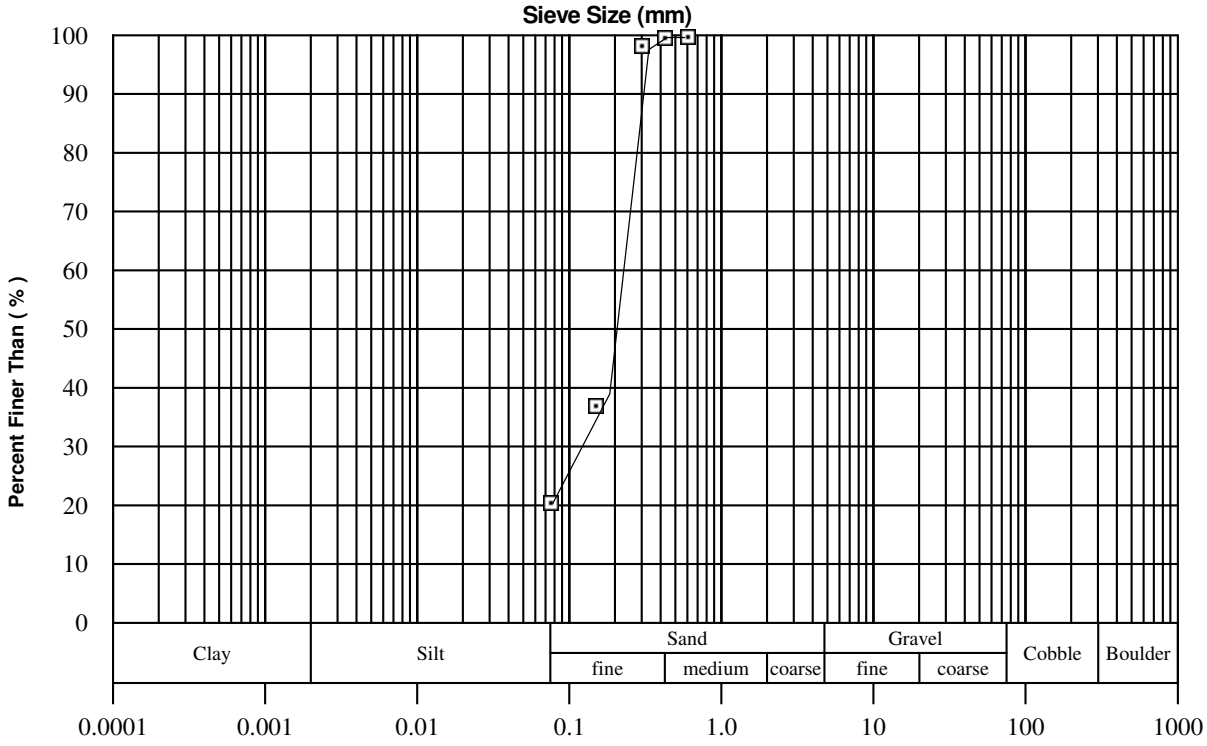


TRIAXIAL TEST CURVES

Job No. : 30796-TP



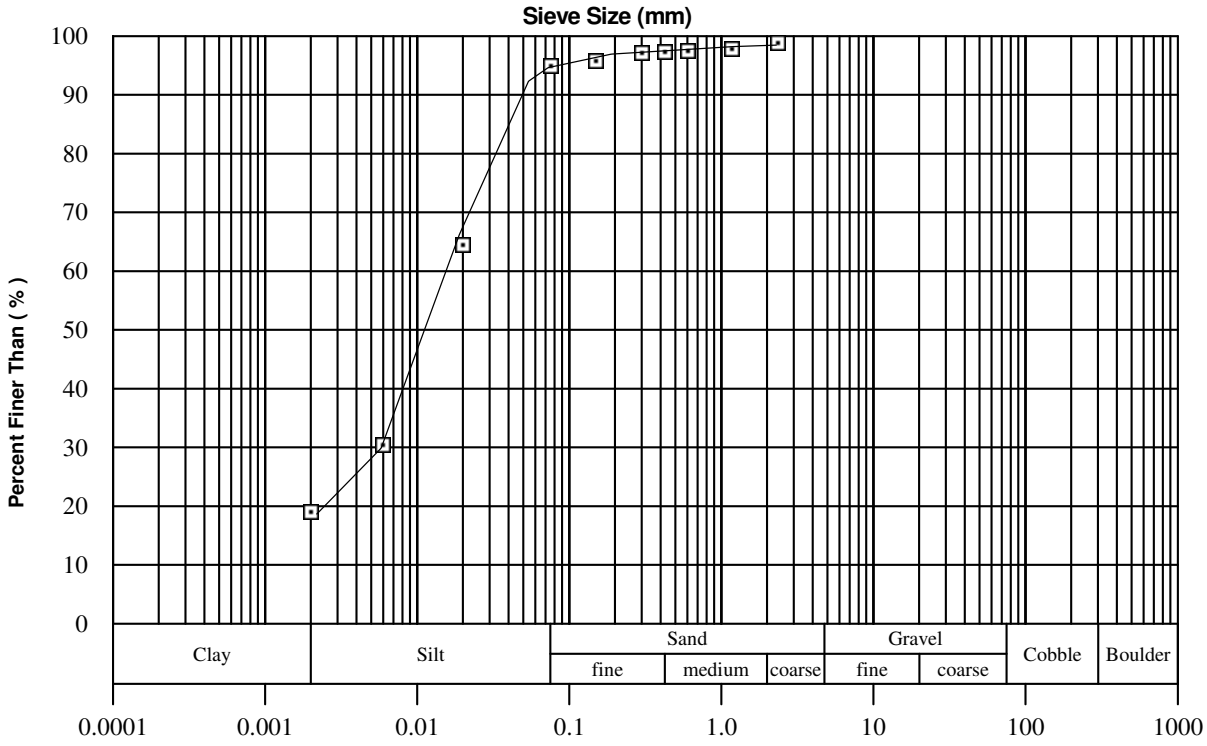
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	01	177125	3.00-3.45	1.60	6.10	70.15	22.15



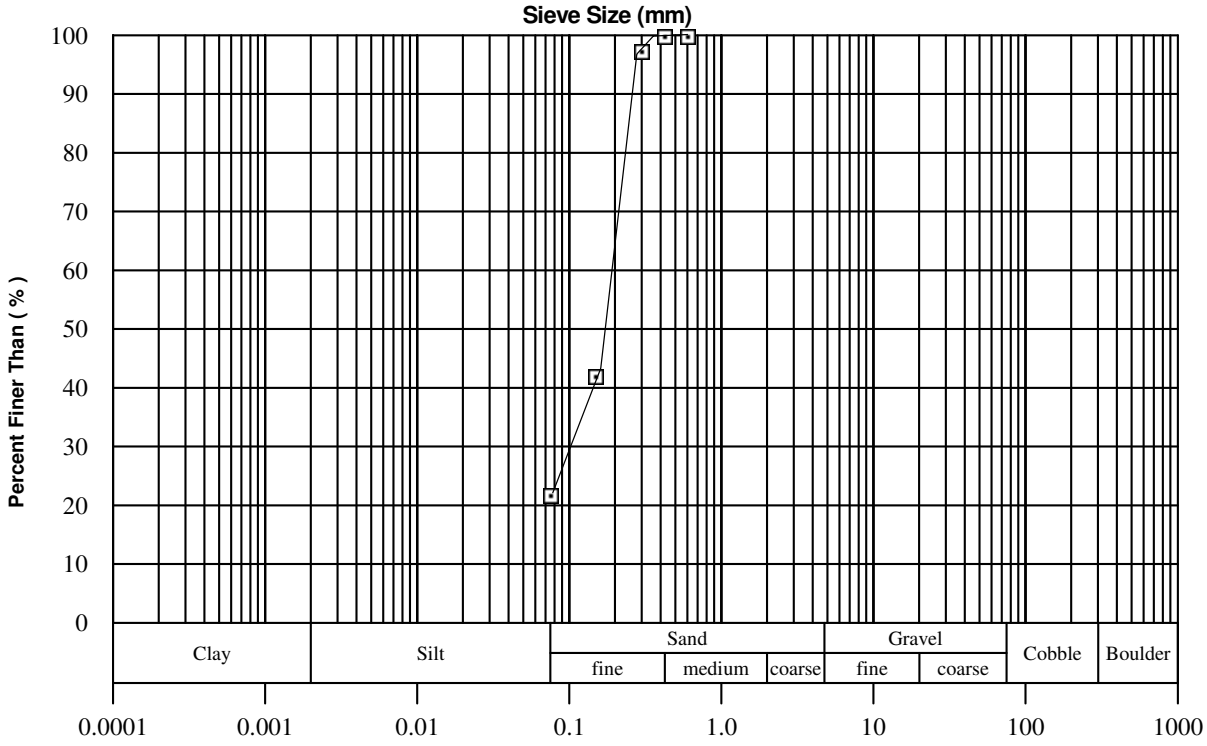
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	01	177131	9.00-9.45		79.60	20.40	

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



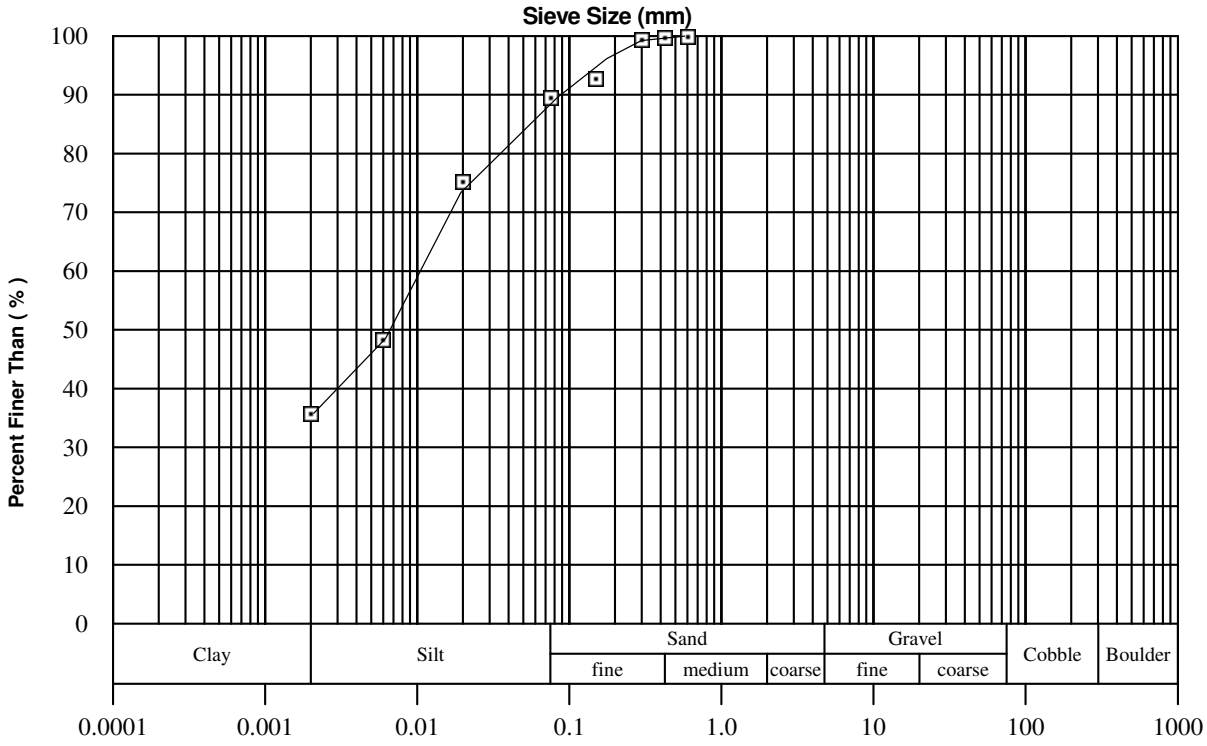
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	02	160128	4.50-4.95		5.00	76.00	19.00



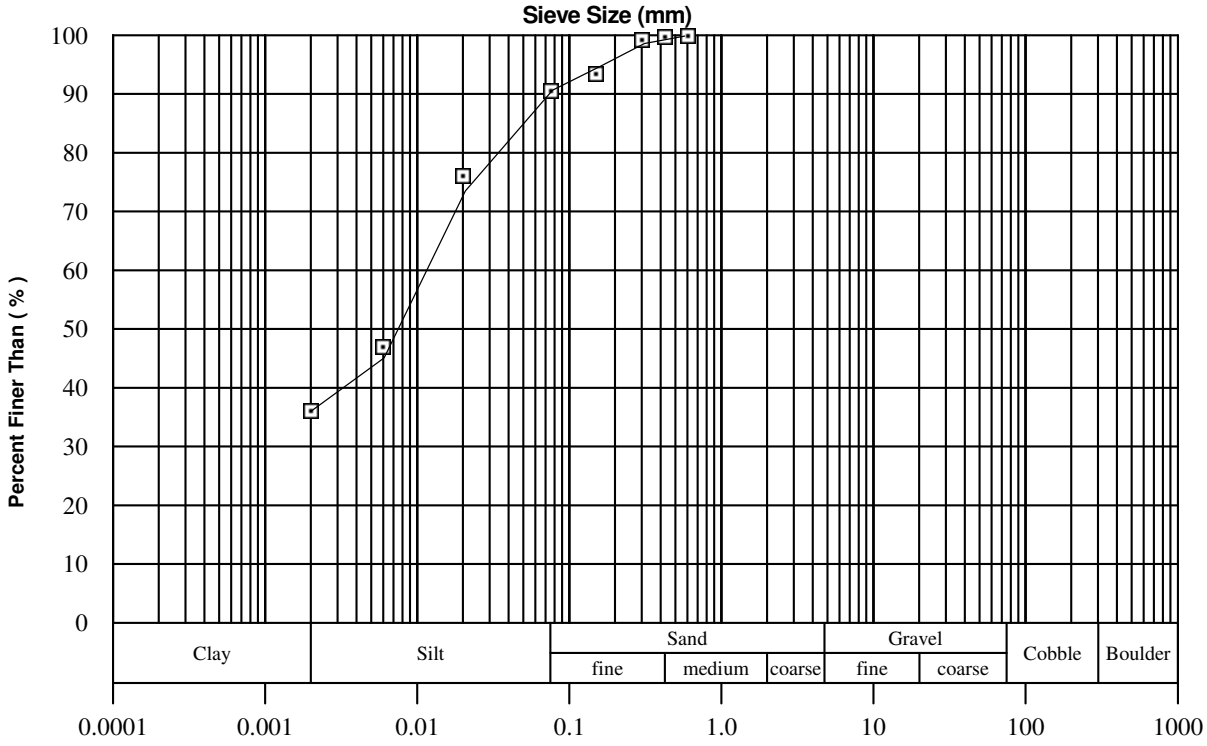
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	02	160134	12.00-12.45		78.40	21.60	

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



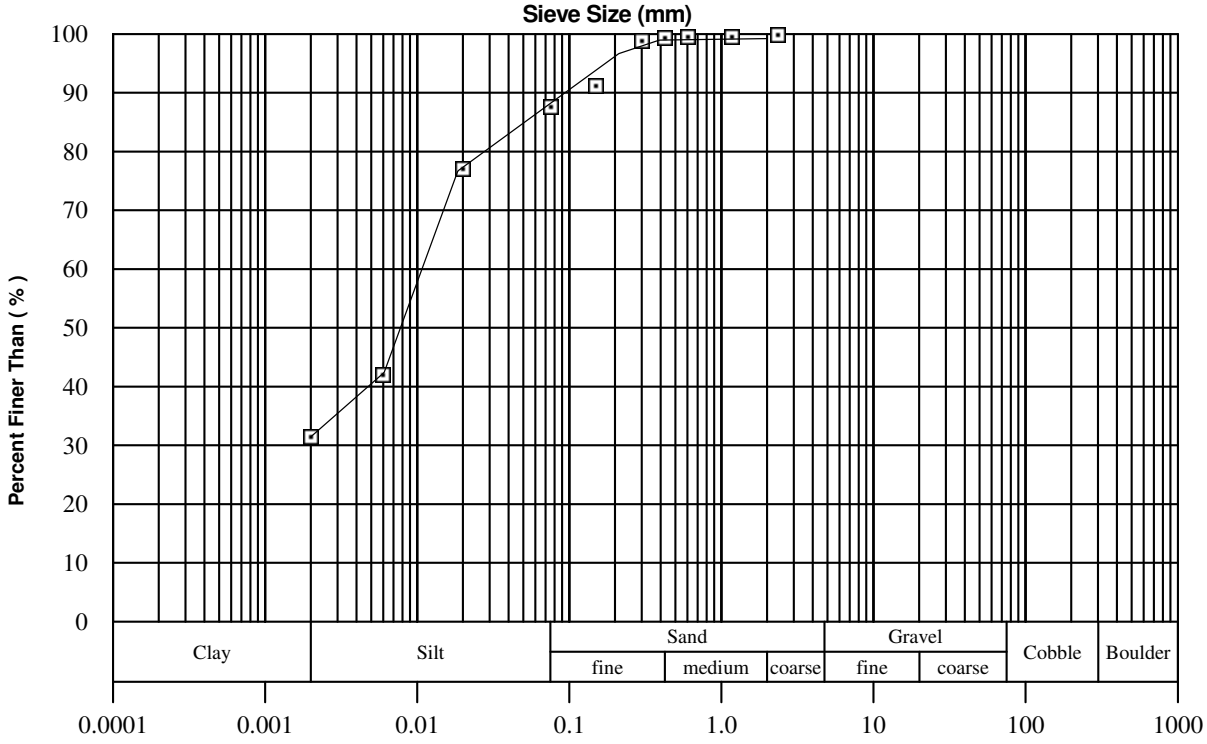
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	03	100869	1.00-1.45		10.50	53.70	35.80



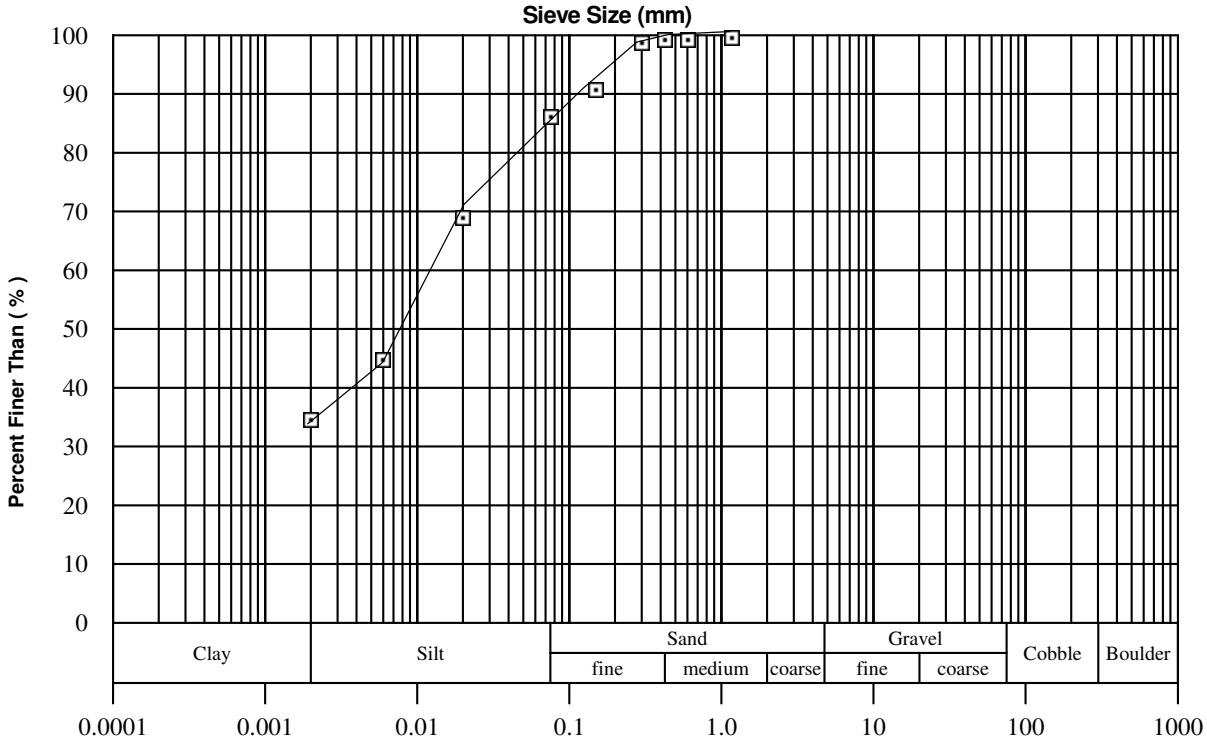
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	03	100873	3.00-3.45		9.50	54.30	36.20

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



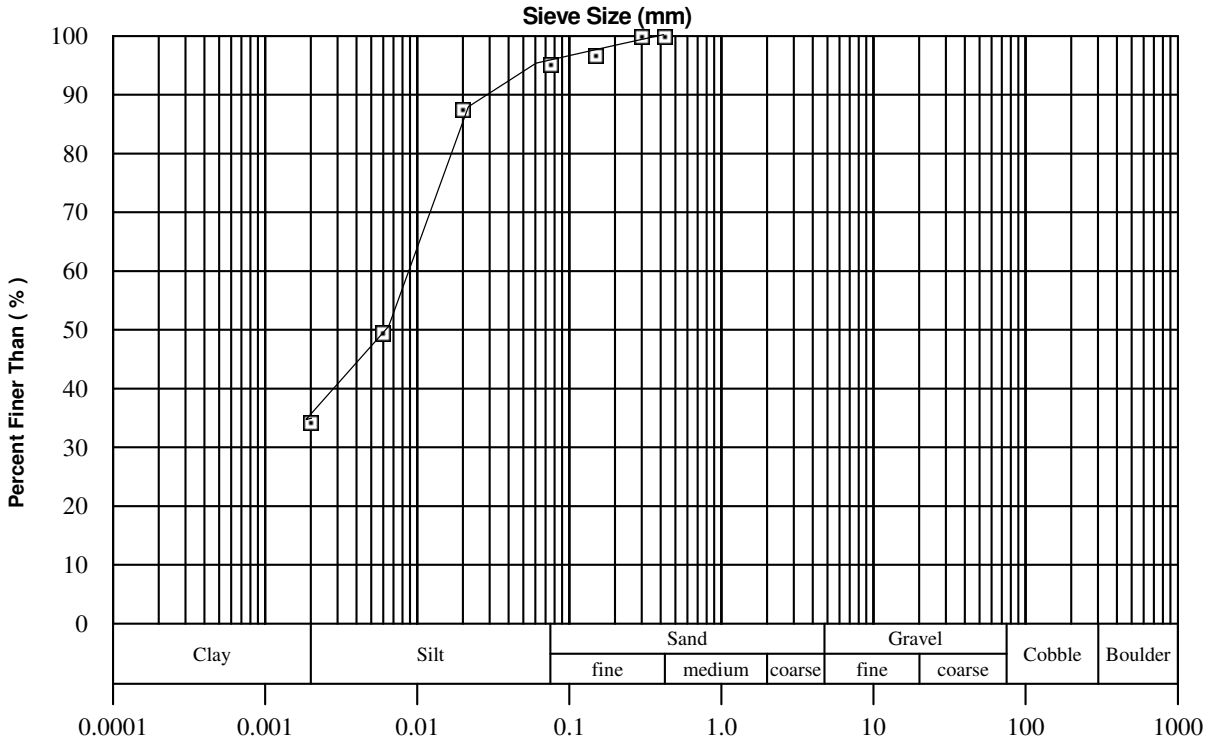
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	03	100877	6.00-6.45		12.40	56.06	31.54



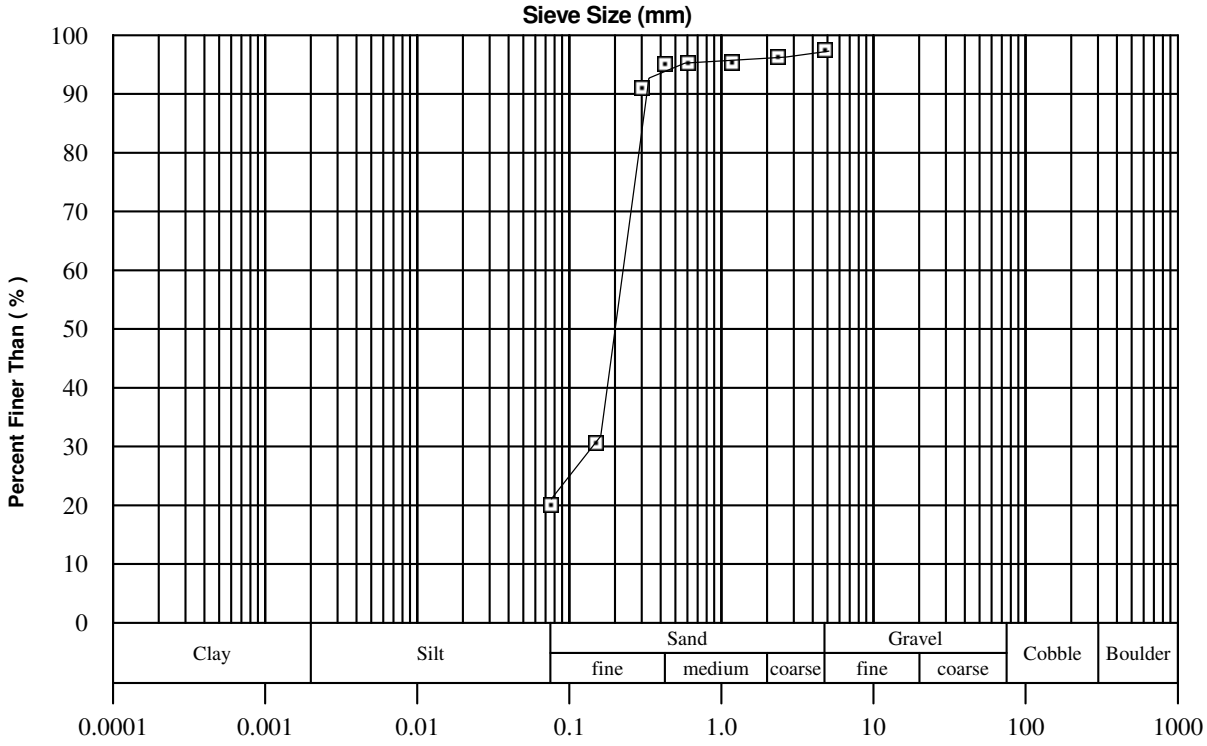
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	03	100879	8.00-8.45		13.80	51.72	34.48

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



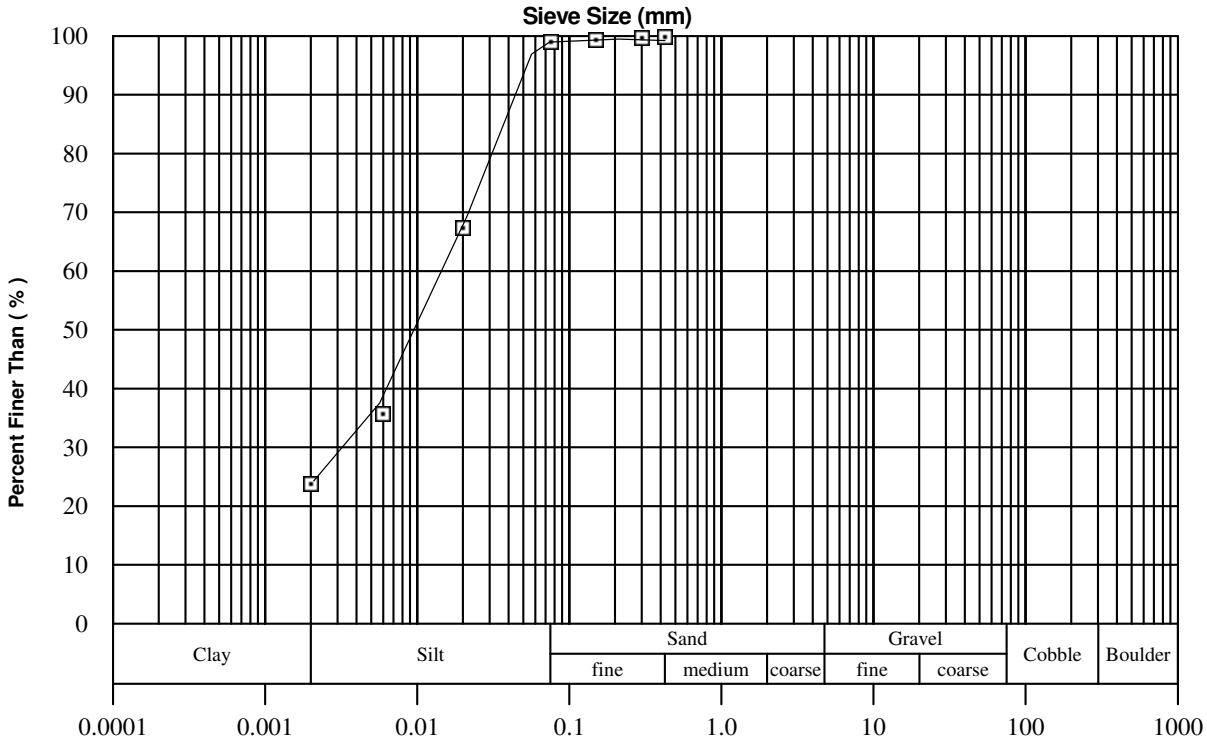
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	03	100881	11.00-11.45		4.90	60.86	34.24



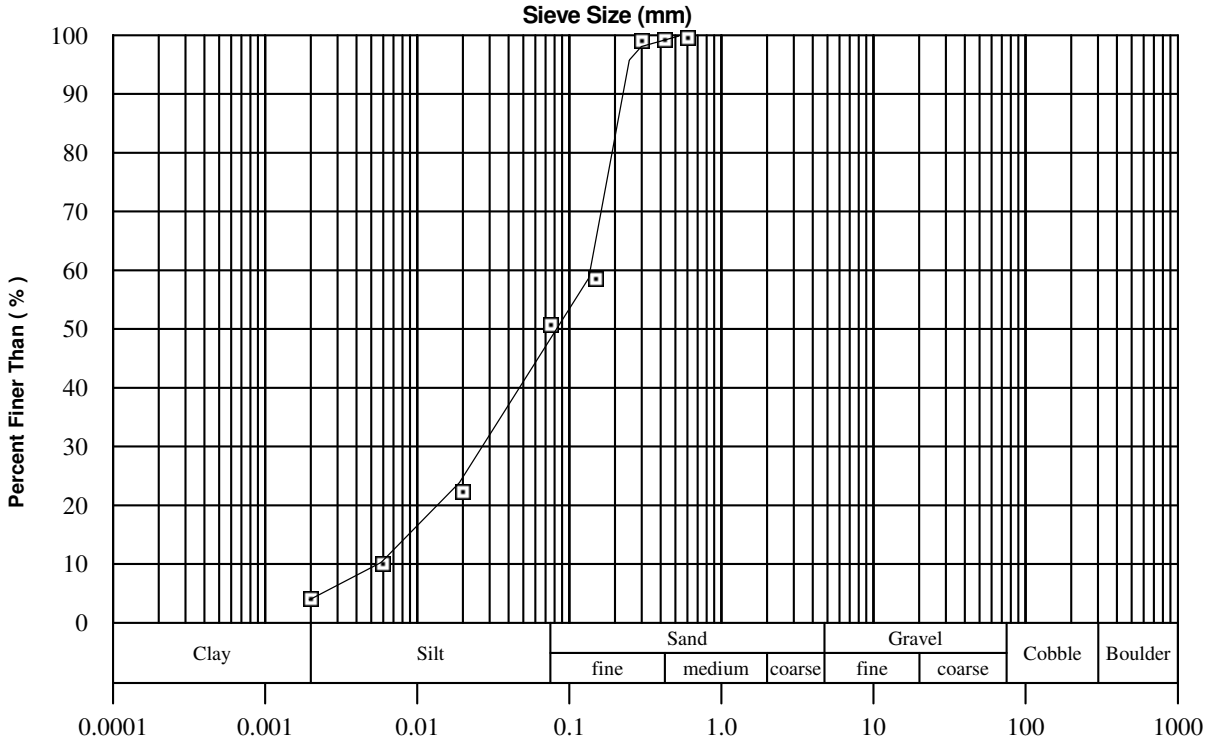
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	03	100884	12.50-12.95	2.50	77.40	20.10	

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



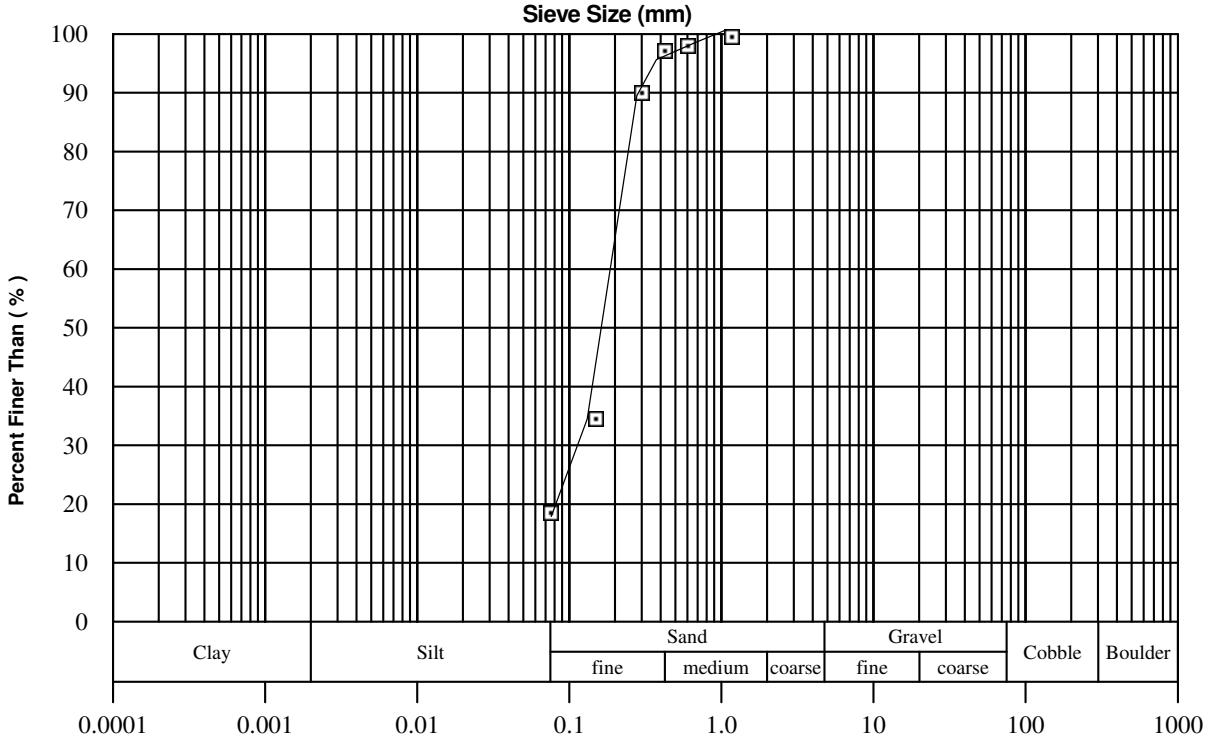
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	04	100902	1.50-1.95		0.90	75.32	23.78



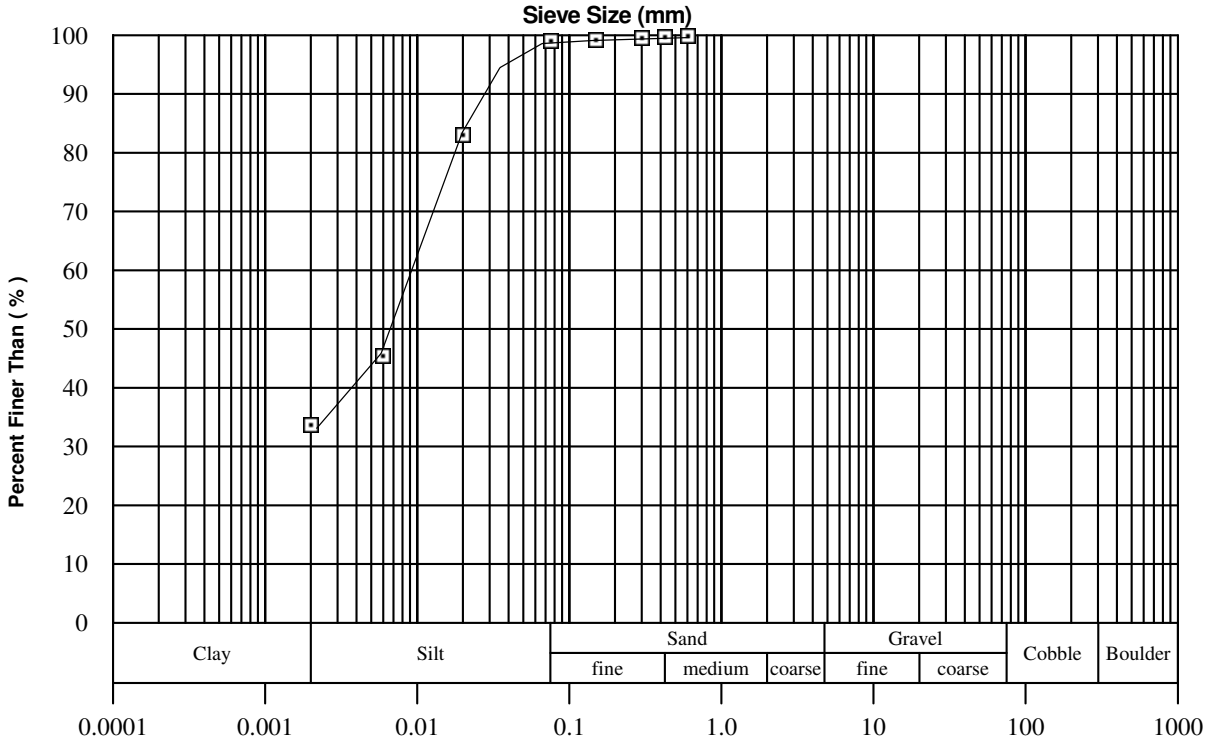
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	04	100906	3.50-3.95		49.30	46.64	4.06

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



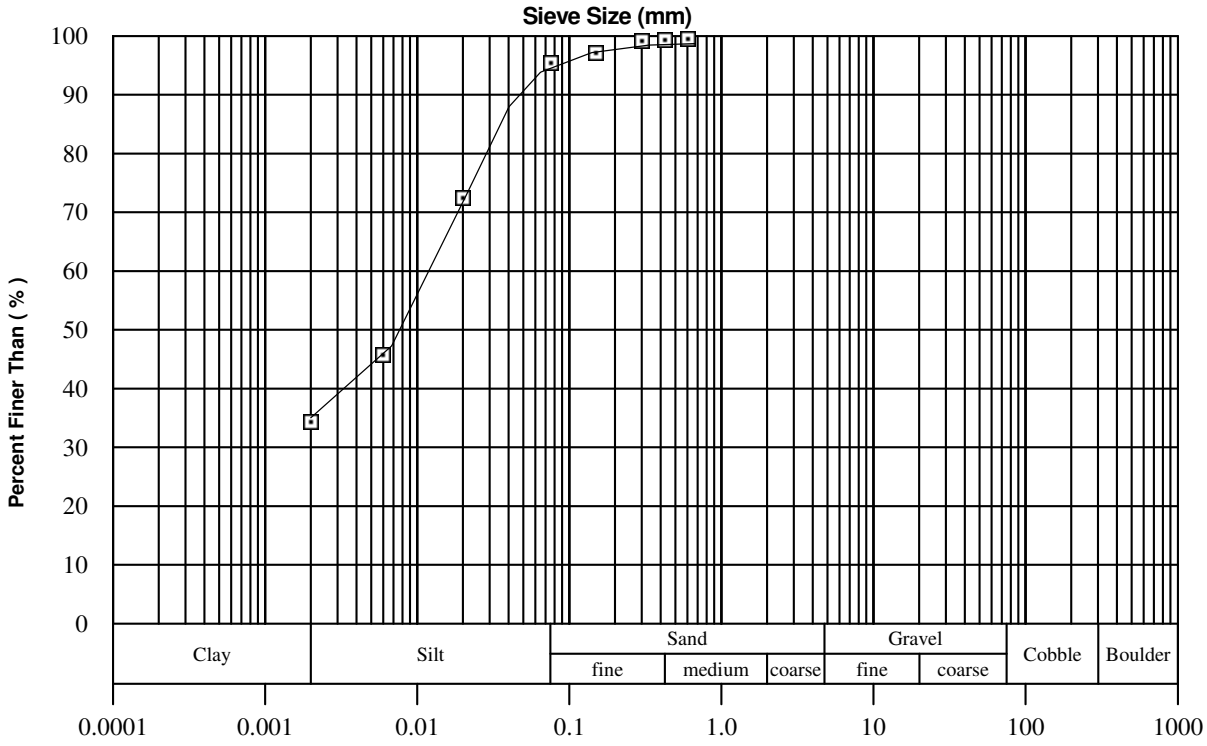
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	04	100908	5.00-5.45		81.50	18.50	



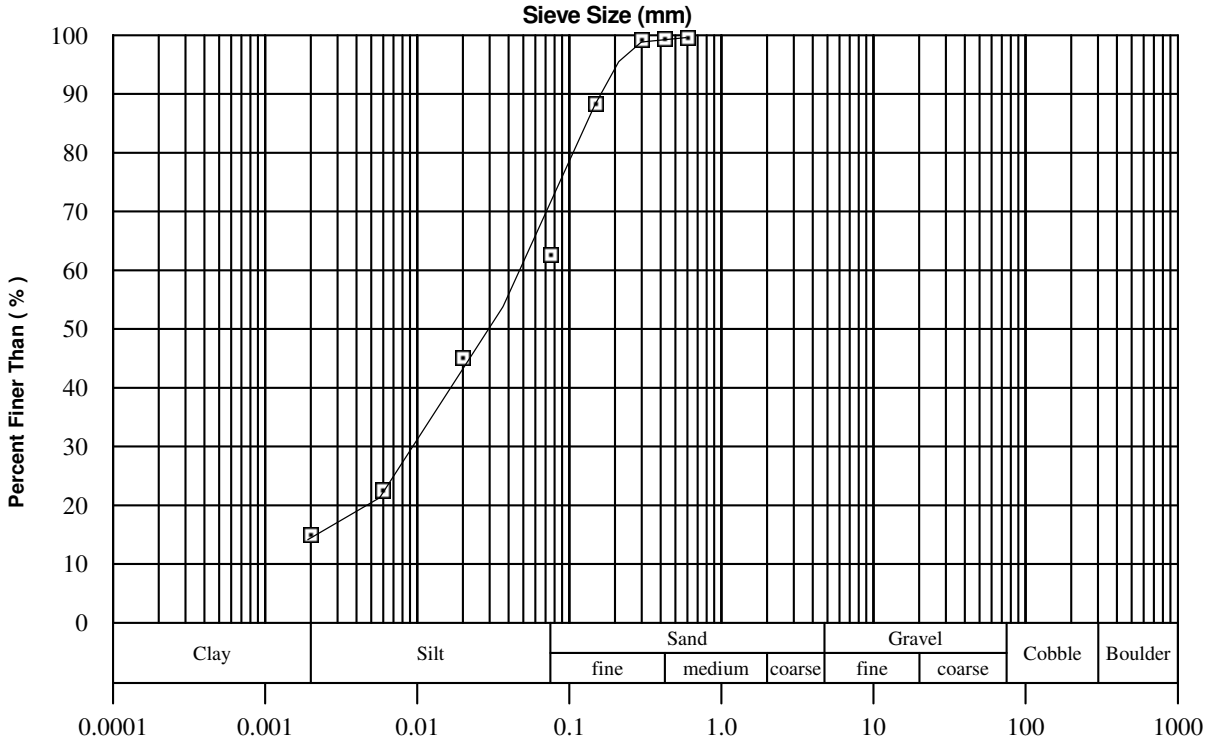
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	05	100453	1.50-1.95		1.00	65.34	33.66

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



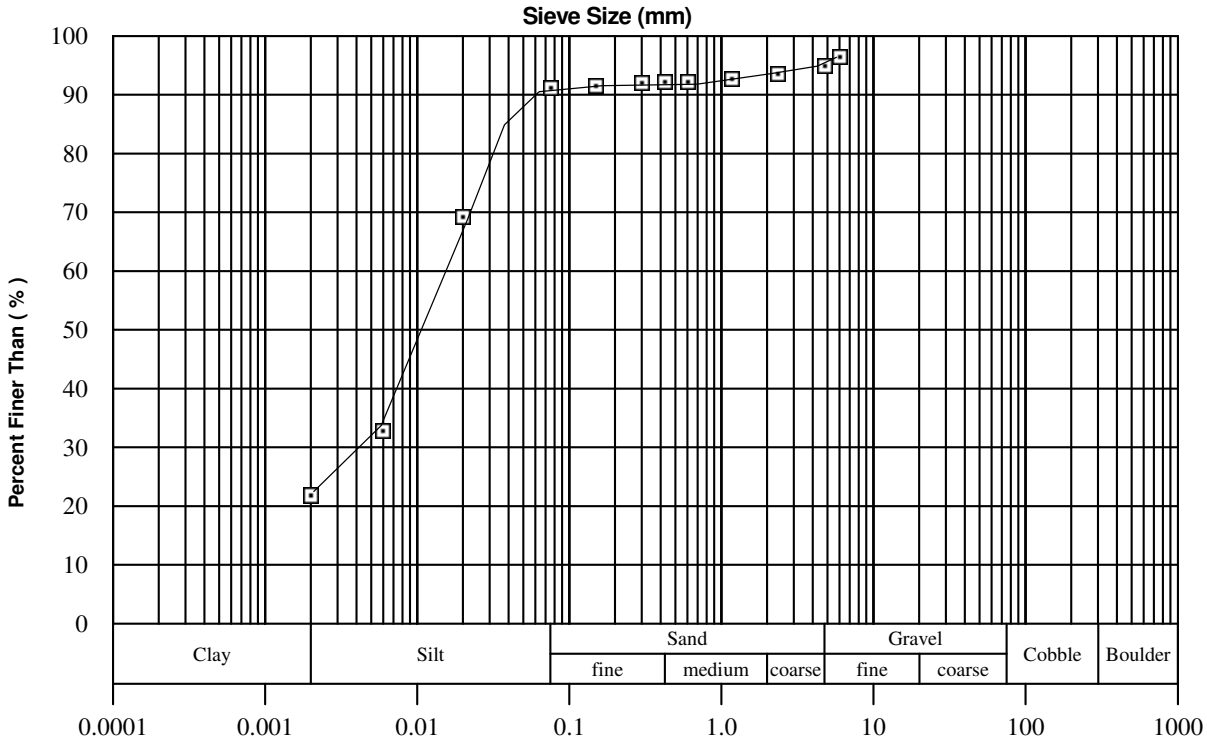
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	05	100457	3.50-3.95		4.50	61.12	34.38



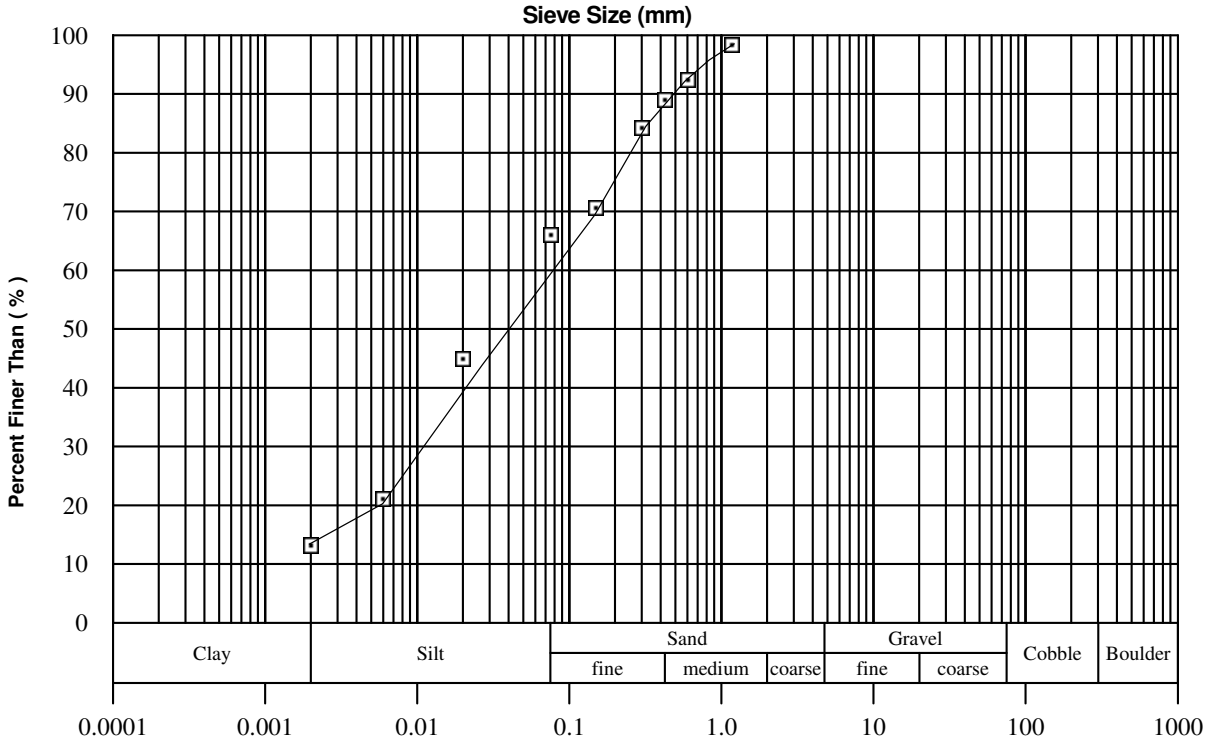
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	05	100459	4.50-4.95		37.27	47.67	15.05

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



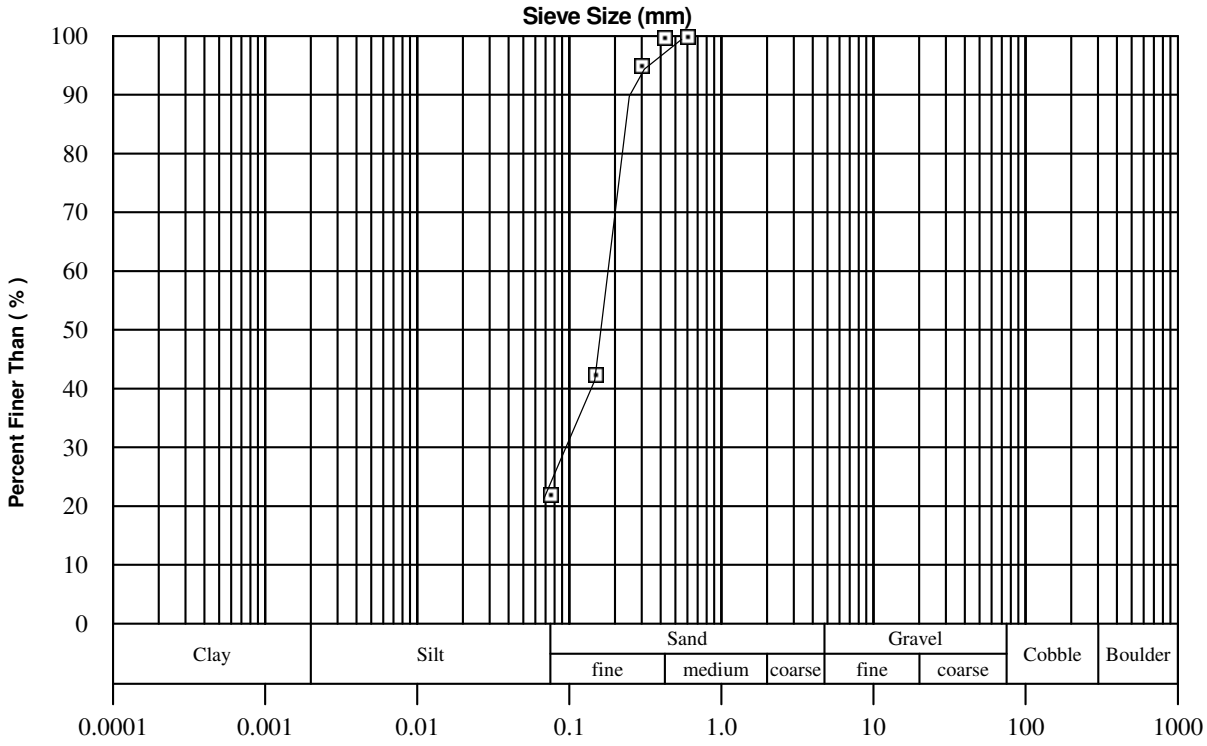
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	06	105112	1.00-1.45	5.10	3.70	69.31	21.89



