Request for Proposal

For

DEVELOPMENT OF BORSOLA BEEL

Design, Build and Operate Basis

Volume II A: Project Description

Client:

GUWAHATI SMART CITY LIMITED

GSCL,

Guwahati, Assam

DOCUMENT NO: 10477A-CV-3000-3102

1.1 Project Description:

Borsola Beel is located at the prime location of the Guwahati city, nearby Paltan Bazar, Guwahati Station and well connected with Guwahati-Shillong road. Due to the prime location of the Beel, it has huge potential to develop as recreational purpose, eco-tourism park and the Beel can also be used for natural retention pond during monsoon from the flood mitigation point of view. Present condition of the Beel is very much poor due to the unauthorized disposal of solid waste at the upstream channel of the Beel as well as deposition of silt and sludge due to the presence of hill at upper catchment and in absence of sewerage network in the whole Guwahati city. Due to this the Beel is on the verge of so called water body.

To rejuvenate the Beel a sewage treatment plant (STP) to be developed, the ultimate design stage will be 30 years. According to that the capacity of the STP will be approx 30 MLD. Due to the space constraint, 15 MLD can be catered at the proposed STP at Borsola Beel location and remaining portion will be catered at downstream STP of Bharalu. Treated water will discharged to the Beel. Discharge level of the treated effluent shall be 0.3 m above the high flood level/full service level of the Borsola Beel.

So for the rejuvenation and development of the Beel following necessary broad works to be taken up:

a) Enabling Works
b) Ground Improvement
c) Inlet Works
d) Sewage Pumping Station (SPS)
e) Sewage Treatment Plant (STP)
f) Structural Works
g) Bridge Across Beel
h) Road
i) Sewage Interception & Collection Drain.
j) Development of Landscape
k) Cable Trench Duct

The above mentioned broad works are divided in to various component. Some work can be taken up consecutively and some can be taken up simultaneously. Detailed scope of work for the development of Borsola Beel are work out here under the each broad scope of work.

1.1.1 ENABLING WORKS

This enabling works consist of the following works which enables to cleaning up the Beel from deposited solid waste, water hyacinth, dismantling of existing structure of 1.5 MLD capacitate Sewage Treatment Plant (STP), construction of temporary bundh for diversion of sewage by constructing permanent sewerage network and other allied work, dewatering of the Beel with necessary pumping arrangement, removal of sludge as required depth of around 3.5 m, disposal of sludge at designated site with necessary treatment as per IS guidelines, refilling of bed of the Beel with approx.

500mm depth of sand, approx. 1500mm depth of gravel and approx. 1500mm depth of boulder and maintaining the slope as indicated in the drawing or as required .

1.1.2 GROUND IMPROVEMENT

Ground strengthening work at the Proposed 15 MLD STP location approx. 1.22 Ha. of land area by providing stone column with backfilling of approx 6.25 m to attain finish ground level (FGL) 50.25m and proper compaction to attain 95% proctor density all complete in all relevant works.

1.1.3 INLET WORKS

A weir at the upstream side of the Beel near existing STP will be constructed to arrest the sewage flow, with a provision of 2 lock gate arrangement and inlet arrangement of sewer pipe for bypassing of sewage during emergency. Salient features of Weir are as follows:

Length of Weir- Approx. 25.00m

Foundation Level- Approx. 44.00m

Bed Level of Beel- Approx. 46.50m

Weir Crest Level- Approx. 48.50m

Other works as per technical specification

A sewerage network to be design laying along the west bank of the Beel for bypass arrangement connecting upstream of Borsola Beel and disposing to Bharalu River. The network to be design for carrying capacity of 15 MLD. Material of pipe will be DI and all necessary guidelines should be followed as per related IS and Manual.

1.1.4 SEWAGE PUMPING STATION (SPS)

Sewage Pumping Station(SPS) to be designed for 30 years horizon. Sewage Pumping Station(SPS) consists of sewage Receiving Chamber, Coarse Screen Channel, Raw Sewage Sump(Wet Well), Pumping Station. The SPS will be designed for peak flow. Waste water will flow through 600mm diameter pipe by gravity flow and it will enter to inlet chamber. Two inlet chamber will be there, 1.2 m wide each with screen. There will be two type of pumps to cater peak and average flow. All pumps shall be operated with PLC. Collected sewage will be delivered to inlet chamber of STP through pumping.

1.1.5 SEWAGE TREATMENT PLANT (STP)

The technology adopted for treatment of sewage is open technology . The STP consists of following units:

1.1.5.1 Inlet Chamber: It receives sewage from SPS. The levels in the chamber shall be controlled through level controller. Suitable arrangement of walkway connecting inlet chamber, screen chamber and degritting system shall be provided.

1.1.5.2 Fine Screen Channel: The fine Screens shall receive sewage from the upstream inlet chamber. The screenings removed by the screens shall be discharged at the appropriate elevation above ground on to a conveyor. The velocity in the channel shall not be less than 0.3 m/sec during minimum flow conditions and not more than 1.2 m/sec during peak flow conditions. The mechanically operated Screens shall be equipped with a mechanism, which shall automatically rake at a pre-set timer control.

1.1.5.3 De-gritting Unit: The screened sewage shall flow from the fine screens to degritting systems. Two de-gritting systems shall be provided each capable of handling ultimate peak flow. The de-gritting tanks shall be of RCC.

1.1.5.4 Parshall Flume: A Parshall flume shall be provided at downstream of Grit Chamber. Parshall flume shall be designed as per IS: 14371:1996.