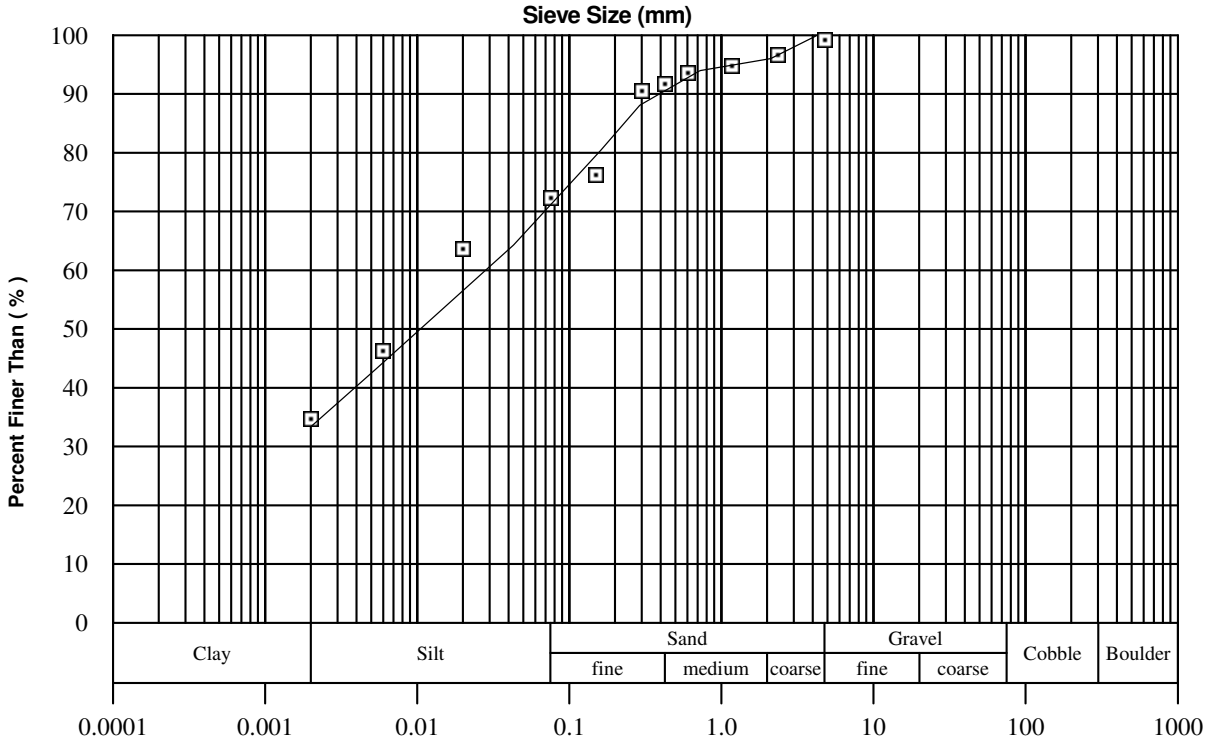
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	06	105116	3.00-3.45		34.00	52.80	13.20

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



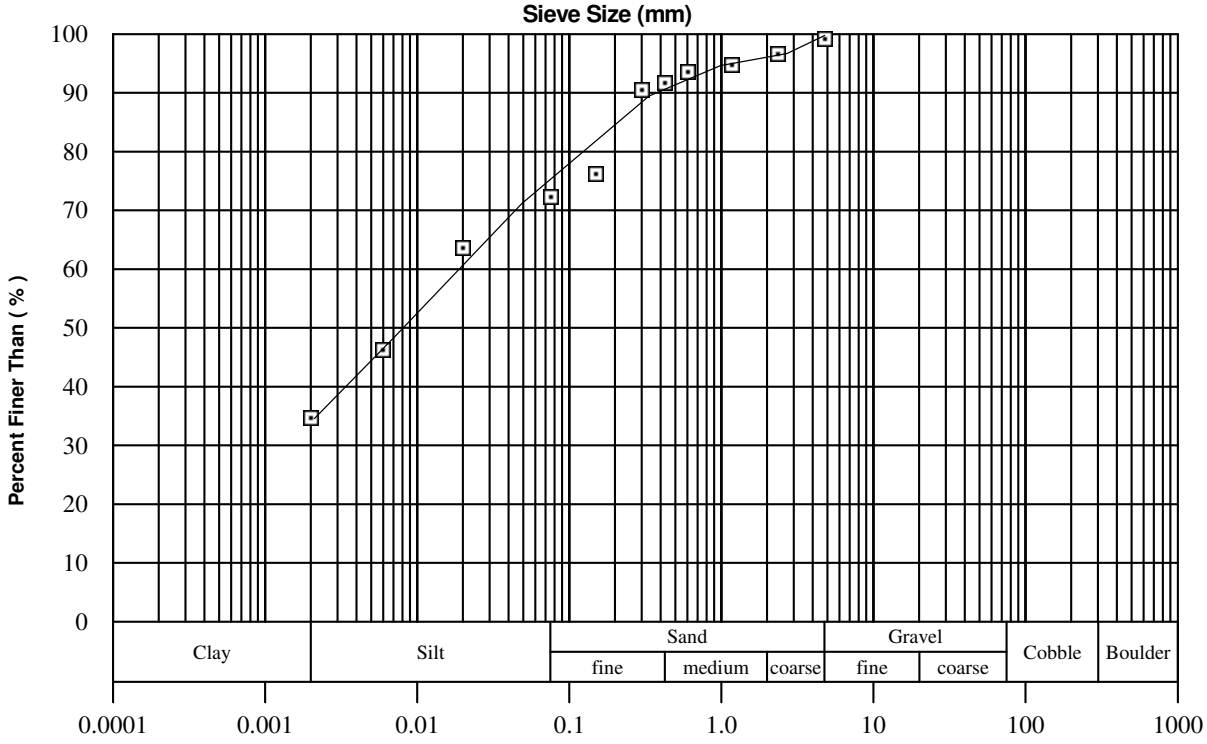
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	06	105118	5.00		78.10	21.90	



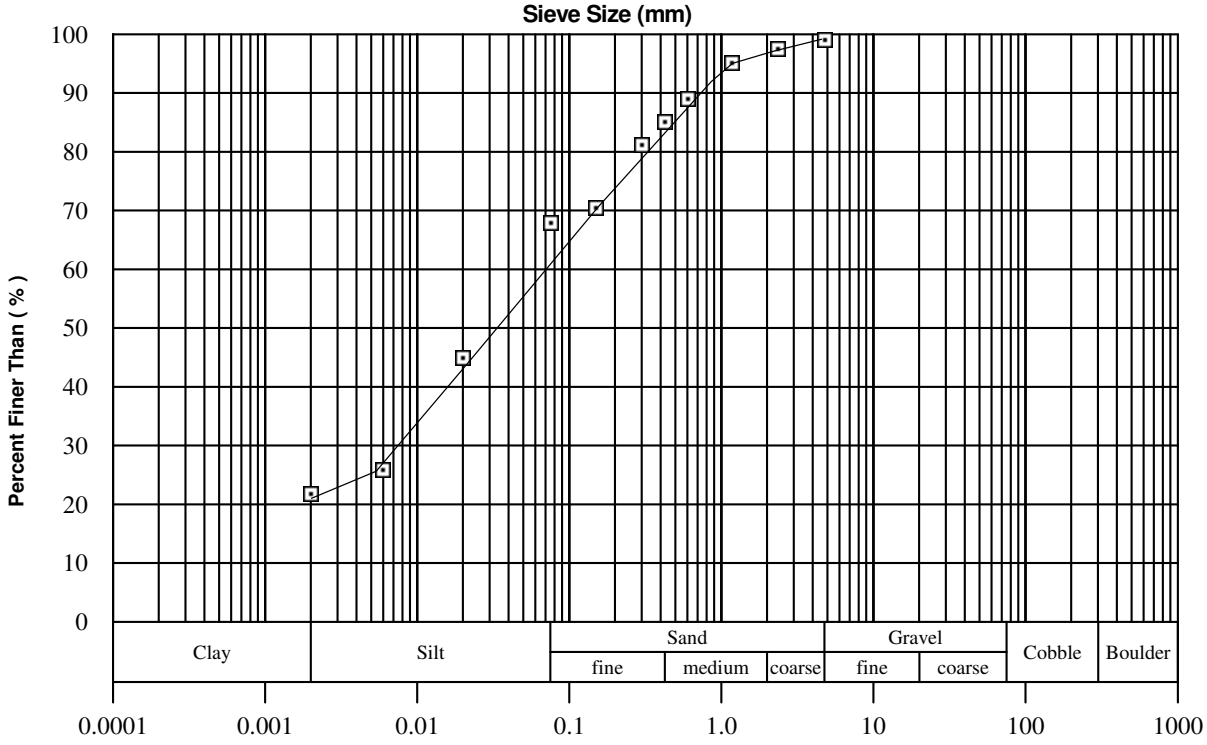
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	07	105102	1.00-1.45	0.80	26.90	37.60	34.70

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



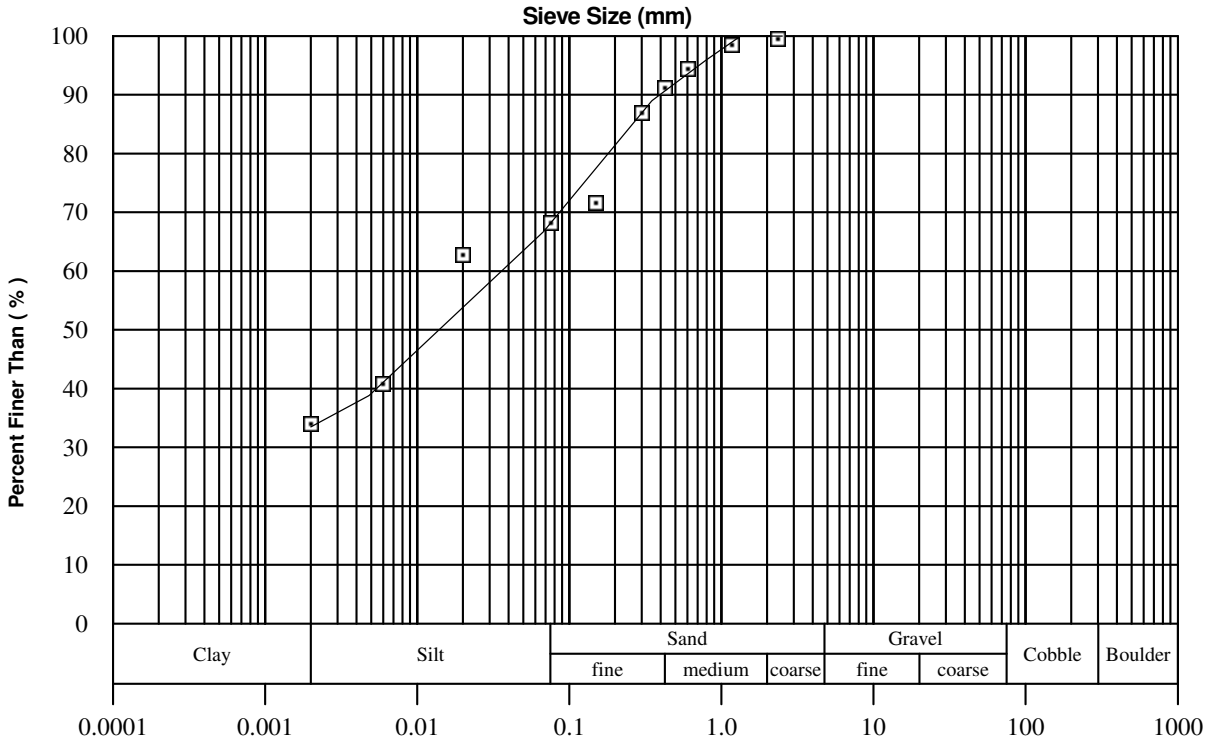
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	07	105102	1.00-1.45	0.80	26.90	37.60	34.70



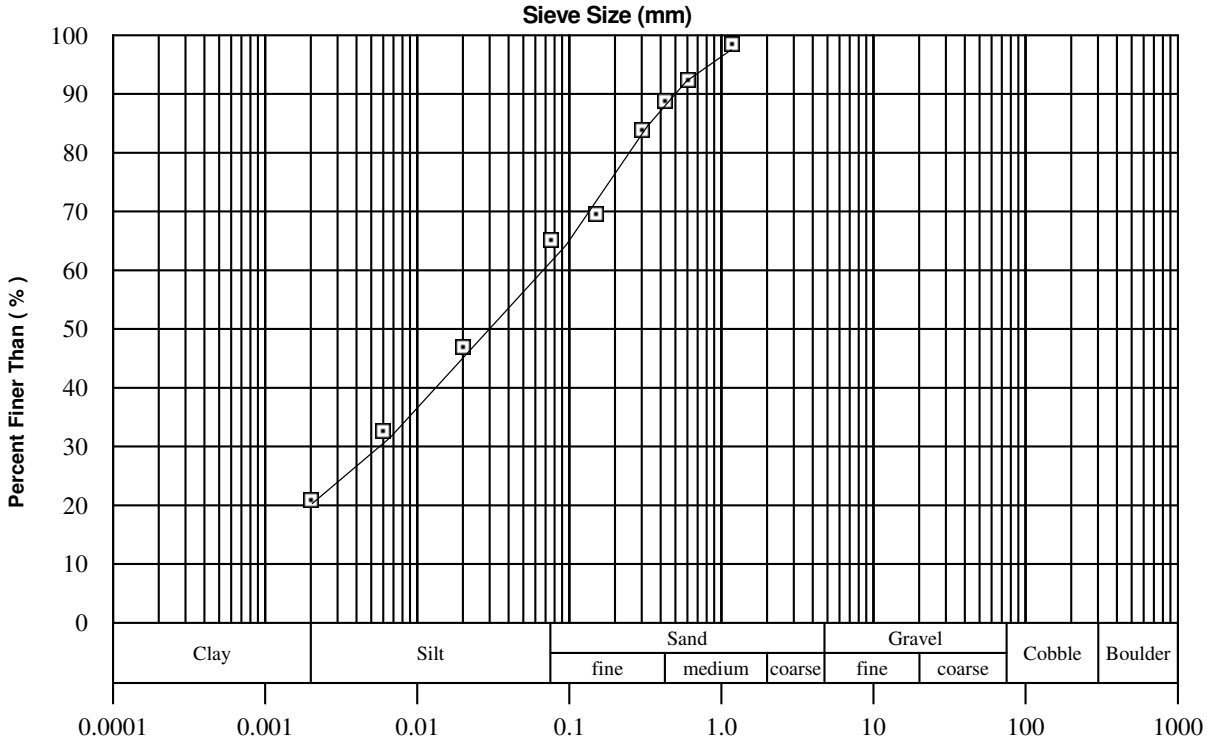
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	07	105104	2.00-2.45	1.00	31.00	46.24	21.76

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



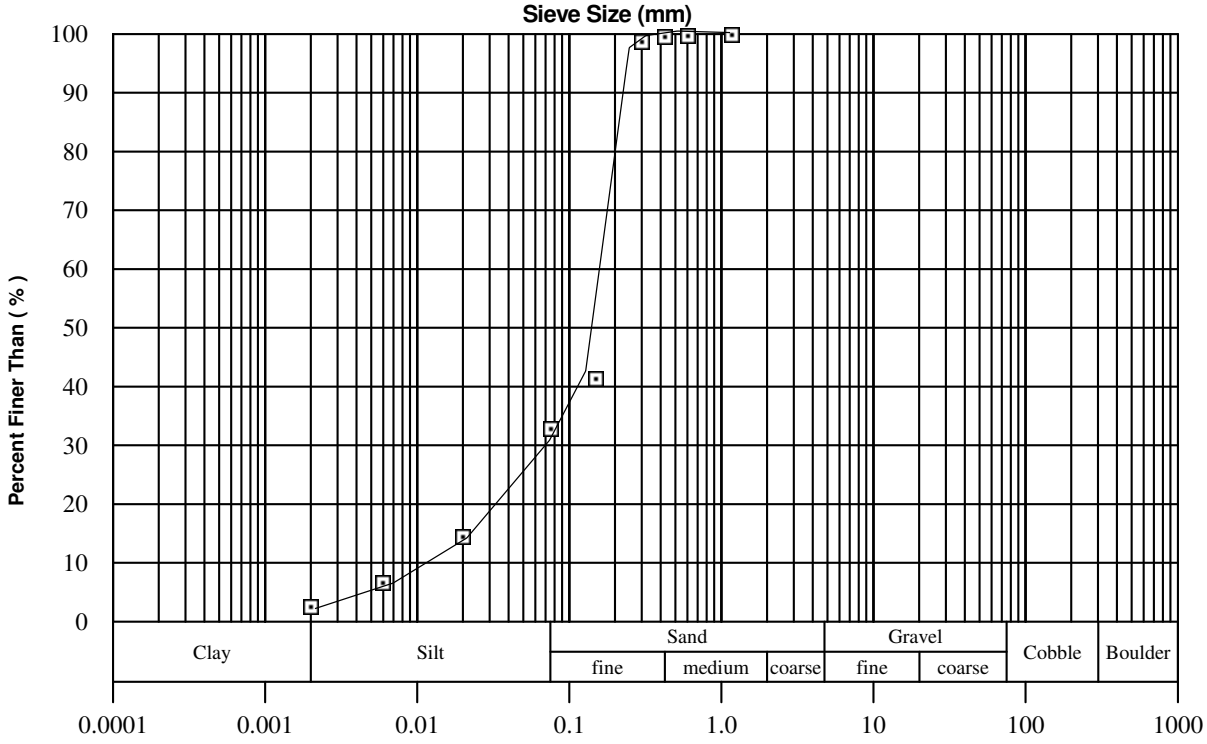
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	08	100968	1.00-1.45		31.80	34.10	34.10



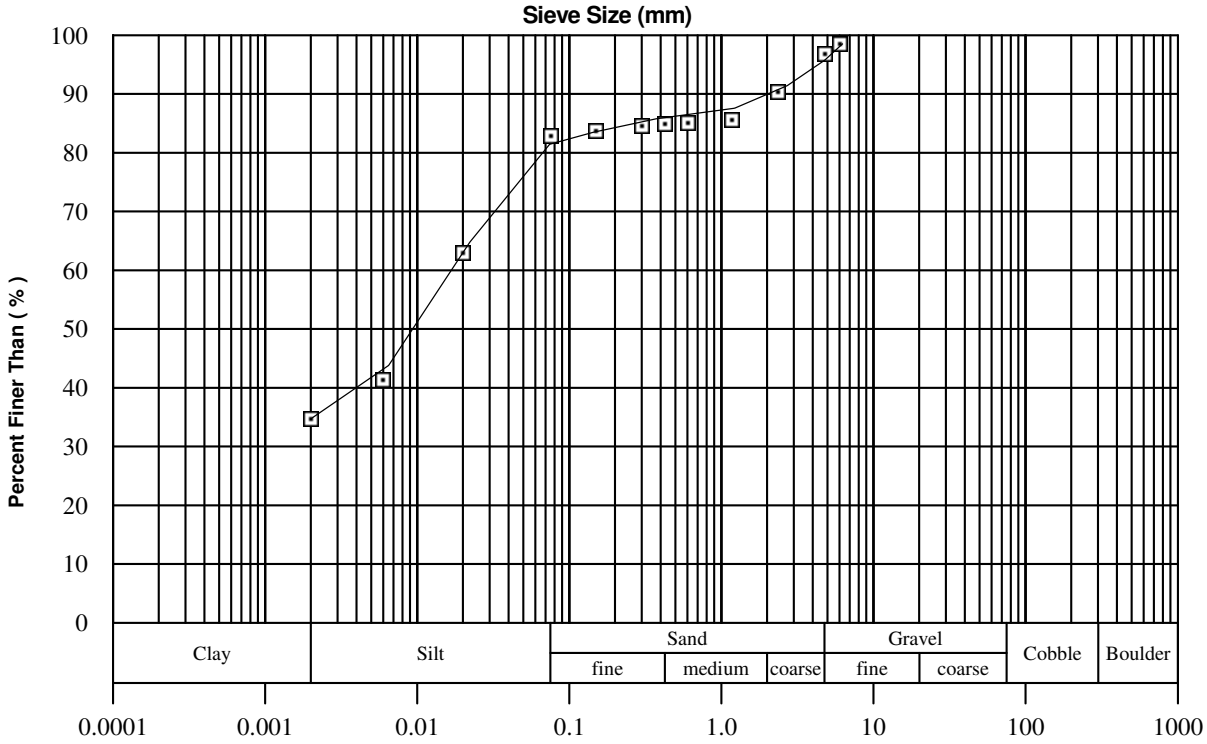
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	08	100972	3.00-3.45		34.70	44.40	20.90

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



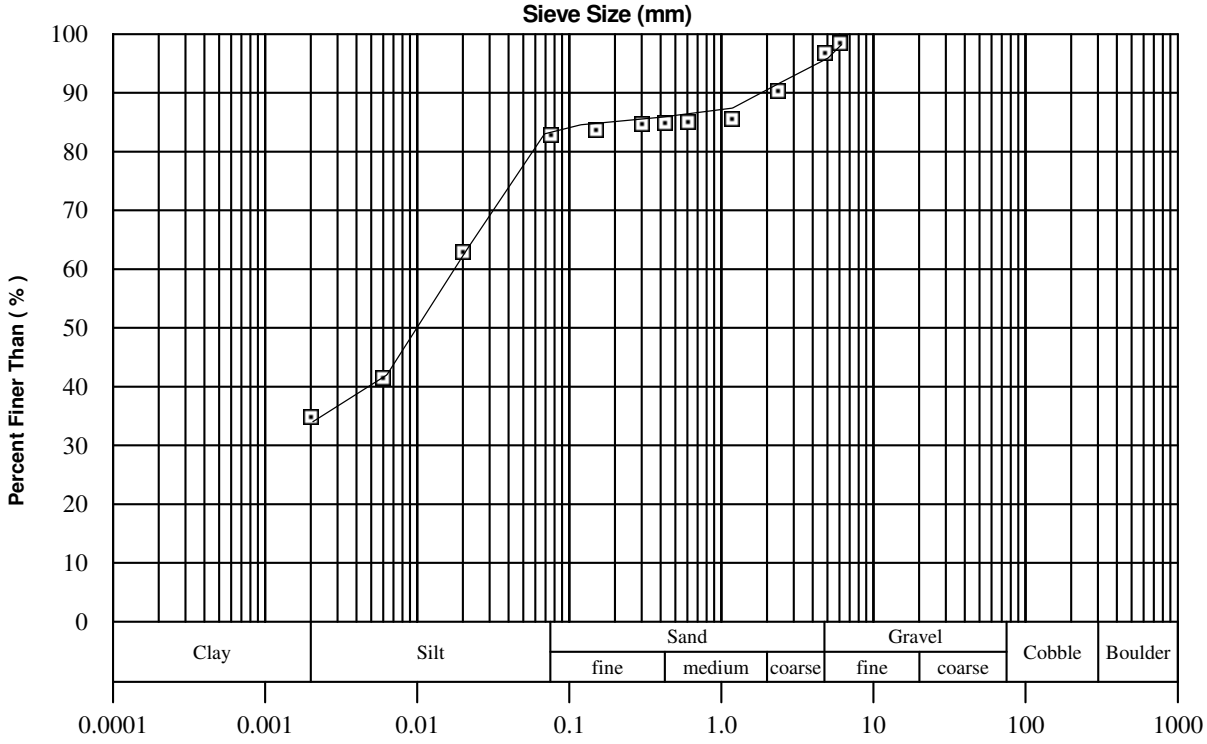
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	08	100976	7.50-7.95		67.23	30.15	2.62



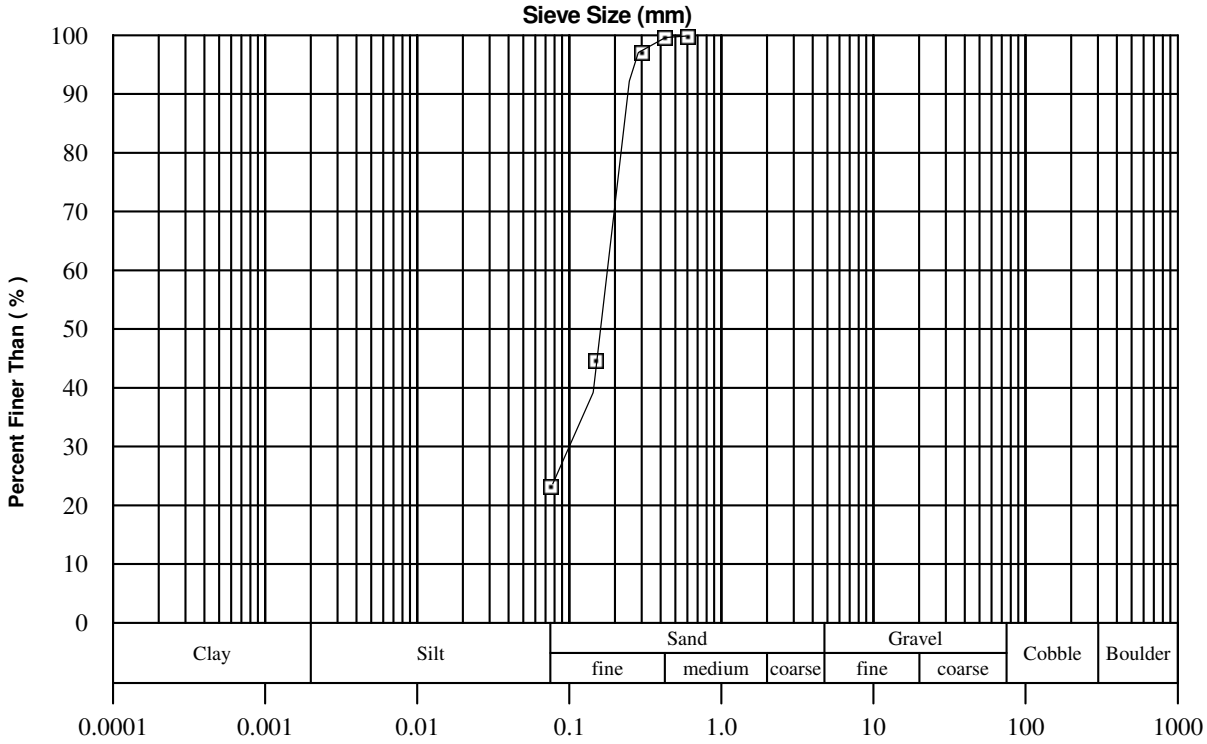
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	09	100878	2.00-2.45	3.20	13.90	48.08	34.82

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



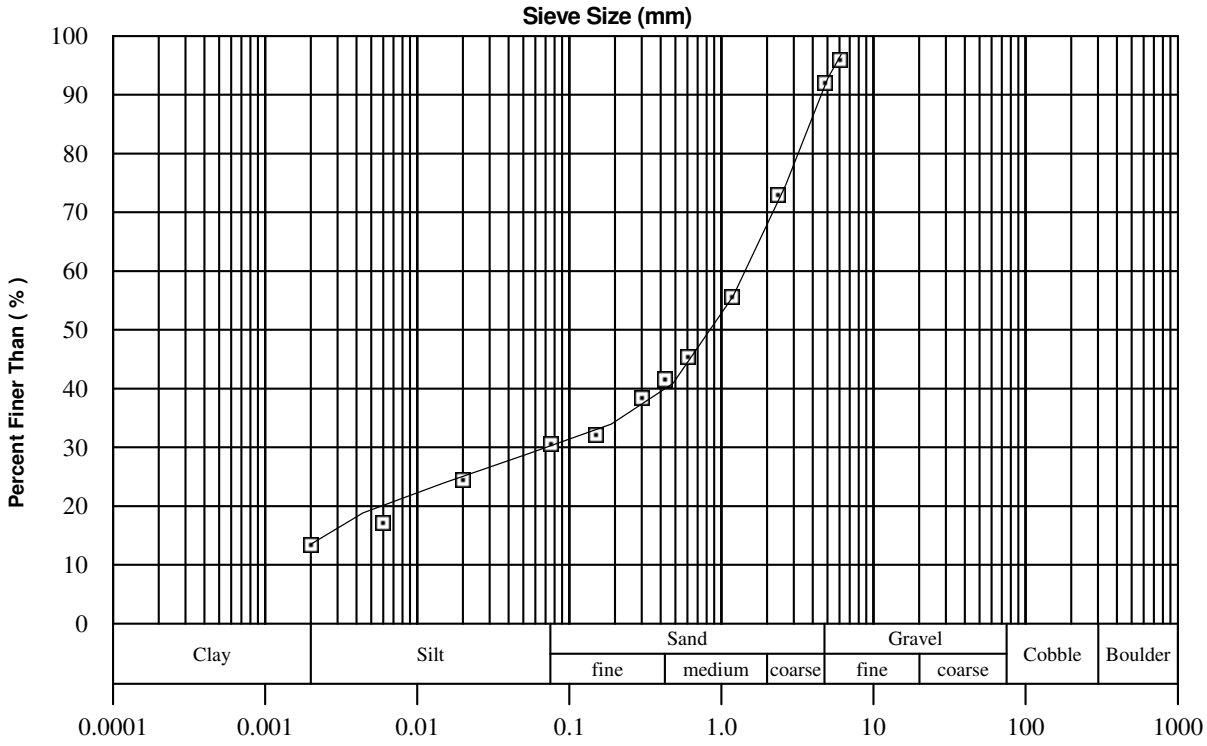
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	09	100878	2.00-2.45	3.20	13.90	48.08	34.82



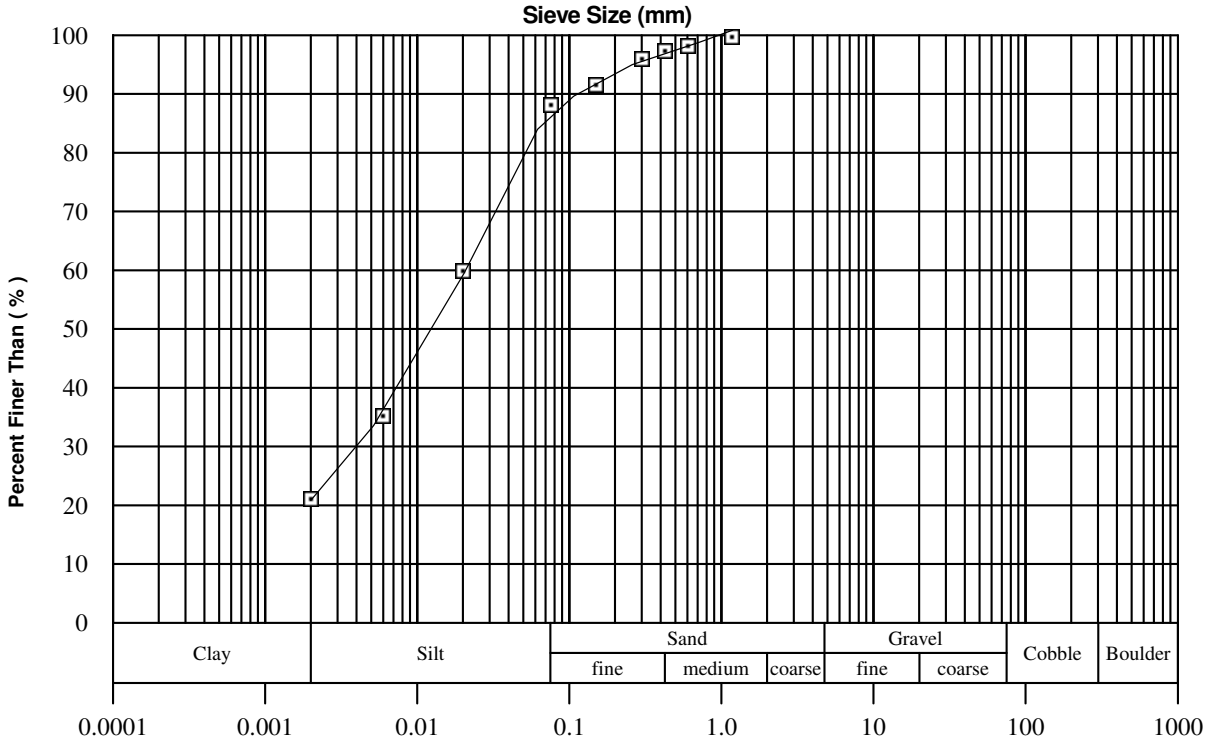
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	09	100884	7.50-7.95		76.80	23.20	

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



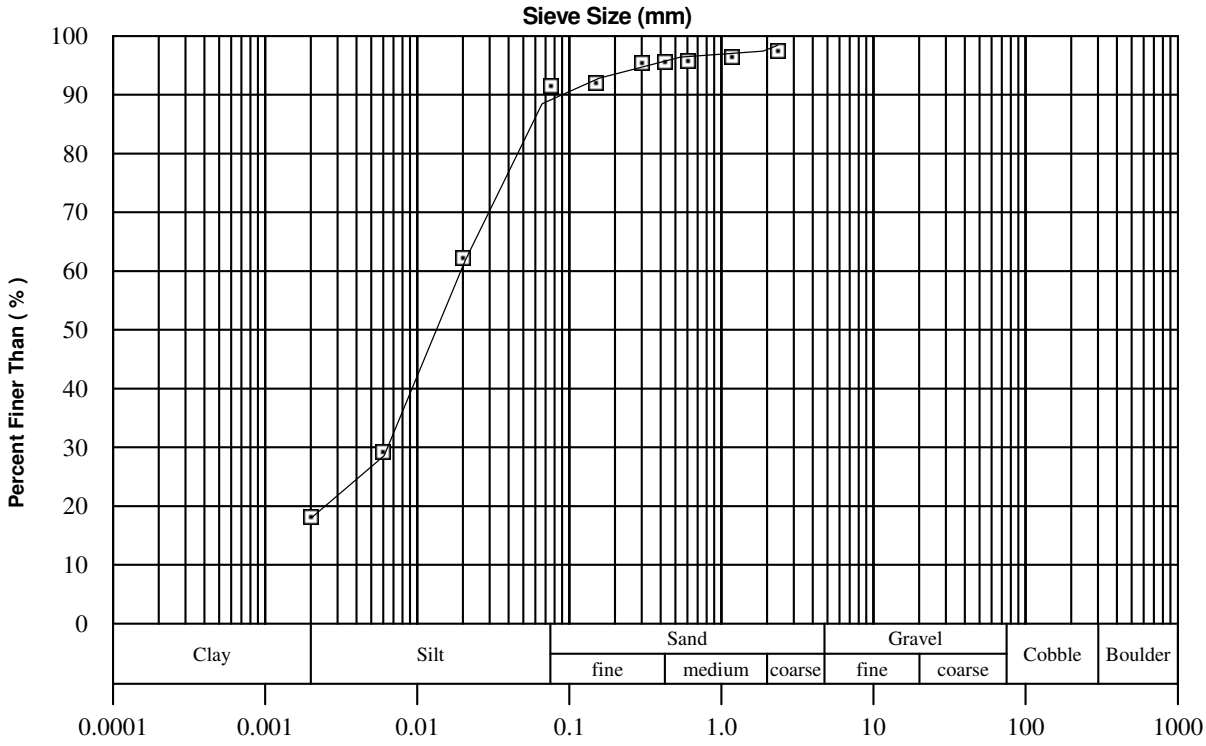
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	10	100472	1.00-1.45	8.00	61.40	17.14	13.46



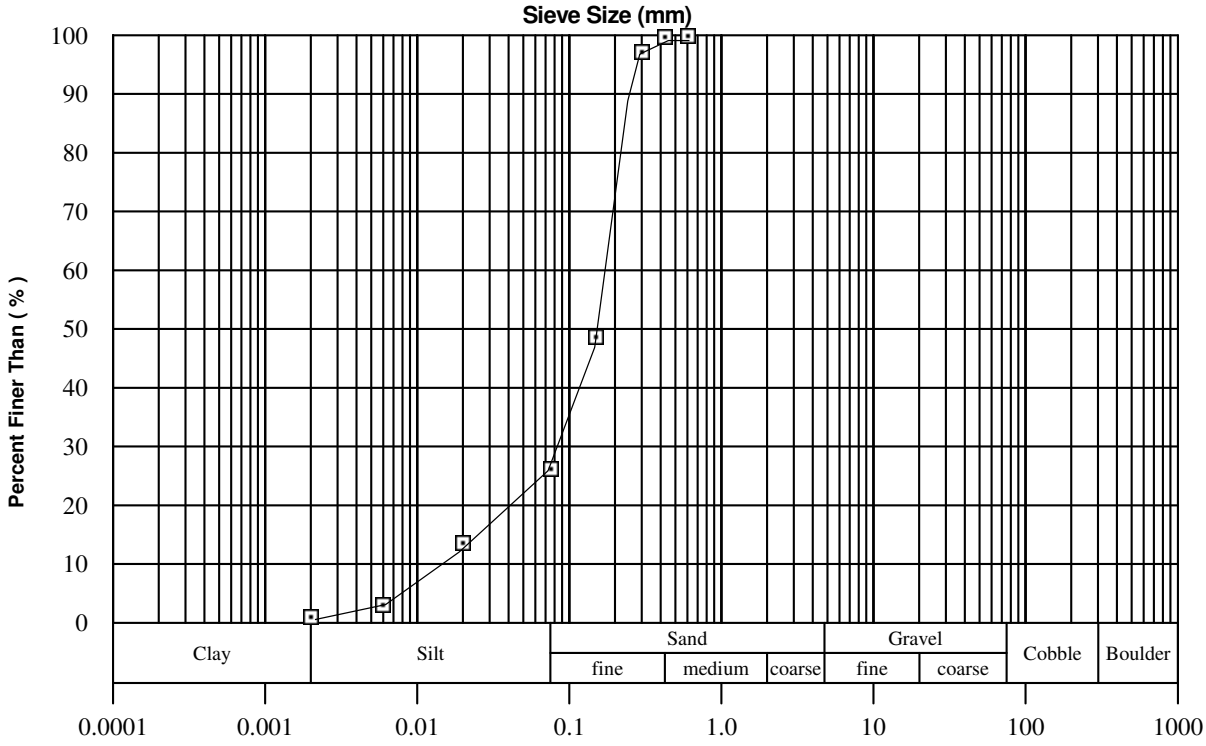
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	10	100476	3.00-3.45		11.83	67.01	21.16

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



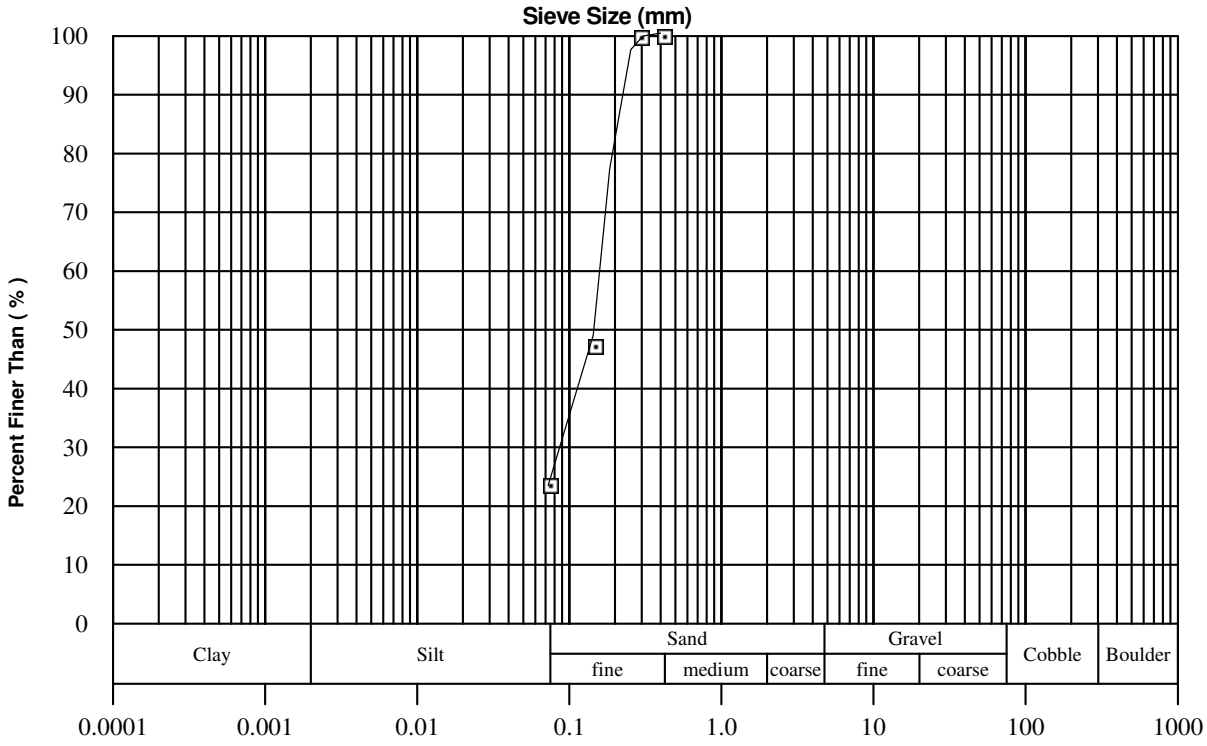
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	11	100852	1.00-1.45		8.50	73.20	18.30



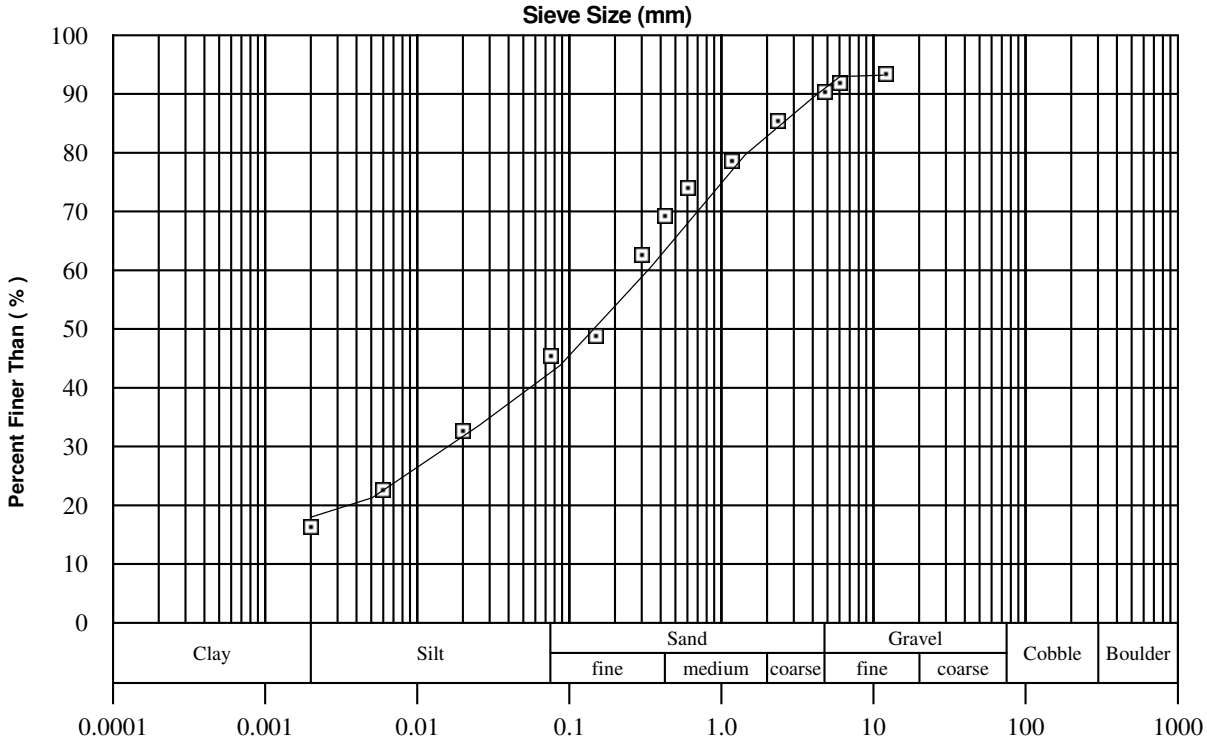
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	11	100860	5.00-5.45		73.70	25.25	1.05

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



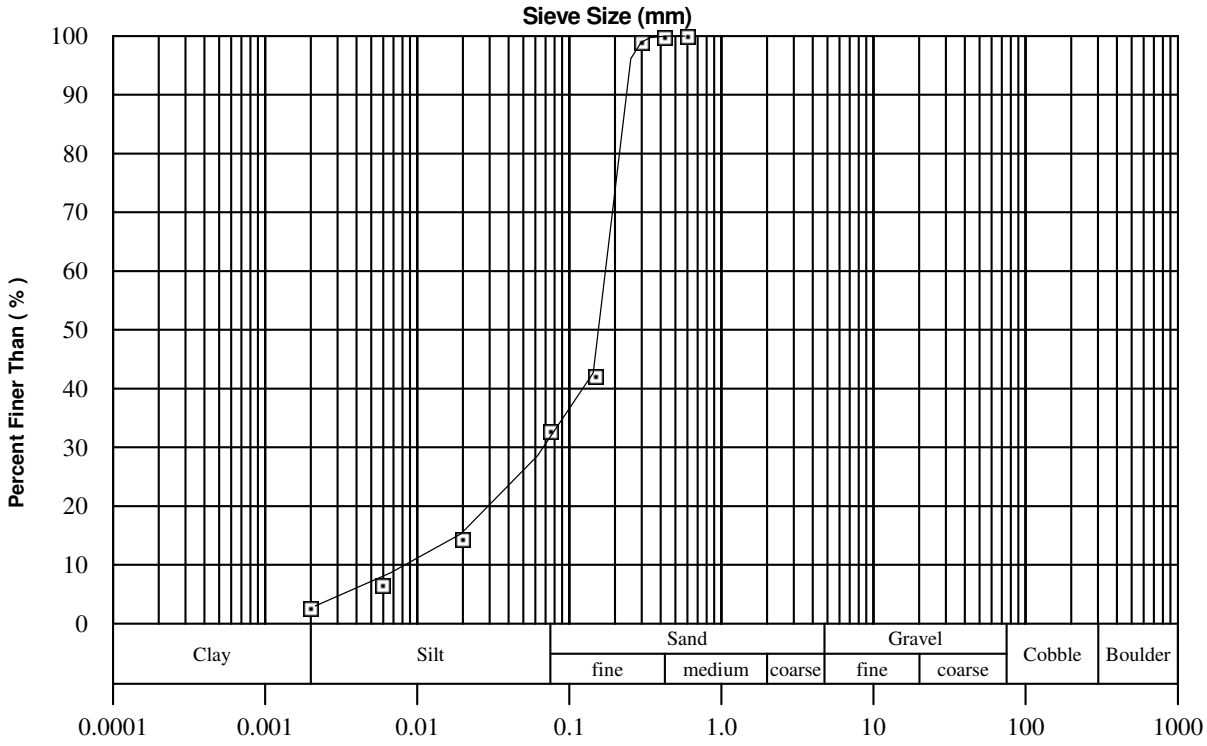
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	11	100872	8.50-8.95		76.60	23.40	



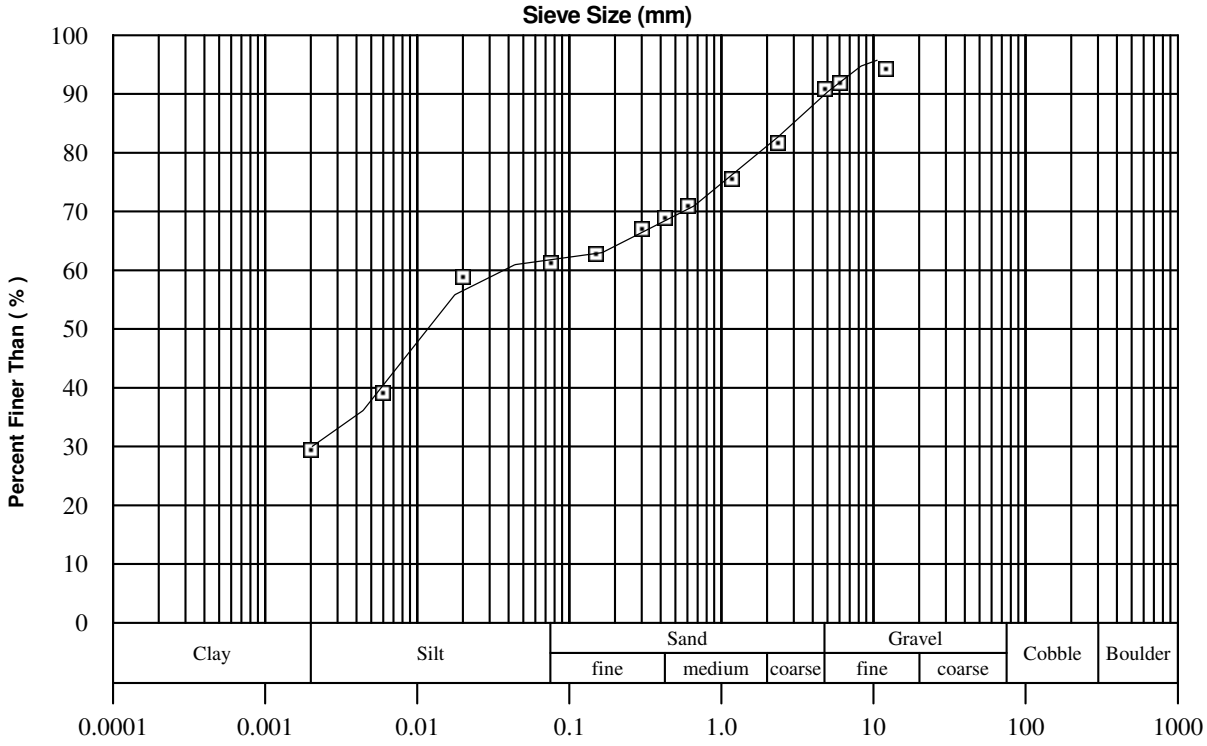
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	12	100982	3.00-3.45	9.67	44.83	29.12	16.38

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



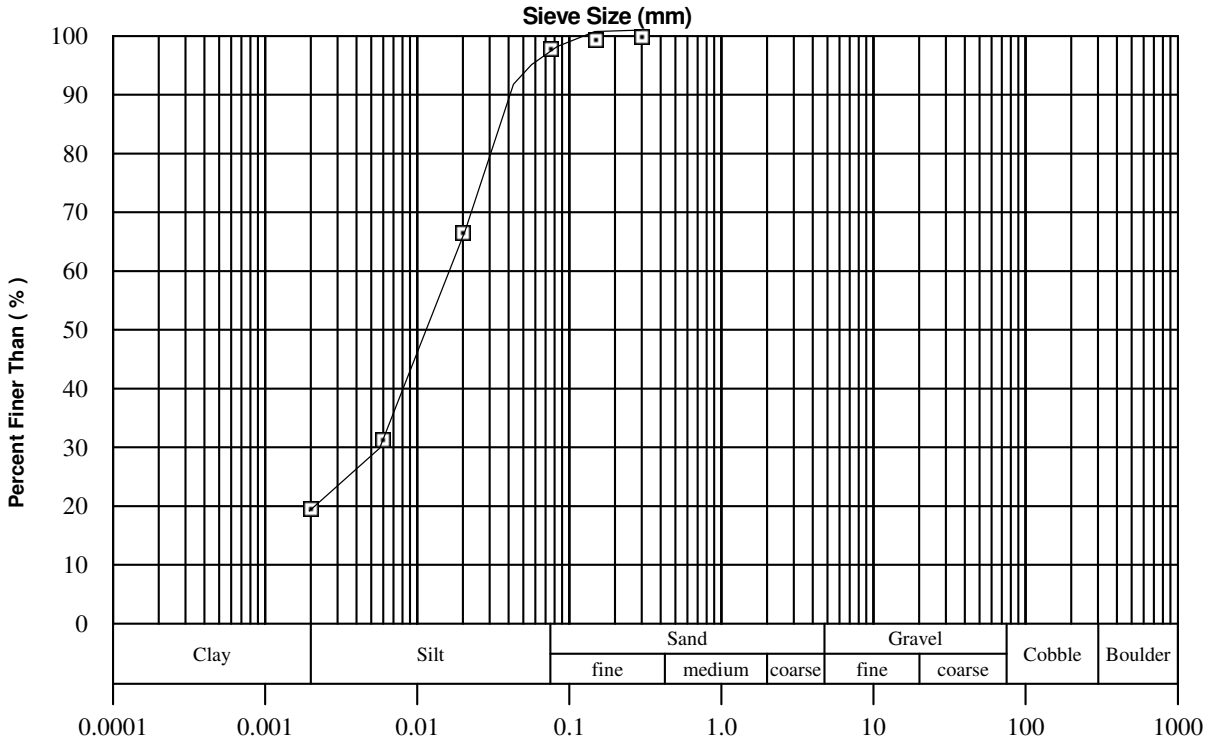
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	12	100985	5.00-5.25		67.33	30.05	2.61



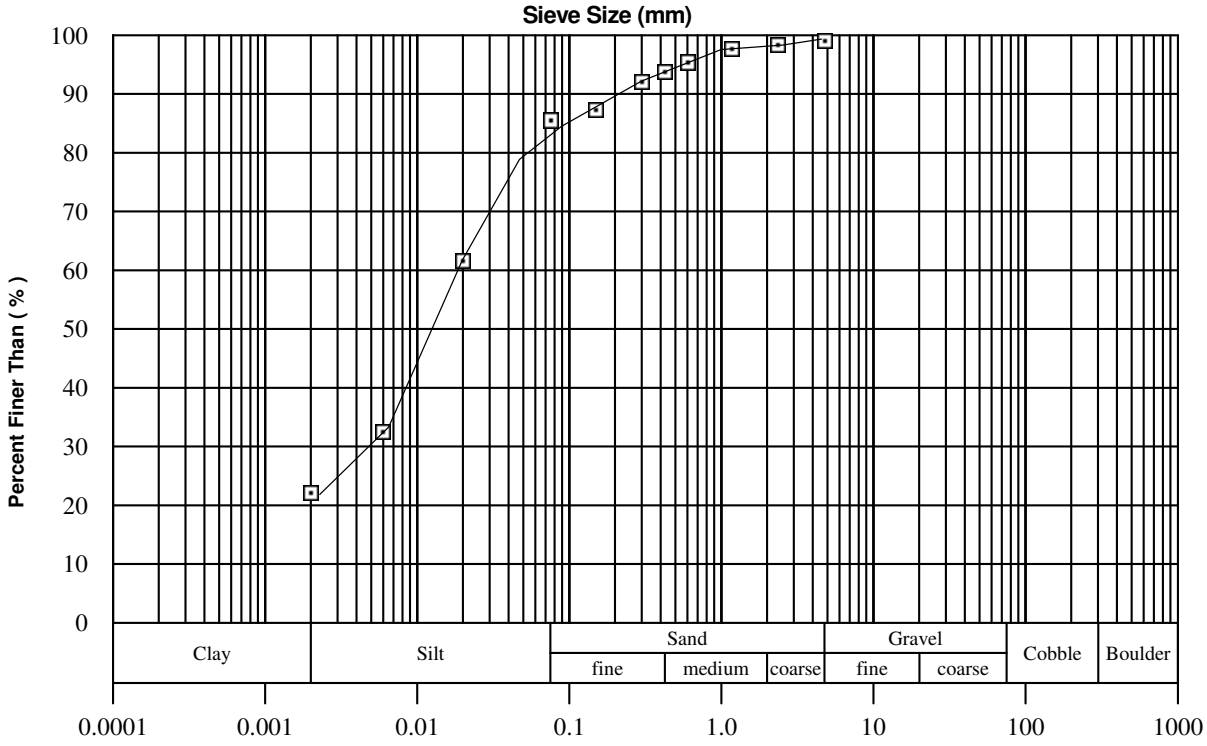
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	13	100485	2.00-2.45	9.10	29.60	31.88	29.42

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



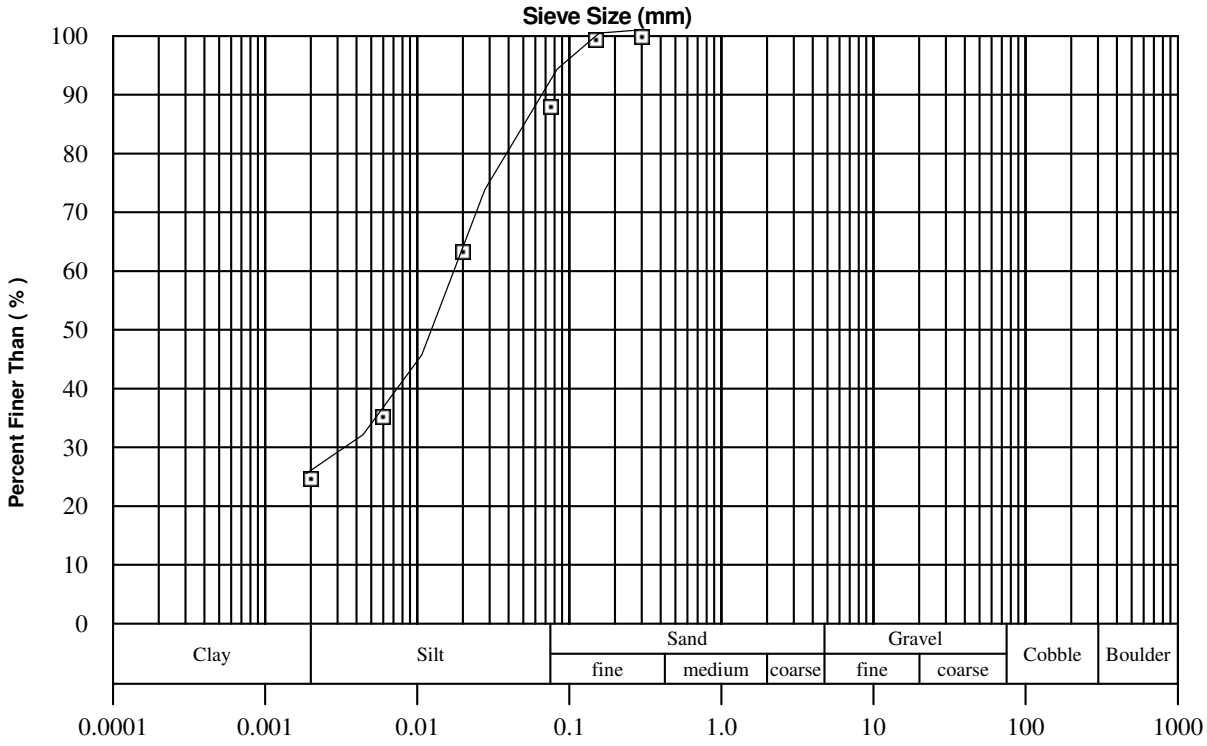
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	13	100489	4.0-4.45		2.10	78.32	19.58



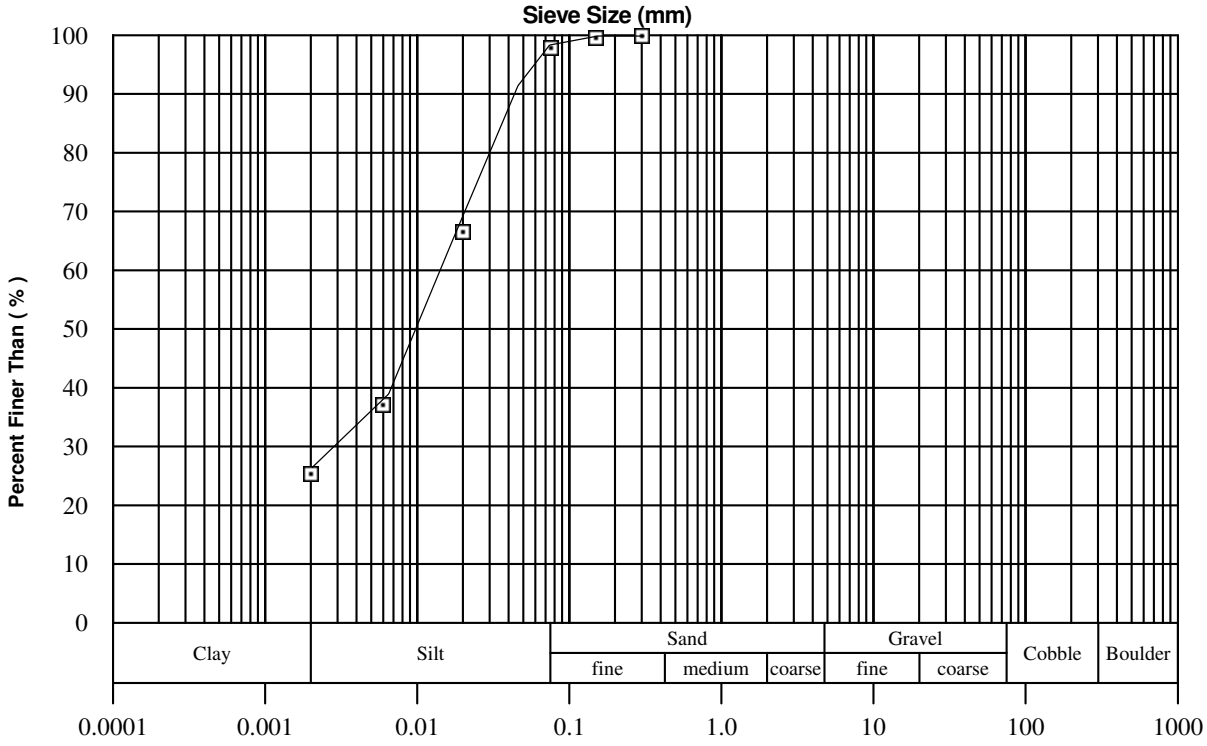
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	14	100554	2.00-2.45	1.00	13.43	63.32	22.25

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



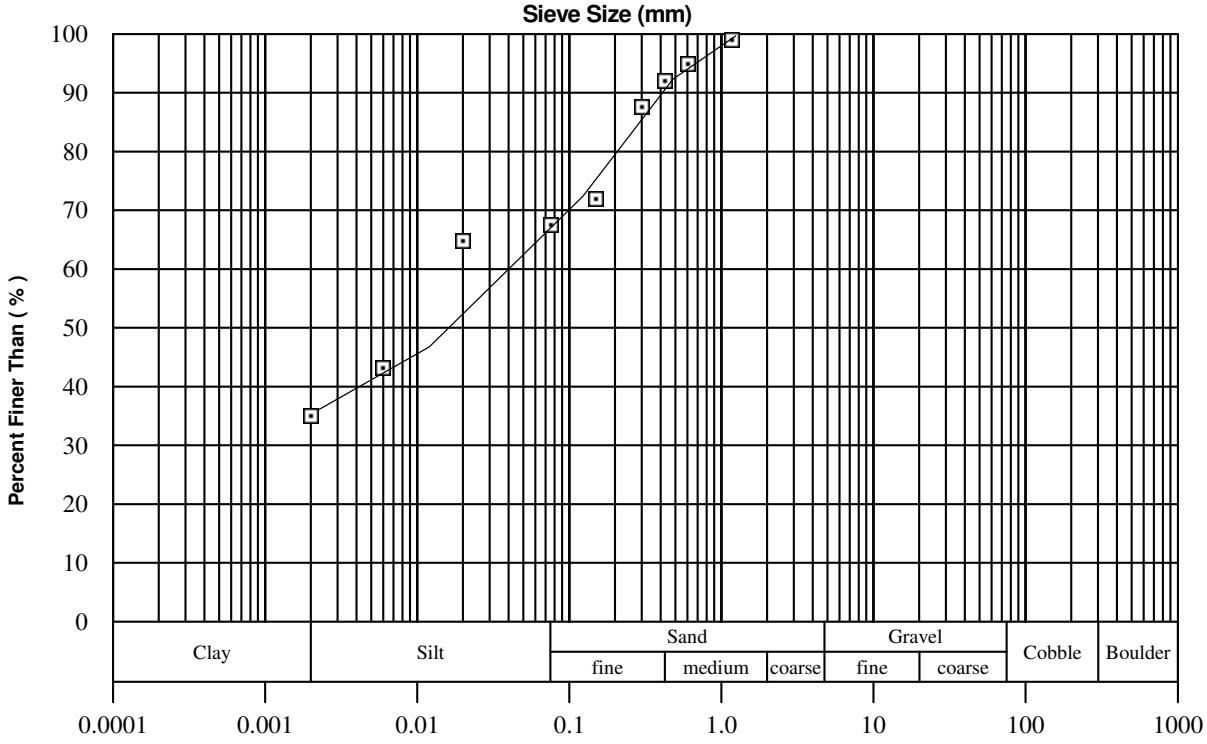
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	14	100556	3.00-3.45		12.00	63.36	24.64



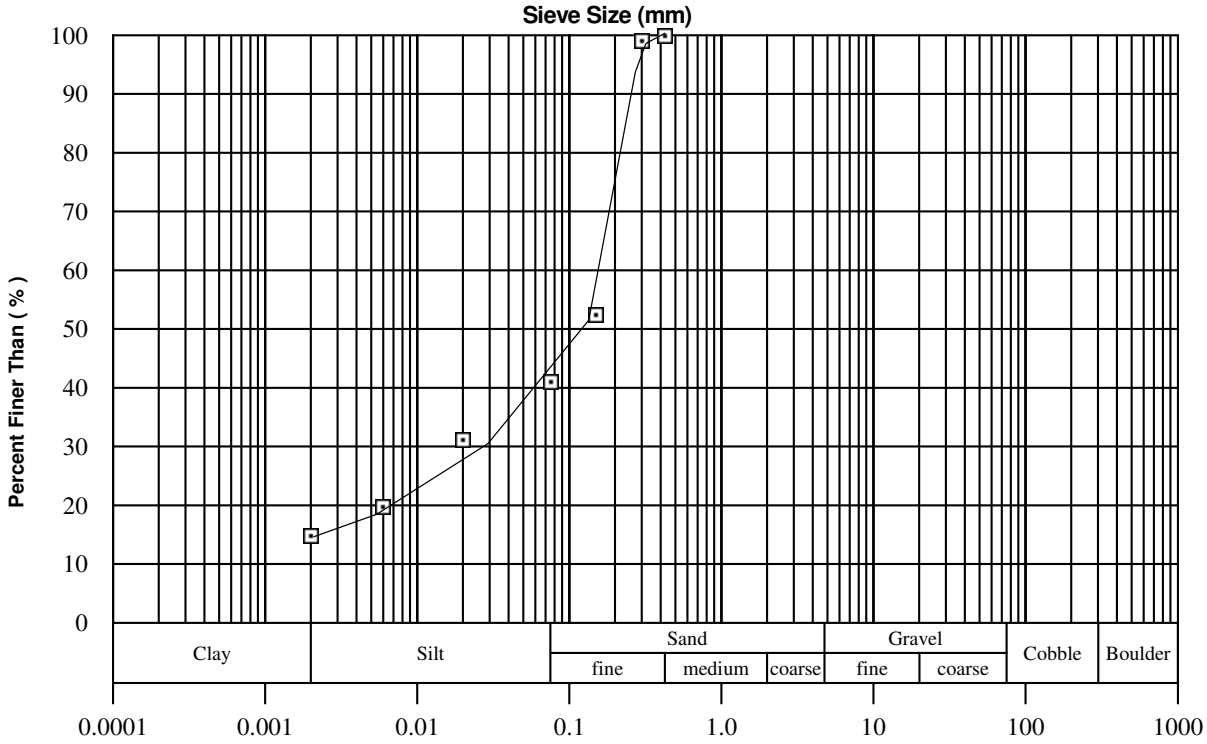
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	15	100465	1.00-1.45		2.10	72.45	25.45

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



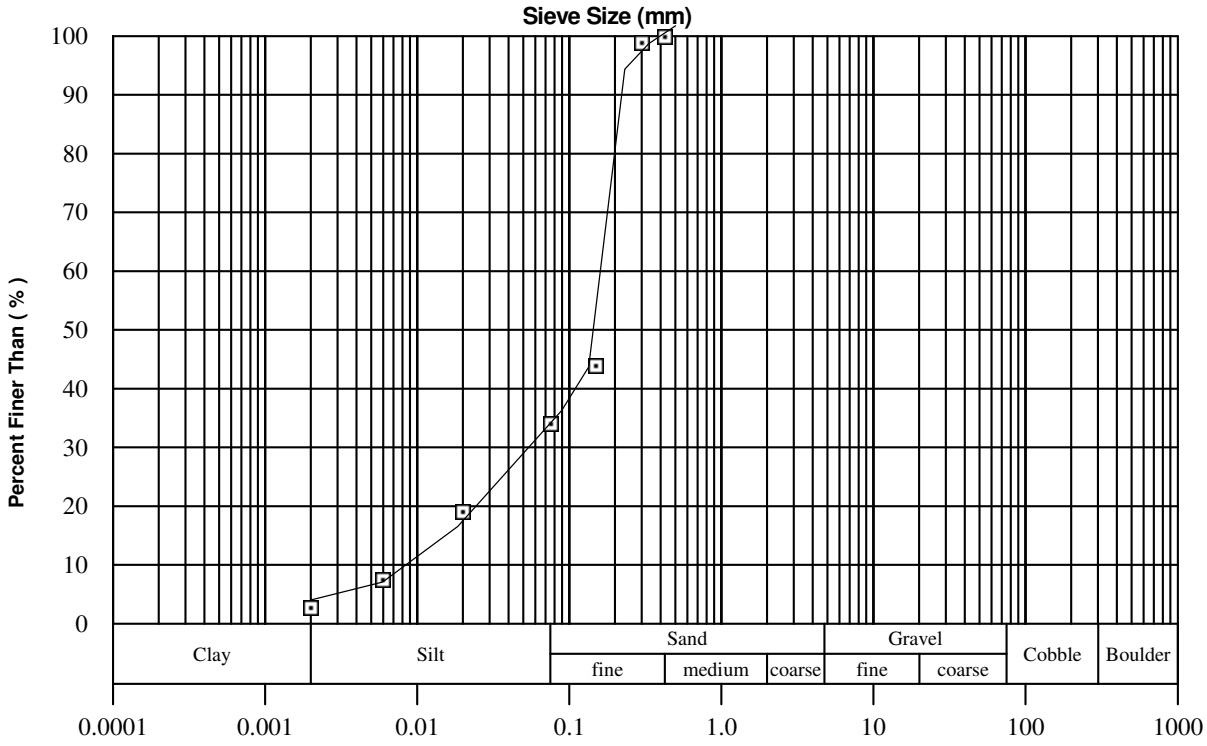
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	16	100954	2.00-2.45		32.50	32.40	35.10



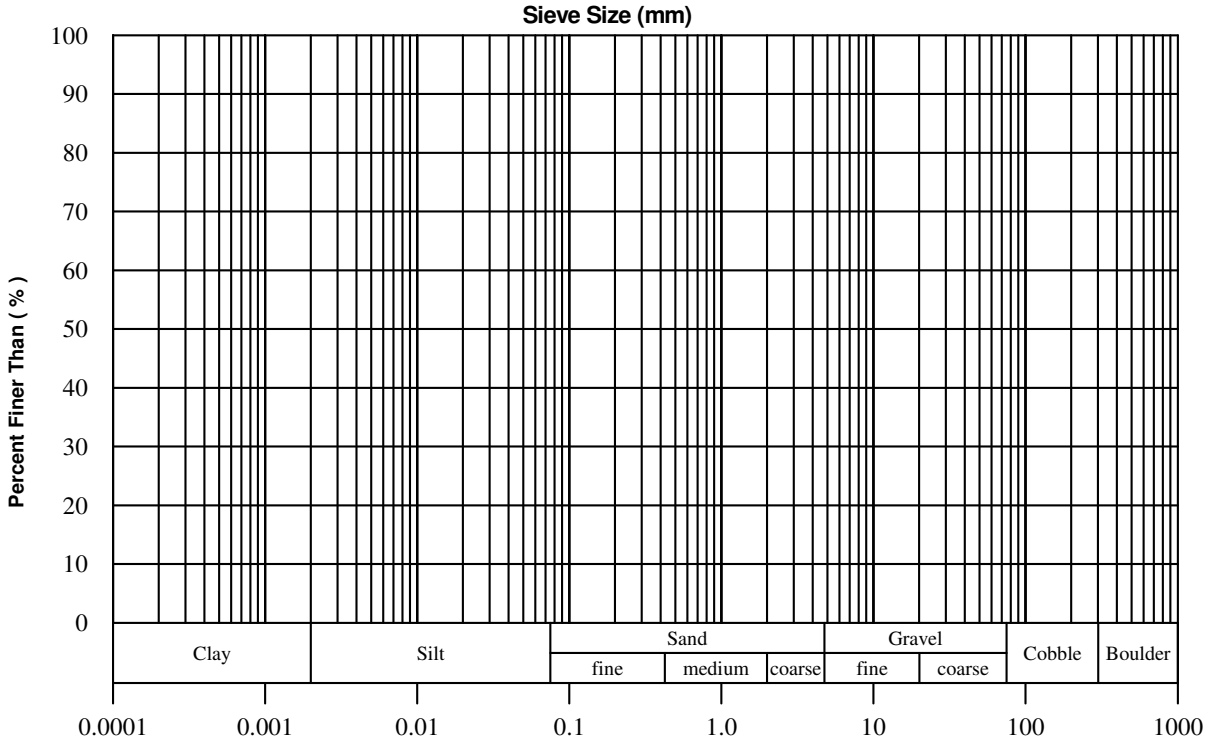
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	16	100958	5.00-5.45		58.90	26.30	14.80

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



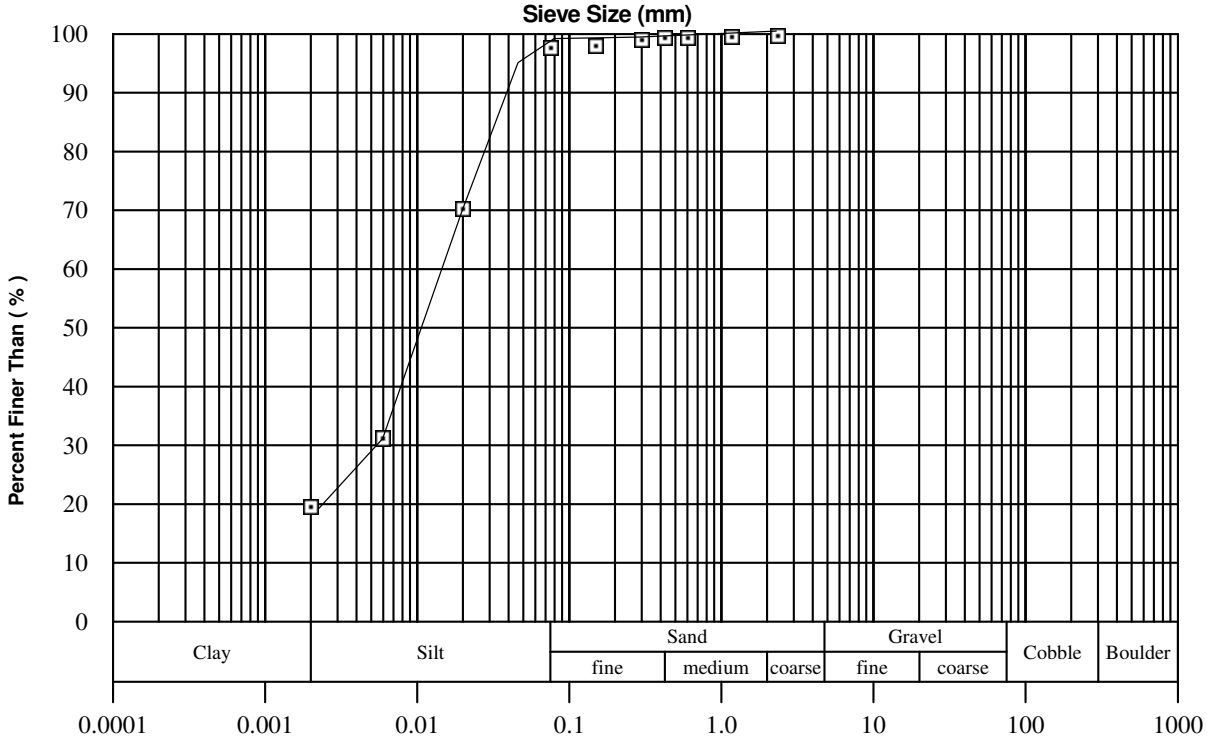
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	16	100962	7.00-7.95		65.90	31.37	2.73



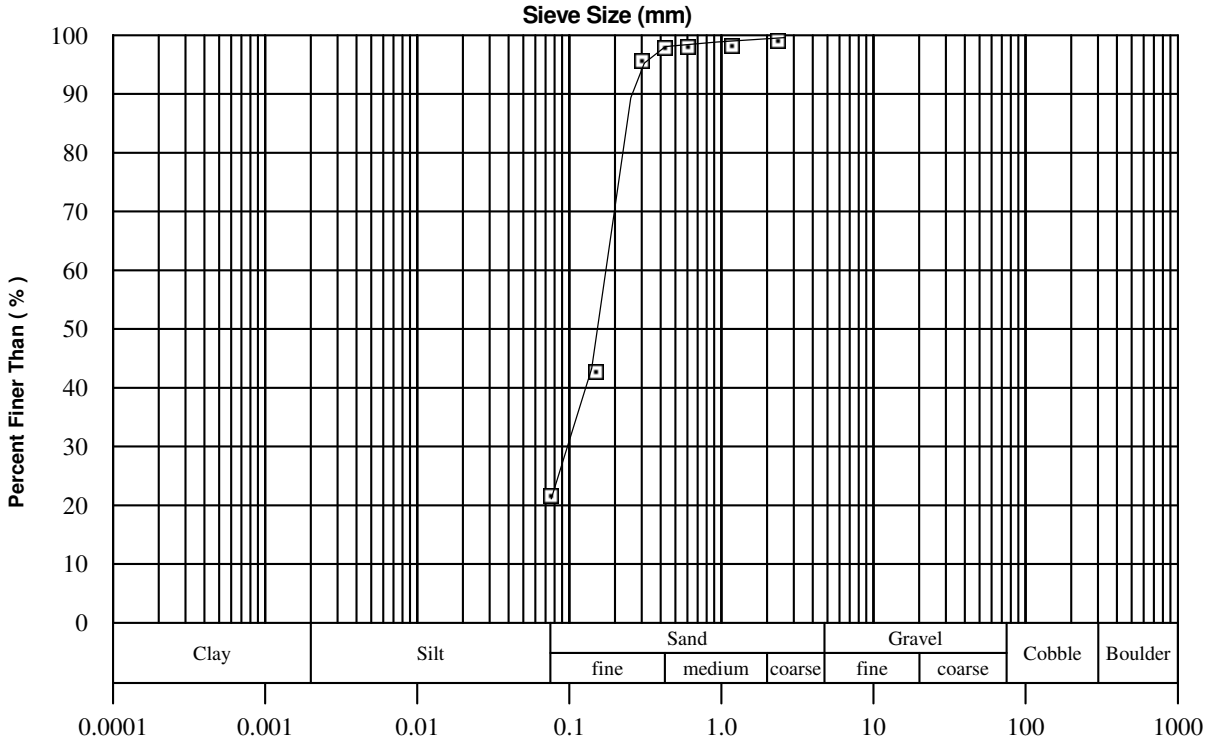
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



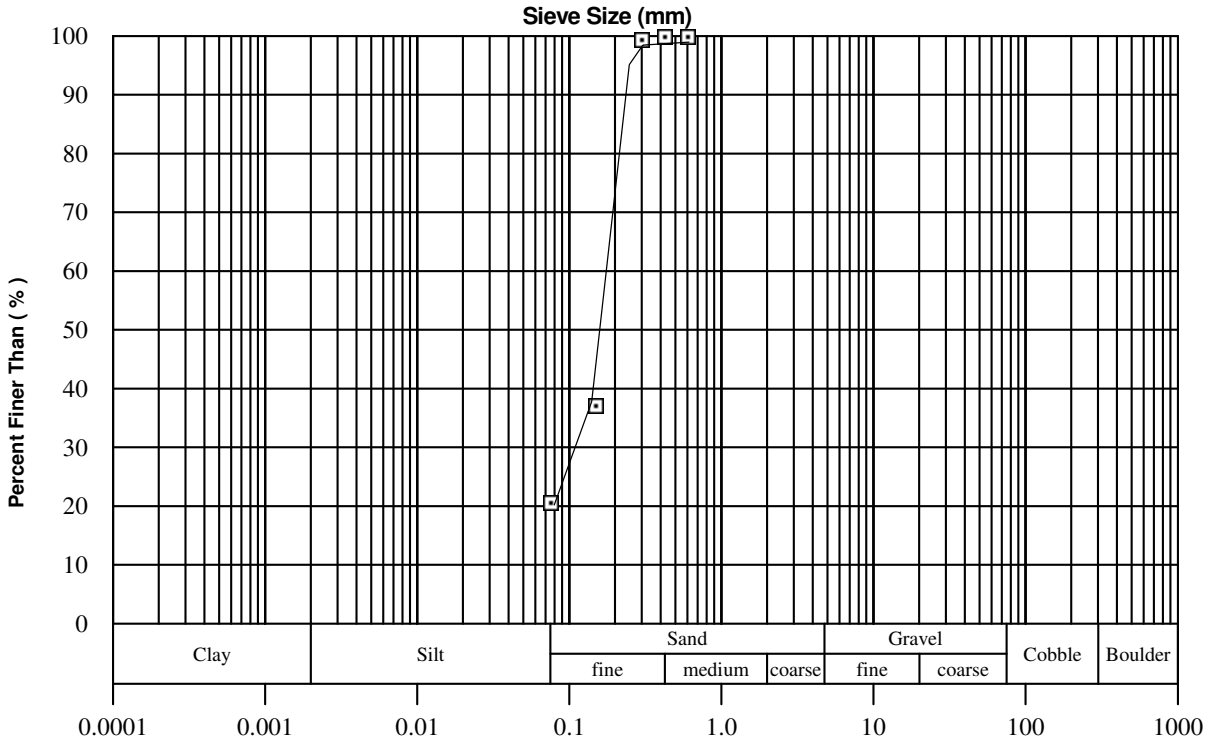
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	17	100521	4.00-4.45		2.40	78.08	19.52



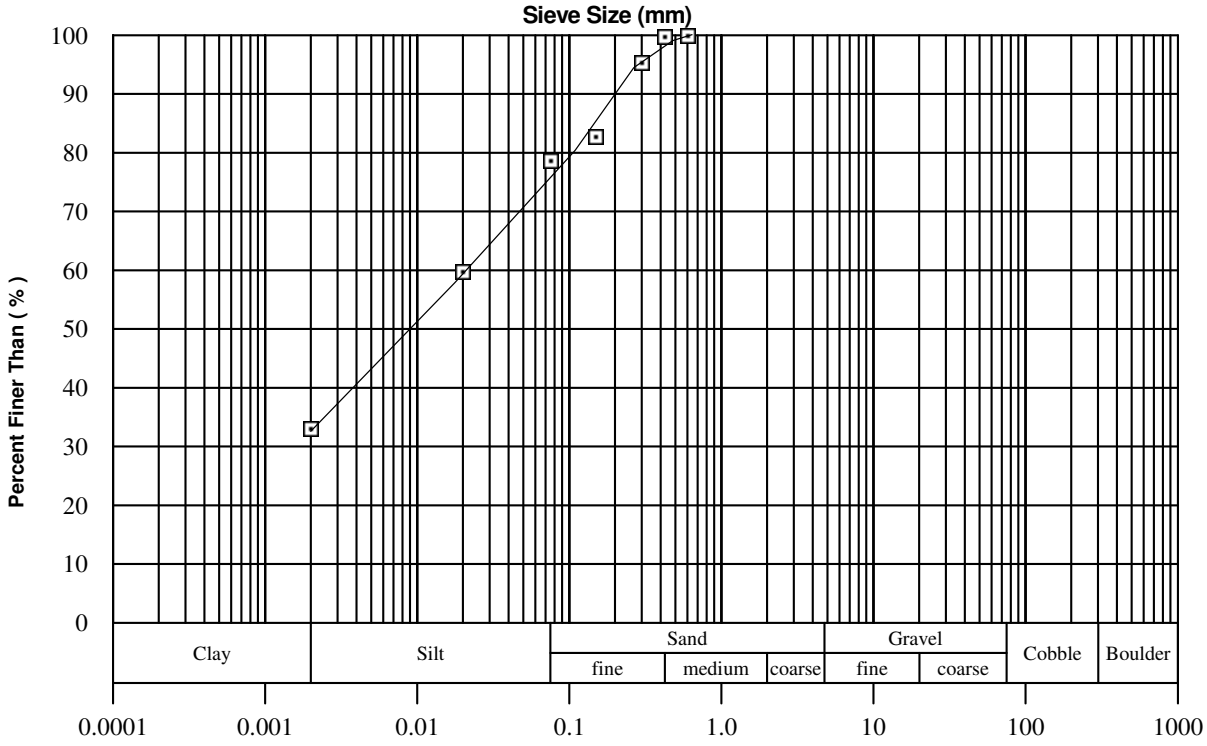
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	17	100524	7.50-7.95		78.40	21.60	

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



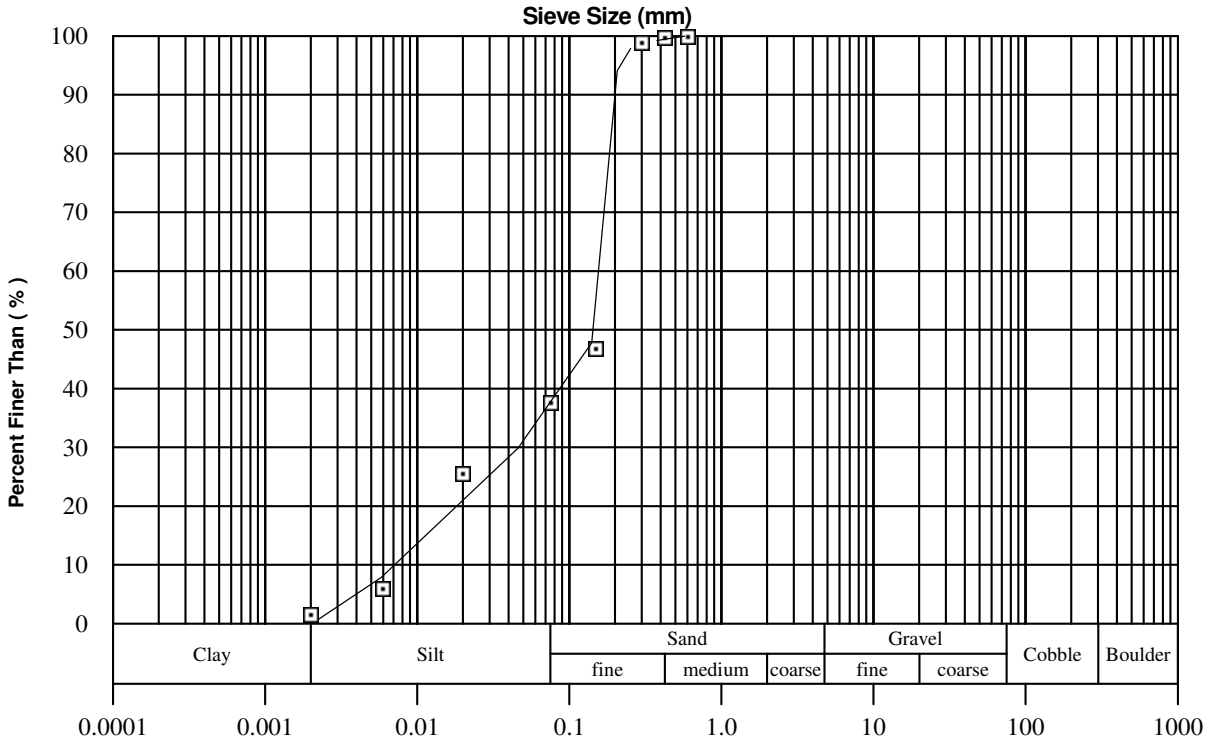
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	17	100527	10.50-10.95		79.40	20.60	



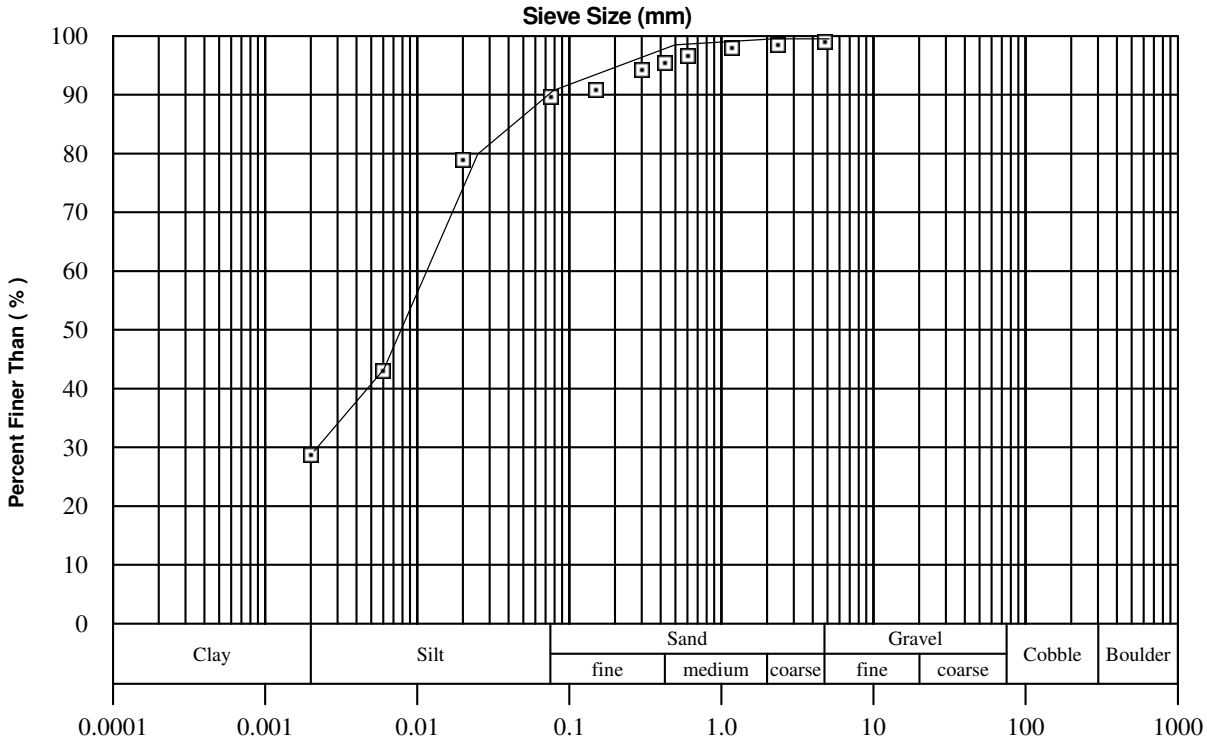
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	18	100531	1.00-1.45		21.40	45.59	33.01

PARTICLE SIZE DISTRIBUTION CURVES

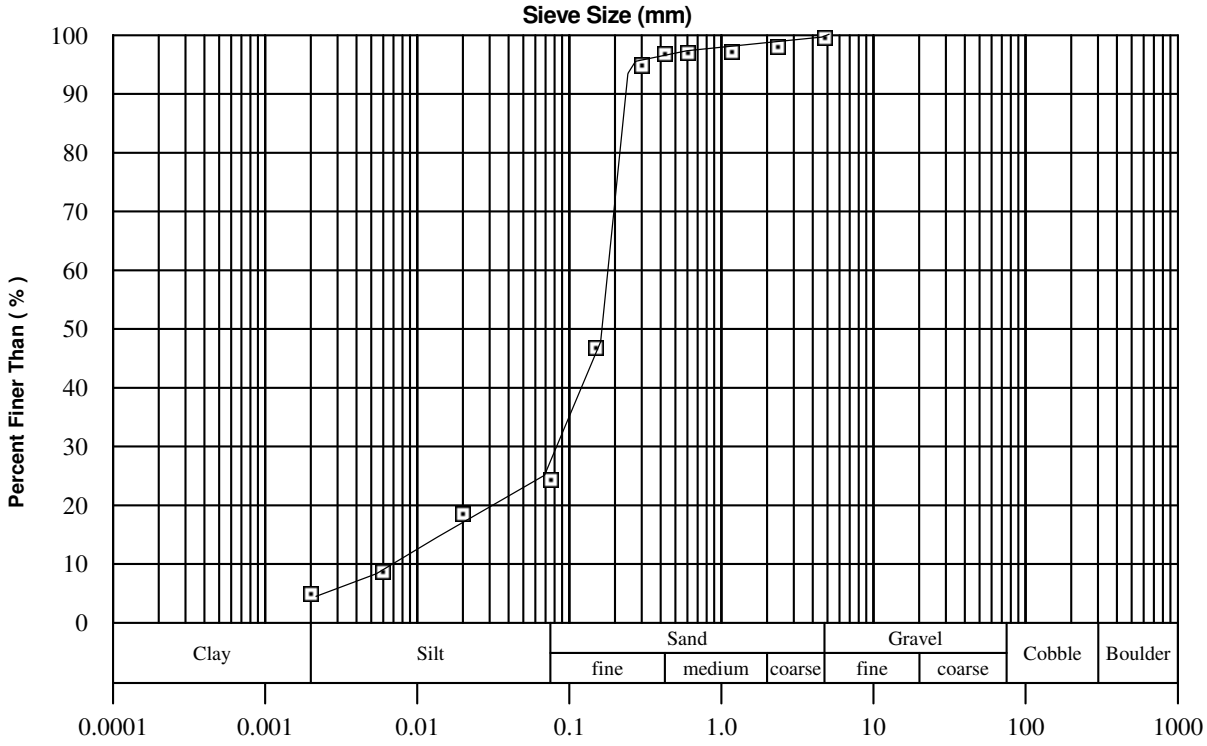
Job No :30796



Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	18	100539	5.50-5.95		62.40	36.10	1.50



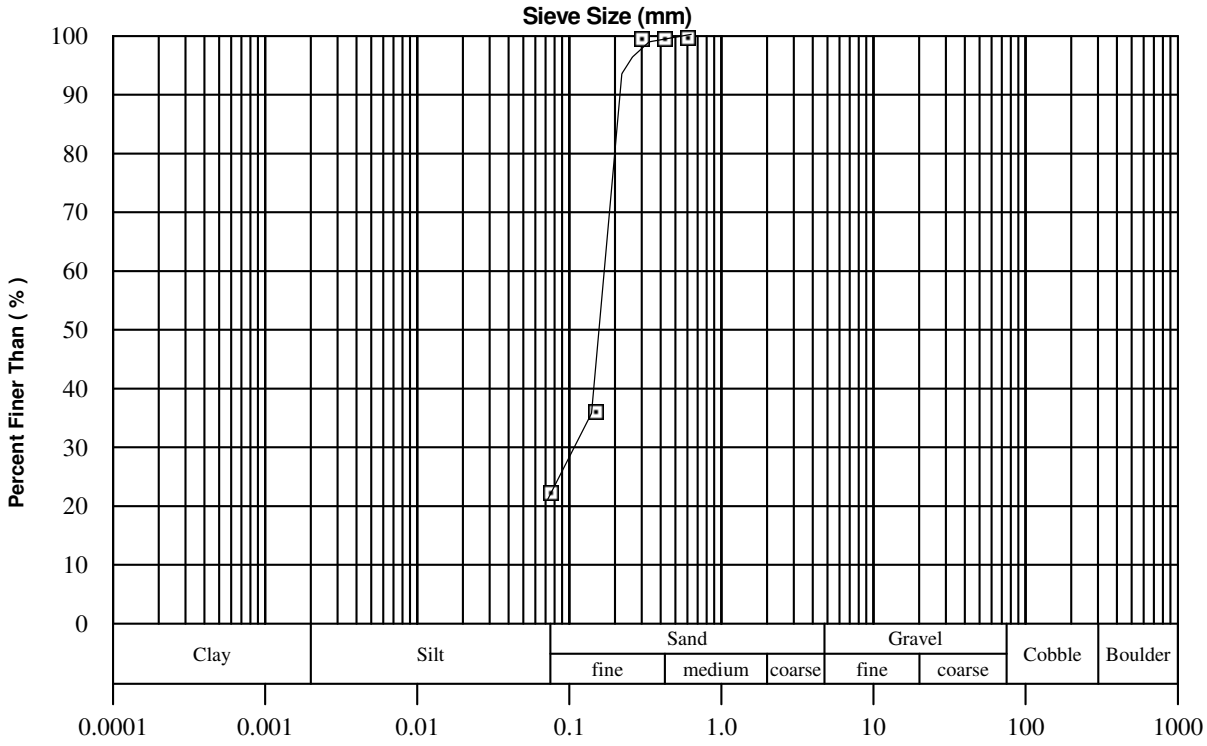
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	19	100503	2.00-2.45	1.00	9.30	61.00	28.70



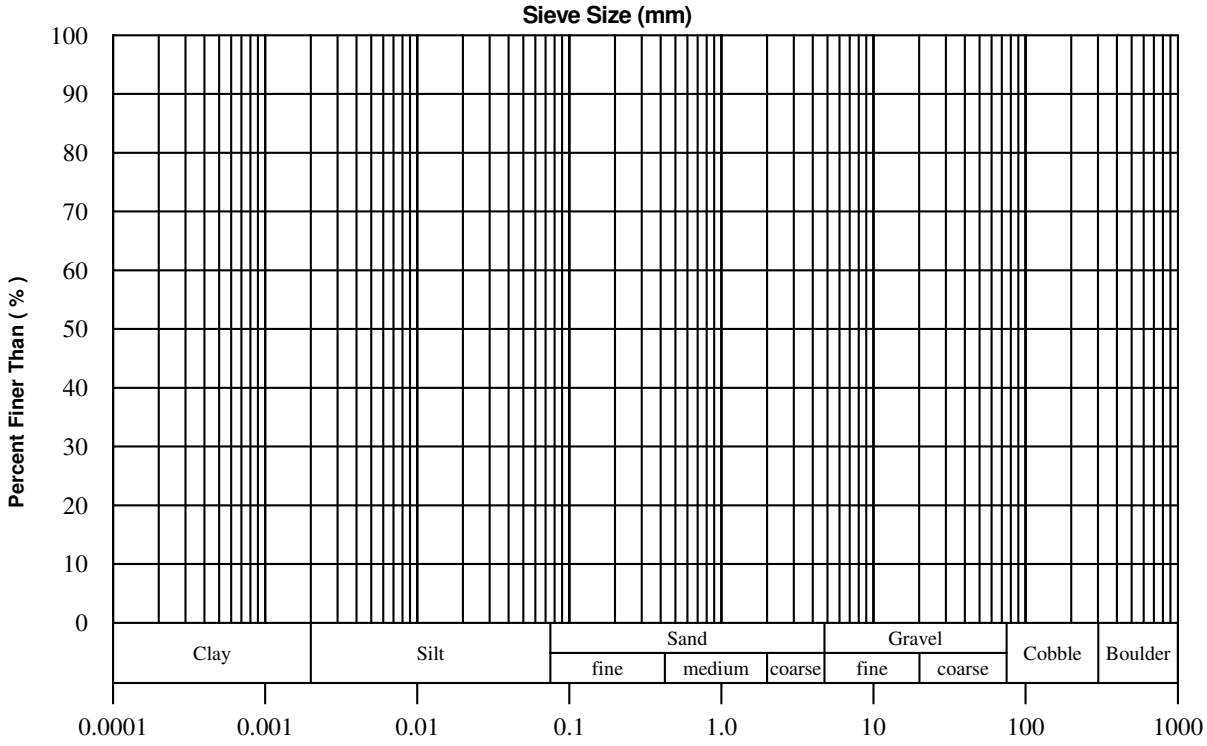
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	19	100507	4.00-4.45	0.50	75.10	19.52	4.88

PARTICLE SIZE DISTRIBUTION CURVES

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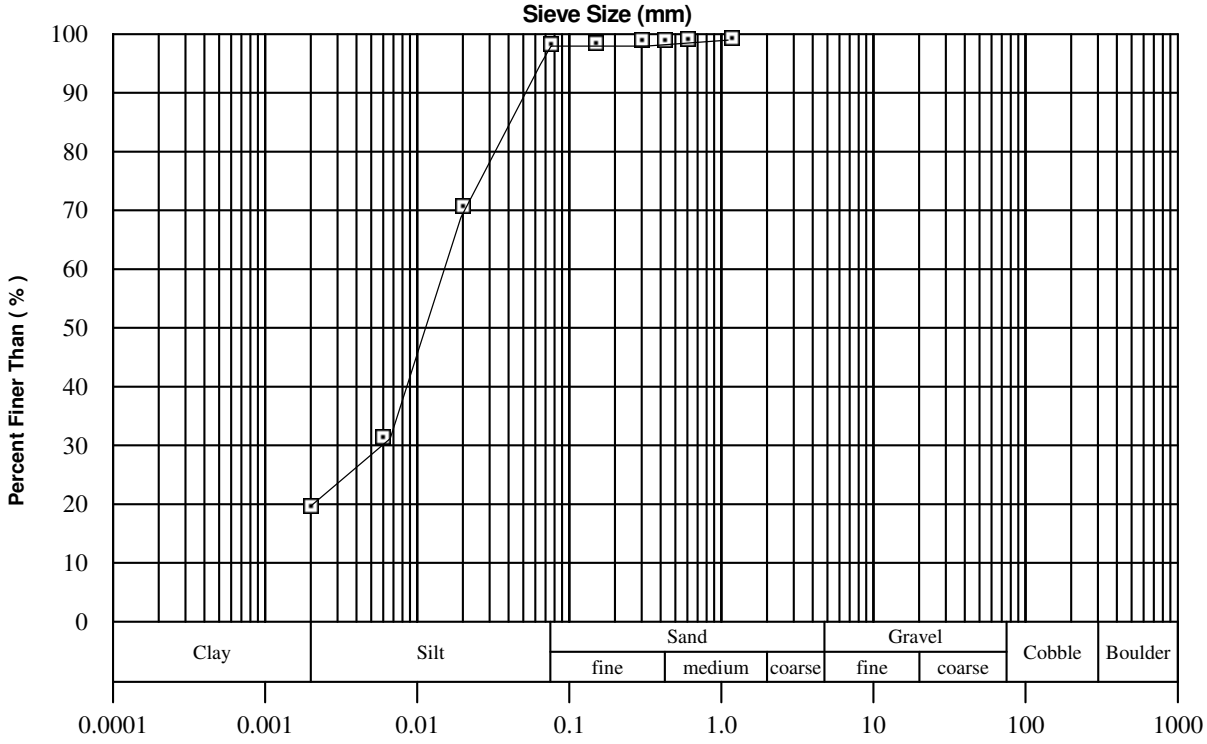
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	19	100511	7.50-7.95		77.70	22.30	



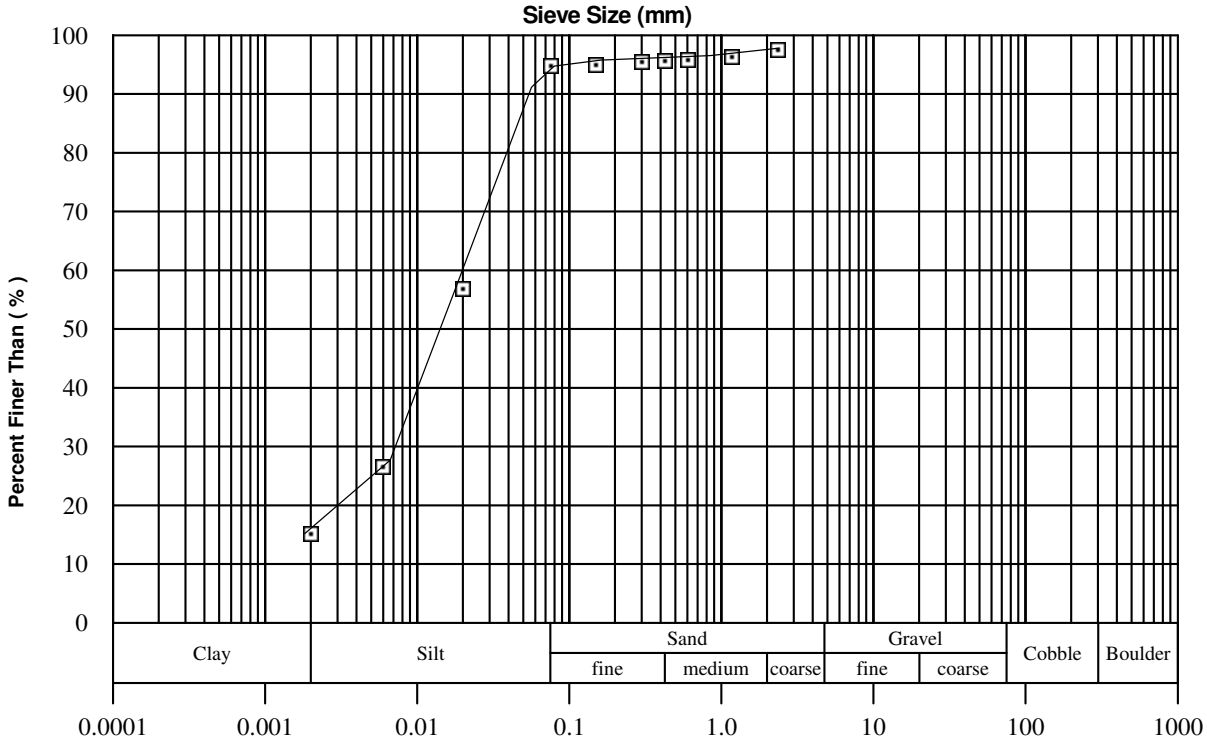
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



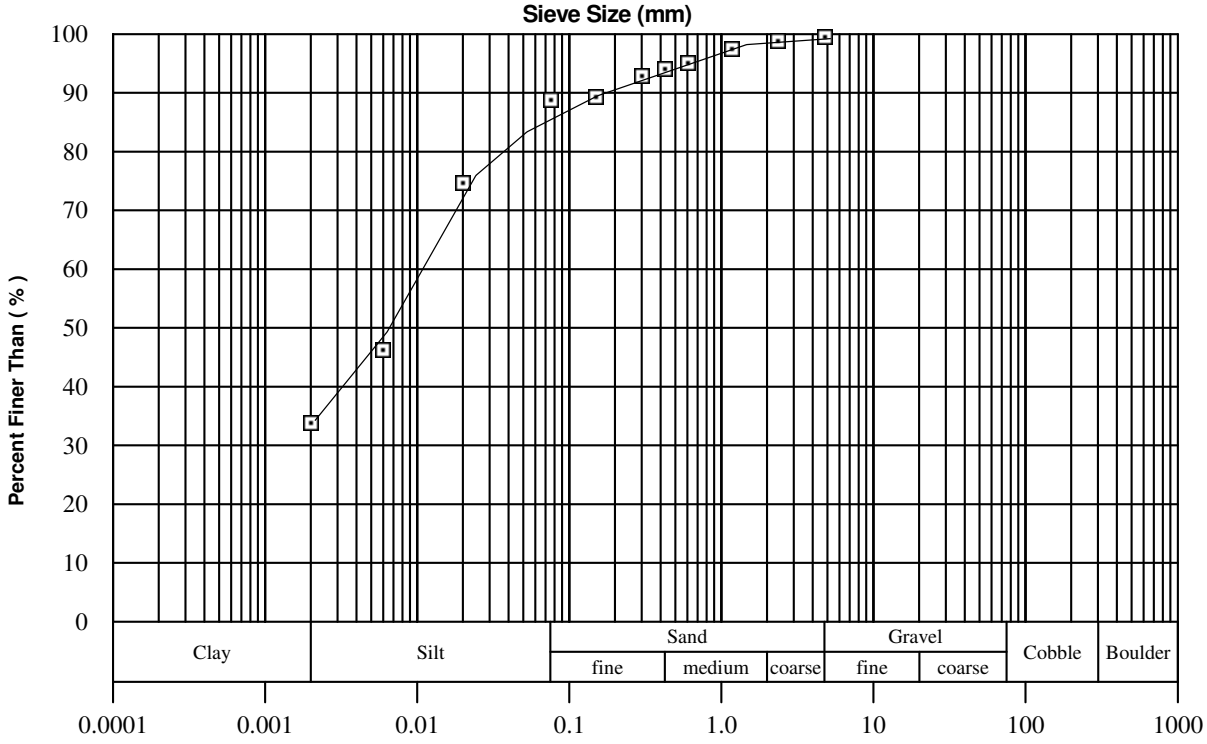
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	20	120103	2.00-2.45		1.70	78.64	19.66



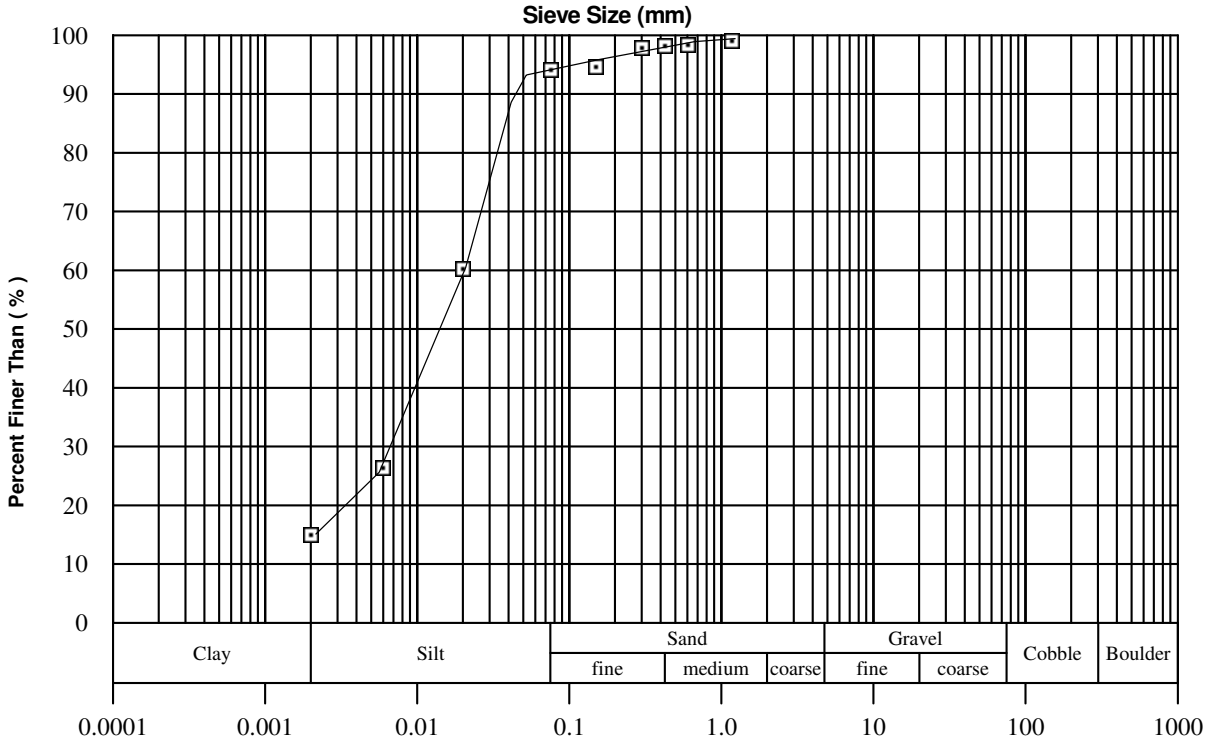
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	20	120106	4.50-4.95		5.20	79.63	15.17

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



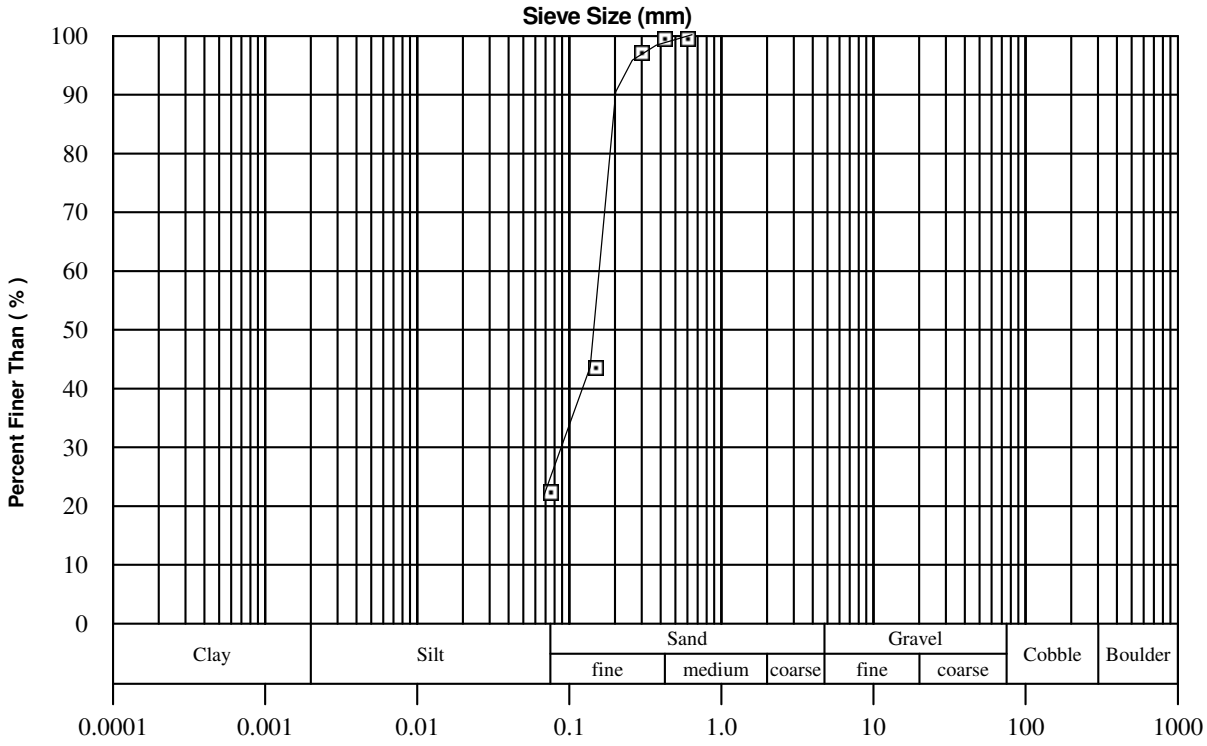
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	21	120111	1.00-1.45	0.50	10.60	55.12	33.78



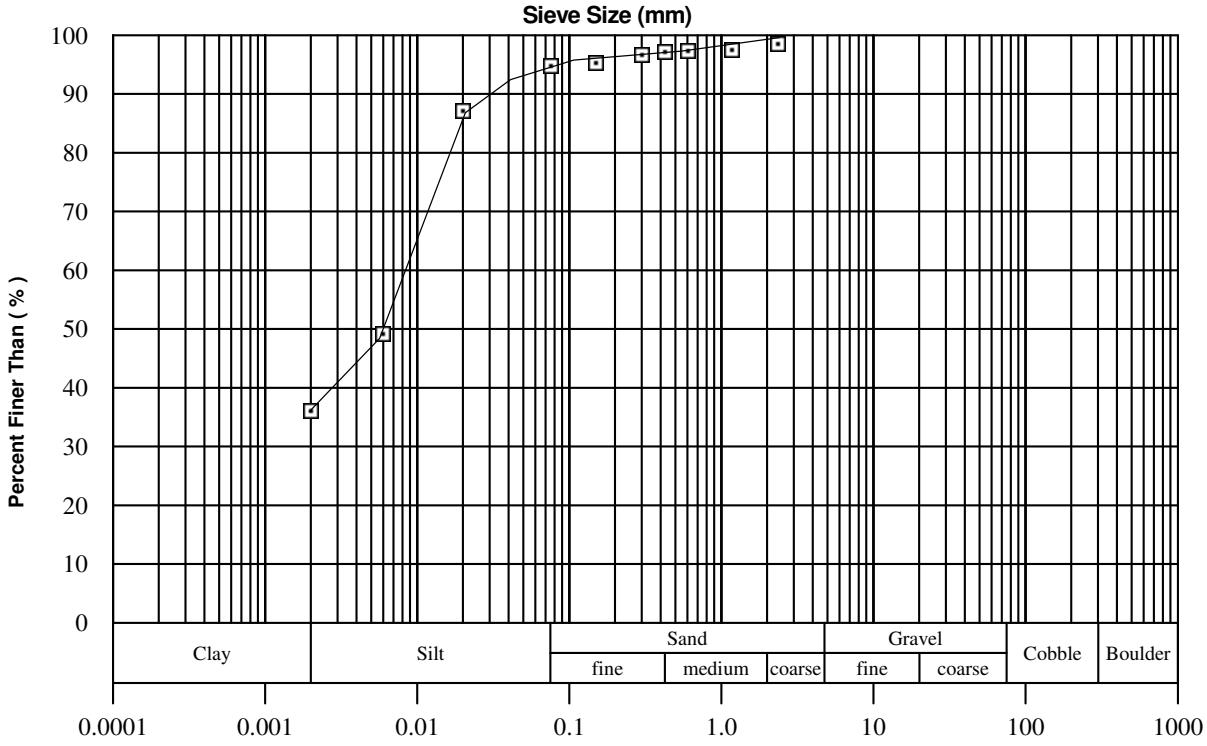
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	21	120117	4.50-4.95		5.80	79.13	15.07

PARTICLE SIZE DISTRIBUTION CURVES

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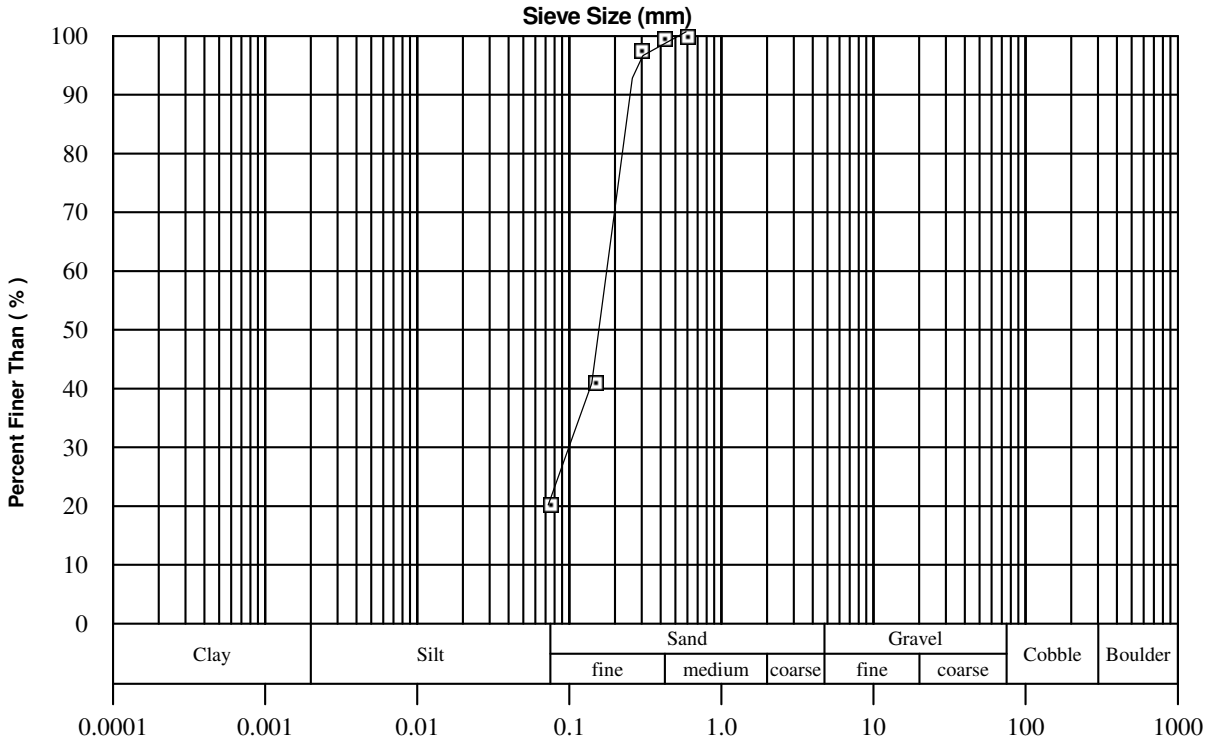
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	21	120119	7.50-7.95		77.60	22.40	



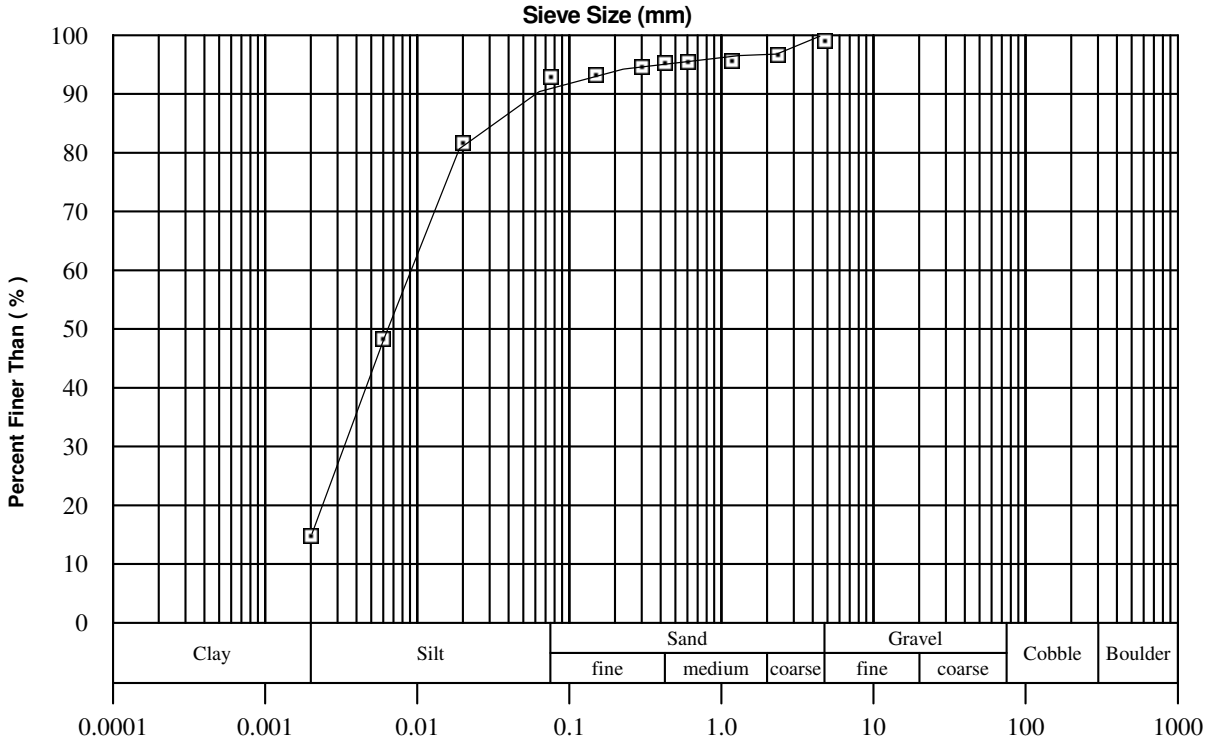
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	22	165101	1.00-1.45		5.20	58.78	36.02

PARTICLE SIZE DISTRIBUTION CURVES

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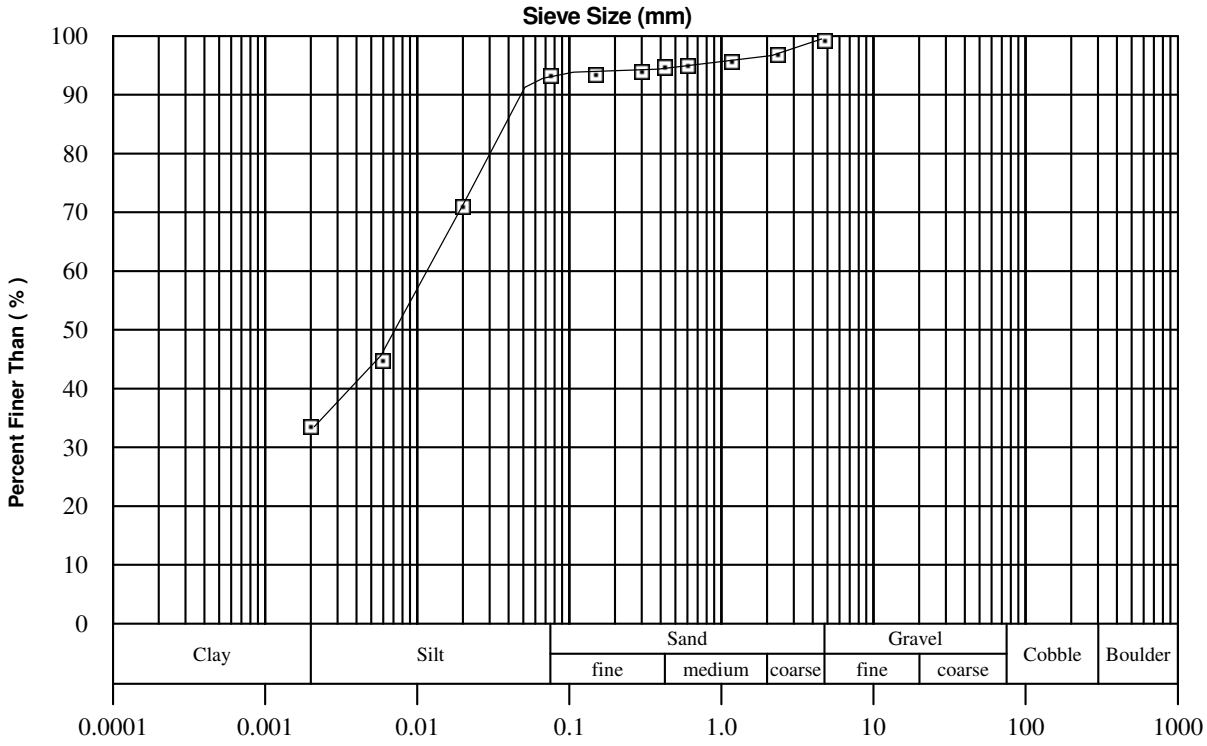
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	22	165109	7.50-7.95		79.70	20.30	



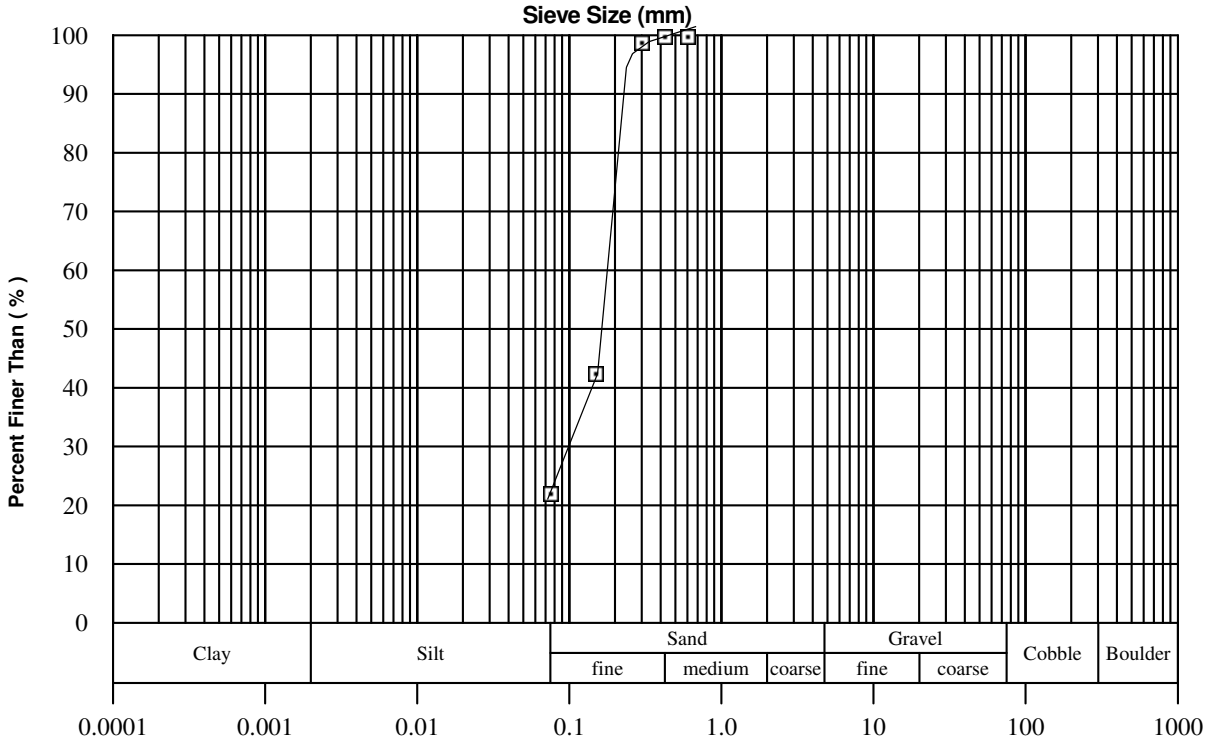
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	25	170020	1.00-1.45	1.00	6.10	78.04	14.86

PARTICLE SIZE DISTRIBUTION CURVES

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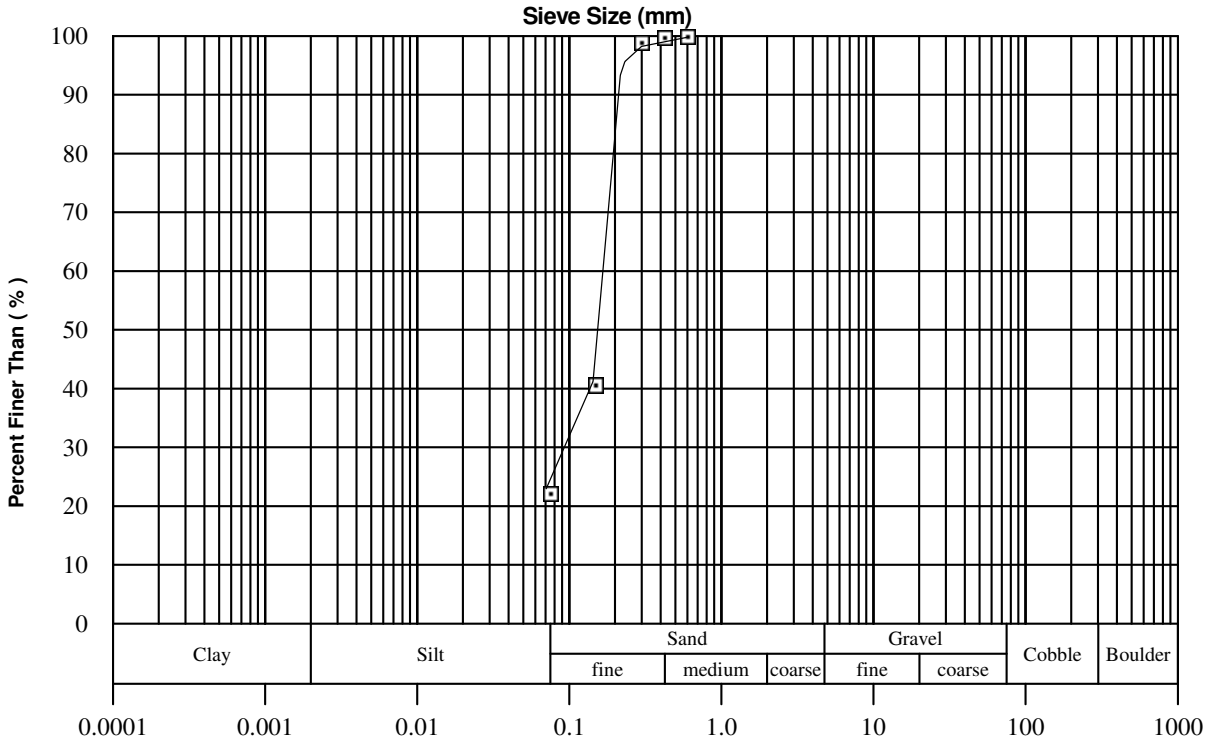
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	23	100251	1.00-1.45	0.80	5.90	59.71	33.59



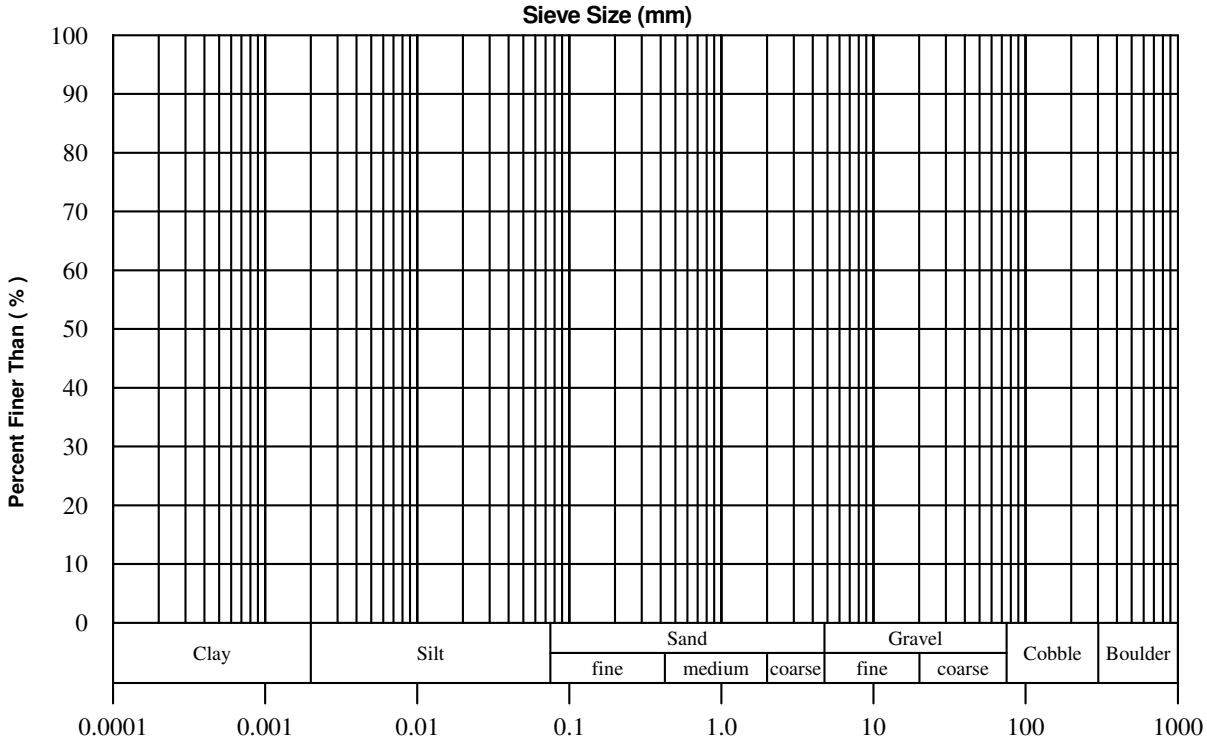
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	23	100258	6.00-6.45		78.00	22.00	

PARTICLE SIZE DISTRIBUTION CURVES

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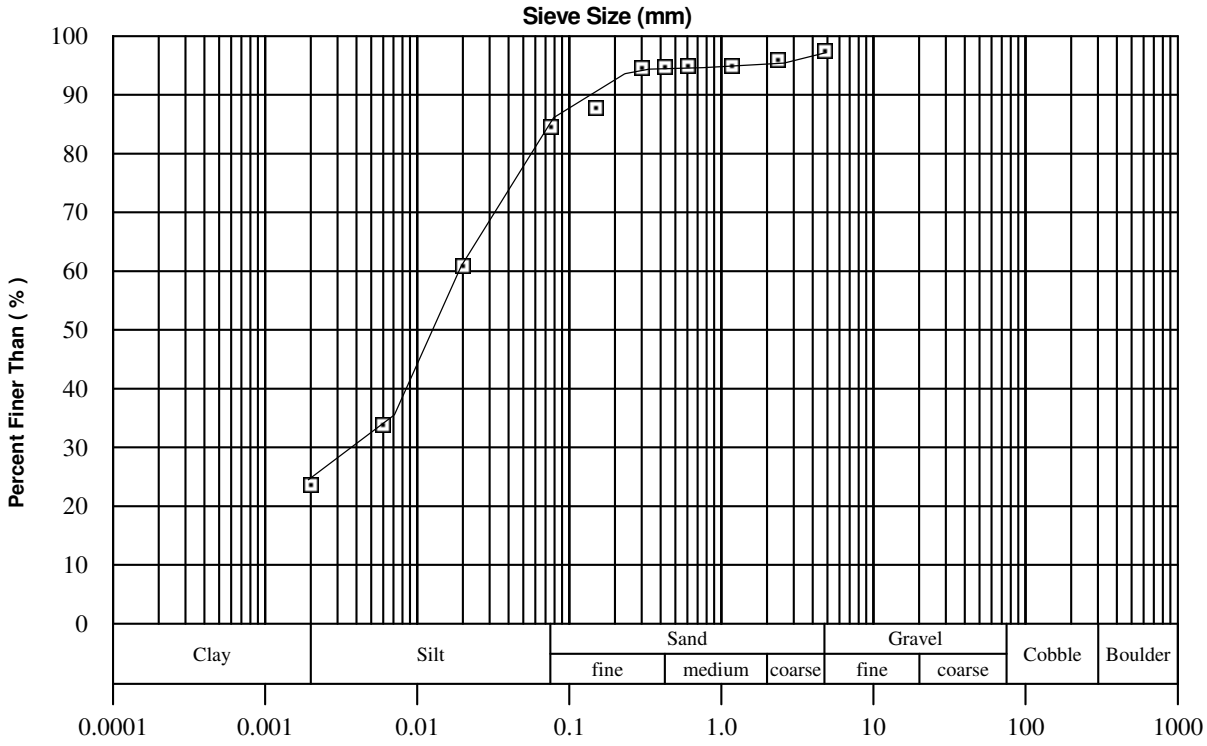
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	23	100260	8.5-8.75		77.90	22.10	



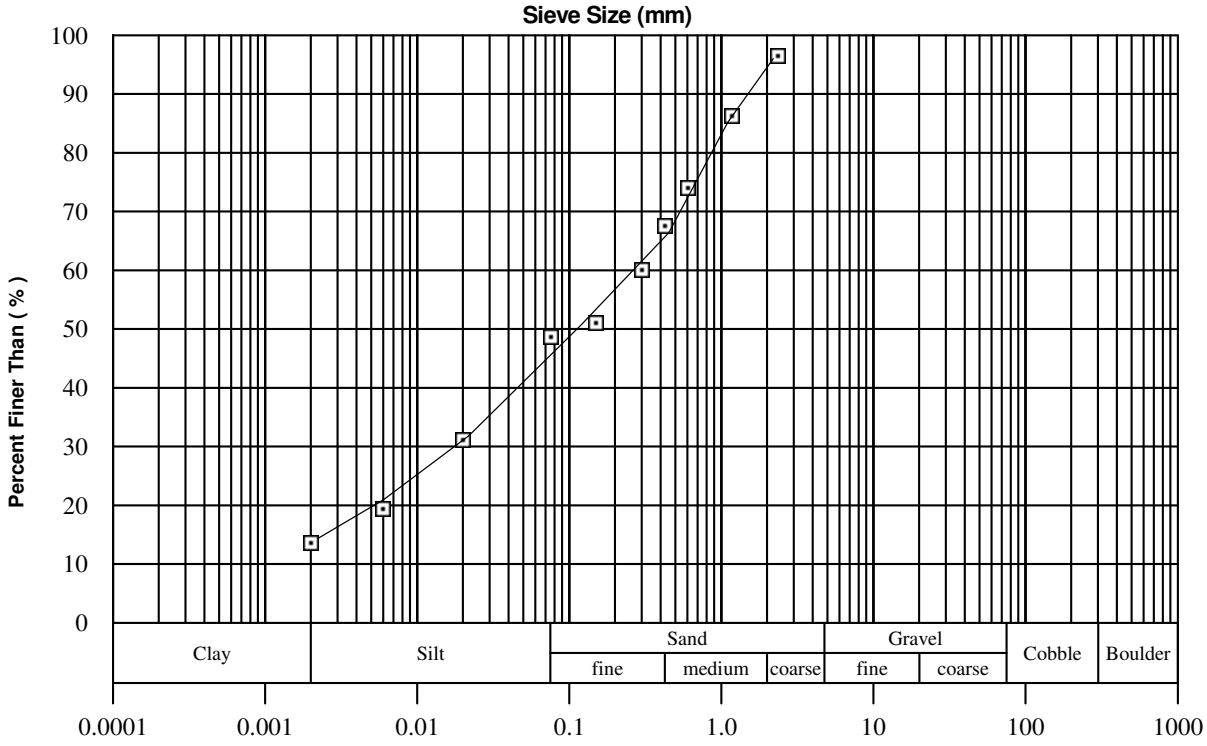
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



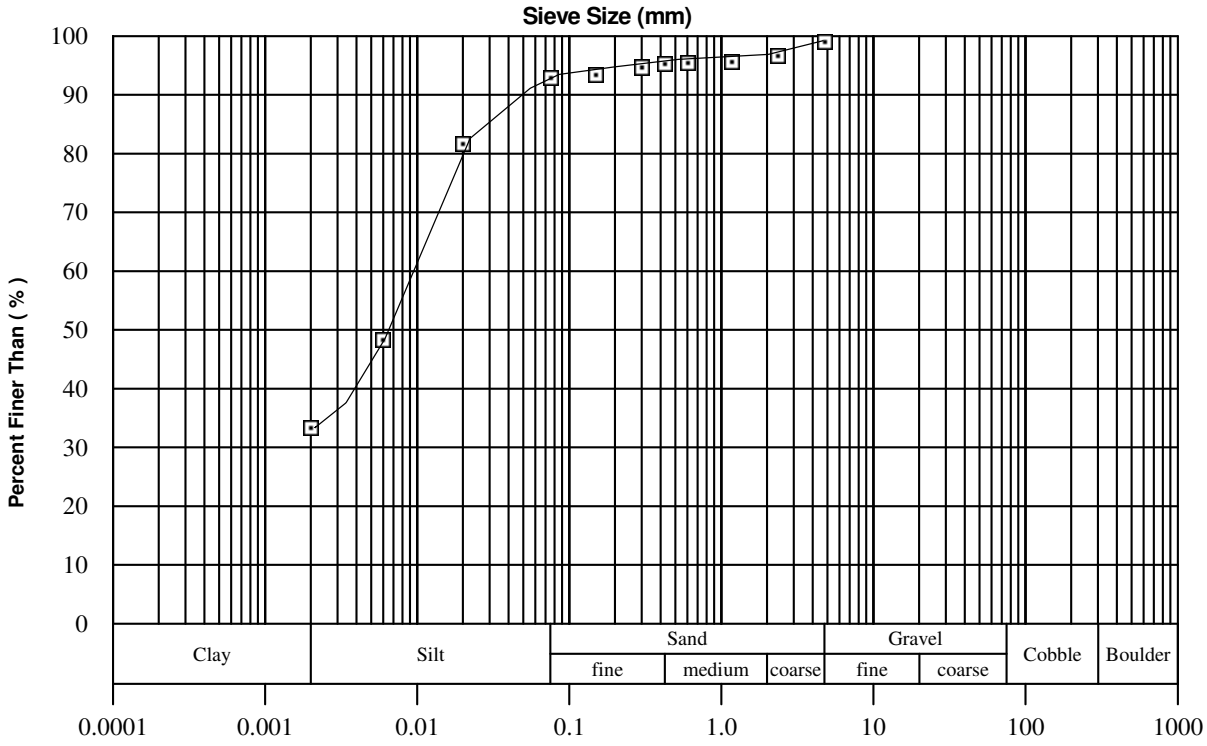
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	24	100102	1.00-1.45	2.50	12.90	60.91	23.69



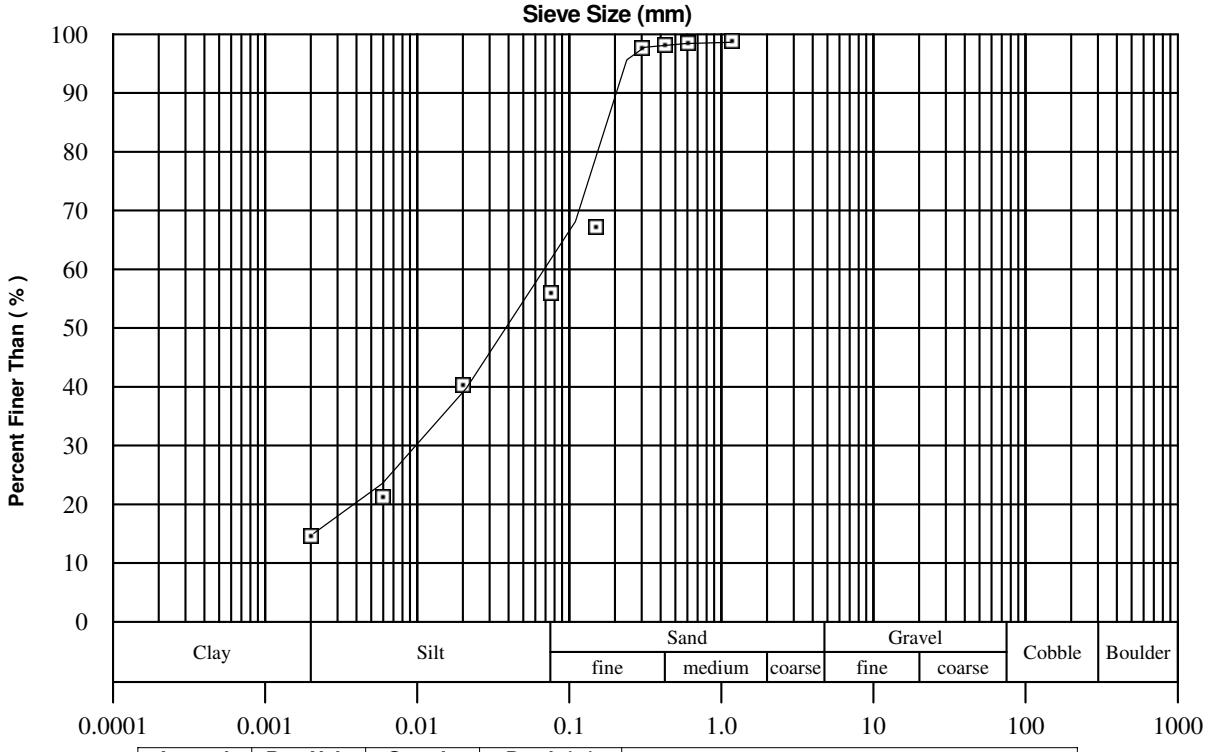
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	24	100109	5.00		51.30	35.06	13.64

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



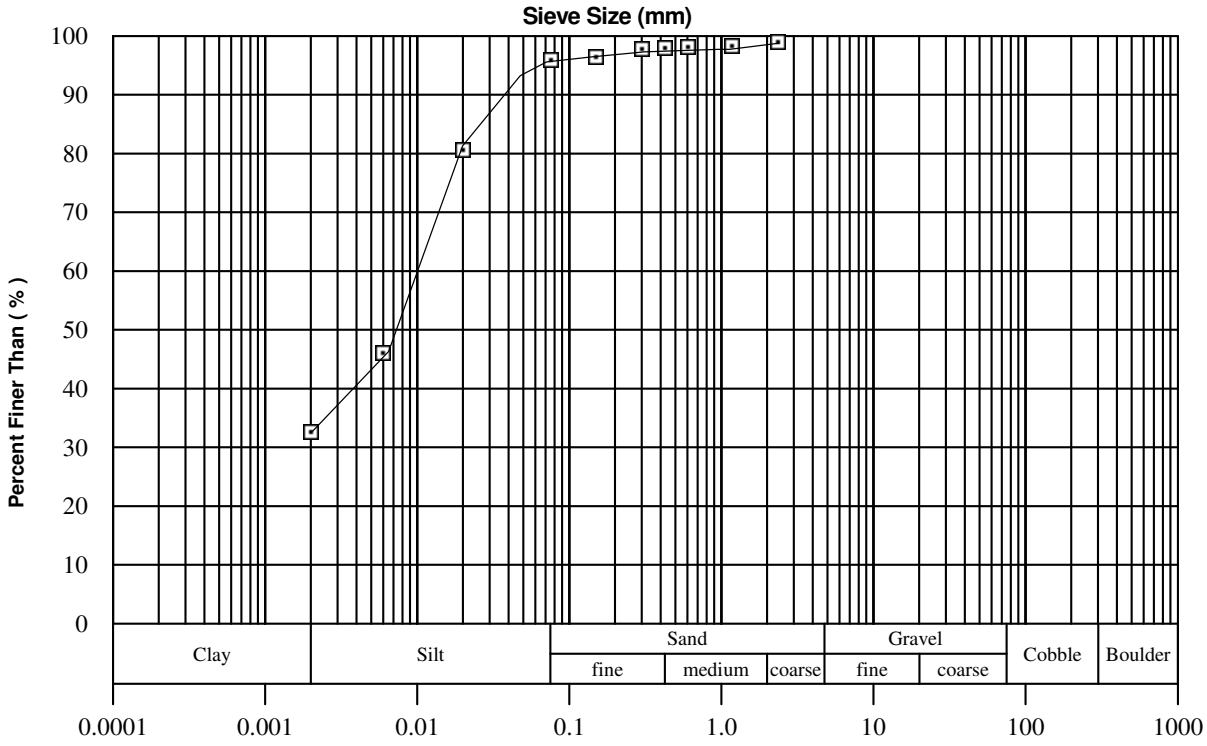
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	25	170020	1.00-1.45	1.00	6.10	59.46	33.44



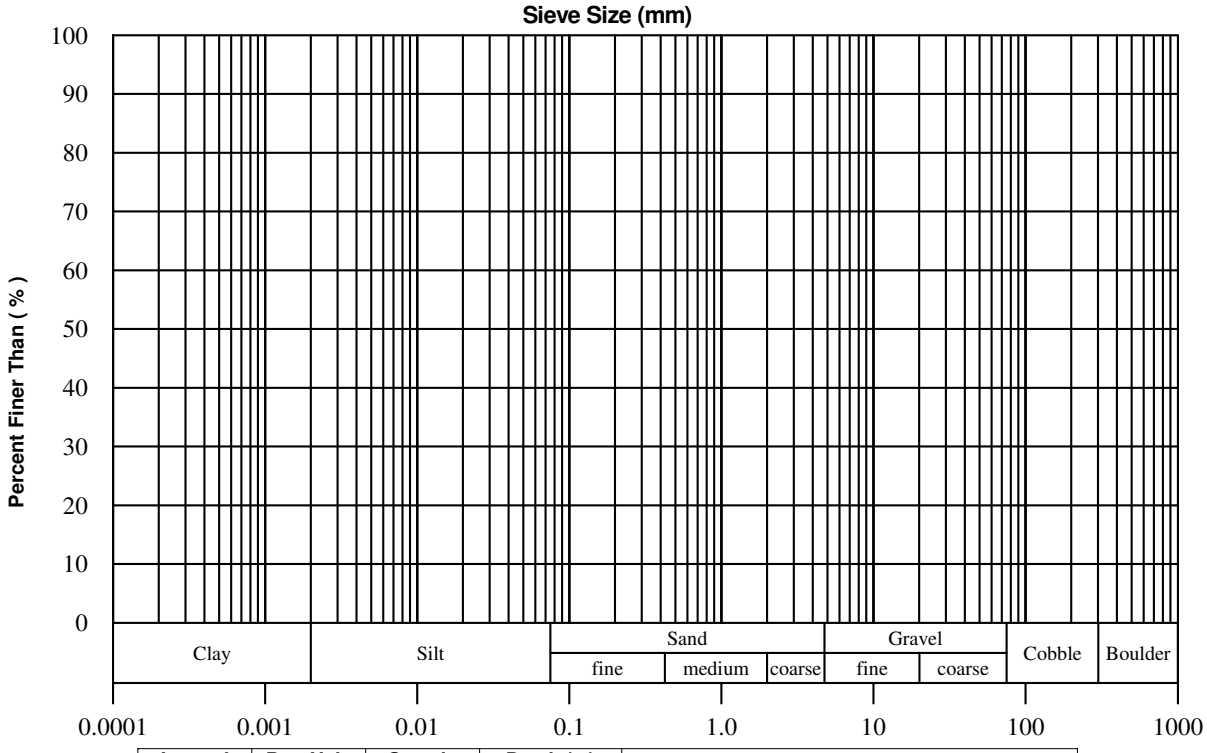
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	25	170027	6.00-6.45		43.90	41.51	14.59

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



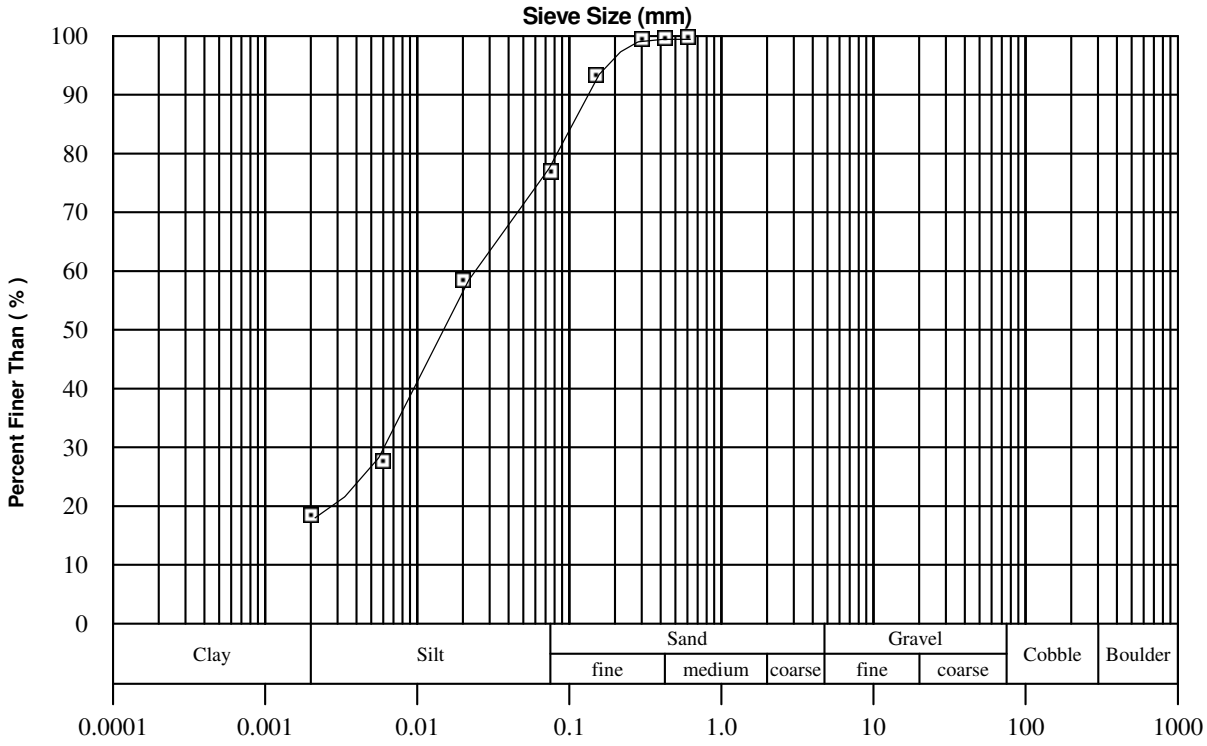
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	26	182156	1.00-1.45		4.00	63.36	32.64



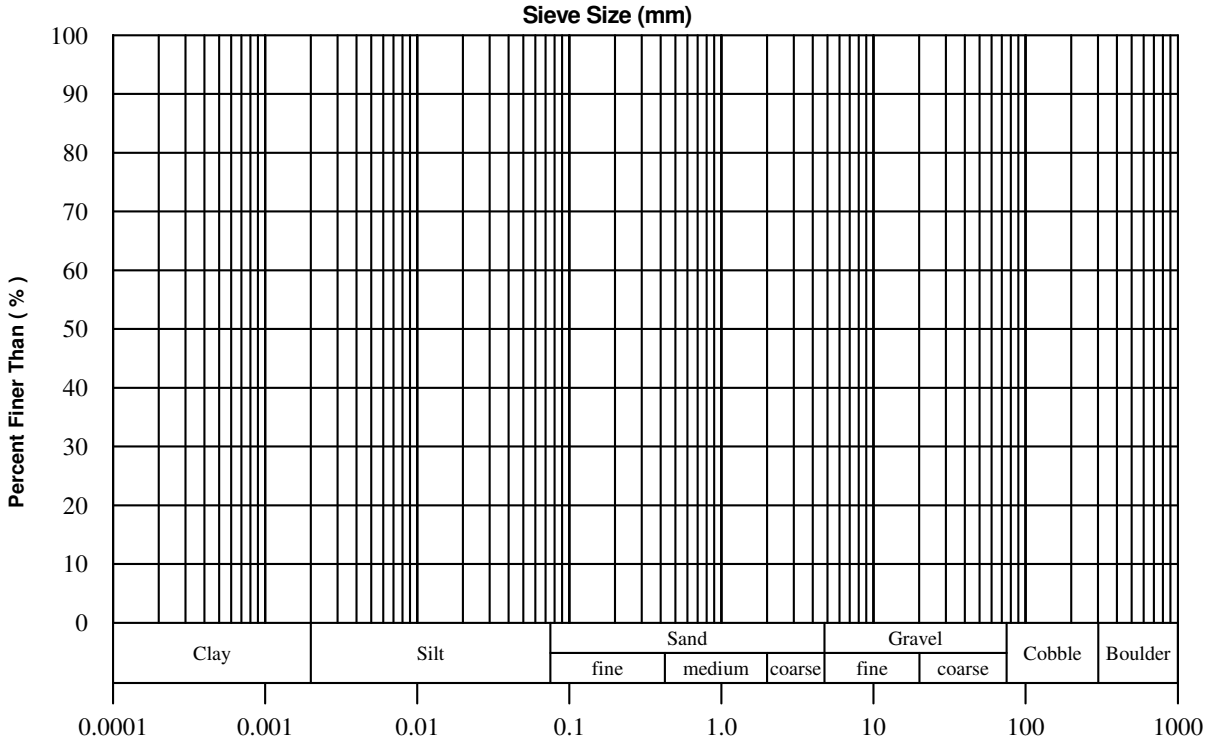
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



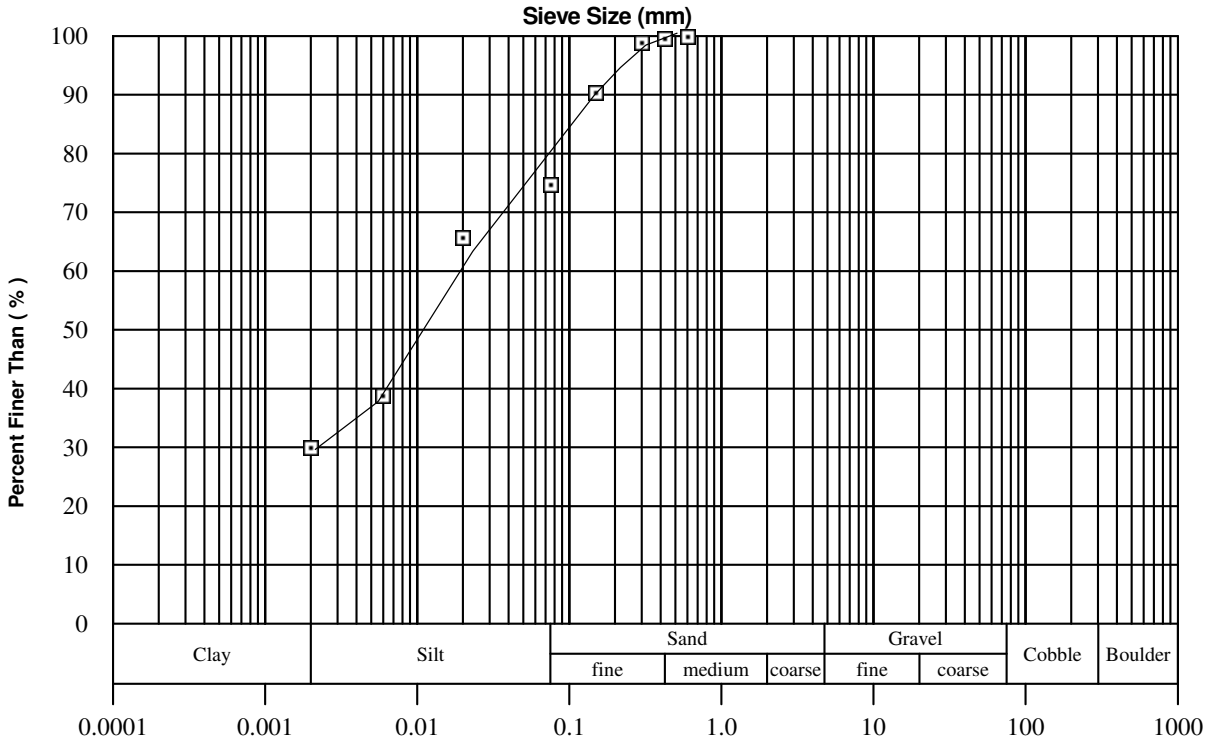
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	27	170667	4.50-4.95		23.00	58.52	18.48



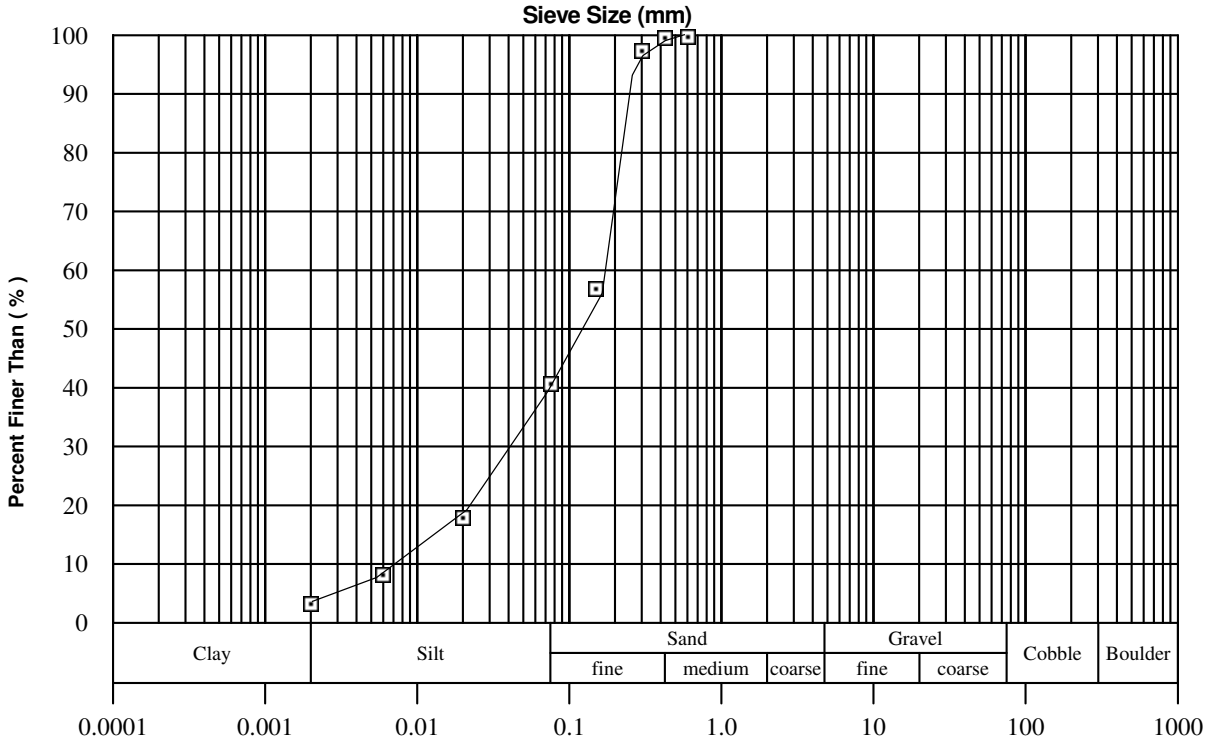
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



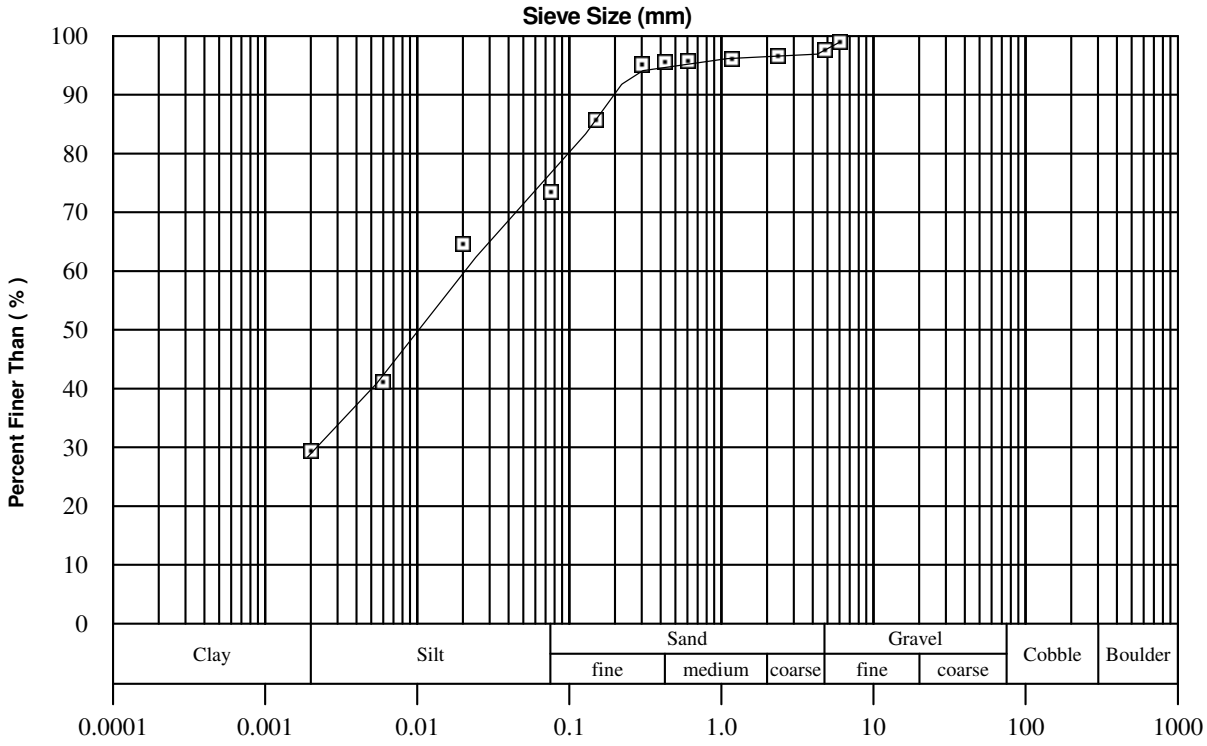
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	28	160771	1.00-1.45		25.30	44.82	29.88



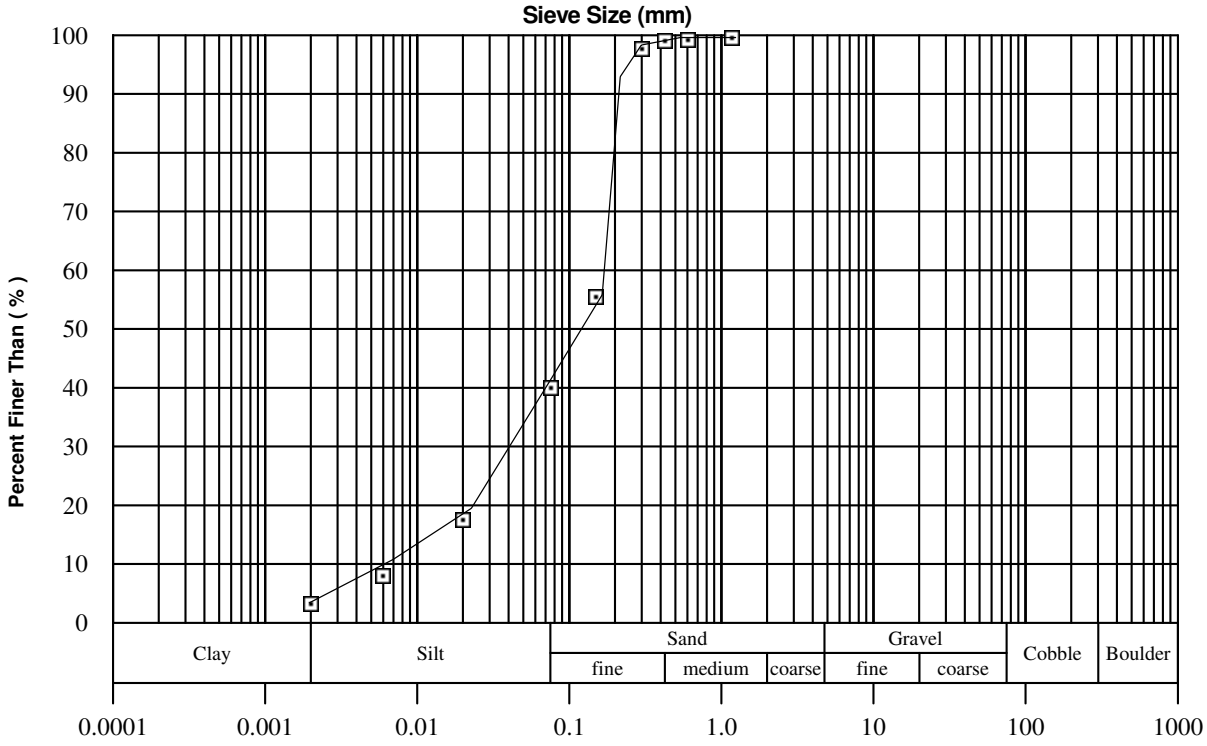
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	28	160778	6.00-6.45		59.30	37.44	3.26

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



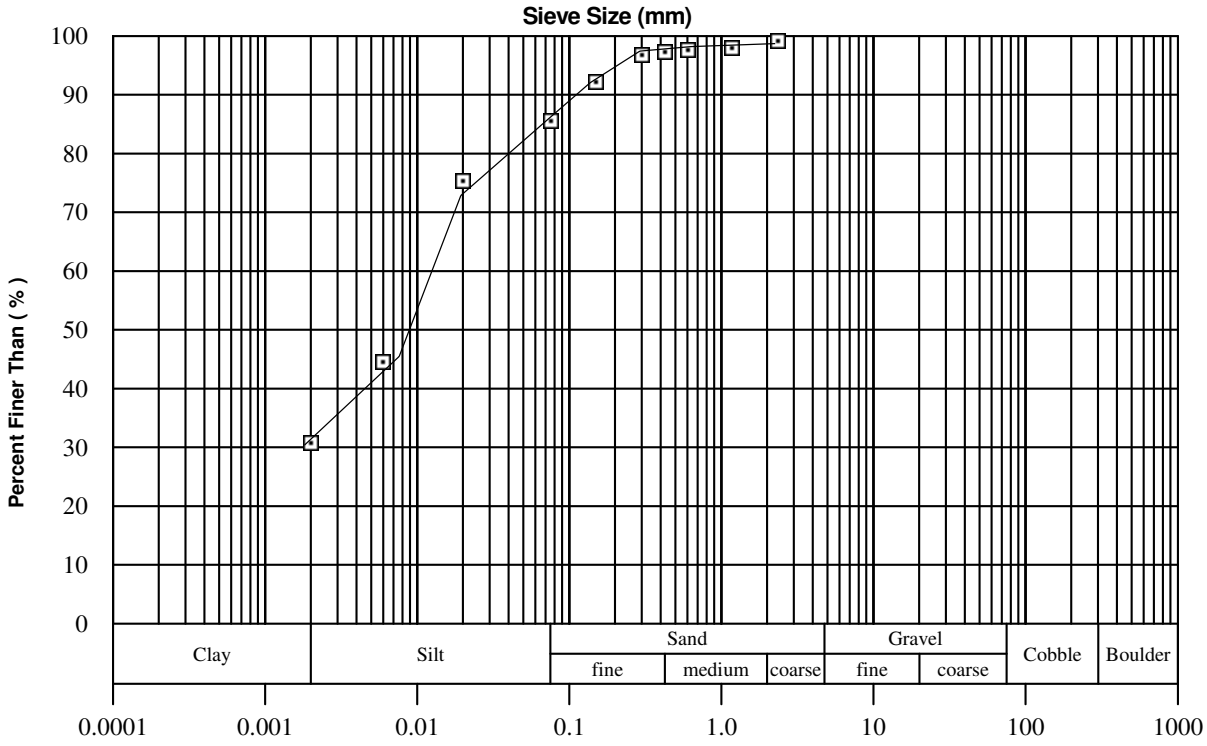
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	29	130154	2.00-2.45	2.40	24.10	44.10	29.40



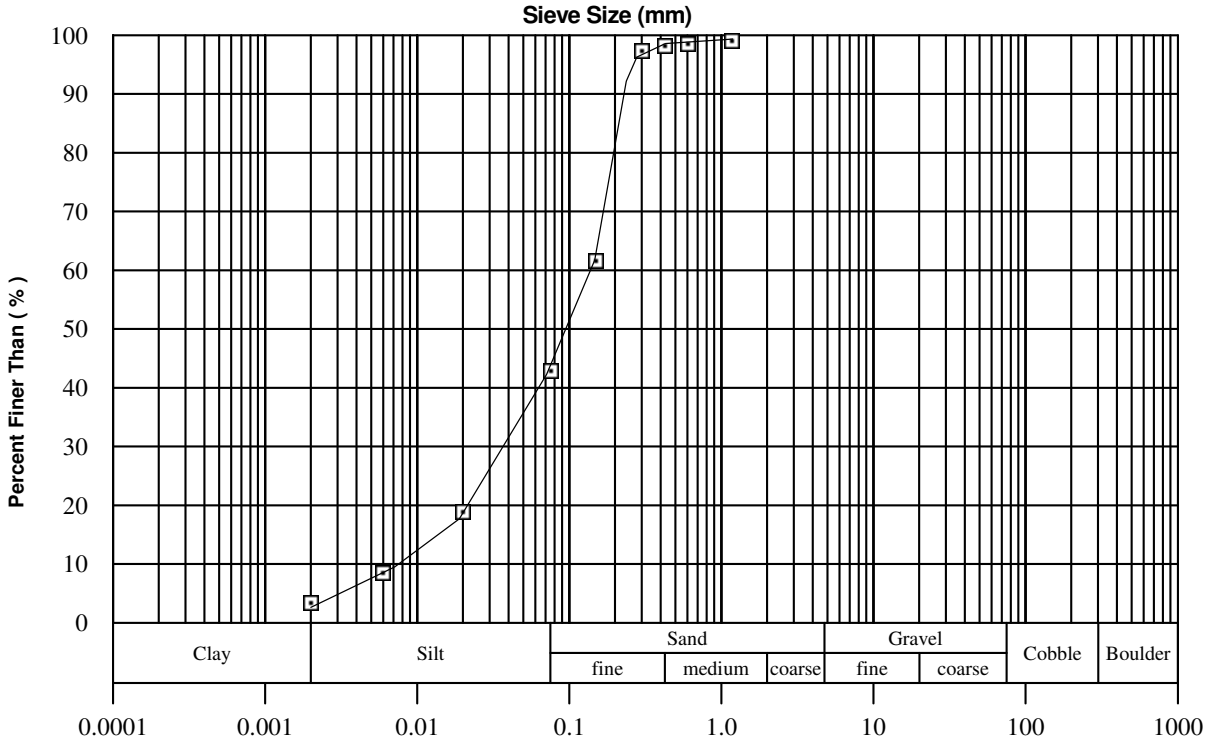
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	29	130160	7.50-7.95		59.90	36.89	3.21

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



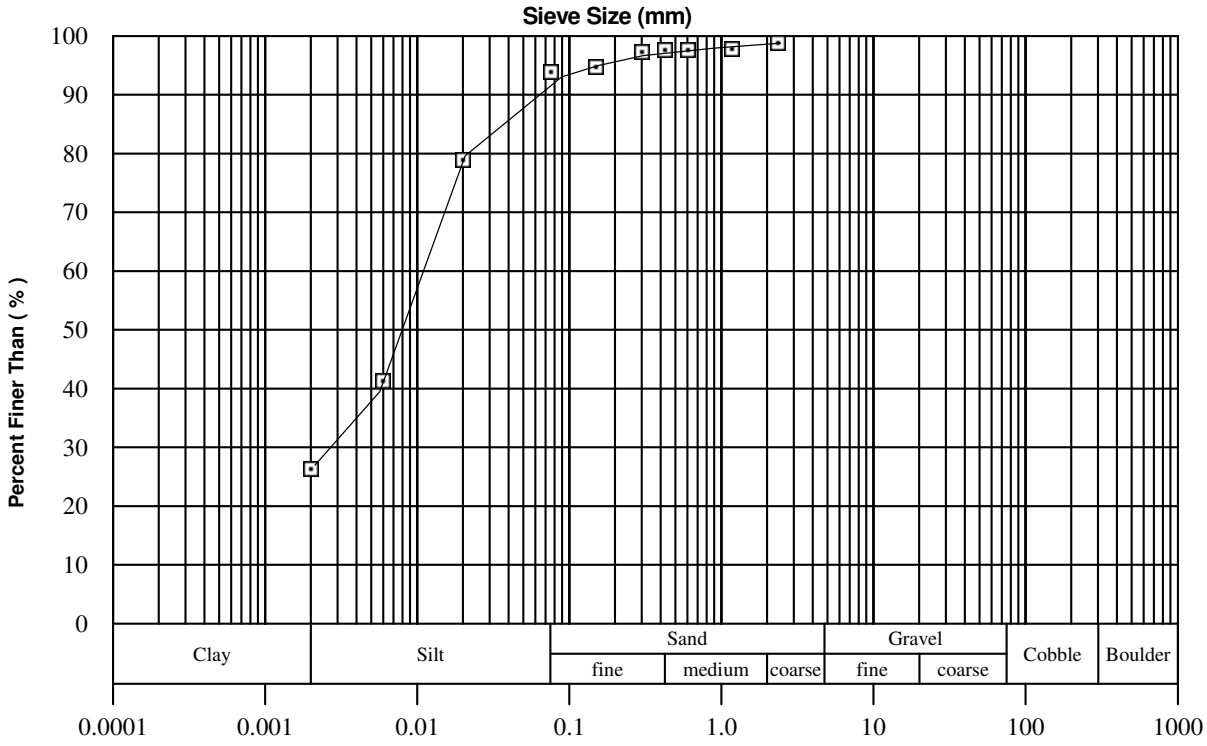
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	30	186111	1.00-1.45		14.40	54.78	30.82



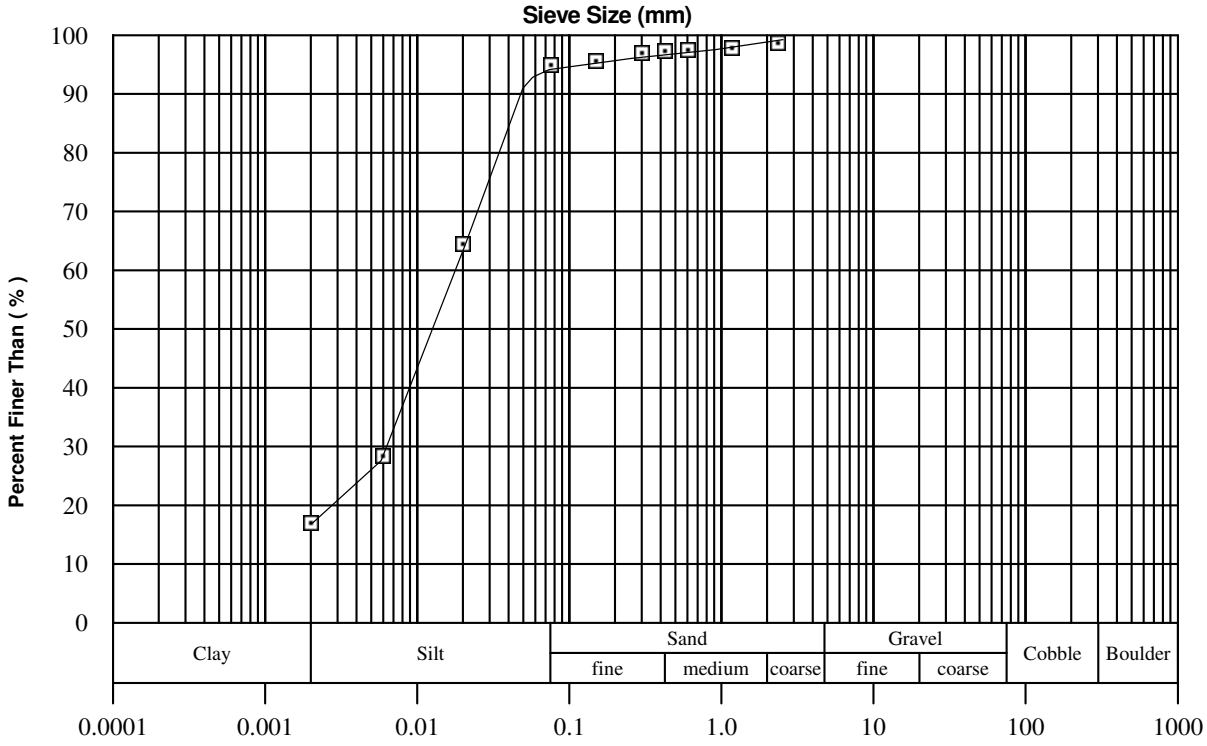
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	30	180118	6.00-6.45		57.00	39.56	3.44

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



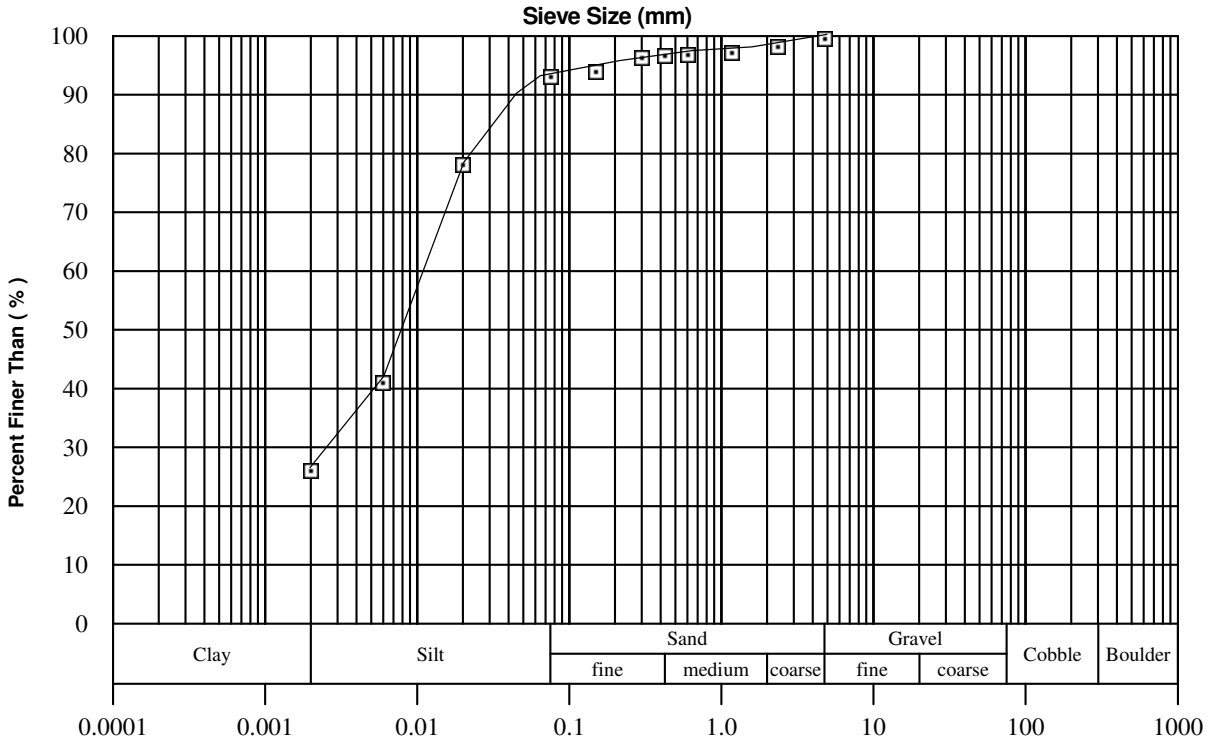
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-1	-	2.00		6.10	67.61	26.29



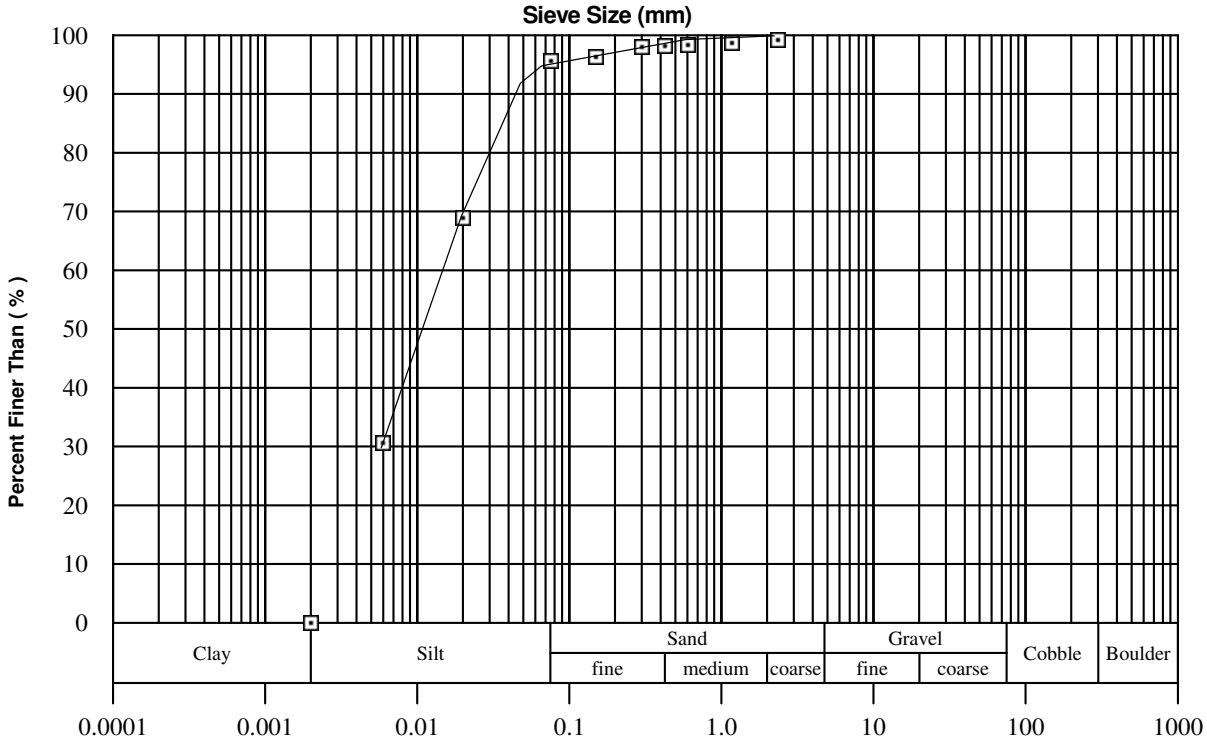
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-1	--	4.00		5.00	77.90	17.10

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



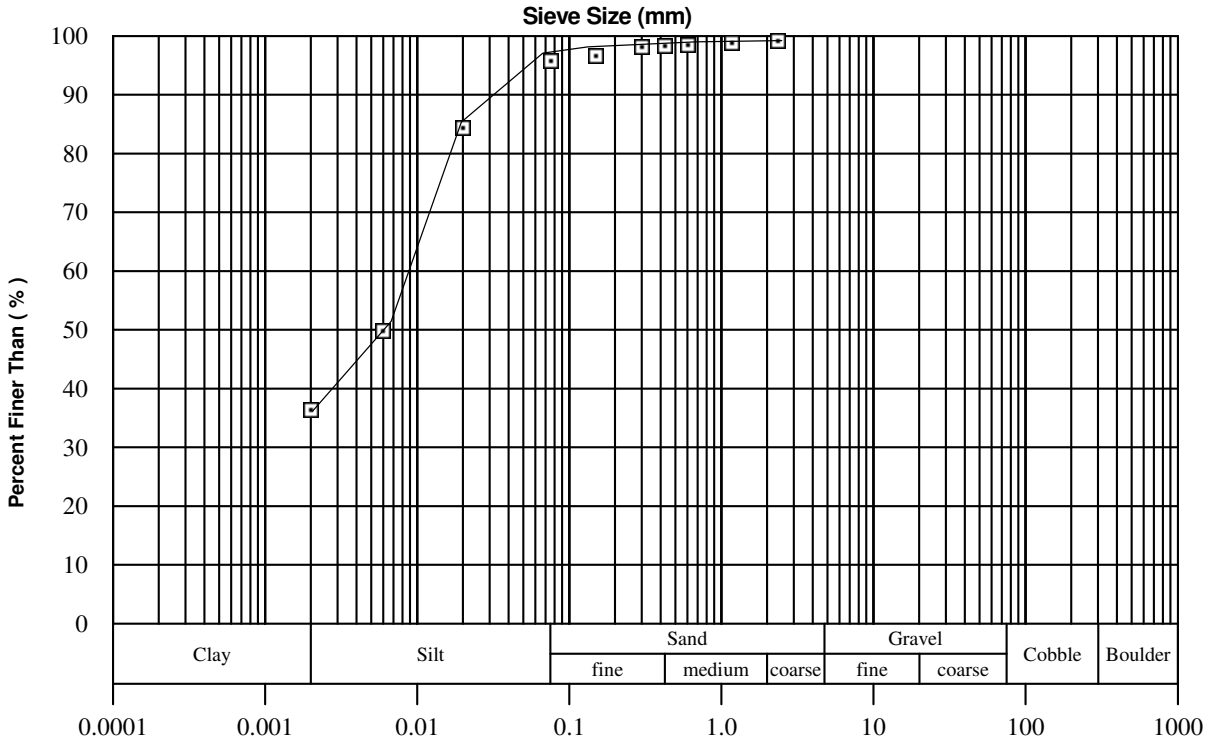
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-2	-	2.00	0.50	6.40	67.03	26.07



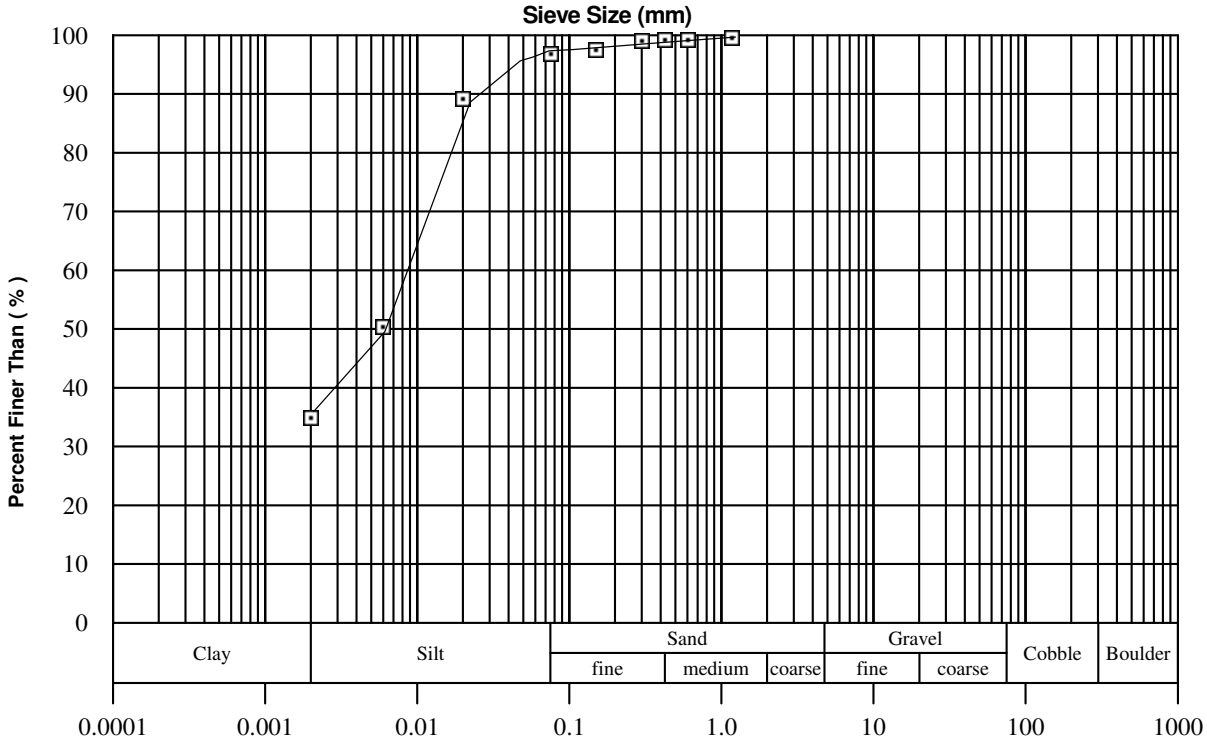
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-2	--	4.00		4.30	95.70	

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



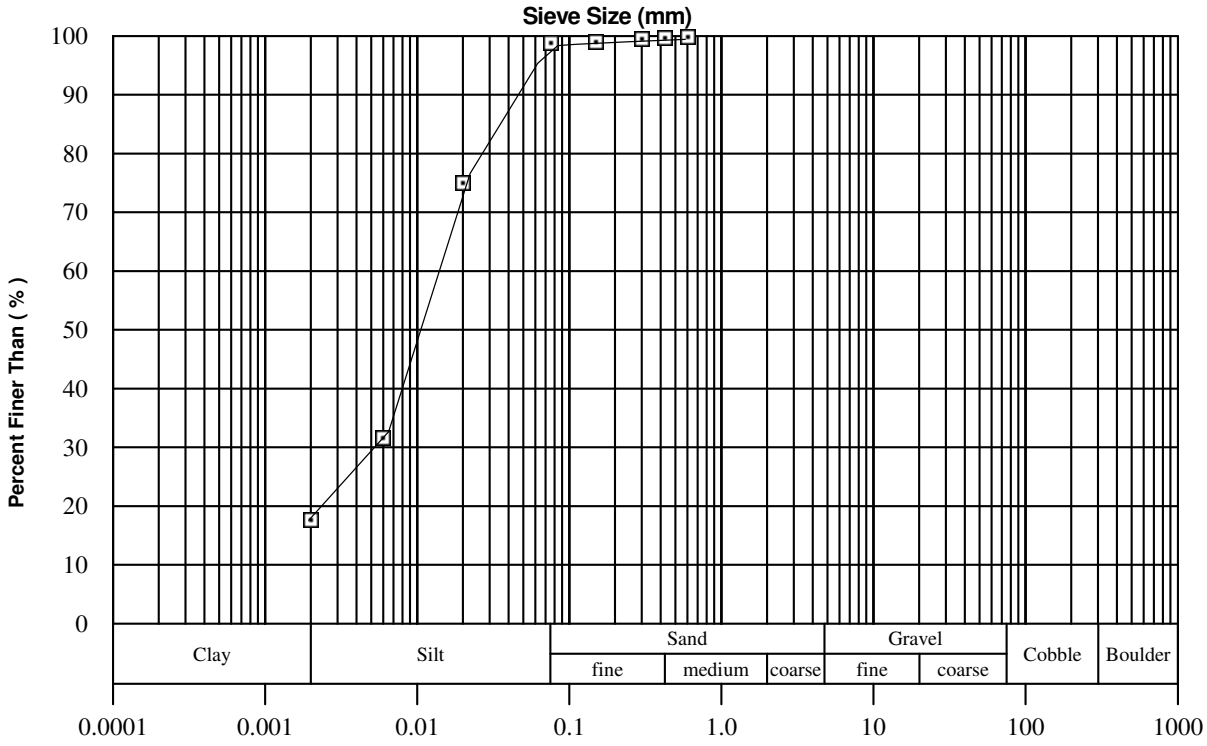
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-3	-	2.00		4.10	59.46	36.44



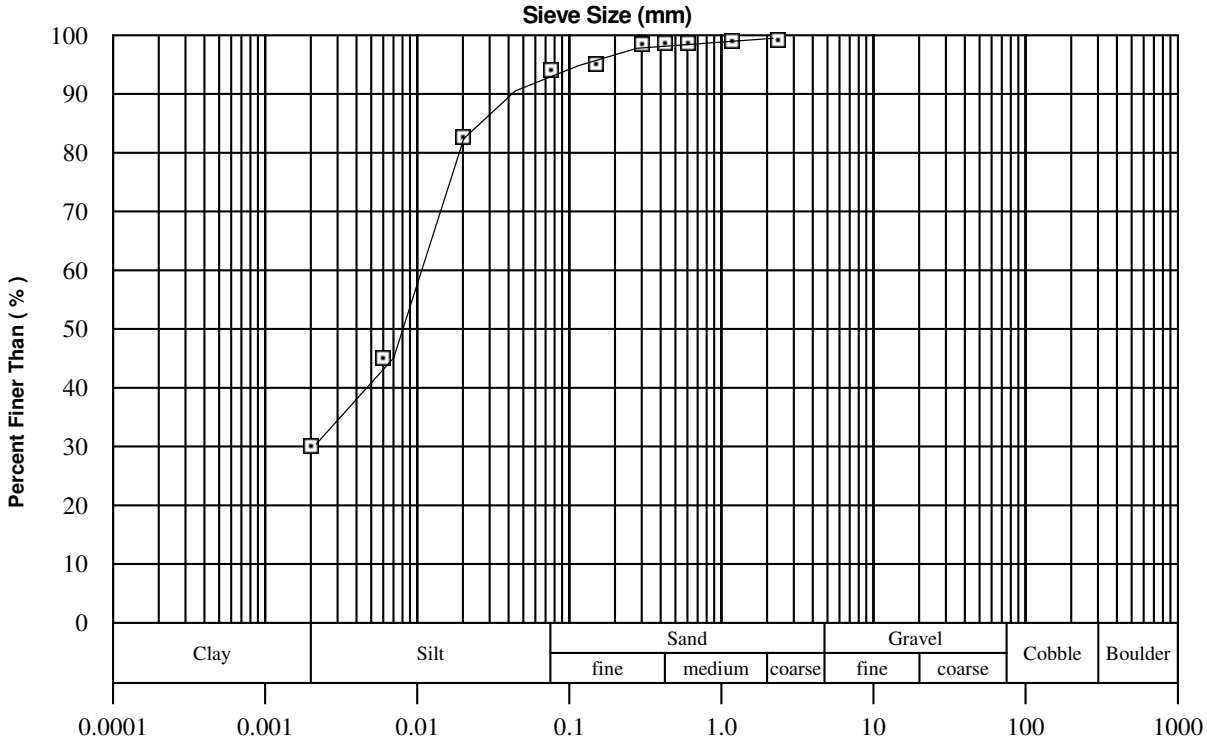
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-3	--	100.00		3.10	62.02	34.88

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



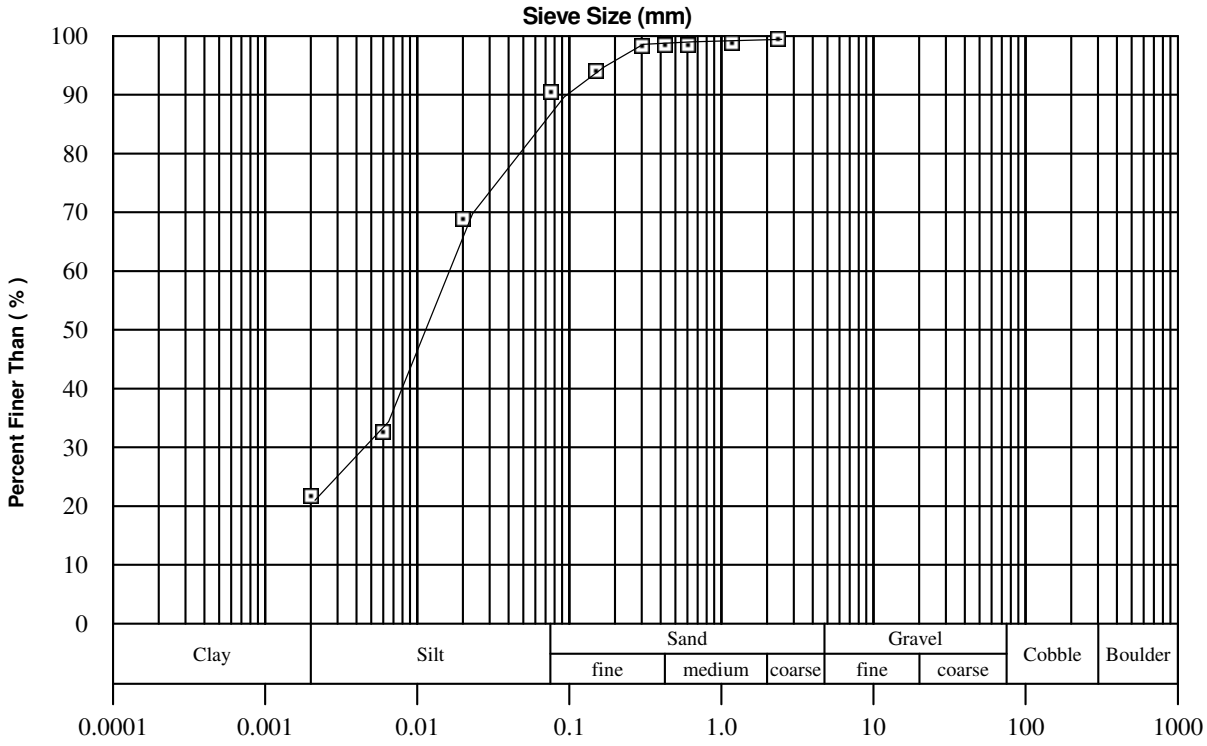
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-4	-	2.00		1.20	81.02	17.78



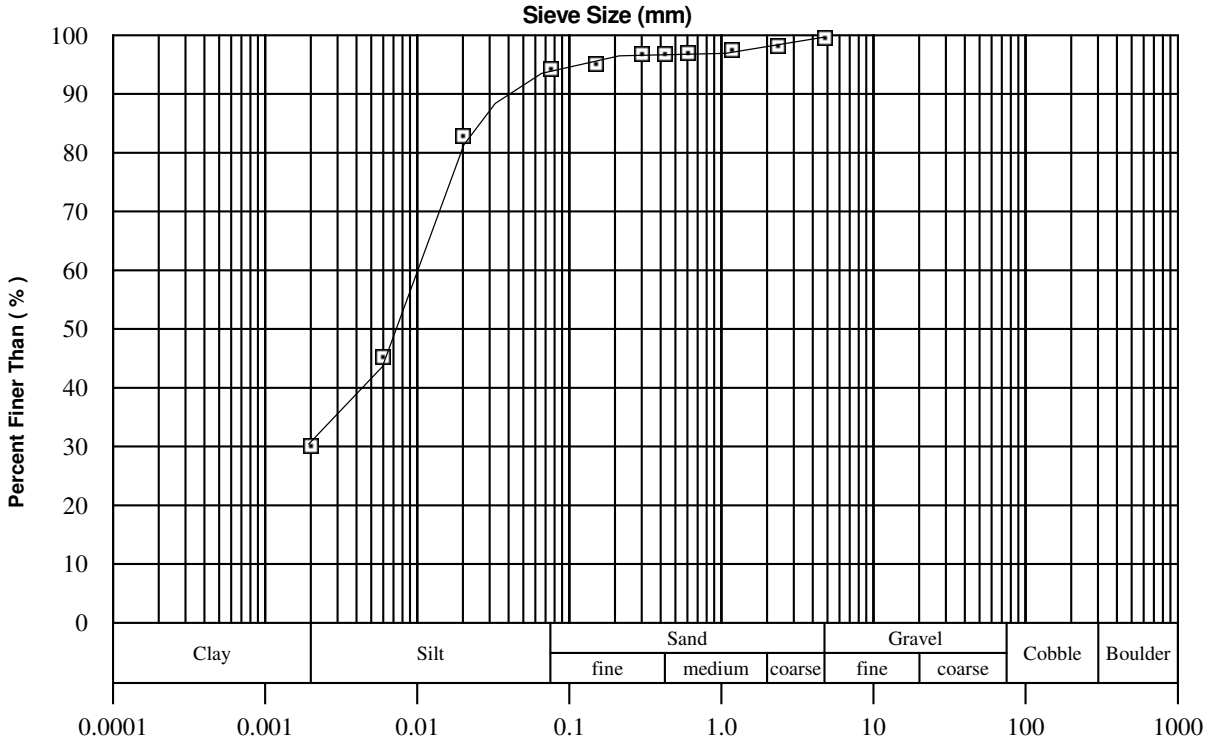
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-5	-	1.00		5.90	63.99	30.11

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



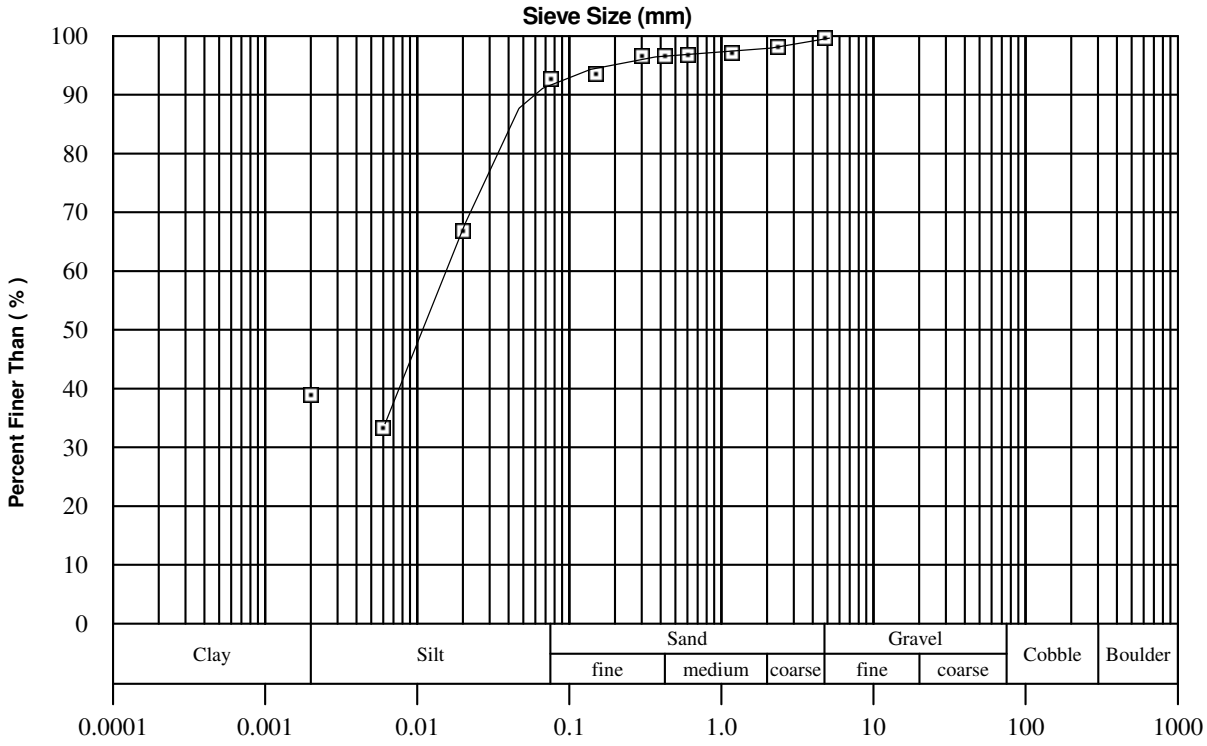
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-5	--	3.00		9.40	68.86	21.74



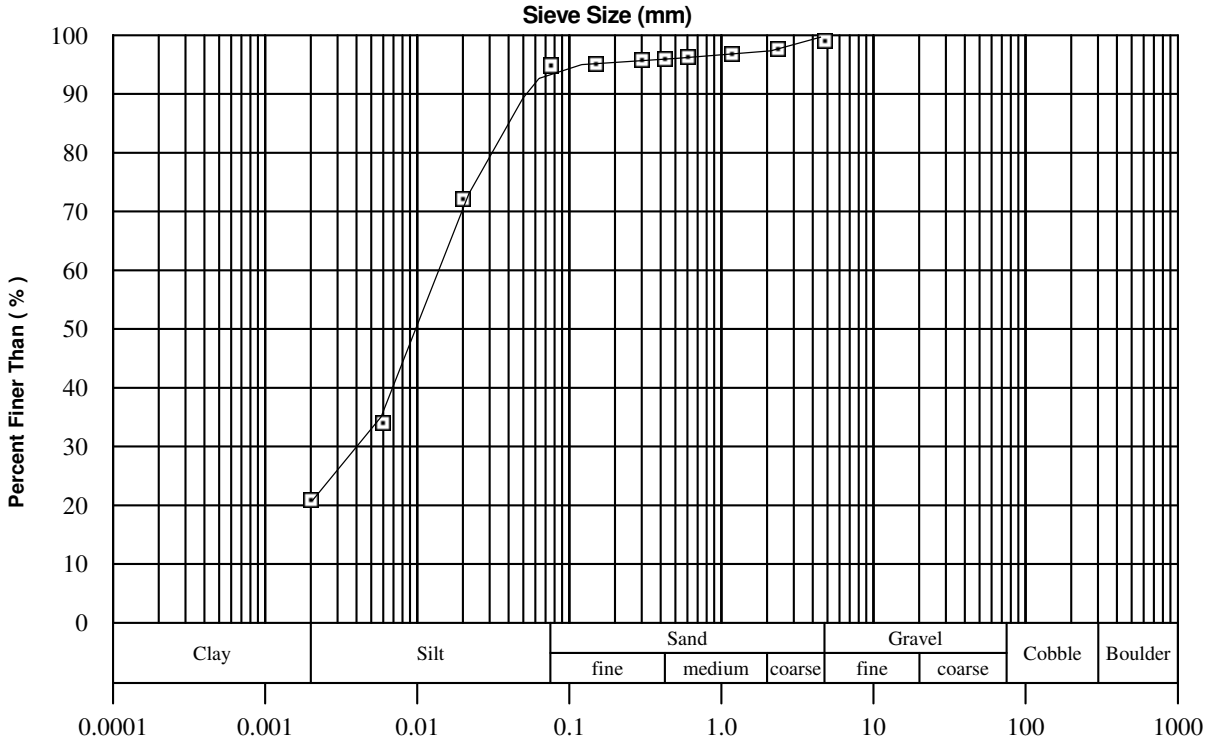
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-6	-	1.00	0.50	5.20	64.12	30.18

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



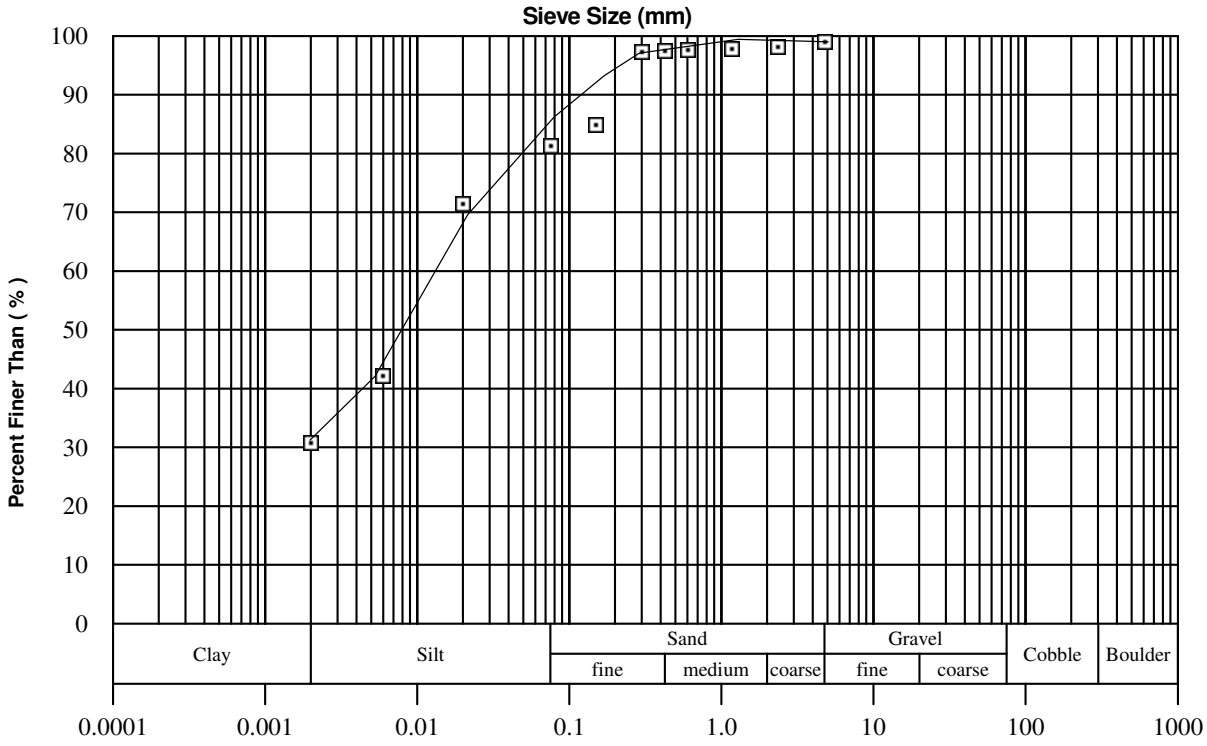
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-6	--	3.00	0.30	6.90	53.82	38.98



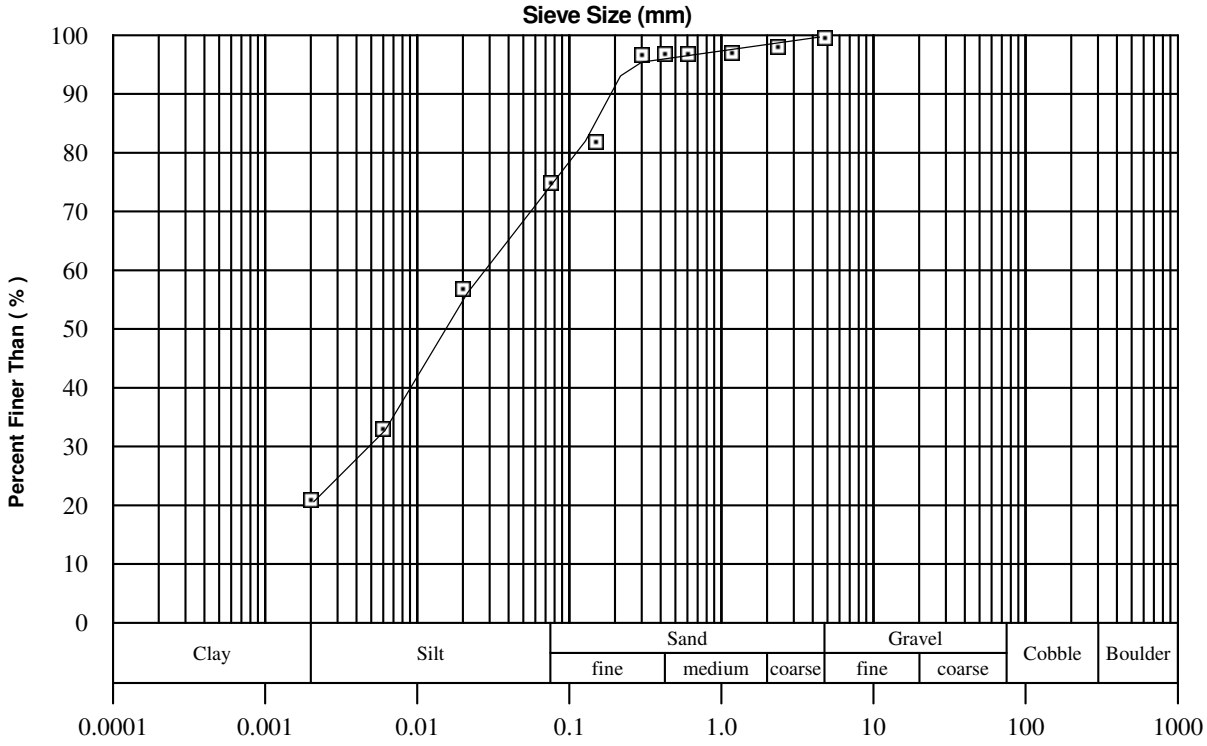
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-7	-	2.00	0.90	4.20	74.02	20.88

PARTICLE SIZE DISTRIBUTION CURVES

Job No :30796



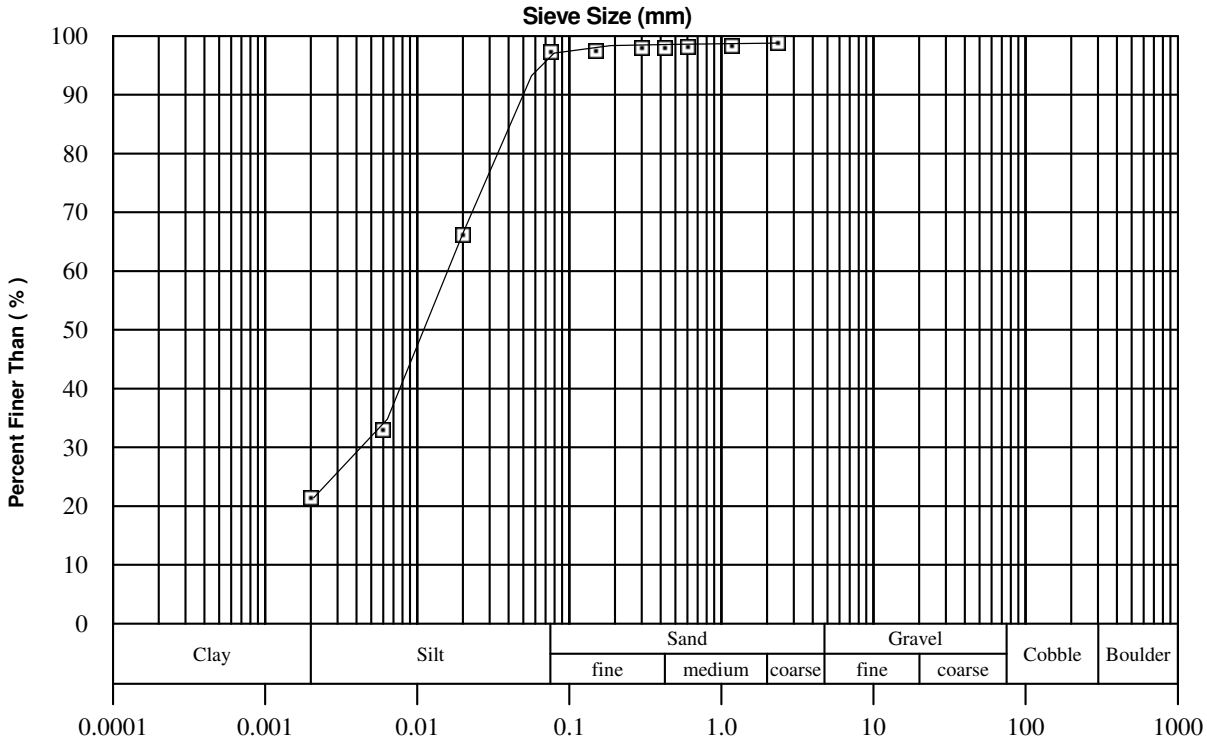
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-8	-	2.00	1.00	17.70	50.41	30.89



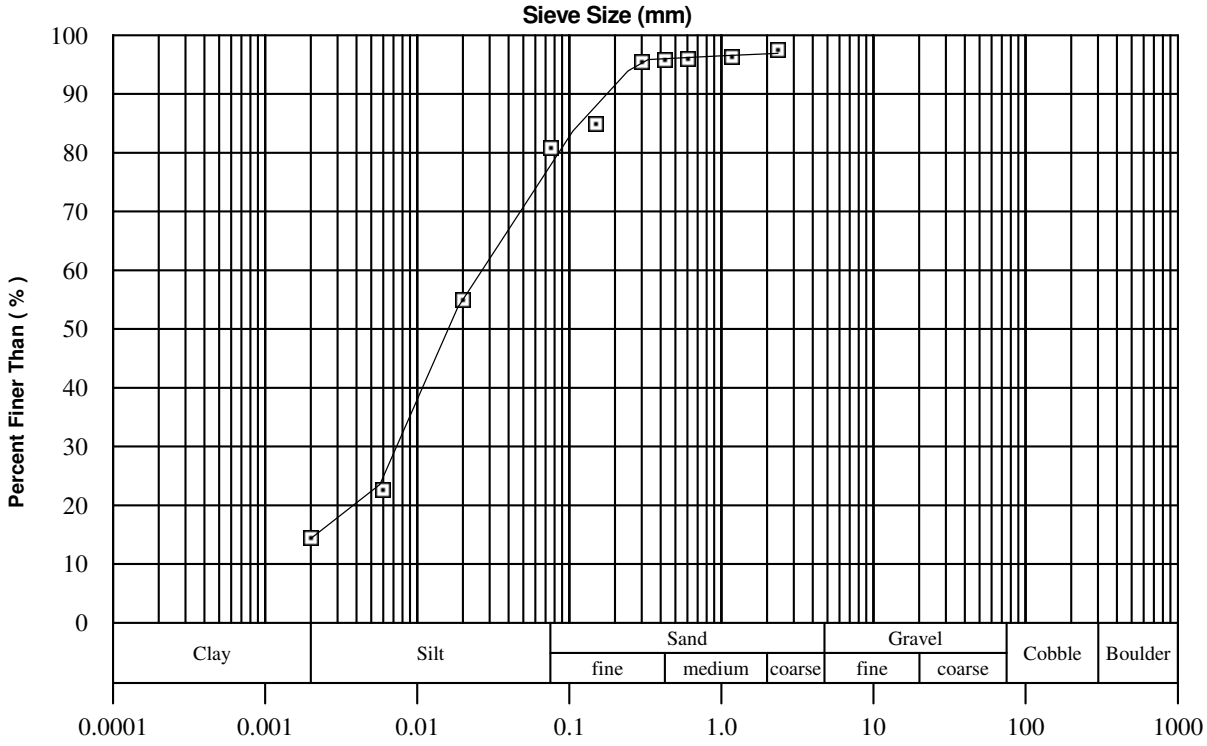
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-8	--	3.00	0.50	24.60	53.93	20.97

PARTICLE SIZE DISTRIBUTION CURVES

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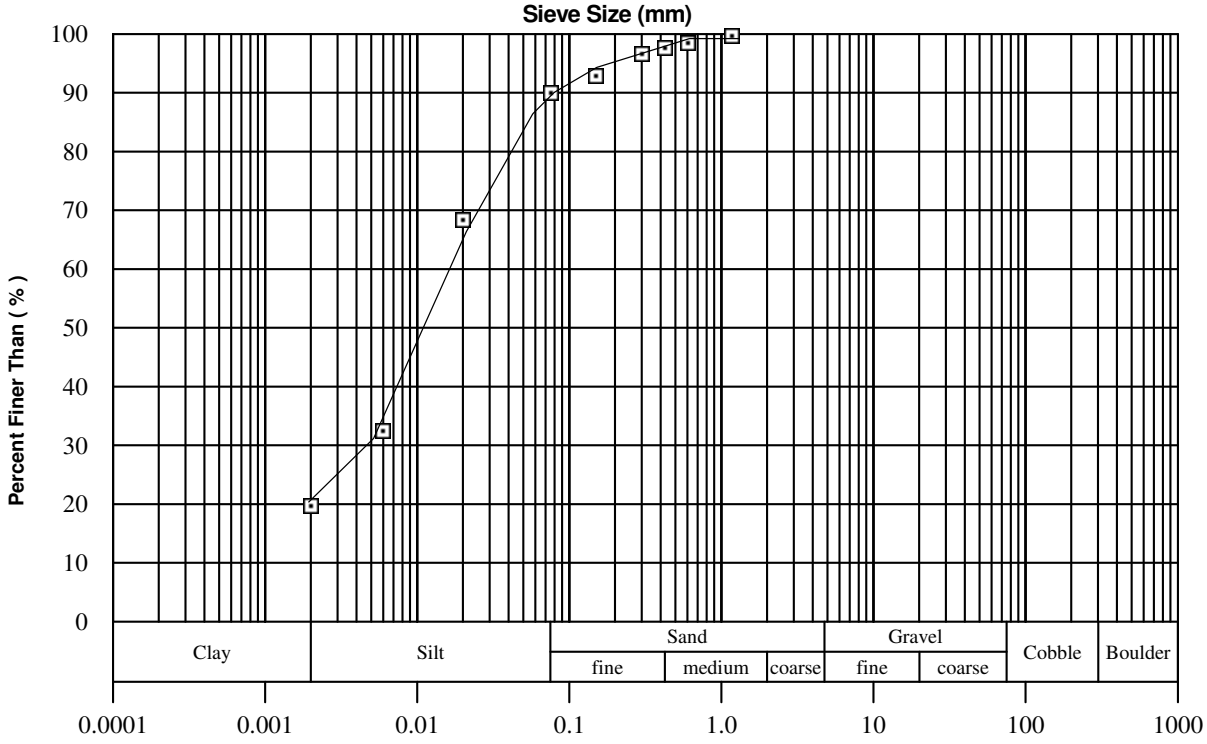
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-9	-	1.00		2.70	75.89	21.41



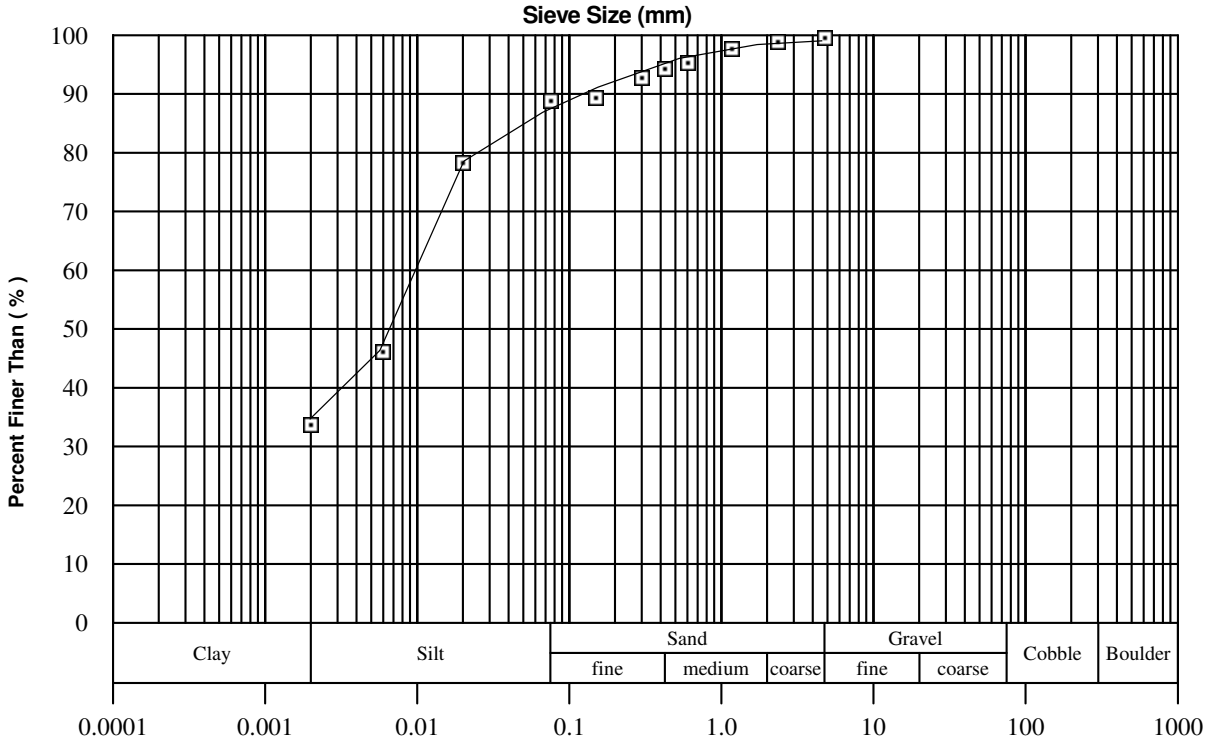
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-9	--	3.00		19.20	66.26	14.54

PARTICLE SIZE DISTRIBUTION CURVES

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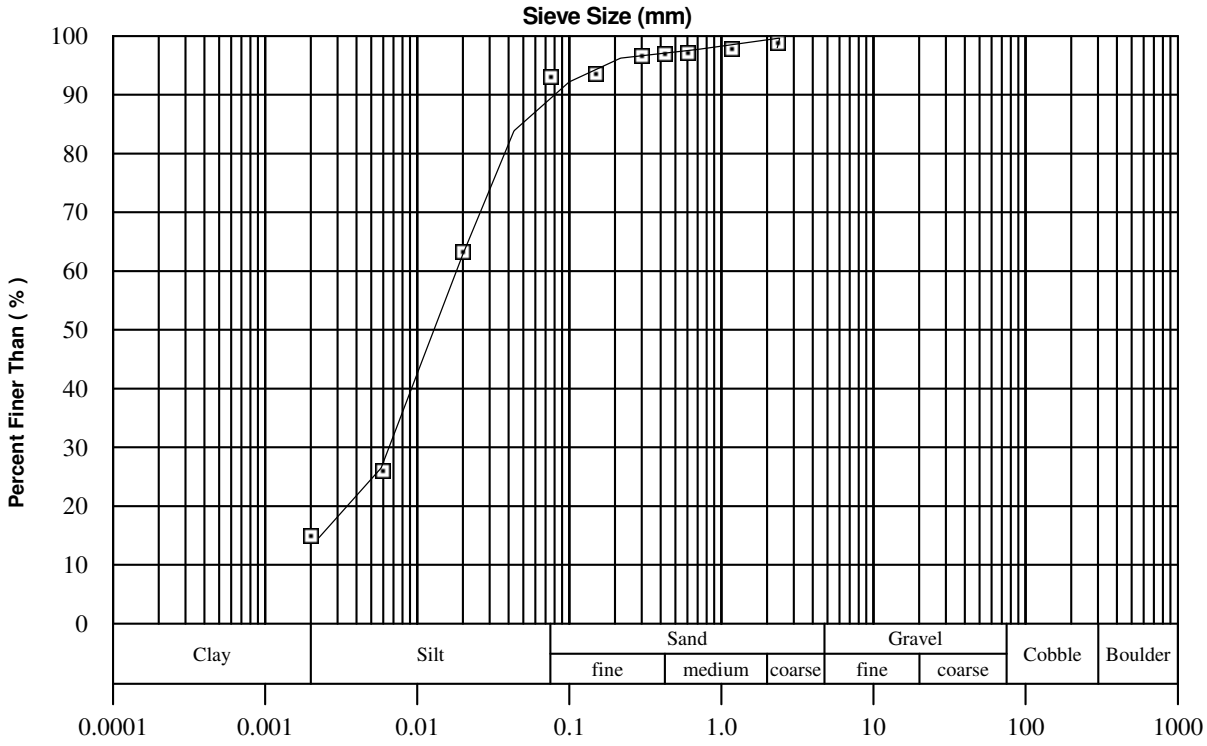
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-10	-	3.00		9.90	70.28	19.82



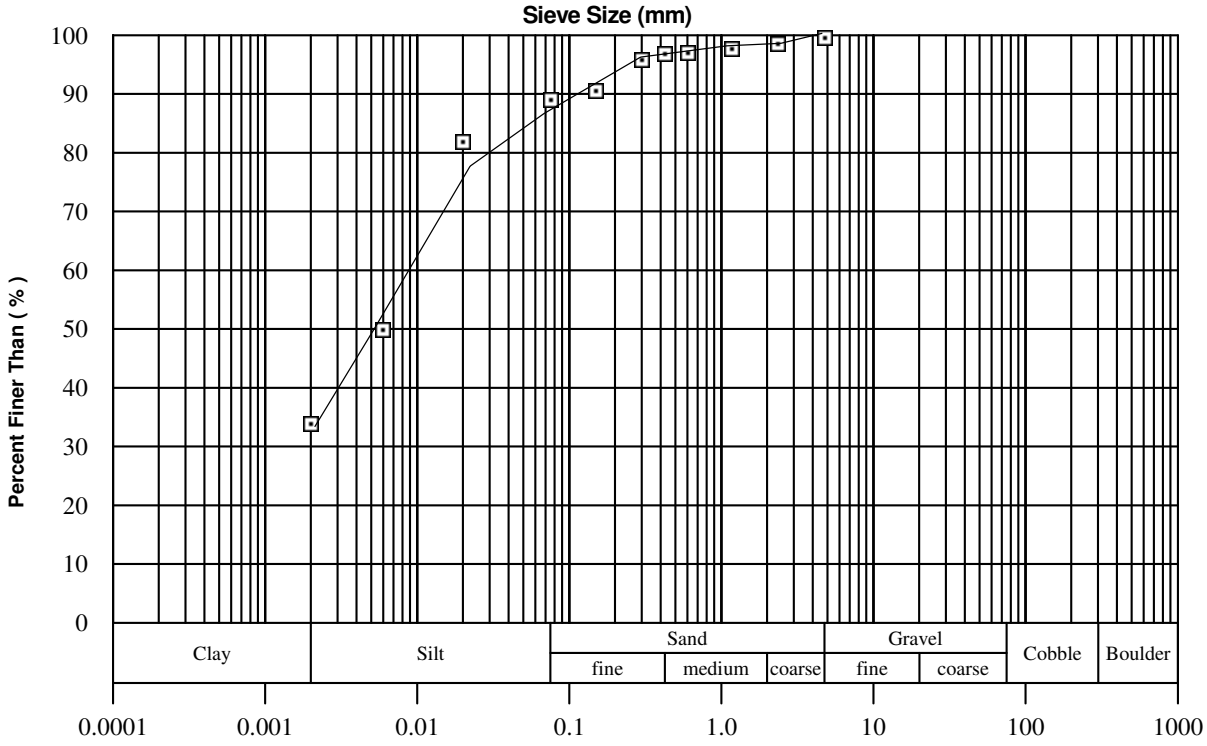
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-11	--	1.00	0.50	10.60	55.12	33.78

PARTICLE SIZE DISTRIBUTION CURVES

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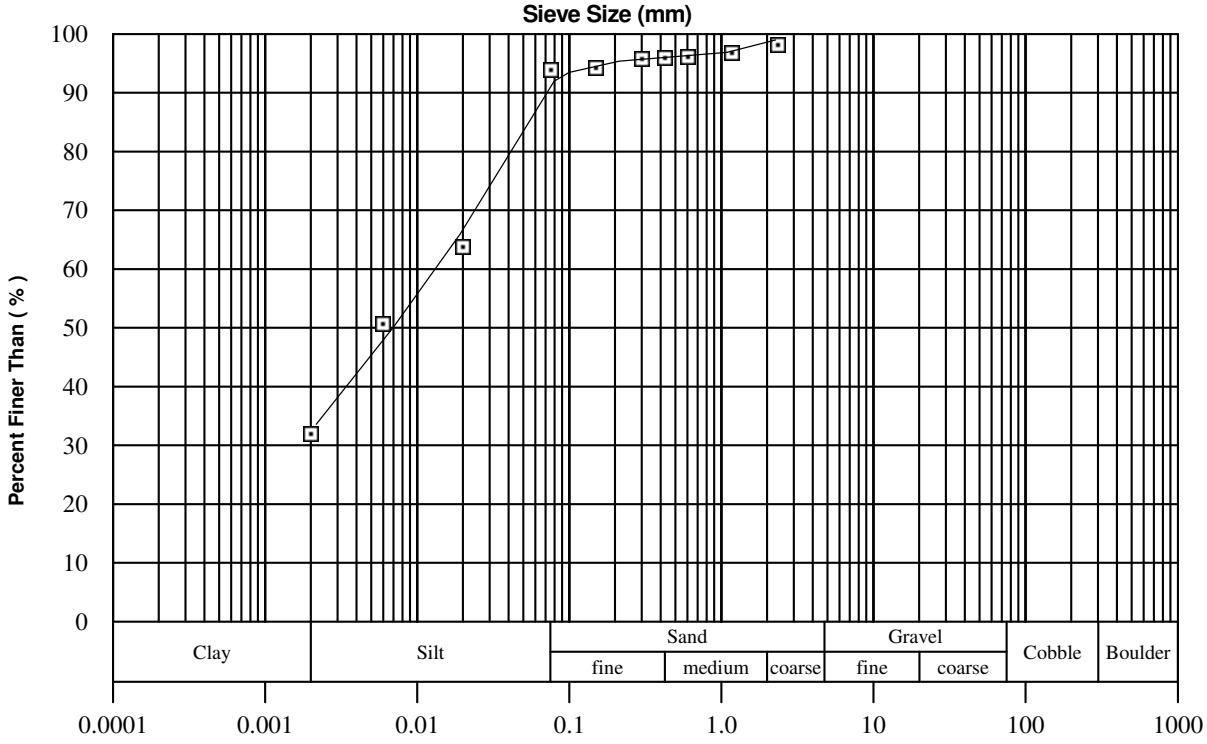
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-11	---	3.00		6.90	78.20	14.90



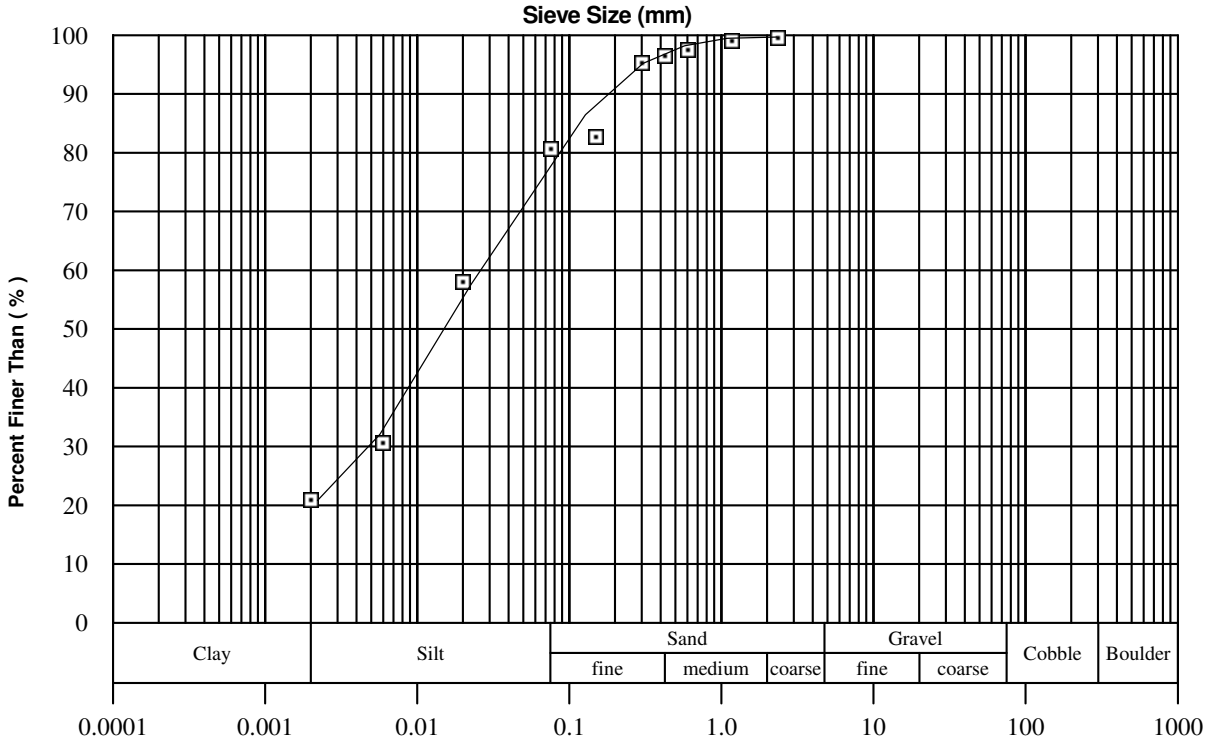
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-12	-	1.00	0.40	10.60	55.18	33.82

PARTICLE SIZE DISTRIBUTION CURVES

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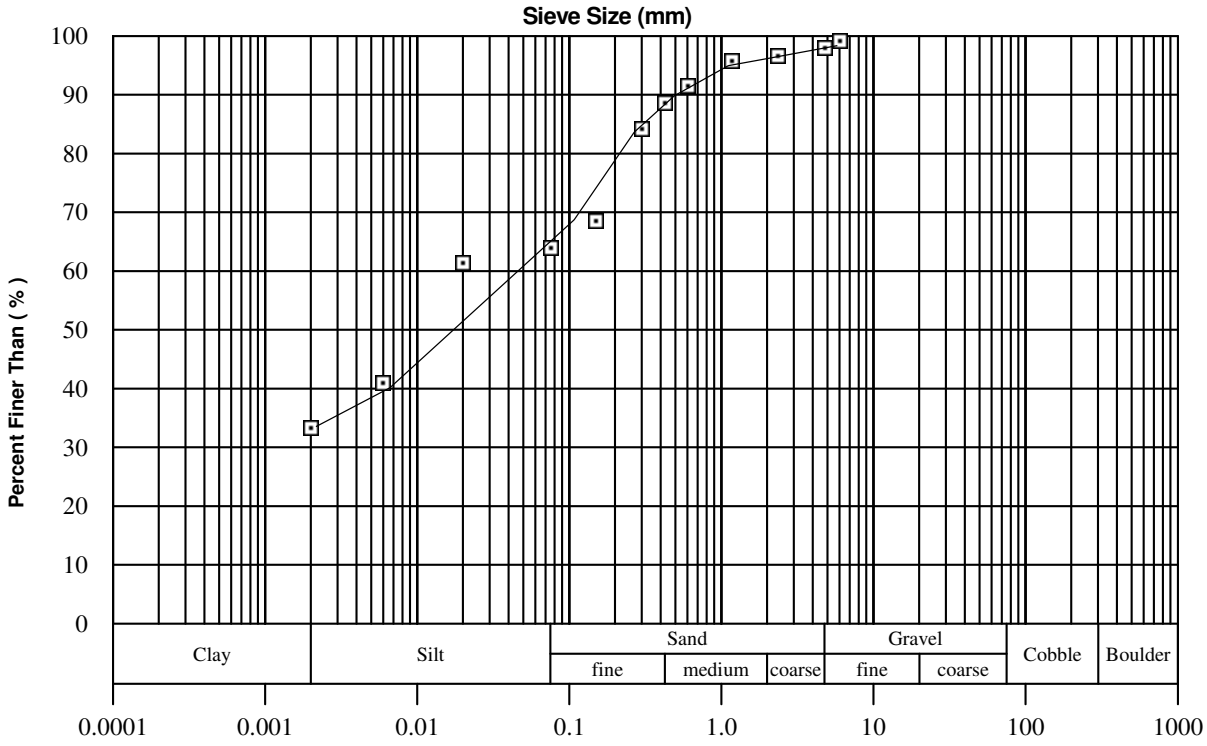
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-12	--	3.00		6.10	61.97	31.93



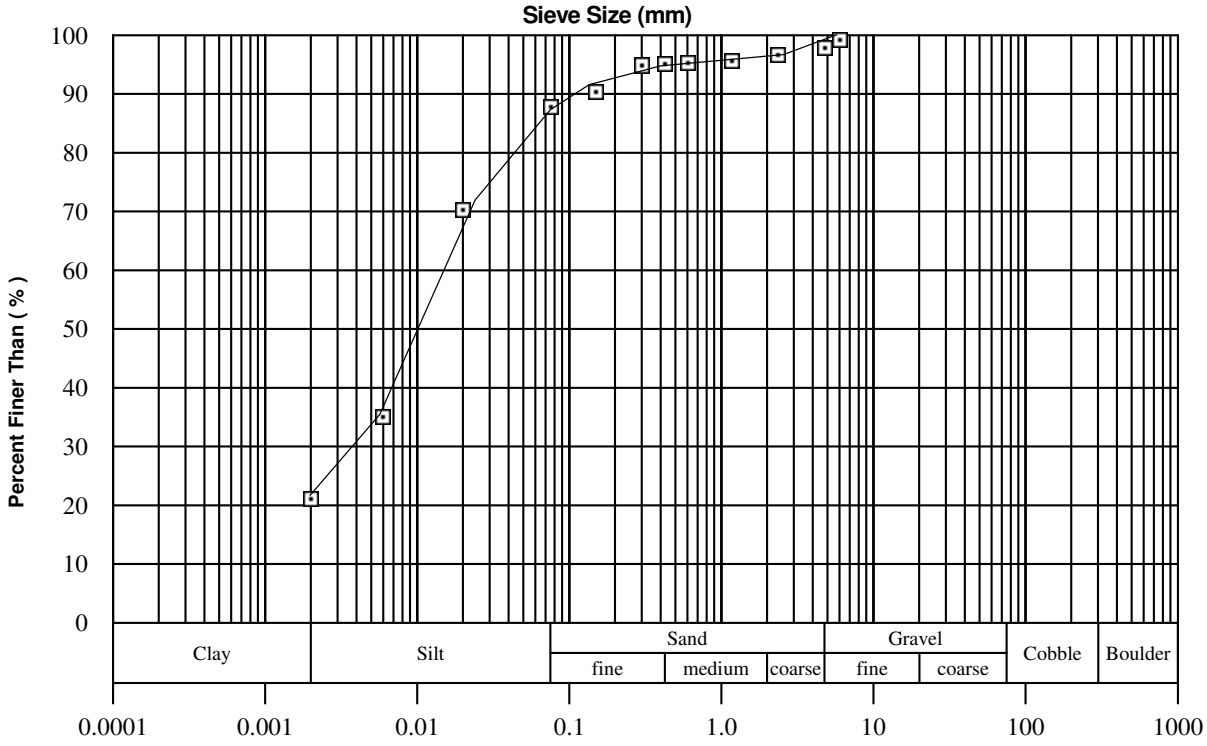
Legend	BoreHole Number	Sample Number	Depth (m)	Grain Size Analysis (%)			
				Gravel	Sand	Silt	Clay
⊡	TP-14	-	2.00		19.30	59.72	20.98

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.

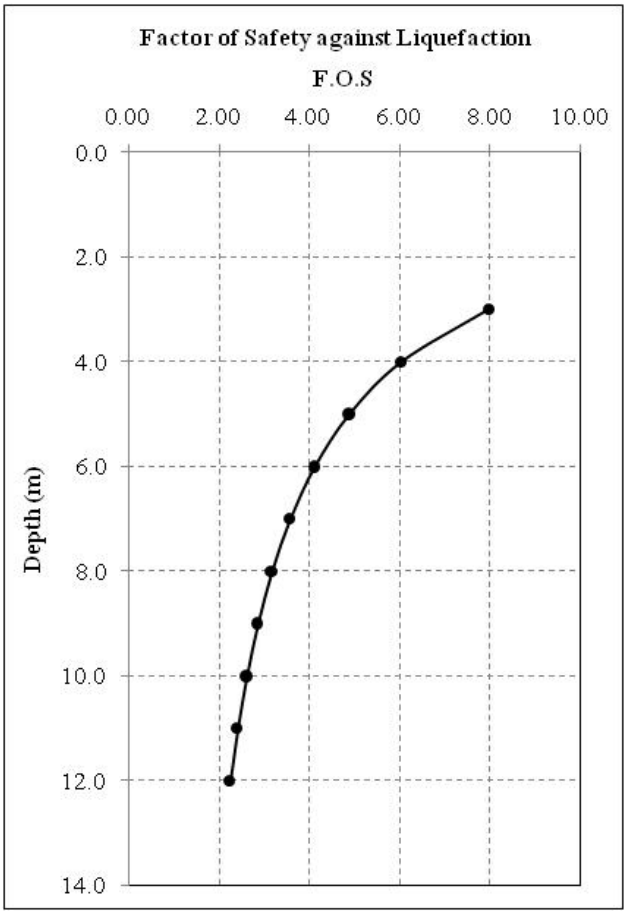
Earthquake magnitude, M = 7.5

Peak ground acceleration amax = 0.16 g

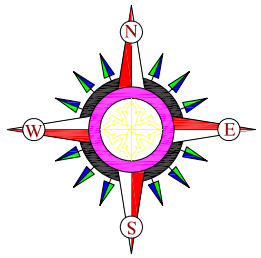
Bh-03

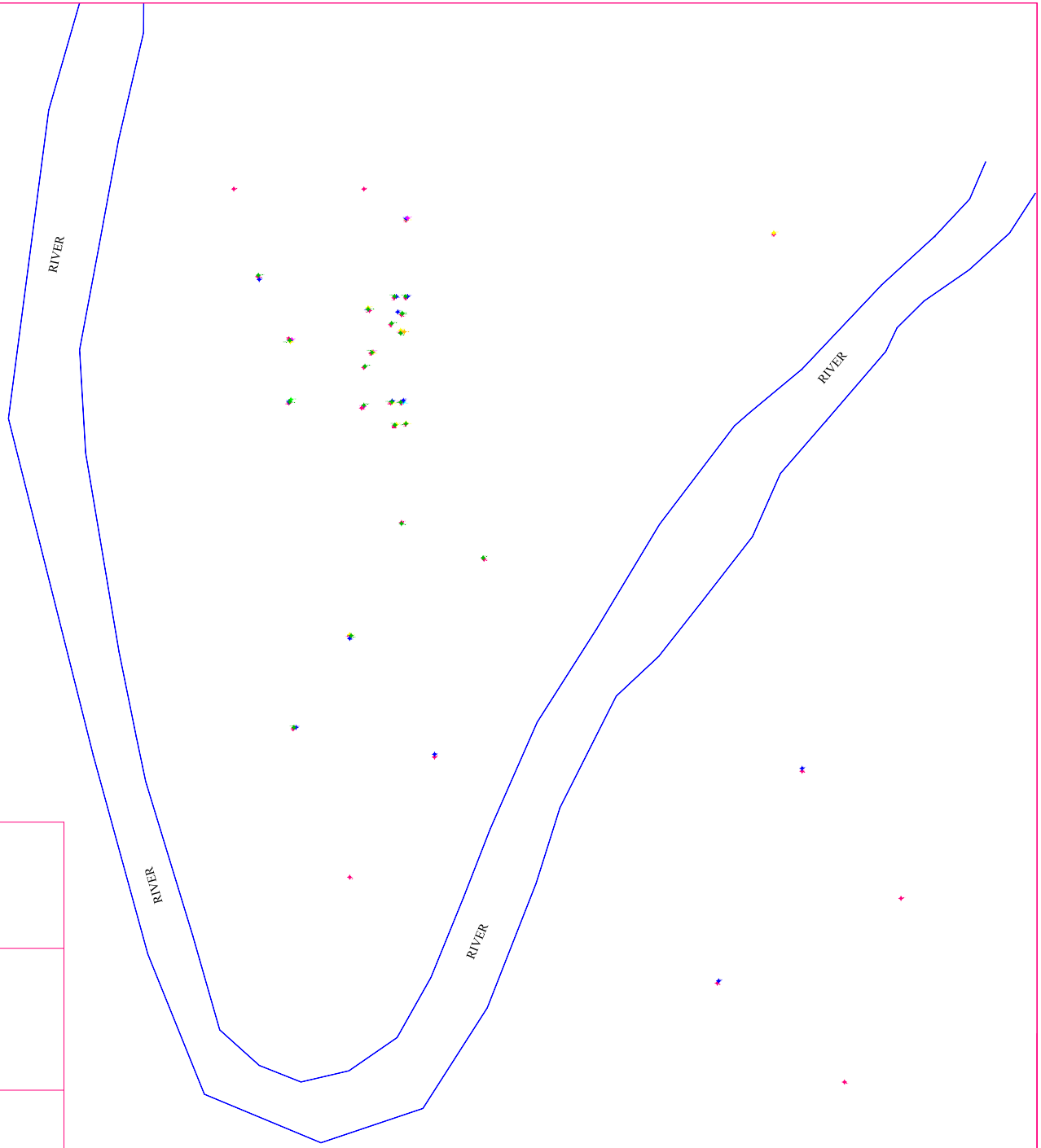
For Clayey Soil

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

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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

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SINGLE PACKAGE ENGINEERING, PROCUREMENT AND CONSTRUCTION

VOLUME: II-G/2

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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
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DRAFT	08.10.2020	R. Moitra	B. Chakraborty	B. Lahiri

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

SINGLE PACKAGE ENGINEERING, PROCUREMENT AND CONSTRUCTION

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VOLUME-II : Technical Specification

VOLUME-III : Bid Proposal Sheets [Technical Part]

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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
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TECHNICAL SPECIFICATIONS
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GUIDELINE
FOR
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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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SECTION: II

GUIDELINE
FOR
GEOTECHNICAL INVESTIGATION

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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

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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.

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SECTION-V

GUIDELINE
FOR
BORED CAST IN SITU CONCRETE PILE

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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	40°C.- 20°C 20°C	20°C - Below 5°C 5°C.		Above 40°C 40°C	40°C.- 20°C 20°C	20°C.- Below 5°C 5°C	
	Days	Days	Days	Days	Days	Days	Days	Days
a) Columns & Walls	2	1	1	Do not remove forms until	1	1	1	Do not remove forms
b) Beam sides	3	2	3	site cured test speci-	2	1	1	until site
c) Slabs, 125 mm	10	7	8	men develop at least 50% of the	7	4	5	cured test specim-
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

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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.

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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.

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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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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

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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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GUIDELINE
FOR
METAL DOORS, WINDOWS, VENTILATORS, LOUVRES, CURTAIN WALL, STRUCTURAL GLAZING, ETC.

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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PART-B

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 1/360th 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-XII

NOT USED

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PART-B

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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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
SAFETY REQUIREMENTS FOR CONSTRUCTION WORKS

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:_____

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PART-B

SECTION-XX

GUIDELINEFOR
FENCING WORK WITH BARBED WIRE,CHAIN LINK
AND
CONCERTINA COIL etc.

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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.

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

EXISTING BRIDGE OVER BHEDAN RIVER

STARTING OF 4 LANE ROAD FROM EXISTING BRIDGE BY EPC/SEC.-A

4 LANE ROAD FROM EXISTING BRIDGE BY EPC/SEC.-A

4 LANE ROAD FROM EXISTING BRIDGE BY EPC/SEC.-A

4M WIDE PERIPHERAL ROAD FOR VILLAGES (OUTSIDE PLANT BOUNDARY FENCE) EPC SECTION:A

SPACE FOR PRE TREATMENT AND EFFLUENT TREATMENT PLANT AREA

HYDROGEN GENERATION PLANT

4M WIDE ROAD

THIS MAY BE USED FOR LAYDOWN AREA /PRE-ASSEMBLY AREA

RAW WATER RESERVOIR AREA (88 ACRES)

COMPARTMENT #1

COMPARTMENT #2

MAKE-UP WATER PIPE LINE

PRE FABRICATION, PRE ASSEMBLY & LAY DOWN MAINTENANCE PLANT

CRUSHED COAL STOCK PILE#1 (350Mx50M)

CRUSHED COAL STOCK PILE#2 (350Mx50M)

CRUSHED COAL STOCK PILE#3 (350Mx50M)

CRUSHED COAL STOCK PILE#4 (350Mx50M)

IDCT – 1

IDCT – 2

IDCT – 3

GATE#1

GATE#5

T.B.M-1

T.B.M-2

T.B.M-3

T.B.M-4

T.B.M-5

T.B.M-6

RL. 202.5

RL. 201

RL. 202

RL. 202.5

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ANNEXURE Bidder- M/s .BHEL Lr. ref No. MS-1-20-E-0007 dt 02.12.2020		
Ref No	**QUERY**	**Remarks**
1	**Topographical survey (Auto** Cad format) :	
	a) Integrated Township area including approach road from plant to Township	Preliminary topographical survey contour drg of Township attached in AUTOCAD format. For Township main approach road and dedicated road from township to power plant, Refer corrigendum Detailed survey of township area and approach road to power plant area are in scope of bidder. PDF format for township contour already attached in Tender document, Section A - Annexure drg No. C26
	b) RCC bridges over Bhedan river	Topographical survey for RCC bridge Included under bidders scope
	c) Embankment formation area along Bhedan river	Refer cross sections of Bhedan river available in attached drainage study report (relevant pages). Refer Tender document, Section A - Annexure drg no. B6 for embankment cross section. Detailed Survey of embankment area in the scope of bidder.
	d) Raw water /intake pump area & proposed route (approx. 22 Km) corridor area	Preliminary survey drg enclosed.
	e) Plant area including office building, CISF Barracks, CISF Armoury and quarter guard, CISF security check post etc.	Preliminary topographical survey contour drawing details of power plant and greenbelt area attached in AUTOCAD format. Detailed survey of power plant and greenbelt area in scope of bidder CISF Barracks, CISF Armoury and quarter guard, CISF Security checkpost etc… located in power plant area in North eastern side (RHS of Forest area) shown in latest power plant layout.
	f) Ash dyke area	Auto CAD drg Enclosed. (pdf copy already uploaded)
	g) Peripheral fencing around acquired land (General layout drawing in Auto Cad)	Preliminary topographical survey contour drawing details of power plant and greenbelt area attached in AUTOCAD format. Refer latest power plant layout given in Section B.
2	**Integrated Township** area including approach road from plant to Township:	
	a) Geotechnical Investigation data	Net safe bearing capacity of soil at 1.5 m below NGL shall be considered as 15t/sq.m However, foundation shall be designed and provided as per detailed soil investigation which is under bidder scope. Net safe bearing capacity of soil will be limited to 15 t/sq.m at 1.50 m below NGL if SBC is ≥ 15t/sq.m.
	(bore logs, NGL, lab test results of soil/rock samples, Chemical analysis of water, Electrical resistivity test results etc).	

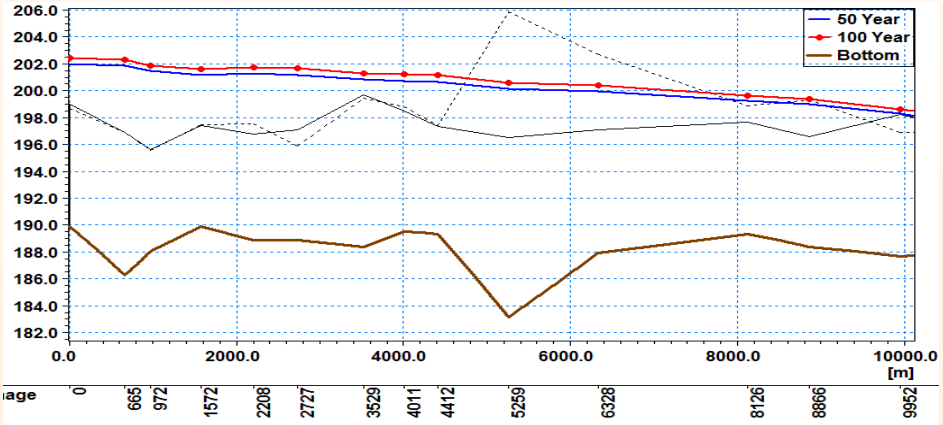
3	**RCC bridges over Bhedan river**	
	a) Longitudinal section and Cross section of the river at the proposed bridge locations	Bidder to refer " Area drainage study report" for details.
	b) Bathymetric survey data of the proposed bridge locations	Bathymetric survey is under the scope of bidder
	c) Highest Flood level (HFL), water level in the river, scour depth, current velocity etc.	Bidder to refer " Area drainage study report" for details.
	d) Geotechnical Investigation data i.e. test results of river bed samples and inland soil	Under the scope of bidder
	e) Tender technical specification for RCC bridges (Not available in specification)	Layout drawings for RCC bridge are to be developed by the bidder.
	f) General layout drawings for RCC bridges	
4	**Embankment formation along Bhedan river along with slope protection and toe drains for plant side and ash dyke side**	
	a) Area drainage study report	Relevant pages of Area drainage study report attached for reference. Refer Section A - Annexure drg no. B6 for embankment cross section
	(conducted by customer through National Institute of Hydrology, Roorkee as mentioned in the specification)	
	b) Geotechnical Investigation	Detailed soil investigation of embankment area is in the scope of bidder. However for Talabira Mines, flood protection bund/embankment, preliminary soil investigation carried out by M/s Fargo Consultants pvt Ltd and relevant bore holes BH101 to BH106 are enclosed for reference.(9 pages)
	(bore logs, NGL, lab test results of soil/rock samples, Chemical analysis of water)	
5	**Raw water intake & transportation system**	
	a) General lay out- 1) raw water intake channel 2) Pumps House & 3) raw water pipe line corridor	Layout drawings are to be developed by the bidder.
	b) Geotechnical Investigation data (bore logs, NGL, lab test results of soil/rock samples, Chemical analysis of water, Electrical resistivity test results)	Geotechnical Investigation for Intake system is under the scope of bidder
	c) Hydrological data (HFL, low water level, high water level , discharge etc. at intake pump house and channel location)	Available data enclosed.
	d) Bathymetric survey data at proposed intake pump house location	Bathymetric survey data at proposed intake pump house location is under the scope of bidder
	e) Longitudinal & Cross section details of Hirakud reservoir along intake channel and intake pump house	Longitudinal & Cross section details of Hirakud reservoir along intake channel is under the scope of bidder
	f) Longitudinal section details along the proposed pipe line corridor	Preliminary survey for raw water intake pipe line details enclosed , Detailed survey for longitudinal section details is under the scope of Bidder.

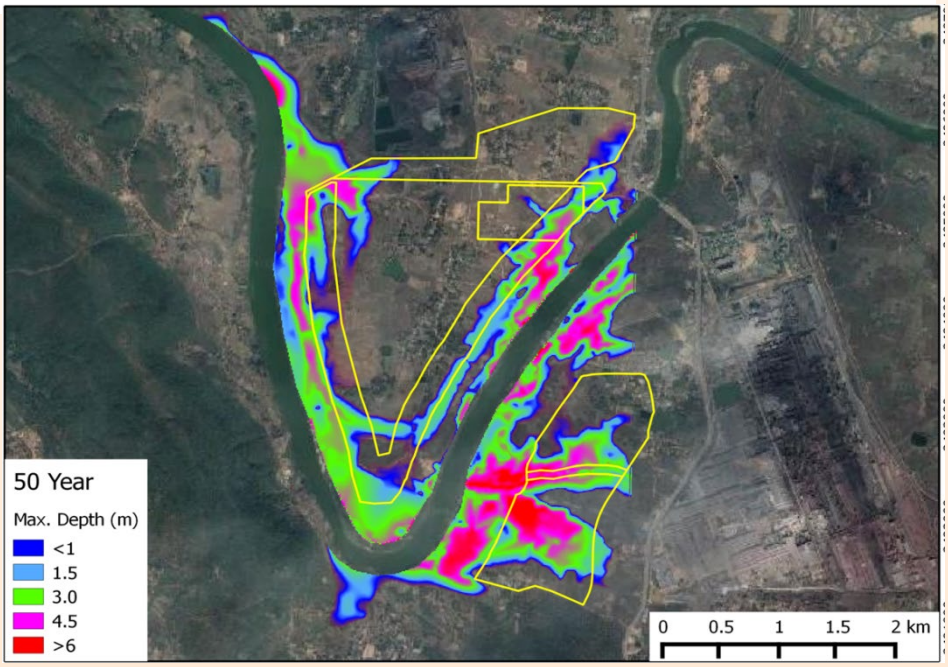
6	**Peripheral fencing around acquired land, peripheral road and Boundary wall of plant area**	
	a) Geotechnical Investigation data including bore logs, NGL, lab test results of soil/rock samples, Chemical analysis of water, Electrical resistivity test results	Peripheral fencing around acquired land, peripheral road & compound wall of Plant area as per latest power plant layout and the approximate length to refer technical specification. Refer latest power plant layout and preliminary soil report attached in Section B
7	**Thermal Project office building, CISF Barracks, CISF Armoury and quarter guard, CISF security check post and toilet block, Gate complex along with security and time office, Parking lot, Watch Tower area**	
	a) General layout drawing	CISF Barracks, CISF Armoury and quarter guard, CISF Security checkpost etc… located in power plant area in North eastern side (RHS of Forest area). Thermal project office building located in power plant area near Main gate complex. For preliminary architectural details, Refer Section A - Annexure drg Nos. B7, B13 to B21 Refer latest power plant layout and preliminary soil report attached in Section B
	b) Geotechnical Investigation data including bore logs, NGL, lab test results of soil/rock samples, Chemical analysis of water, Electrical resistivity test results	
8	**Ash dyke Area**	
	a) General arrangement drawing of ash dyke showing embankment details, inlet & outlet details, no. of lagoons, details of decantation well/water escaping structure, road details etc.	Tender drawing already uploaded on 01-12-2020, the same is enlcosed for reference

Area Drainage Study for NLC Talabira Thermal Power Project, Stage I (3x800 MW)

Sponsored by

NLC India Limited (NLCIL), Neyveli





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NATIONAL INSTITUTE OF HYDROLOGY

ROORKEE – 247 667, UTTARAKHAND

October, 2018

Area Drainage Study for NLC Talabira Thermal Power Project, Stage I (3x800 MW)

Study Group

J. P. Patra, Scientist C & PI
Rakesh Kumar, Scientist G & Head SWHD
Pankaj Mani, Scientist E
R. P. Pandey, Scientist G

NATIONAL INSTITUTE OF HYDROLOGY, ROORKEE – 247 667

Executive Summary

NLC India Ltd (NLCIL) formerly, Neyveli Lignite Corporation Limited, a Navaratna enterprise of Government of India (GoI) is an existing, profit making, public sector enterprise engaged in mining of lignite and generation of power through lignite based thermal power plants. Now, NLCIL is planning to implement a 3200 MW NLC Talabira TPP in 2 Stages (Stage-I - 3x800 MW and Stage-II – 1x800 MW at a later date) with linkage to Talabira-II & III captive coal blocks allocated to NLCIL, which are situated in very close proximity to the project site. The project site is located near Kumbhari and Tareikela villages on south west of Brijraj Nagar town on Sambalpur Rourkela highway in Jharsuguda district. The geographical extent of the proposed project area lies along both banks of Bhedan river, which is a tributary of IB river. The study envisages identification of various flooding sources, estimation of maximum floods and their routing to the plant site for estimating the maximum flood level. Further, this study also includes analysis of local drainage pattern and final disposal point for the storm water and plant drainage.

The Digital Elevation Model (DEM) of the study area is prepared from surveyed contour for the plant area, spot heights; contours digitized from the SOI toposheets and SRTM data. The basin boundary and river networks are delineated from the DEM using HEC-GeoHMS and various catchment characteristics are estimated. The catchment area of Bhedan river at proposed plant site is about 3185.5 km^2. Synthetic Unit Hydrograph is developed using the catchment characteristics and following the guideline given in Flood Estimation Report. Daily rainfall data of ten raingauge stations in and around the catchment are procured from IMD, Pune and the annual 1-day maximum rainfall series are extracted for rainfall frequency analysis. Regional rainfall frequency analysis using L-moments approach is carried out for estimating rainfall of various return periods. The robust frequency distribution among twelve frequency distribution is identified based on L-moments ratio diagram and Z_i^{dist} –statistic criteria. Generalized Extreme Value (GEV) is identified as the robust frequency distribution for this case. The 1-day annual maximum rainfall for 25 year, 50 year and 100 year return periods are estimated to be 27.25 cm, 31.04 cm and 34.86 cm respectively. The design flood hydrograph are developed by convoluting the SUH with estimated hourly incremental design rainfall. The peak floods in

Bhedan river due 50 year and 100 year return period flood are estimated to be 9956.07 m^3/s and 11278.65 m^3/s respectively.

The flood routing study has been carried out using MIKE FLOOD package (a coupled 1D and 2-D flow analysis). The bathymetry of the flood plain around the plant site has been created from the DEM. The spills from catchment drainage and local rainfall have been simulated in MIKE-21. The 1-D model in Mike 11 is prepared for the study reach of Bhedan river using surveyed river cross-section at fifteen locations and 2-D model in Mike 21 is developed for both main plant area and ash pond area using 10m cell size. Under pre-project condition the maximum water level in the river varies from 201.5 m to 199 m along the river stretch from cross-section 3 to cross-section 13 for 50 year return period flood. The flood levels are estimated to be about 0.4 m higher in case of 100 year return period flood. The potential source of flooding at the plant site can be due to the flooding from Bhedan rive in the areas below RL202 m level. As a protection measure, construction of embankments on both left and right bank is also analysed for various return period floods. It is suggested that embankment is to be constructed on both banks, as construction of embankments only in right bank (main plant area) will not be able to protect the ash pond area. However, instead of creating embankment along the left bank of river, selective protection to only ash dyke can be made as per requirement. The water level in river with proposed embankment varies from 203.1 m to 200.6 m along the river reach form CS3 to CS 13 for 100 year return period flood. It is also observed that at present embankment of different stretches along the right bank are not flooded in the modelling study. However, the embankment is not continuous and need to be strengthened. It is observed that the main plant area has negligible flow from the upstream area and can be easily diverted along the plan boundary/ periphery road. However, two natural stream/nall are flowing in and around the ash pond area flowing from east (from Bhushan plant) to west and joins Bhedan river. The drain in the north of proposed ash pond area of NLCIL will not interfere with the proposed ash pond area of NLCIL. The other drain (D2) passes through the proposed ash pond area of NLCIL and joins to Bhedan river. Two alternatives for the drain D2 are analysed. The first alternative is to leave the alignment of drain D2 as it is, dividing the ash pond area in two portions and area north of drain may be used for fly ash pond and area south of drain may be used for bottom ash pond. In this case there will be very little

modification in the present alignment of the drain as the drain may be straightened and strengthened with capacity in the area between the fly ash pond and bottom ash pond. However, the drain caries discharge from Bhushan plant area including discharge from iron ore washing plant etc. Hence it will be difficult for controlling water quality in the drain section where it passes through the ash pond area. As second alternative, it is proposed to divert the drain along the boundary of ash pond area in by diverting to first south and then west direction. However, it is to be noted that in two stretches the cutting would be in the range of about 8 m to maintain bed slope of drain. The estimated peak runoff in the drain for 50 year and 100 year return period are 55.5 m^3/s and 61.3 m^3/s. Both unlined trapezoidal section with a side slope of 1.5:1 (H:V) and lined rectangular section drains are designed for longitudinal slope of 0.0015 m/m (1.5 m/km) to carry the estimated runoff.

2 DESCRIPTION OF STUDY AREA

2.1 General

NLC India Ltd (NLCIL) formerly, Neyveli Lignite Corporation Limited, a Navaratna enterprise of Government of India (GoI) is an existing, profit making, public sector enterprise engaged in mining of lignite and generation of power through lignite based thermal power plants. NLCIL was established by GoI in 1956, following the discovery of lignite deposits in Neyveli, Tamil Nadu. NLCIL has lined up a number of projects including expansion/augmentation of its existing mines and power plants, setting up of green-field mines & power plants, acquisition of power assets, acquisition of overseas mine assets, setting up of wind and solar power plants across the country. Now, NLCIL is planning to implement a 3200 MW NLC Talabira TPP in 2 Stages (Stage-I - 3x800 MW and Stage-II – 1x800 MW at a later date) with linkage to Talabira-II & III captive coal blocks allocated to NLCIL, which are situated in very close proximity to the project site.

The project site is located near Kumbhari and Tareikela villages on south west of Brijraj Nagar town on Sambalpur Rourkela highway in Jharsuguda district. 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 km. The geographical extent of the proposed project area lies along both banks of Bhedan river, which is a tributary of IB river. The location of the site is given in Figure 2.1.

2.2 Climate and Rainfall

The Jharsuguda district is characterized by a hot dry summer. The maximum temperature in the month of May is about 46 °C. It has an average rainfall of about 1527 mm. From April to August the wind blows from south and southwest whereas from September onwards wind blows from North West.

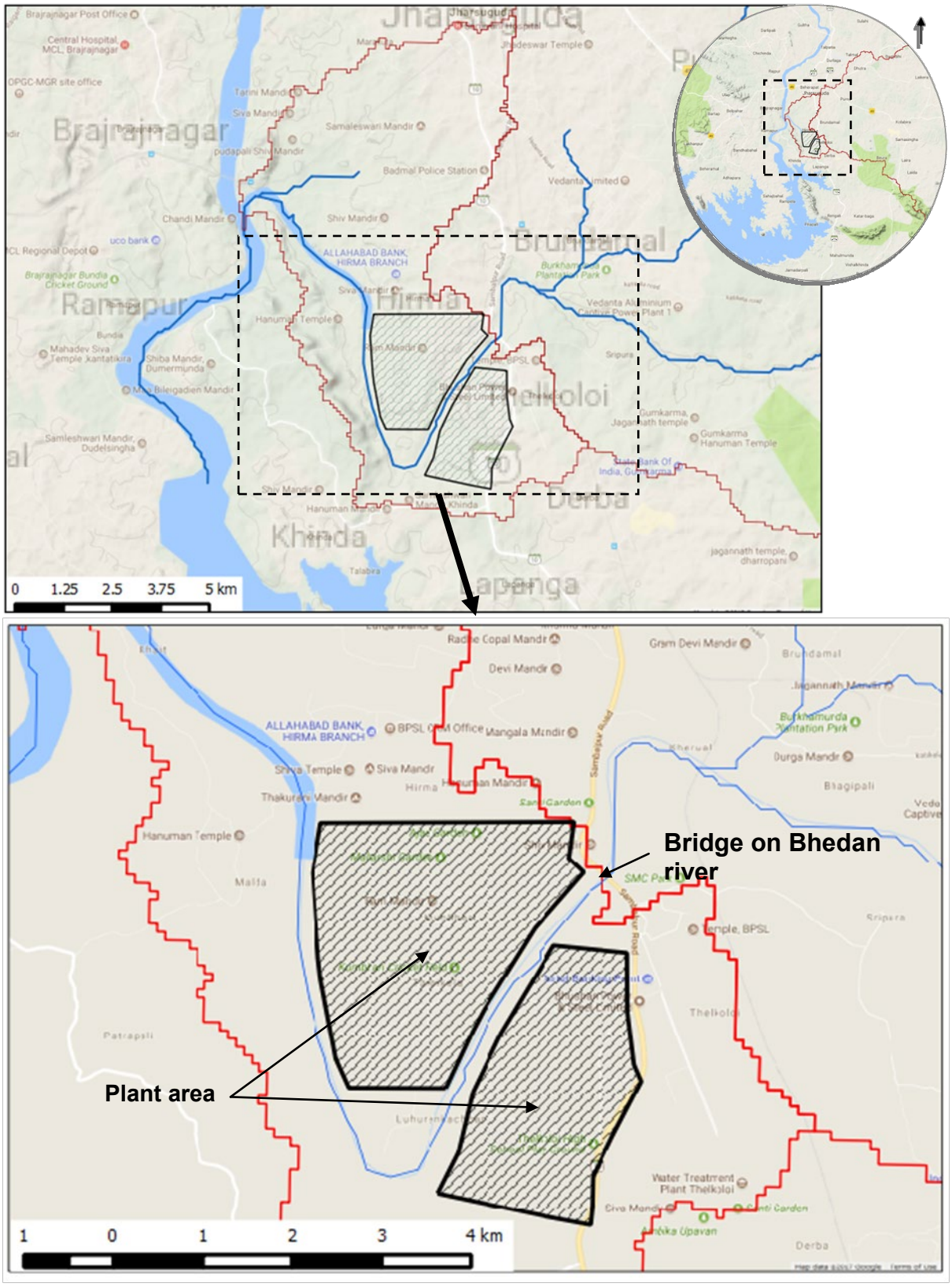


Figure 2.1: Index map of the study Area

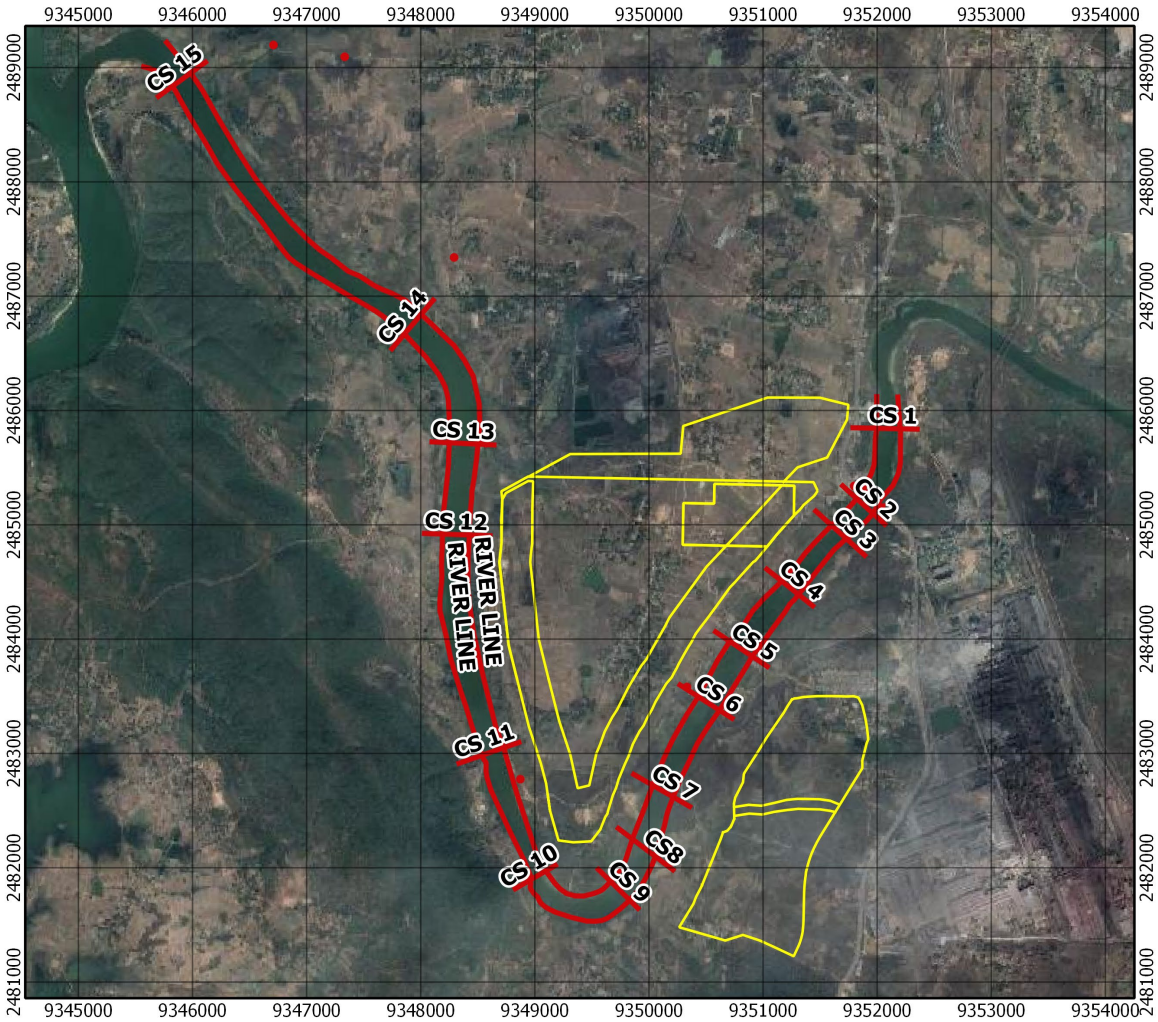
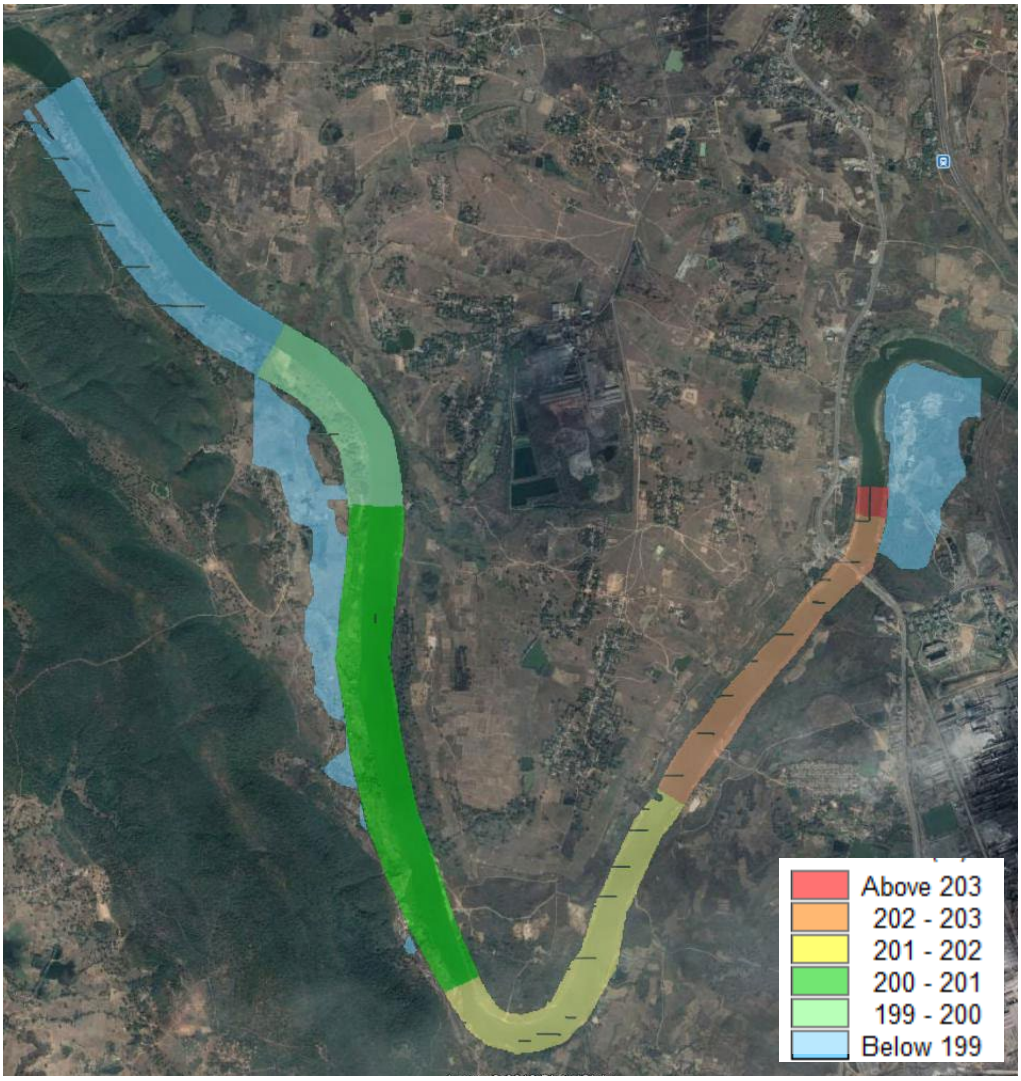
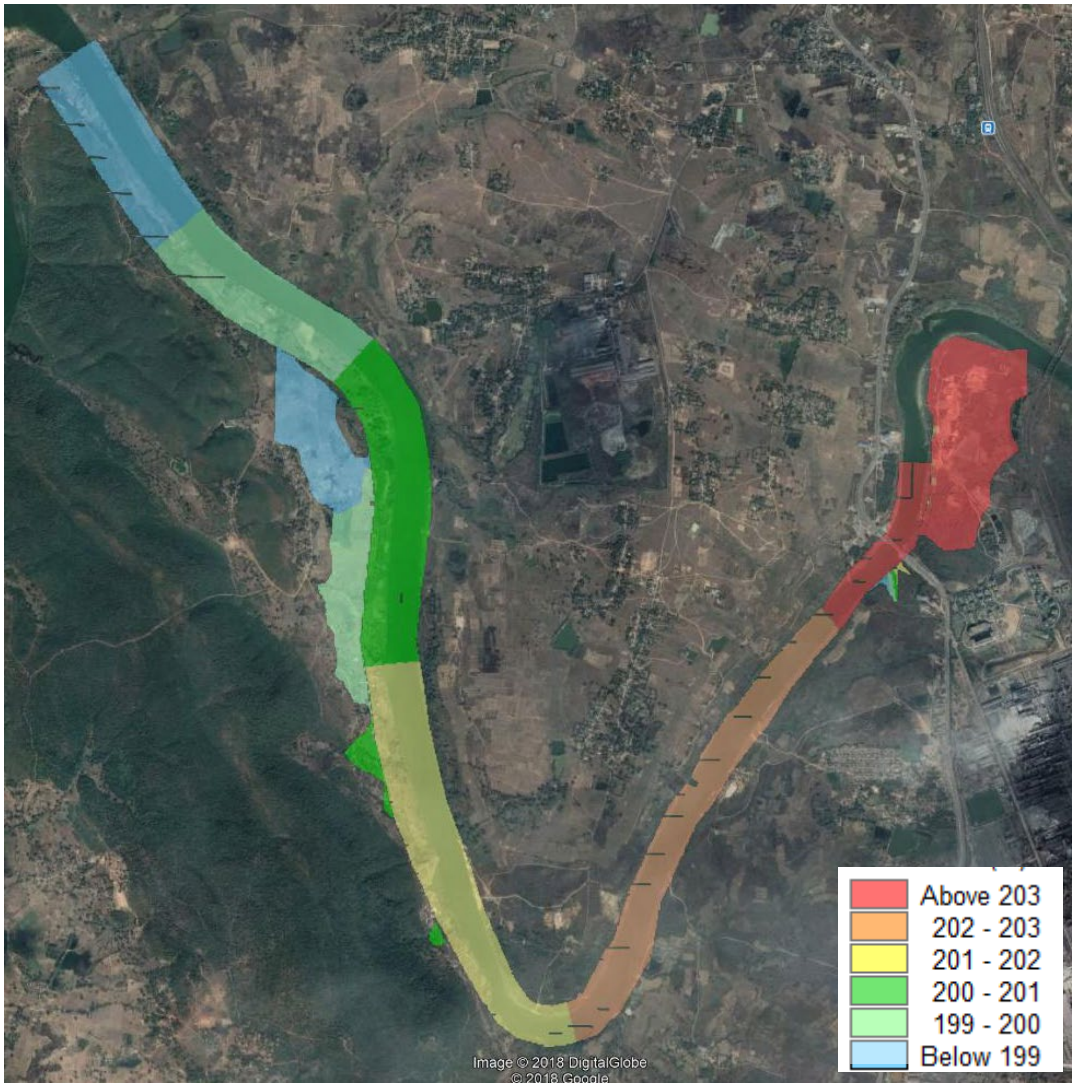


Figure 3.3: Location of river cross-section



(a) Inundation map for 50 year flood



(b) Inundation map for 100 year flood

Figure 5.22: Inundation map for various flood estimates

Table 5.9: Water level with embankment for 100 year return period flood

Location	Water level with embankment	Top of the proposed embankment	UTM Coordinate			
			Left Bank		Right Bank	
			X	Y	X	Y
CS2(665)	203.5	204.50	811300.72	2411477.80	811130.78	2411622.00
CS3(972)	203.1	204.10	811070.50	2411261.30	810929.50	2411401.80
CS4(1570)	202.9	203.90	810719.91	2410780.60	810550.52	2410921.30
CS5(2208)	202.9	203.90	810360.57	2410269.70	810139.98	2410425.70
CS6(2727)	202.5	203.50	810076.72	2409846.40	809865.26	2409960.70
CS7(3529)	202.2	203.20	809708.96	2409124.30	809496.91	2409245.60
CS8(4011)	202.2	203.20	809580.45	2408626.80	809332.63	2408812.40
CS9(4412)	202.1	203.10	809376.44	2408308.30	809154.97	2408511.30
CS10(5259)	201.6	202.60	808498.37	2408375.40	808753.00	2408534.20
CS11(6328)	201.5	202.50	807973.09	2409374.10	808345.22	2409492.00
CS12(8126)	200.8	201.80	807630.59	2411263.80	808014.80	2411197.30
CS13(8866)	200.6	201.60	807669.89	2411961.60	808075.06	2411961.40
CS14(9952)	200.0	201.00	807337.38	2412673.40	807599.60	2413001.60

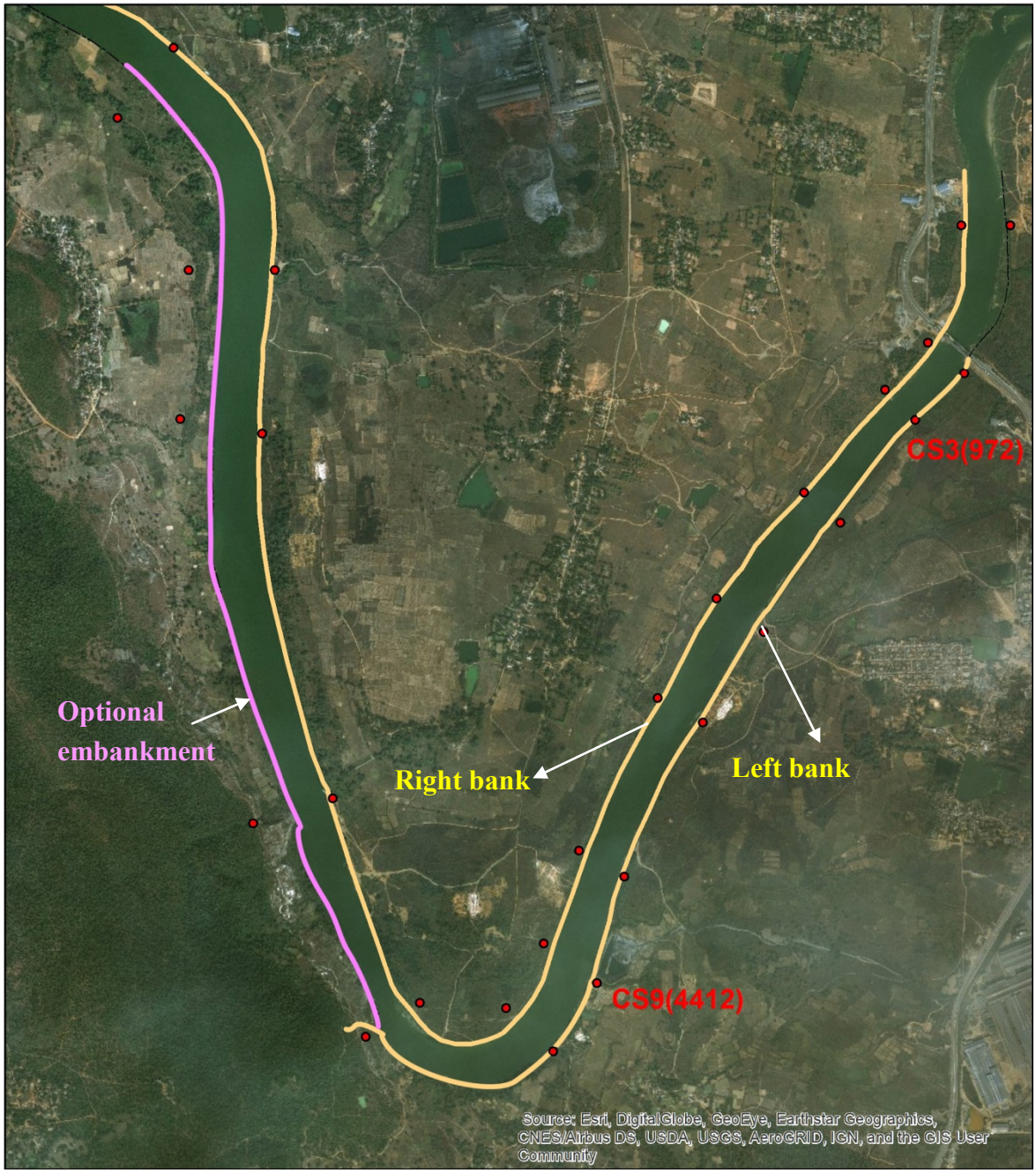


Figure 5.24: Alignment of proposed embankments over satellite images.

5.8 Impact of Hirakud reservoir

The FRL/ MWL of Hirakud reservoir is at RL 192.024m (http://www.dowrorissa.gov.in/Projects/MajMed/DetailsCompletedOngoing/Ongoing/CEUMB/Hirakud%20System%20%28Completed%29/SFHirakud.pdf) and Top dam level is at R.L. 195.680 m (http://www.ohpcltd.com/Hirakud/dam). The elevations in the study area are above RL 193 m excluding river section. Moreover, the safe grade level is recommended to be above RL 202 m. This level is more than 6 m higher than top level of Hirakud dam. Hence, after construction of proposed embankments on Bhedan River and site levelling above 202 m, the water level of Hirakud reservoir will not have adverse impact on the site.

6 CONCLUSIONS

Based on study following conclusions are drawn:

1 The Digital Elevation Model (DEM) of the study area is prepared from surveyed contour for the plant area, spot heights; contours digitized from the SOI toposheets and SRTM data. The basin boundary and river networks are delineated from the DEM using HEC-GeoHMS and the catchment characteristics are estimated.

2 Synthetic Unit Hydrograph is developed following the guideline of Flood Estimation Report (CWC, 1993) and estimated catchment characteristics.

3 The daily rainfall data for ten raingauge stations are procured from IMD, Pune and the annual 1-day maximum rainfall series is extracted for rainfall frequency analysis.

4 Generalized Extreme Value (GEV) is identified as the robust frequency distribution following the regional rainfall frequency analysis using the L-moments approach. The robust frequency distribution is identified based on L-moments ratio diagram and Z_i^{dist} –statistic. The 1-day annual maximum rainfall for 25 year, 50 year and 100 year return periods are estimated as 27. 25 cm, 31.04 cm and 34. 86 cm respectively.

5 The design flood hydrograph are developed by convoluting the SUH with estimated design rainfall. The peak floods in Bhedan river due 50 year and 100 year return period rainfall for 1 day are estimated to be 9956.07 m^3/s and 11278.65 m^3/s respectively.

6 The flood inundation study for 50 year 100 year return period flood is carried out using the coupled 1D- and 2-D hydrodynamic model Mike Flood. The 1-D model in Mike 11 is prepared for the study reach of Bhedan river using surveyed river cross-section at fifteen locations. The 2D model in Mike 21 is developed for both main plant area and ash pond area using 10m cell size.

7 Under pre-project condition the maximum water level in the river varies from 201.5 m to 199 m along the river stretch from CS3 to CS 13 for 50 year return

period flood. The flood levels are about 0.4 m higher in case of 100 year return period flood.

8 The potential source of flooding at the plant site can be due to the flooding from Bhedan rive in the areas below RL202 m level. Hence, the safe grade level is recommended to be above RL 202 m.

9 Further, construction of embankments on both left and right bank is also analysed for various return period floods. It is suggested that embankment is to be constructed on both banks, as construction of embankments only in right bank (main plant area) will not be able to protect the ash pond area. However, instead of creating embankment along the left bank of river, selective protection to only ash dyke can be made.

10 The water level in river with embankment varies from 203.1 m to 200.6 m along the river reach form CS3 to CS 13 for 100 year return period flood. It is also observed that present embankment of different stretches along the right bank are not flooded in the modelling study. However, presently the embankment is not continuous.

11 It is observed that the main plant area has negligible flow from the upstream area and can be easily diverted along the plan boundary/ periphery road. However, two natural stream/nall are observed in and around the ash pond area flowing from east (from Bhushan plant) to west and joins Bhedan river.

12 The drain in the north of proposed ash pond area of NLCIL will not interfere with the ash pond area of NLCIL. The other drain (D2) passes through the proposed ash pond area of NLCIL and joins to Bhedan river. Two alternatives for the drain D2 are analysed.

13 The first alternative is to leave the alignment of drain D2 as it is, dividing the ash pond area in two portions and area north of drain may be used for fly ash pond and area south of drain may be used for bottom ash pond. In this case there will be very little modification in the present alignment of the drain as the drain may be straightened and strengthened with capacity in the area between the fly ash pond and bottom ash pond. However, the drain caries discharge from Bhushan plant area including discharge from iron ore washing plant etc. Hence it will be difficult for controlling water quality in the drain section where it passes through the ash pond area.

14 As second alternative, it is proposed to divert the drain along the boundary of ash pond area in by diverting to first south and then west direction. However, it is to be noted that in two stretches the cutting would be in the range of about 8 m to maintain bed slope of drain.

15 The estimated peak runoff in the drain for 50 year and 100 year return period are 55.5 m^3/s and 61.3 m^3/s. The Trapezoidal section drains are designed with a side slope of 1.5:1 (H:V) and longitudinal slope of 0.0015 m/m (1.5 m/km) to carry the runoff generated locally.

Annexure-I

Annual 1 day maximum rainfall (mm) at various stations

Year	Deogarh	Jamankiru	Jharsuguda	Kirimira	Kolobira	Kuchinda	Kusumi	Kutra	Laikera_BL_II	Sambalpur
1960			161.6				295.8			290.7
1961			197.9				254.2			220.4
1962			85.4				72.5			131
1963			155.4				164.6			156.4
1964			109.6				184.2			308.6
1965			67.6				211.4			98.3
1966			113.8				135.5			136.7
1967		237	132				116		156	188.5
1968			197.9				132.6			156
1969			186.6				101.1			113.2
1970			102				129			
1971		180	110.6			198.3	200.6		100	156.2
1972			137.8				85.2			131.3
1973		259	190.9			299.4	308.4		185	174.2
1974		114	102.3				170.2		94.1	101.4
1975		203.2	257.8				413			102.2
1976		128	131.4				180			205
1977		75	116.4				69			87.2
1978		115	103				265			42.4
1979		126	81.4				70			63.4
1980			120.3				160			188.1
1981		100	82.2	57	42		188		57.5	94
1982		112	196				83.1			581.9
1983		147	110.2				164.2		91	206.8
1984		219	128				278.6		182	177
1985		205	97.7				130.6		132	216.8
1986		178.8	118.3				143.2		91	167.8
1987		55	127.1				209.2		187	100.8
1988		87	92.3				148.2		68	95.6
1989		113	174.3				155.6		86	86.4
1990		132.6	83.2				84.8		112	107.8
1991		176	118.7	126	133	120	129.6	105	94	193.1
1992	210	153			96	139	158	68	78	159.6
1993	80.2		130.8				233.8			200.8
1994	74.8	123	185.6	178	104	121.4	227.4	119	115	189.2
1995		101	152.7	86	78	60	217	74	62	95.6
1996		177	96.6	108	147	218.5	220.8	123	146	126
1997	84	53	123.4	52	68	41.4	110.4	91	40	199

Year	Deogarh	Jamankiru	Jharsuguda	Kirimira	Kolobira	Kuchinda	Kusumi	Kutra	Laikera_BL_II	Sambalpur
1998	110.5		170.8				243.8			146.3
1999	99.8		110.6				188.2			146.2
2000	62.6	55	58.6	36	65	45.8	82.8	119	30	99.2
2001	308.4	205	169.5	166	98	369	342.8	42	185	152.9
2002	47.2	75	195.1	111	85	78.6	125.2	39.4	98	84.2
2003	125	129	220.8	173	90	80.4		85.2	165	75.6
2004	122.5	150	170.3	230	108	99		189.8	306	155.8
2005		214	241.5	156	61	168.4		76.4	180	159
2006	162.9	86.8	98.7	105	149	94.8		117.4	220	283
2007	221.3	196.6	143.8	240	128	141.8		215.4	144	184
2008	138.6	153.2	191.8	210	207	175.8		136.2	195	220.8
2009	62.5	123.2	90.4	166	115	96.2		86.8	187	206.4
2010	118.6	54	76.7	72	96	50.2		144.2	85.2	99
2011	86.5	155	171.1	113	173	144.2		124.8	125.5	128.2
2012	58.4	98.6	224.4	273	221	192.6		100	350.2	120
2013	220	94	118.8	99	84	86.6	92.9	126	105.2	60.5
2014	263.1	256		106	222	319		160	123	
2015		154.4		162	165	95.4		196	142.2	
2016		106		105	58	82.2		110	83.3	

Annexure-II

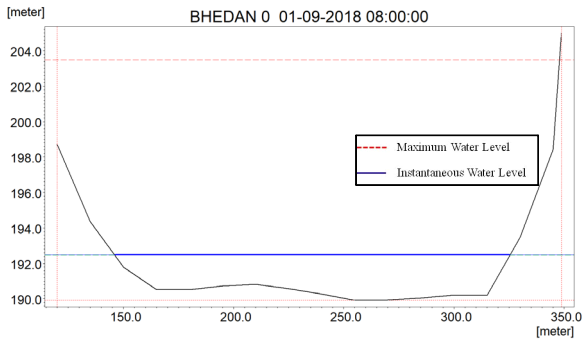
Effective rainfall and Runoff for various return period

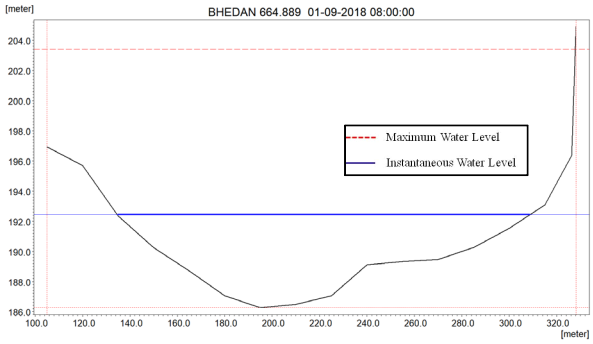
Time (h)	50 Year		100 Year	
	Rainfall (cm)	Runoff (m^3/s)	Rainfall (cm)	Runoff (m^3/s)
1	0.407	318.55	0.476	318.55
2	0.407	322.01	0.476	322.6
3	0.407	328.93	0.476	330.69
4	0.407	338.29	0.476	341.64
5	0.546	350.5	0.632	355.92
6	0.546	367.55	0.632	375.81
7	0.546	391.49	0.632	403.69
8	0.685	421.95	0.788	439.17
9	0.546	464.75	0.632	488.96
10	0.407	521.01	0.476	554.45
11	0.407	592.33	0.476	637.53
12	0.268	682.88	0.319	743.05
13	0.685	795.51	0.788	874.31
14	0.685	937.59	0.788	1039.73
15	0.964	1110.56	1.101	1240.96
16	0.964	1318.91	1.101	1483.1
17	1.521	1563.45	1.727	1767.11
18	1.799	1832.73	2.039	2079.42
19	2.634	2116.05	2.978	2407.29
20	**4.583**	2410.51	**5.167**	2747.15
21	2.077	2732.64	2.352	3117.37
22	1.242	3055.67	1.414	3487.88
23	0.825	3371.46	0.945	3849.63
24	0.685	3690.58	0.788	4214.54
25		4020.99		4591.56
26		4374.84		4994.31
27		4762		5433.81
28		5221.53		5954.04
29		5754.9		6556.7
30		6356.57		7235.56
31		7009.76		7971.63
32		7686.18		8733.2
33		8359.81		9490.88
34		8983.29		10191.4
35		9510.77		10783.21
36		9877.73		11193.63
37		**9956.07**		**11278.65**
38		9744.14		11036.34

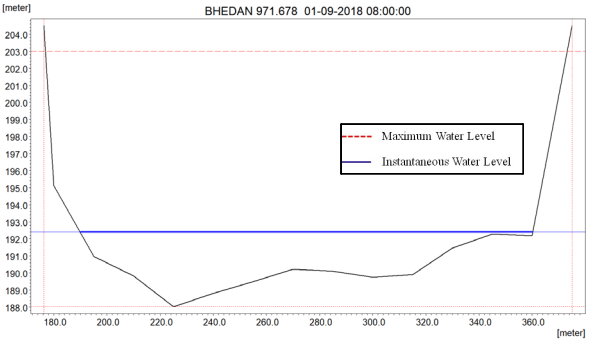
Time (h)	50 Year		100 Year	
	Rainfall (cm)	Runoff (m^3/s)	Rainfall (cm)	Runoff (m^3/s)
39		9327.15		10562.34
40		8776.83		9937.24
41		8160.22		9236.33
42		7537.67		8528.11
43		6937.19		7844.8
44		6367.24		7196.2
45		5842.61		6599.1
46		5346.57		6034.74
47		4883.76		5508.27
48		4453.51		5018.87
49		4049.69		4559.68
50		3660.42		4117.19
51		3303.34		3711.28
52		2978.34		3341.78
53		2679.6		3002.11
54		2413.23		2699.16
55		2171.08		2423.81
56		1953.01		2175.84
57		1756.48		1952.37
58		1580.09		1751.85
59		1423.35		1573.65
60		1283.15		1414.27
61		1160.5		1274.82
62		1054.76		1154.56
63		961.38		1048.36
64		870.97		945.66
65		798.05		862.74
66		732.68		788.44
67		672.39		719.93
68		614.75		654.48
69		555.56		587.41
70		503.1		527.97
71		454.07		472.42
72		413.57		426.52
73		383.2		392.03
74		358.02		363.47
75		337.72		340.44
76		328.02		329.4
77		323.11		323.79
78		320.06		320.29
79		318.55		318.55

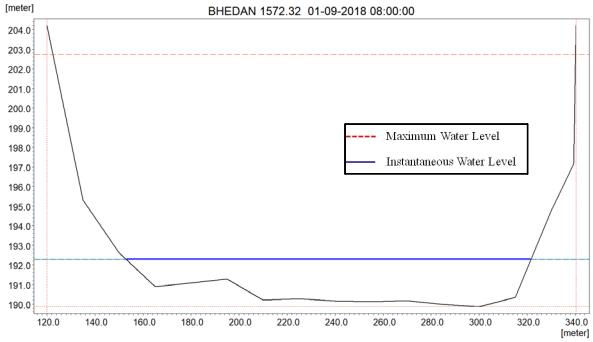
Annexure-III

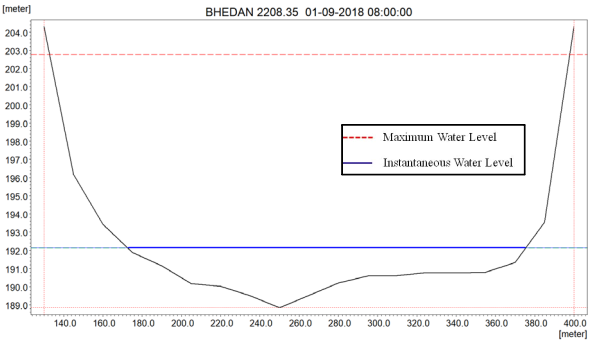
Cross Section profile with embankment

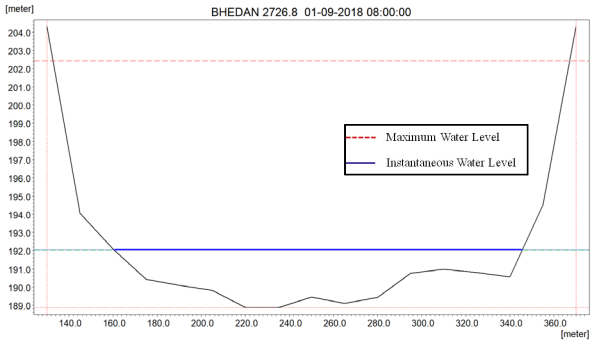


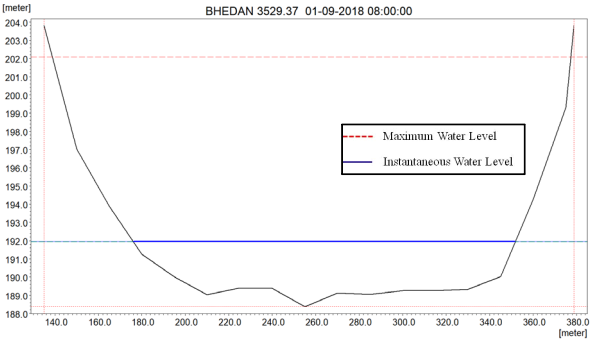


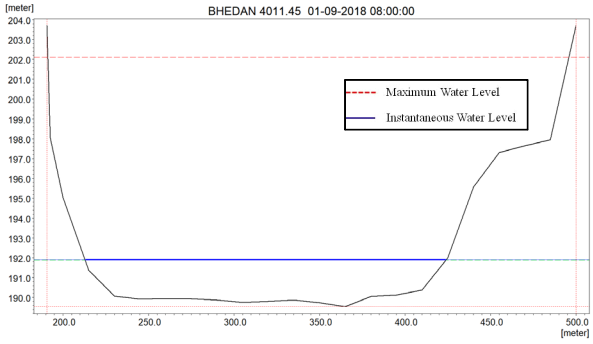


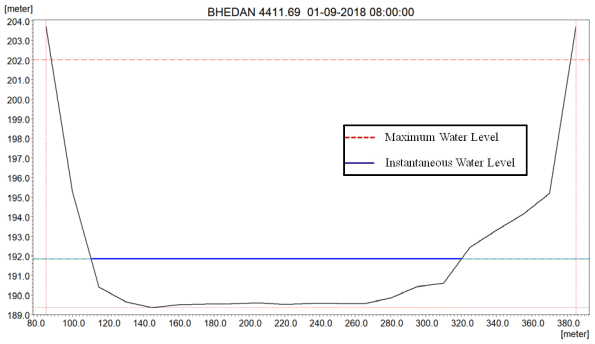


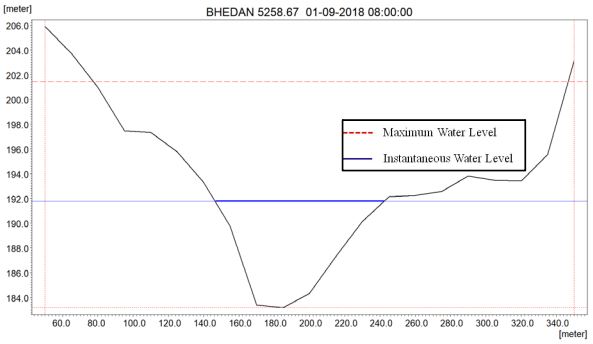


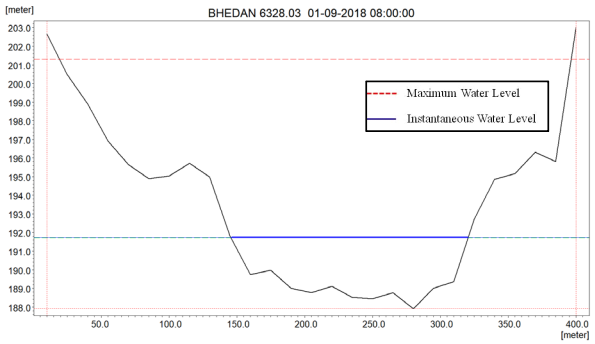


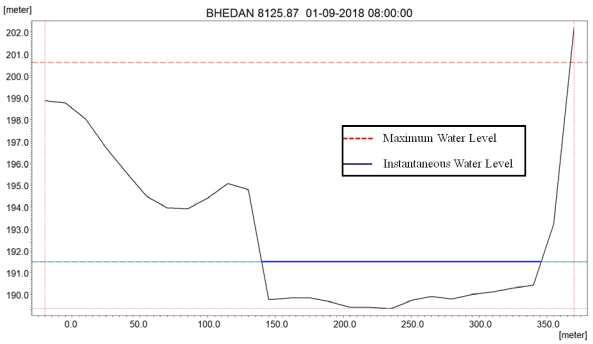


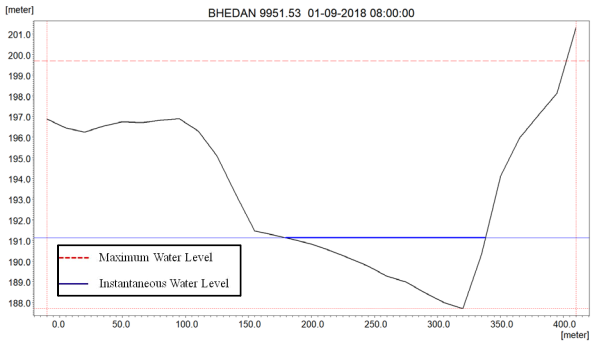



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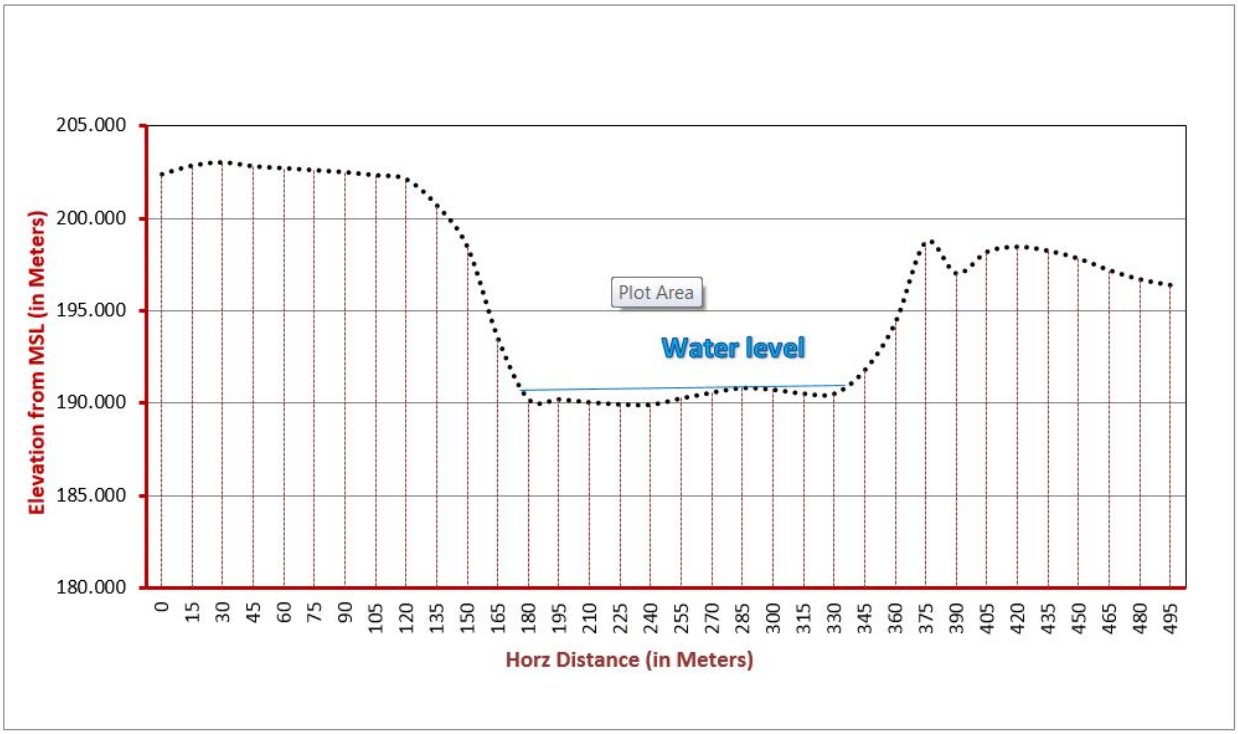

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Maximum Water Level
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Cross Section - 1









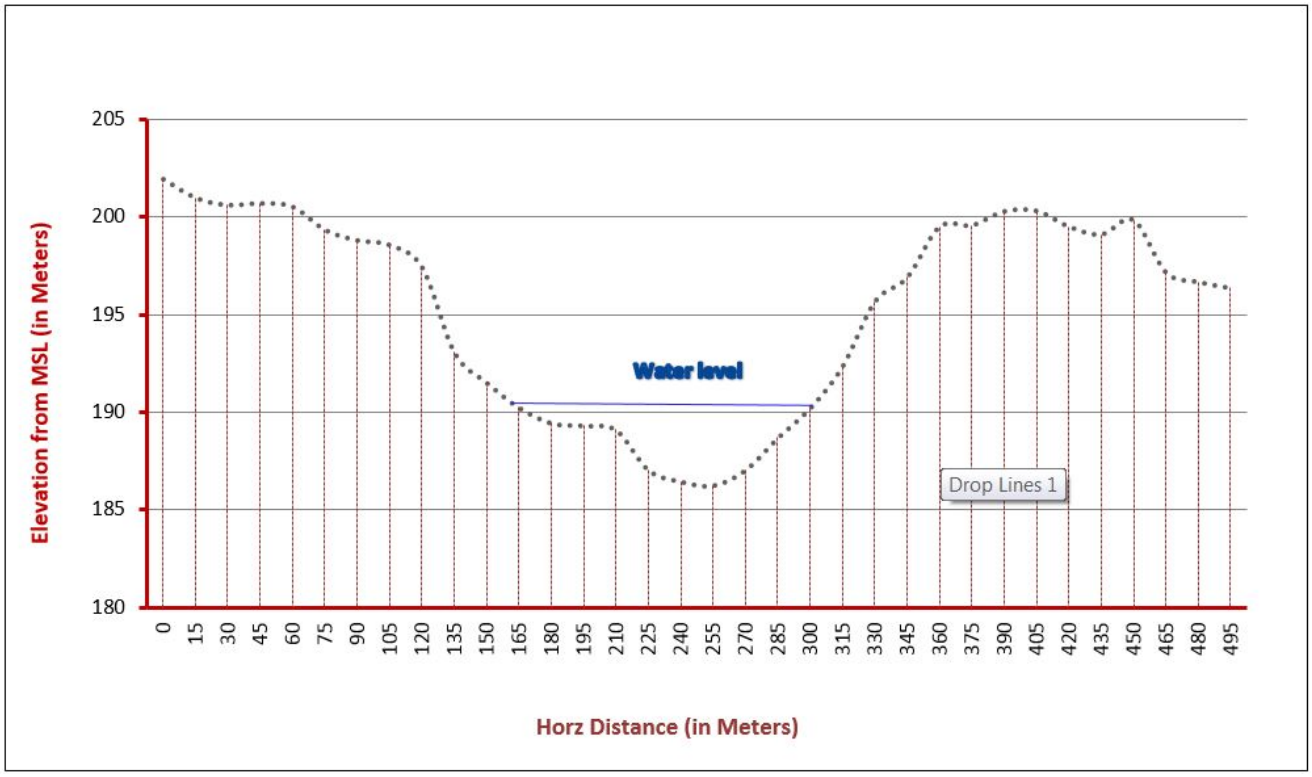
CROSS SECTION 01		
Chainage	**RL**	**Remarks**
0	202.362	
15	202.836073	
30	203.0000875	
45	202.7905352	
60	202.6896835	
75	202.5851793	
90	202.4725887	
105	202.3099194	
120	202.086608	
135	200.668958	
150	198.4176781	
165	193.4768848	
180	190.2011523	
195	190.2066824	
210	190.0432711	
225	189.9389895	
240	189.9212303	
255	190.2683263	
270	190.5747622	
285	190.8239424	
300	190.730536	
315	190.5183377	
330	190.5120565	
345	191.7901078	
360	194.3638458	
375	198.7068299	
390	196.9988018	
405	198.1773712	
420	198.4425666	
435	198.2319406	
450	197.8045302	
465	197.1784823	
480	196.6835214	
495	196.3745428	

Cross Section - 2









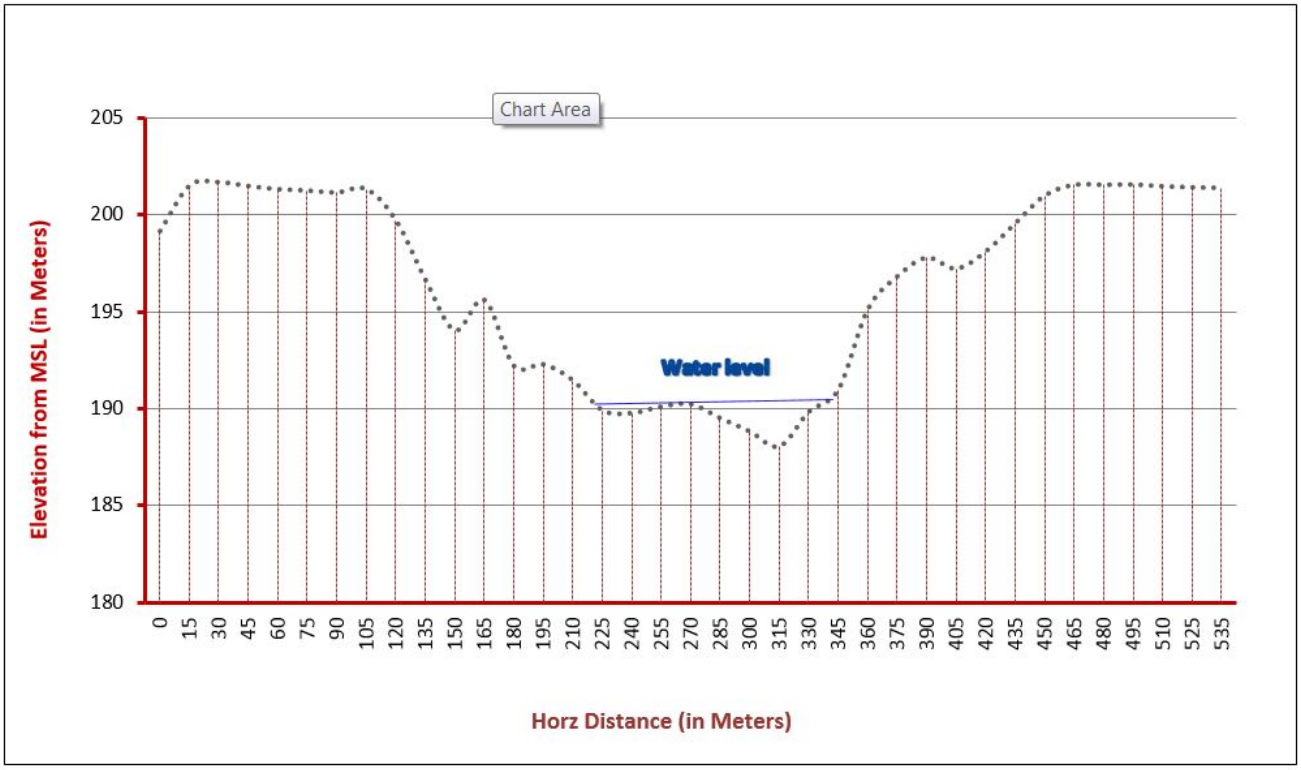
CROSS SECTION 02		
Chainage	**RL**	**Remarks**
0	201.95	
15	200.99	
30	200.62	
45	200.71	
60	200.54	
75	199.35	
90	198.82	
105	198.58	
120	197.44	
135	193.08	
150	191.53	
165	190.25	
180	189.46	
195	189.33	
210	189.10	
225	187.06	
240	186.47	
255	186.26	
270	187.05	
285	188.70	
300	190.22	
315	192.36	
330	195.68	
345	196.92	
360	199.52	
375	199.59	
390	200.30	
405	200.33	
420	199.52	
435	199.12	
450	199.85	

Cross Section – 3





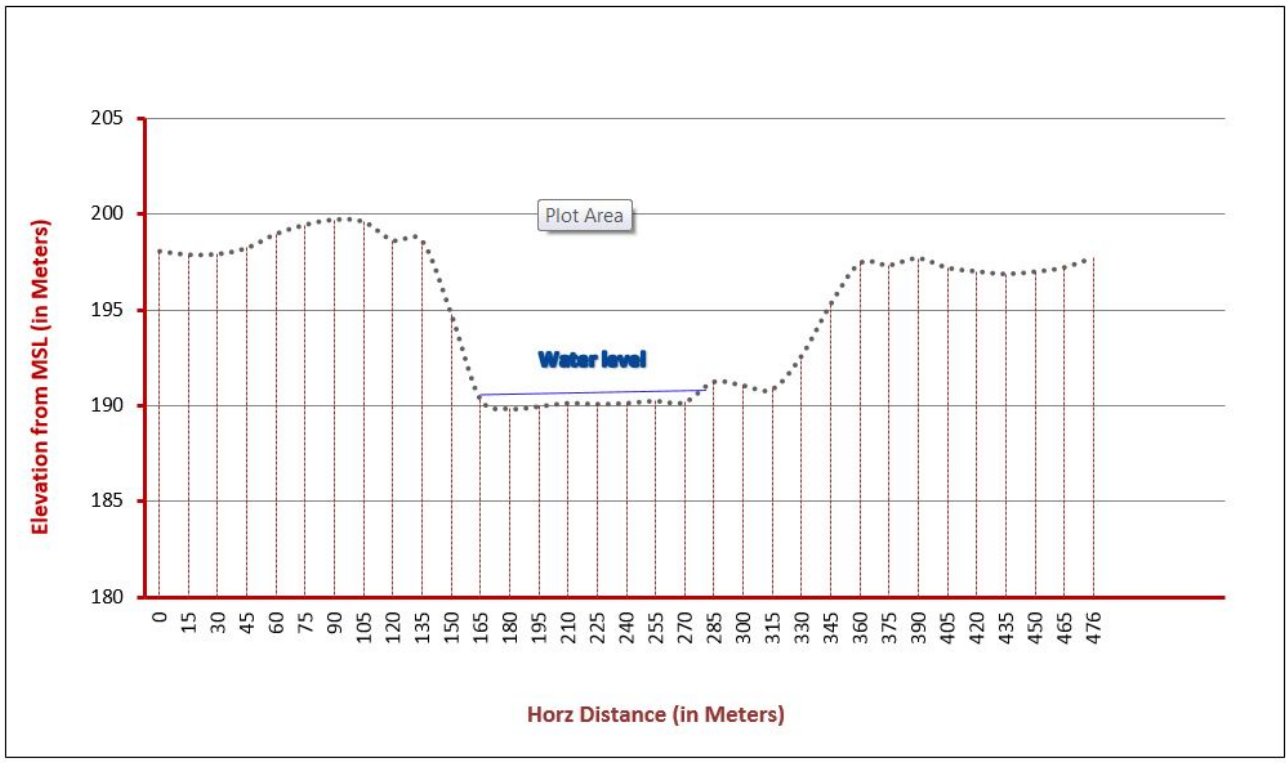




CROSS SECTION 03		
Chainage	**RL**	**Remarks**
0	199.17	
15	201.52	
30	201.69	
45	201.49	
60	201.33	
75	201.26	
90	201.16	
105	201.33	
120	199.72	
135	196.64	
150	194.03	
165	195.61	
180	192.19	
195	192.28	
210	191.45	
225	189.90	
240	189.76	
255	190.09	
270	190.22	
285	189.49	
300	188.81	
315	188.03	
330	189.82	
345	190.96	
360	195.12	
375	196.82	
390	197.78	
405	197.22	
420	198.11	
435	199.56	
450	201.00	
465	201.55	
480	201.55	
495	201.57	
510	201.48	
525	201.43	
535	201.40	

Cross Section - 4





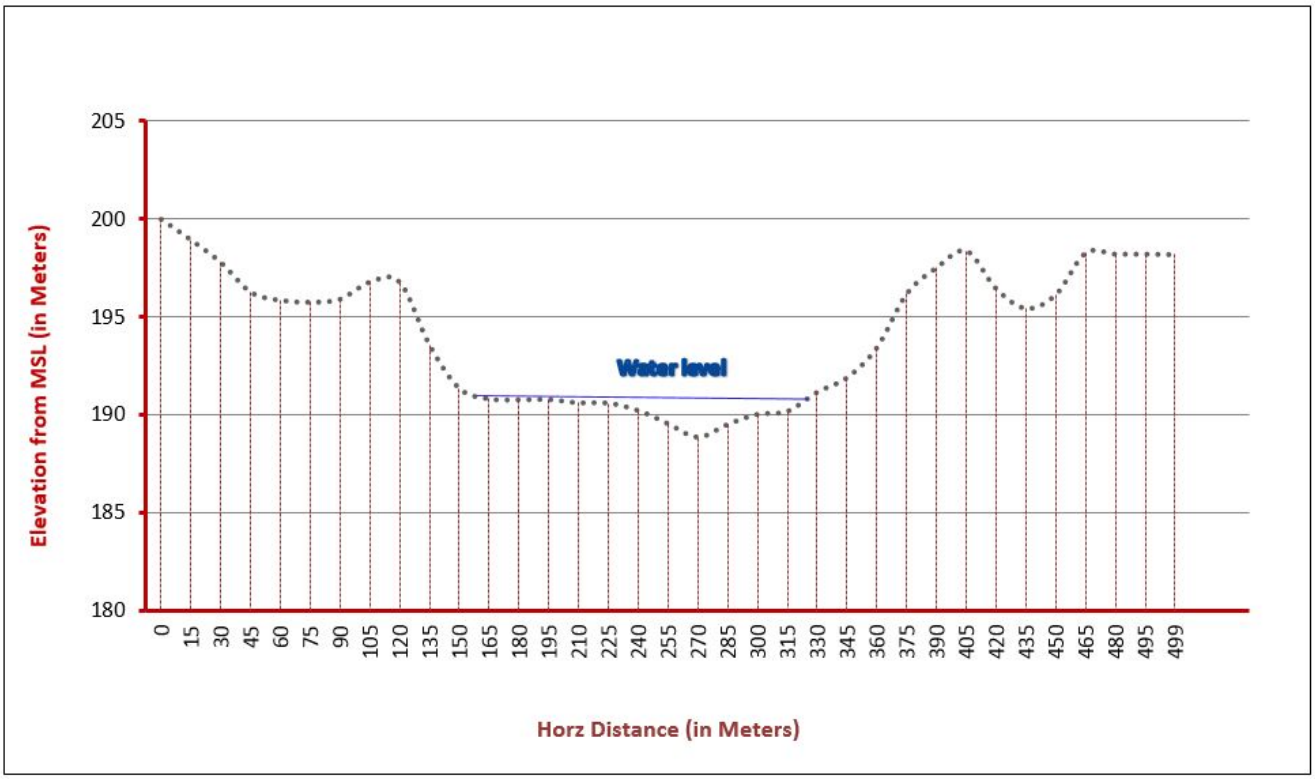
CROSS SECTION 04		
Chainage	**RL**	**Remark**
0	198.07	
15	197.89	
30	197.93	
45	198.25	
60	198.98	
75	199.46	
90	199.72	
105	199.60	
120	198.63	
135	198.60	
150	194.78	
165	190.34	
180	189.87	
195	189.99	
210	190.17	
225	190.12	
240	190.16	
255	190.28	
270	190.21	
285	191.28	
300	191.08	
315	190.89	
330	192.61	
345	195.30	
360	197.45	
375	197.35	
390	197.70	
405	197.22	
420	197.03	
435	196.89	
450	197.01	
465	197.23	
476	197.74	

Cross Section – 5









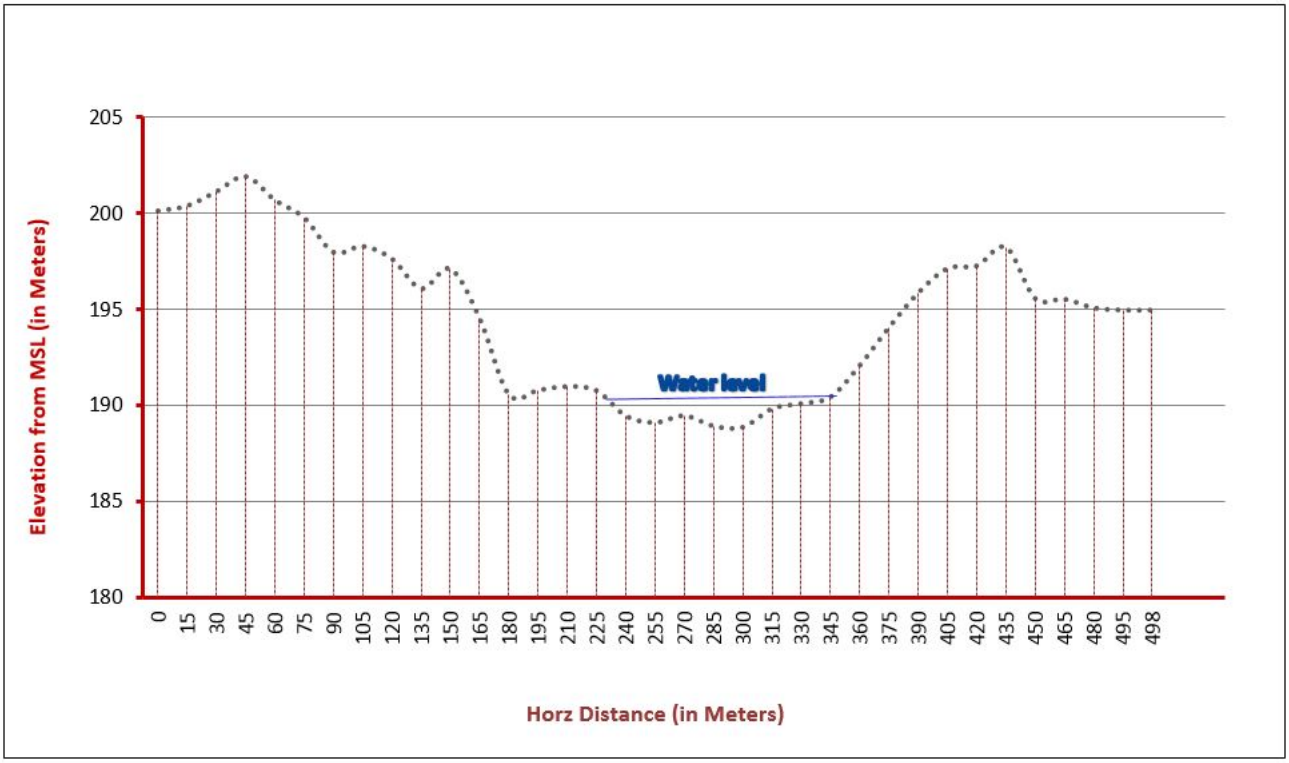
CROSS SECTION 05		
Chainage	RL	Remark
0	199.986	
15	198.927	
30	197.772	
45	196.26	
60	195.844	
75	195.747	
90	195.904	
105	196.782	
120	196.77	
135	193.54	
150	191.337	
165	190.804	
180	190.756	
195	190.77	
210	190.605	
225	190.588	
240	190.211	
255	189.532	
270	188.851	
285	189.511	
300	190.019	
315	190.17	
330	191.152	
345	191.892	
360	193.427	
375	196.179	
390	197.508	
405	198.369	
420	196.437	
435	195.433	
450	196.127	
465	198.268	
480	198.205	
495	198.205	
499	198.178	

Cross Section - 6









CROSS SECTION 06

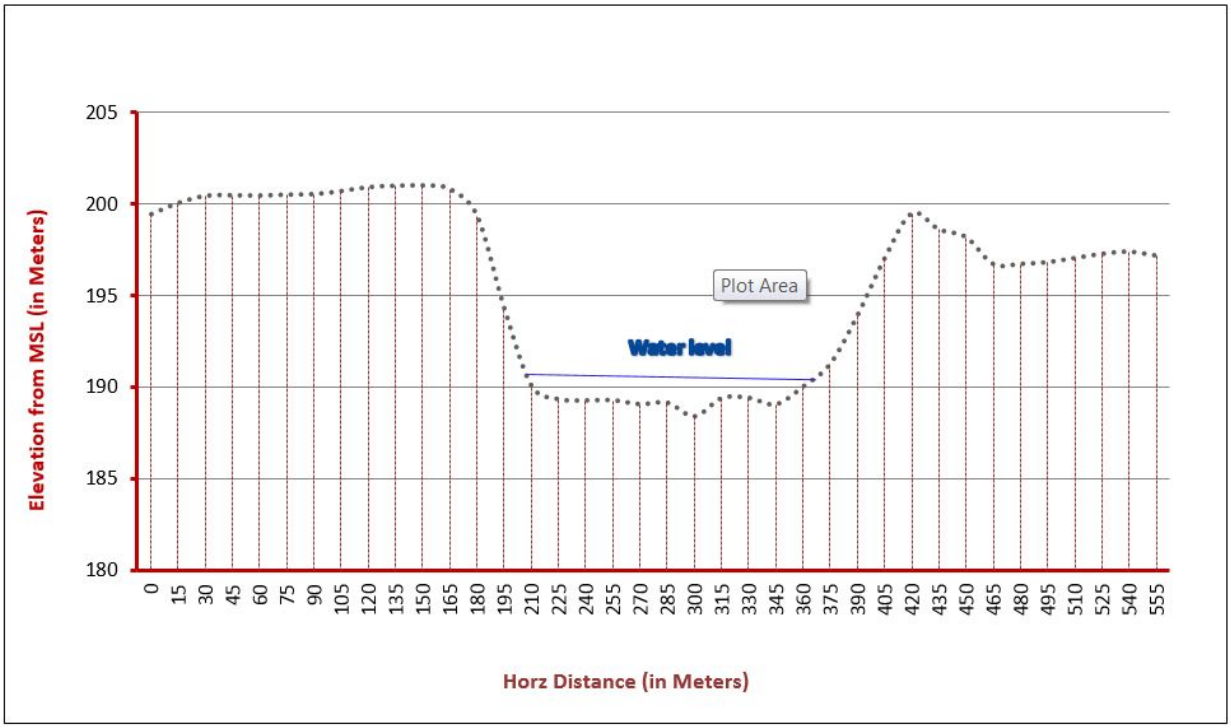
Chainage	RL	Remark
0	200.126	
15	200.386	
30	201.135	
45	201.917	
60	200.676	
75	199.761	
90	197.969	
105	198.284	
120	197.622	
135	196.079	
150	197.103	
165	194.505	
180	190.547	
195	190.787	
210	190.977	
225	190.762	
240	189.439	
255	189.099	
270	189.454	
285	188.918	
300	188.857	
315	189.82	
330	190.088	
345	190.433	
360	192.082	
375	194.059	
390	195.86	
405	197.124	
420	197.262	
435	198.226	
450	195.559	
465	195.532	
480	195.074	
495	194.958	
498	194.955	

Cross Section - 7









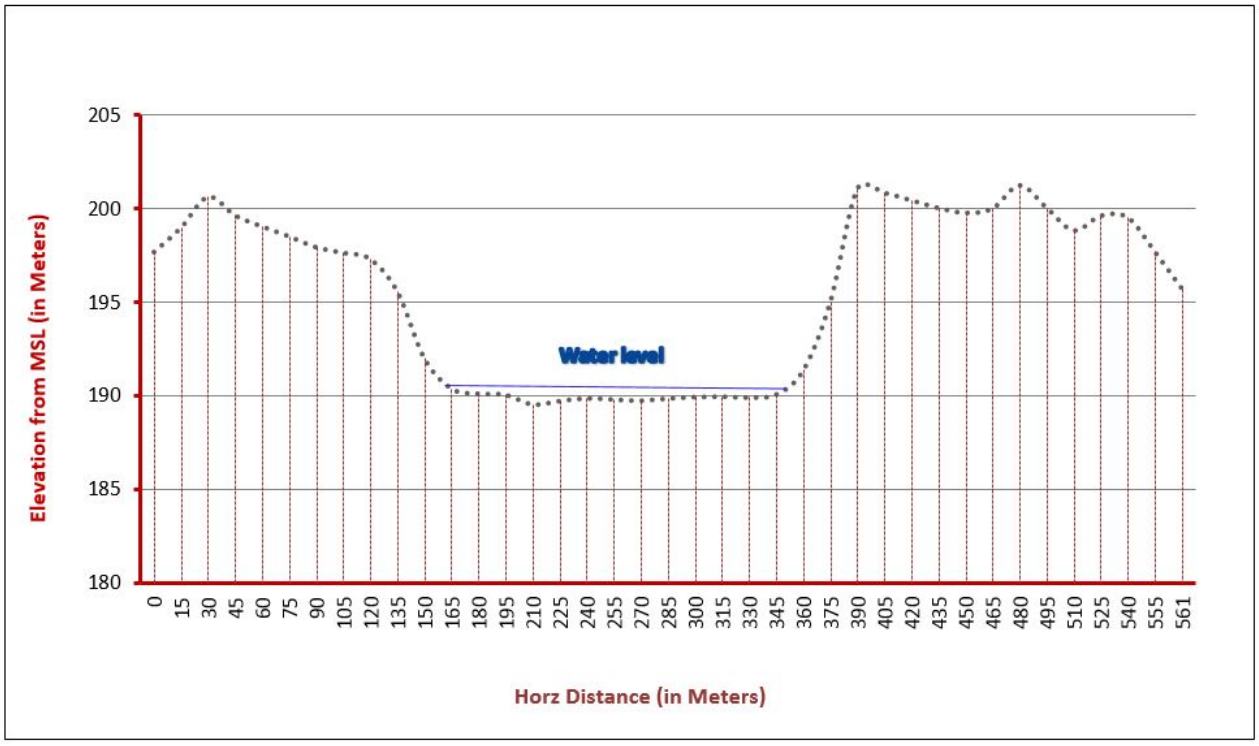
CROSS SECTION 07		
Chainage	**RL**	**Remark**
0	199.43	
15	200.048	
30	200.432	
45	200.459	
60	200.448	
75	200.497	
90	200.527	
105	200.696	
120	200.91	
135	200.981	
150	200.998	
165	200.795	
180	199.321	
195	194.258	
210	190.03	
225	189.32	
240	189.25	
255	189.263	
270	189.043	
285	189.129	
300	188.379	
315	189.38	
330	189.392	
345	189.034	
360	190.008	
375	191.256	
390	193.899	
405	197.02	
420	199.474	
435	198.591	
450	198.172	
465	196.701	
480	196.711	
495	196.806	
510	197.033	
525	197.26	
540	197.381	
555	197.161	

Cross Section - 8







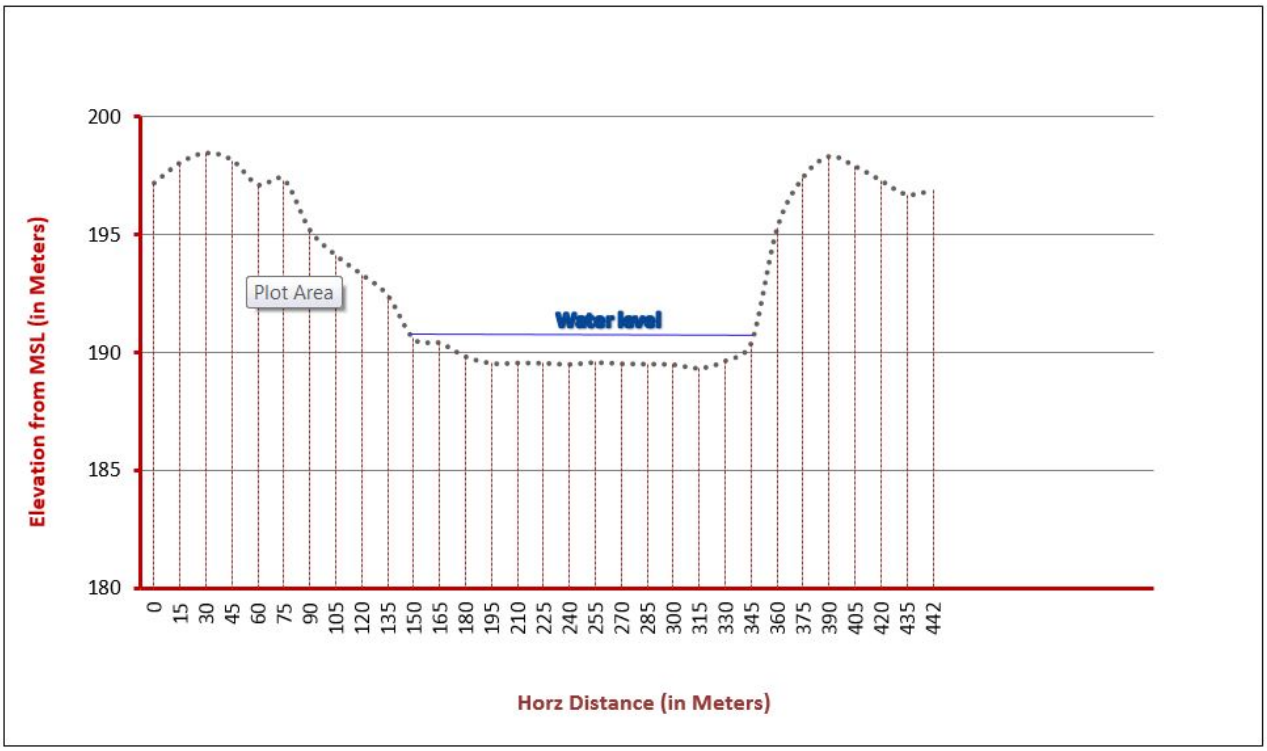


CROSS SECTION 08		
Chainage	**RL**	**Remark**
0	197.692	
15	198.993	
30	200.641	
45	199.641	
60	199.055	
75	198.518	
90	197.945	
105	197.644	
120	197.308	
135	195.562	
150	191.992	
165	190.383	
180	190.118	
195	190.055	
210	189.539	
225	189.73	
240	189.867	
255	189.806	
270	189.744	
285	189.861	
300	189.943	
315	189.961	
330	189.917	
345	190.071	
360	191.365	
375	195.034	
390	201.07	
405	200.854	
420	200.451	
435	200.042	
450	199.786	
465	200.016	
480	201.257	
495	200.046	
510	198.836	
525	199.631	
540	199.528	
555	197.693	
561	195.723	

Cross Section - 9



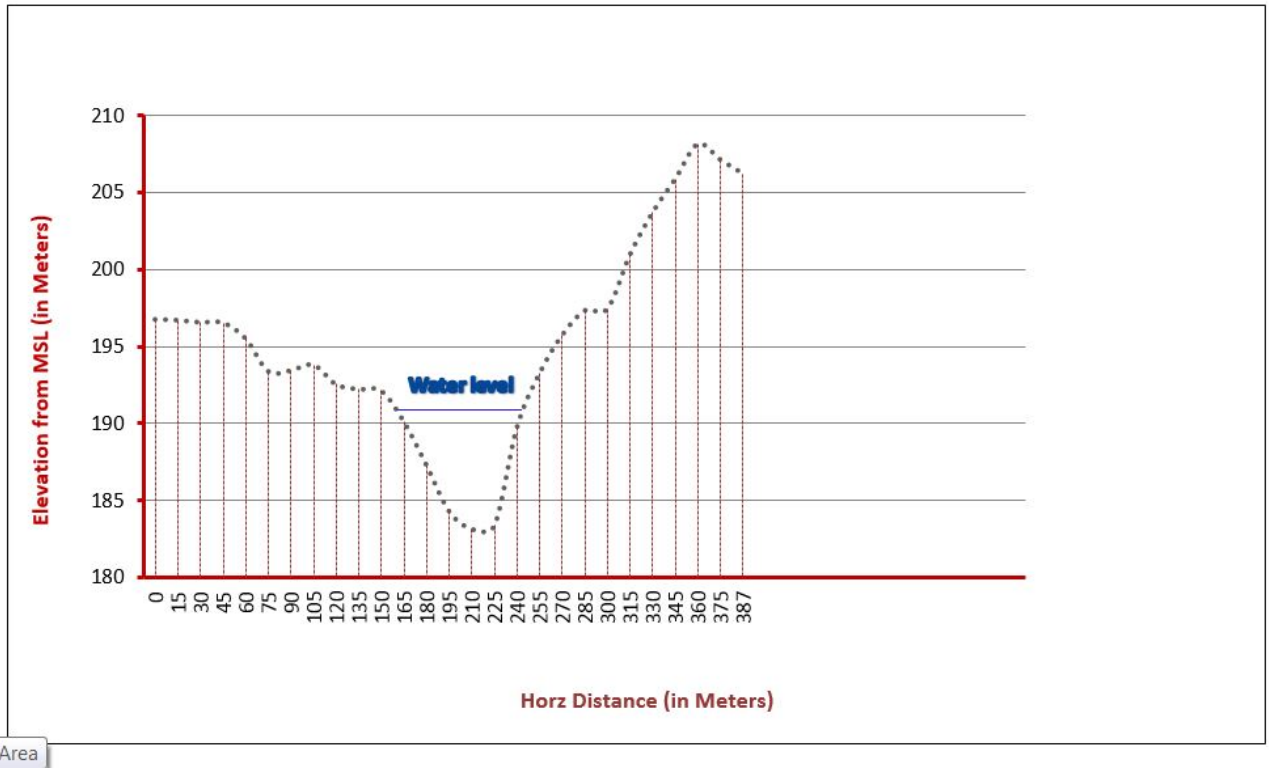




CROSS SECTION 09		
Chainage	**RL**	**Remark**
0	197.173	
15	198.03	
30	198.441	
45	198.145	
60	197.09	
75	197.314	
90	195.188	
105	194.123	
120	193.309	
135	192.425	
150	190.591	
165	190.425	
180	189.842	
195	189.559	
210	189.578	
225	189.57	
240	189.518	
255	189.599	
270	189.546	
285	189.531	
300	189.51	
315	189.356	
330	189.662	
345	190.411	
360	195.263	
375	197.412	
390	198.294	
405	197.878	
420	197.278	
435	196.686	
442	196.881	

Cross Section - 10





t Area

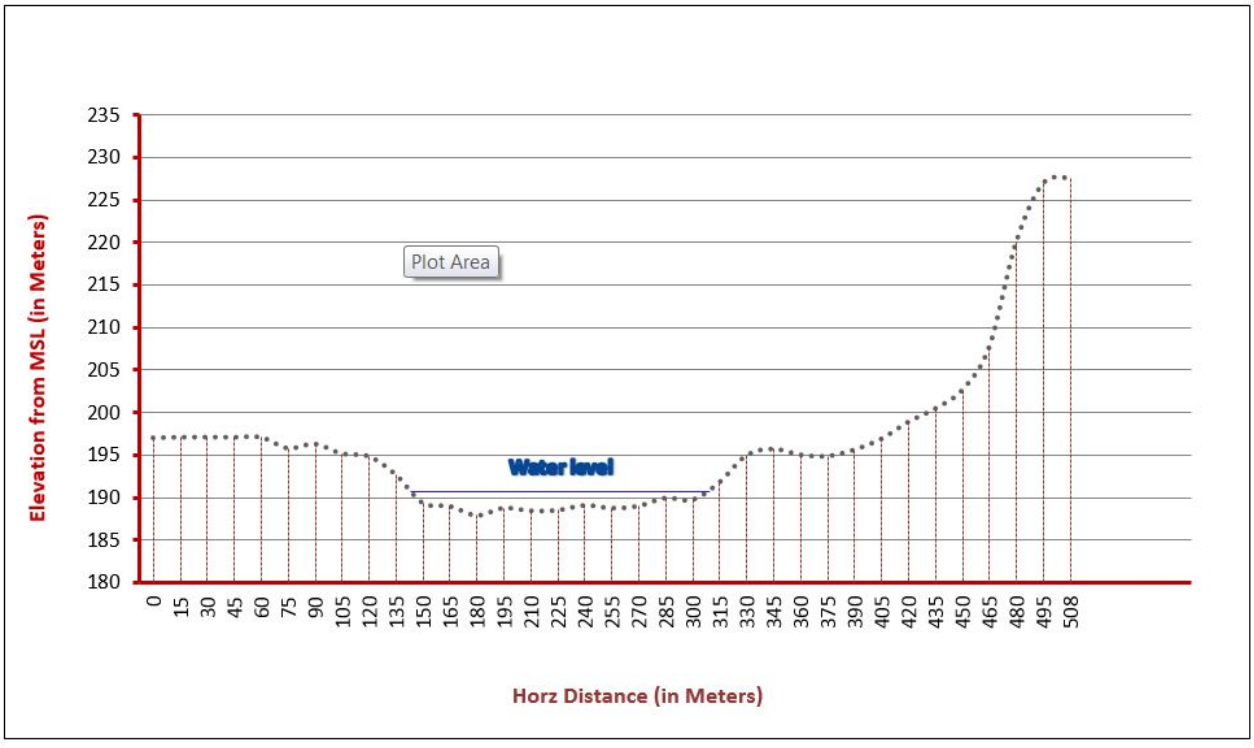
CROSS SECTION 10		
Chainage	**RL**	**Remark**
0	196.764	
15	196.711	
30	196.573	
45	196.539	
60	195.527	
75	193.398	
90	193.449	
105	193.811	
120	192.551	
135	192.234	
150	192.124	
165	190.124	
180	187.3	
195	184.315	
210	183.166	
225	183.381	
240	189.777	
255	193.285	
270	195.749	
285	197.341	
300	197.457	
315	200.982	
330	203.715	
345	205.881	
360	208.134	
375	207.103	
387	206.213	

Cross Section - 11









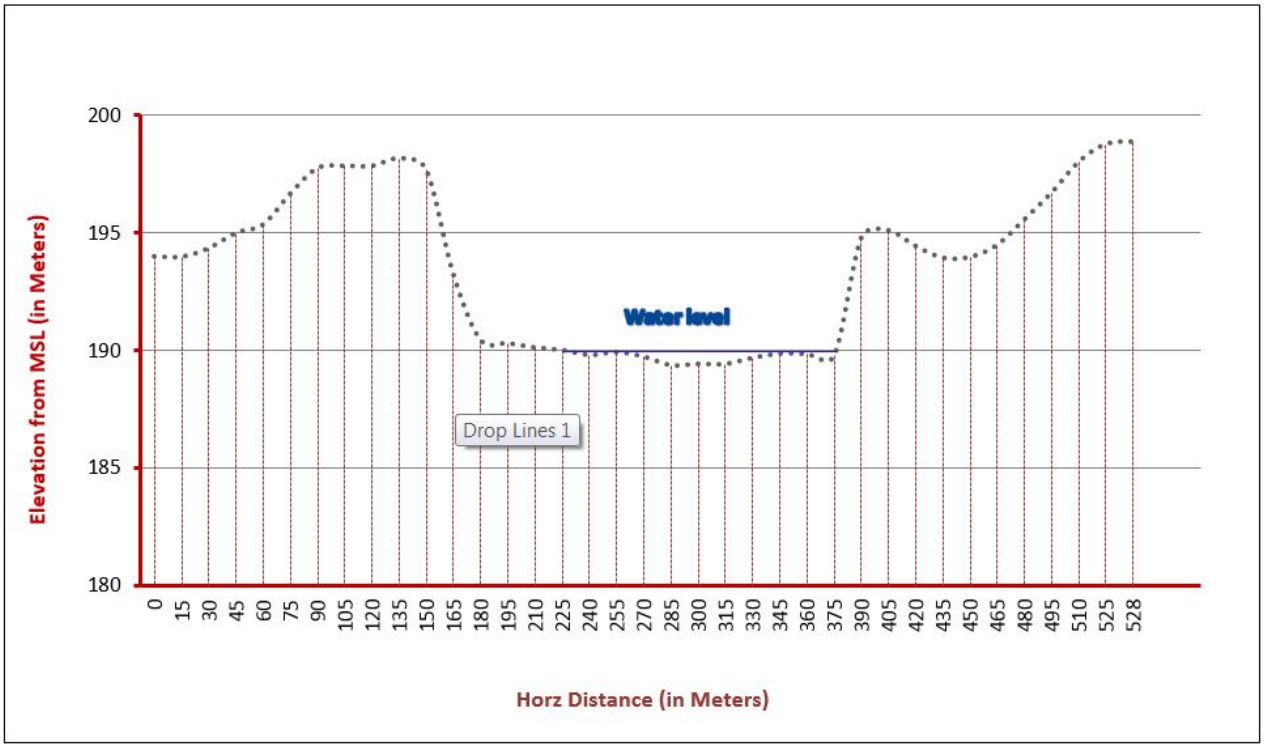
CROSS SECTION 11		
Chainage	**RL**	**Remark**
0	197.035	
15	197.108	
30	197.126	
45	197.102	
60	197.105	
75	195.806	
90	196.315	
105	195.166	
120	194.848	
135	192.702	
150	189.358	
165	189.002	
180	187.912	
195	188.772	
210	188.452	
225	188.515	
240	189.102	
255	188.772	
270	189.008	
285	189.977	
300	189.739	
315	191.815	
330	194.981	
345	195.723	
360	195.04	
375	194.888	
390	195.642	
405	196.913	
420	198.91	
435	200.476	
450	202.662	
465	207.723	
480	220.073	
495	226.985	
508	227.579	

Cross Section - 12









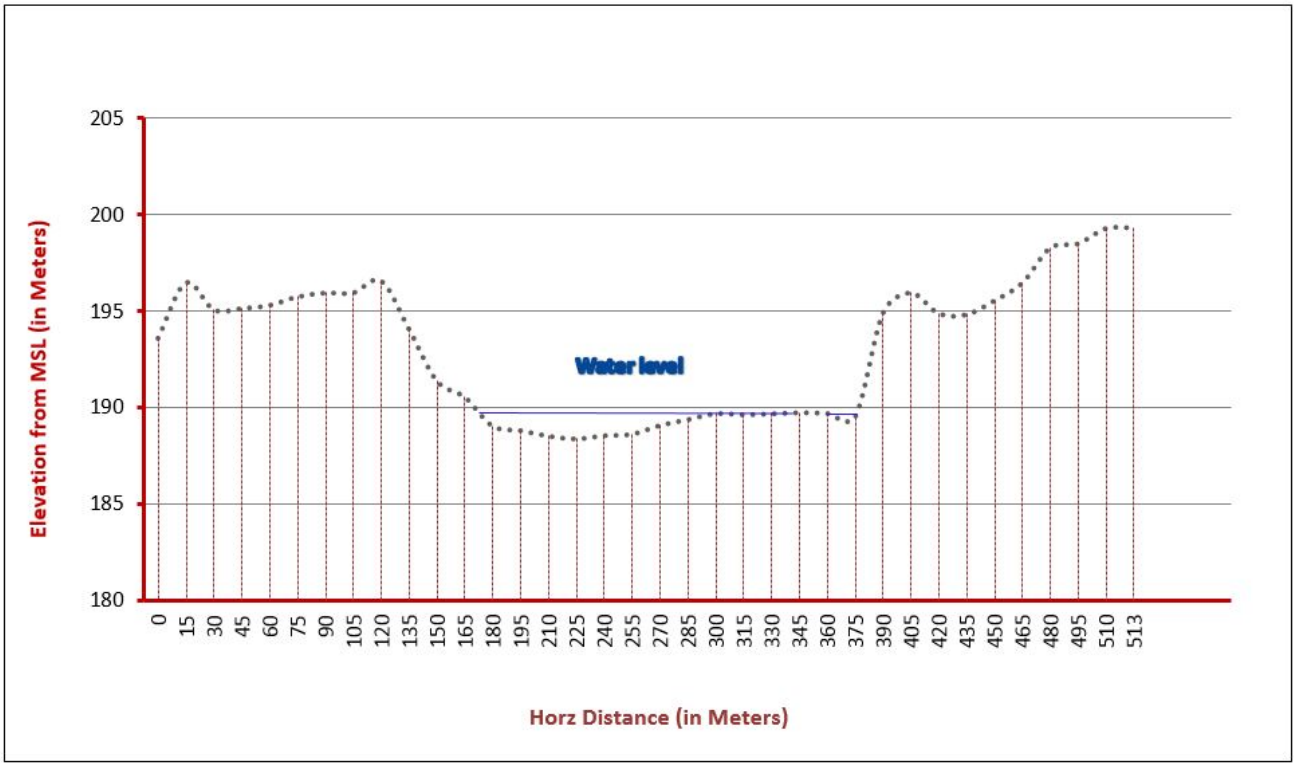
CROSS SECTION 12		
Chainage	**RL**	**Remark**
0	193.982	
15	193.964	
30	194.323	
45	194.975	
60	195.329	
75	196.636	
90	197.731	
105	197.823	
120	197.82	
135	198.146	
150	197.664	
165	193.215	
180	190.425	
195	190.293	
210	190.107	
225	190.003	
240	189.791	
255	189.909	
270	189.722	
285	189.352	
300	189.412	
315	189.408	
330	189.672	
345	189.852	
360	189.838	
375	189.762	
390	194.786	
405	195.082	
420	194.411	
435	193.919	
450	193.954	
465	194.48	
480	195.564	
495	196.703	
510	198.015	
525	198.763	
528	198.86	

Cross Section - 13









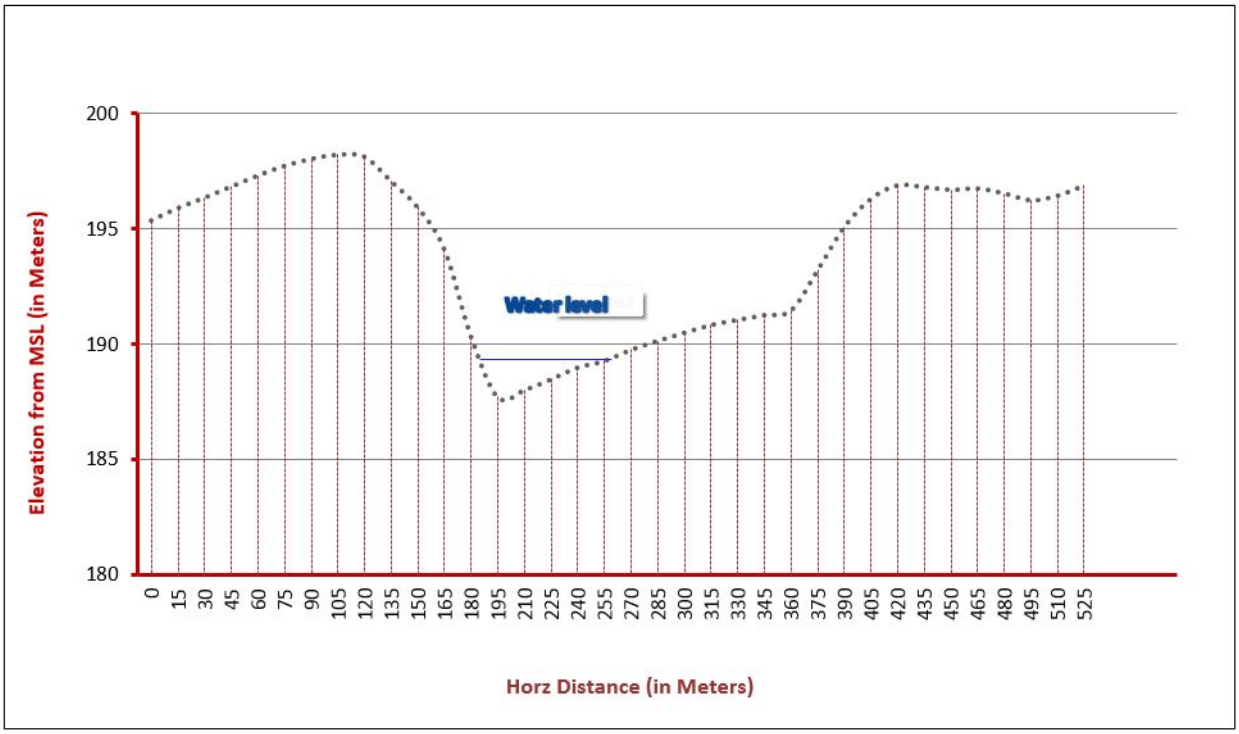
CROSS SECTION 13		
Chainage	**RL**	**Remark**
0	193.624	
15	196.494	
30	195.098	
45	195.165	
60	195.328	
75	195.769	
90	195.971	
105	195.974	
120	196.597	
135	194.091	
150	191.406	
165	190.567	
180	189.064	
195	188.83	
210	188.545	
225	188.401	
240	188.569	
255	188.644	
270	189.1	
285	189.4	
300	189.71	
315	189.654	
330	189.701	
345	189.758	
360	189.721	
375	189.54	
390	194.937	
405	195.975	
420	194.896	
435	194.853	
450	195.576	
465	196.492	
480	198.309	
495	198.522	
510	199.321	
513	199.326	

Cross Section - 14









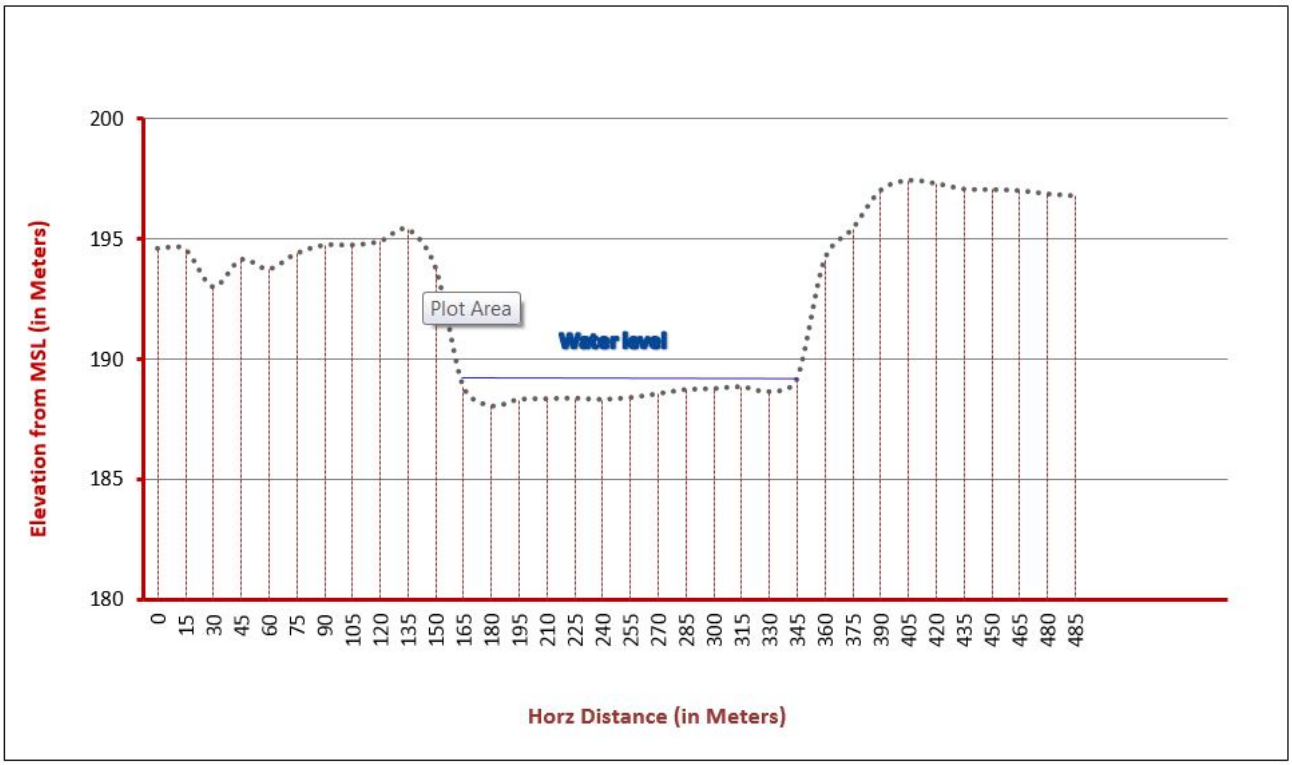
CROSS SECTION 14		
Chainage	**RL**	**Remark**
0	195.361	
15	195.902	
30	196.348	
45	196.828	
60	197.311	
75	197.728	
90	198.033	
105	198.21	
120	198.128	
135	197.062	
150	195.93	
165	194.107	
180	190.321	
195	187.699	
210	188.003	
225	188.476	
240	188.987	
255	189.271	
270	189.756	
285	190.141	
300	190.495	
315	190.831	
330	191.054	
345	191.259	
360	191.459	
375	193.204	
390	195.084	
405	196.299	
420	196.89	
435	196.809	
450	196.696	
465	196.749	
480	196.538	
495	196.239	
510	196.44	
525	196.881	

Cross Section - 15

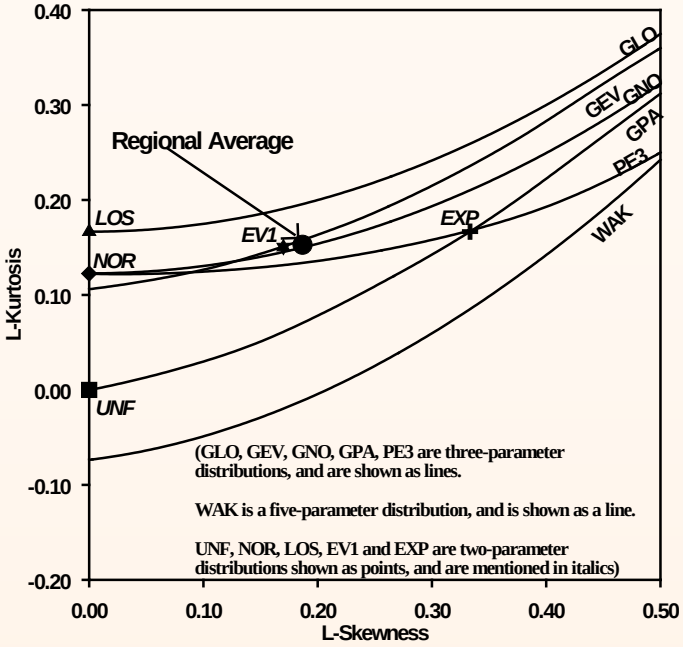


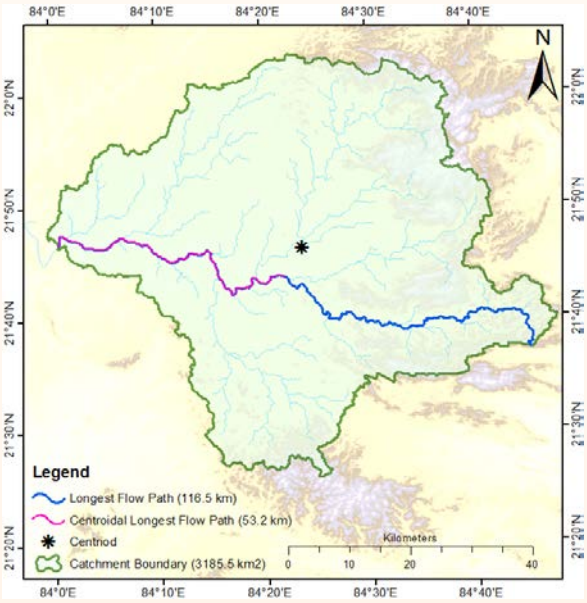


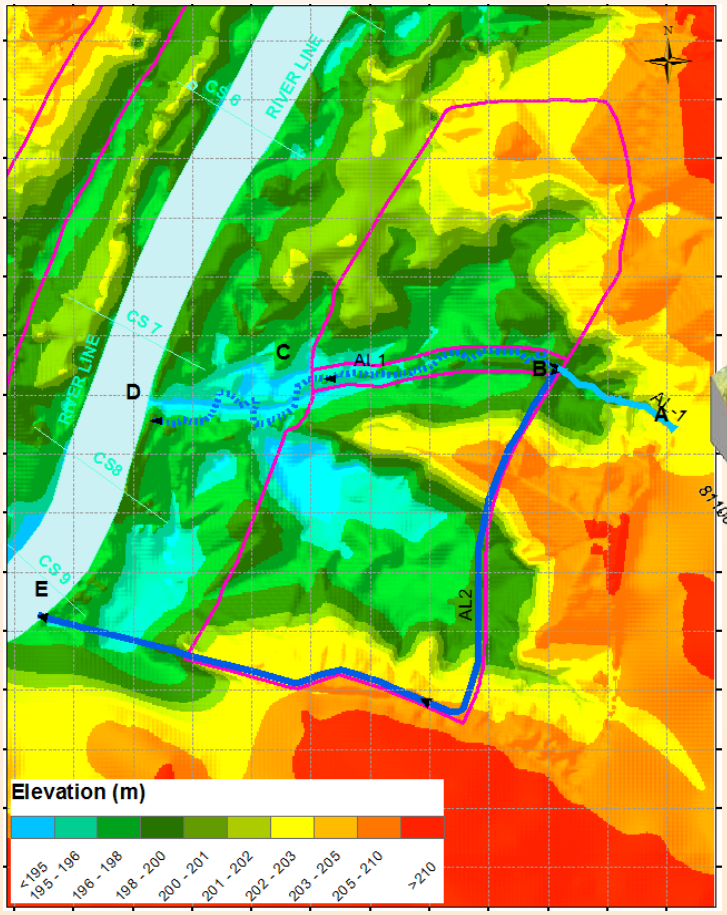


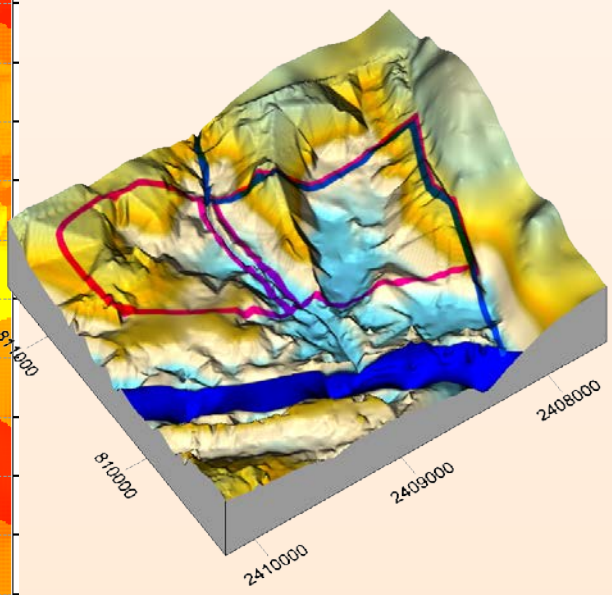


CROSS SECTION 15		
Chainage	**RL**	**Remark**
0	194.593	
15	194.543	
30	192.988	
45	194.129	
60	193.737	
75	194.388	
90	194.727	
105	194.735	
120	194.889	
135	195.389	
150	193.798	
165	188.847	
180	188.041	
195	188.306	
210	188.334	
225	188.359	
240	188.307	
255	188.384	
270	188.543	
285	188.718	
300	188.753	
315	188.833	
330	188.632	
345	189.153	
360	194.138	
375	195.406	
390	196.997	
405	197.421	
420	197.294	
435	197.067	
450	197.043	
465	197	
480	196.865	
485	196.782	









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