1.1.5.5 Secondary Biological Treatment Basins: process shall be designed to treat peak flow sewage for organic load reduction along with built-in nitrification-denitrification and biological phosphorus removal.

1.1.5.6 Disinfection: Chlorine Contact Tanks shall be provided for disinfection of treated sewage from the secondary and/ or tertiary treatment process. A complete Chlorination system with necessary safety accessory and controls shall be provided as per IS code.

All mechanical and electrical work related to STP should be done with proper as per the relevant technical specification attached with this document.

1.1.6 STRUCTURAL WORKS

Before commencement of the execution work, dismantling of existing walkway and detail investigation to be done for foundation of the existing structure (pile foundation or open foundation). However excavation to be carried out up to the foundation level of the retaining wall using concrete brakers. If there is a pile foundation of the existing structure it will be retained since it will provide additional soil strength to the new structure. If proposed pile location is over lapping with those existing old piles, location of new pile to be shifted as per site condition.

Cantilever retaining walls are made of reinforced concrete that consists of a thin stem and a base slab. Retaining wall is proposed all along the Beel for a length of 2600m. Height of retaining Wall is varying from 6m to 4.0m. So three type of retaining wall sections are designed to minimize the cost and economical. A cantilever (2.5m) portion is provided for pedestrian walking / Jogging Track. Foundation is proposed is Pile Foundation. Cantilever portion is kept above the Maximum Water Level.

The deck runs all along the 1500 mts Beel edge. The deck area has 10 viewing deck which gives accessibility to the Beel and 14 nos of trellis. Viewing deck will be the

cultural deck represent the rich cultural heritage of the seven sister states of North East India.. The Deck area steps down of the Beel and also creates a beautiful view of the Beel.

There will be 3 entrance gate for accessing to the landscape area of the Beel. 1200 mts in length of 1.5 mts brick masonry boundary wall to be constructed along the periphery of the landscape area on both the bank of the Beel.

1.1.7 BRIDGE ACROSS BEEL

One parking bridge at the downstream side of the Beel will be constructed with a parking capacity of 40+2 cars. The length and width of the bridge is around 70 mts and 20 mts respectively. The entire bridge consists of 3 nos. of pre-cast girders at regular spacing's.

Two nos. of pedestrian bridges of 70 mts in length and 5 mts wide with gate facility will be constructed. The deck level of the bridges should be maintained a clear height of 3.5 mts from the average water level.

One arch bridge at the upstream side of the Beel near the weir will be constructed. Arch bridge shall be a classic architectural presentation. The top width of the pathway will be 3.0m and length is around 20 m.

1.1.8 ROAD

A road length of 2350 mts with 6.0 m carriage way will be constructed along both the bank of the Beel along with electrical trench, storm sewer drain, water supply line.

1.1.9 SEWAGE INTERCEPTION & COLLECTION DRAIN

From the surrounding areas sewage water is connected with the Beel. All these drain needs to be intercepted and diverted to the upstream side of weir or channelized to downstream side of the Beel.

1.1.10 DEVELOPMENT OF LANDSCAPE

The development of landscape will be inclusive of softscape, hardscape and architectural block and gates etc. Development of toilet blocks, parking facility, shops etc. will be developed inside the landscaped area of the Beel. Grasscrete, pathway, fountain area, paving and railing will be developed. In softscaping works includes preparation of soil, planting of shrubs, planting of trees, installation of drip irrigation, sprinkler irrigation, electrical etc. as specified in the TS.

1.1.11 CABLE TRENCH DUCT

Construction of electrical trench of 2.0 km in length with 1.0 m wide and 1.5m depth RCC trench with necessary arrangement for HT cable as per technical specification and tender drawing.

		Implementation Schedule									
		Quarters									
Sl. No.	Items of works	Design and Drawing Stage	Execution Stage								
		1	2	3	4	5	6	7	8	9	10
1	**Diversion Weir and Diversion of Sewage**										
2	**Cleaning of Beel**										
3	**Infrastructural Work**										
a	Construction of Retaining Wall										
b	Bridges, Parking Bridge and Arch Bridge										
c	Other Infrastructural Work(Road, Drain, Water Supply Line, Electrical Trench)										
4	**Sewage Treatment Plant**										
a	Primary treatment works with electrical and mechanical works										
b	Secondary Treatment works including electrical and mechanical works										
c	Recycling unit including electrical and mechanical works										
5	**Outfall sewers with allied works**										
6	**Landscaping, parks, jogging track, footpaths**										
7	**Testing and commissioning**										
NOTE: 1. First six months are for Surveys, soil investigation , Design , Drawing and taking approvals of all drawings etc submitted by contractor, mobilization at site and setting out											
	2. Preliminary works in item 1 and 2 shall be carried out on priority.										

Note: The schedule is broad basis schedule. The contractor shall submit detailed project schedule and take approval.

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Volume II A: EXTENT OF WORK & PROCESS REQUIREMENT

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EXTENT OF WORK AND PROCESS REQUIREMENTS

1.1 Sewage Treatment Plant

The STP is to be constructed on turnkey basis such that scope includes Design, construction, supply, erection, testing, commissioning, three (3) month trail run, Five (5) years of operation and maintenance (including defect liability period of one year) of Sewage Treatment Plant (STP) with pumping station of following capacity, including all civil, electrical, mechanical, instrumentation and all other allied Works.

All works from influent received at inlet pumping station to STP site to final disposal is the responsibility of the contractor.

Technology Requirements for the following STP with pumping station are included in this contract and are described here in “Minimum Process Requirements”.

Average Flow (MLD)	Peak Factor (Population)	Treatment Process
15	As per CHPEEO Manual 2013 Edition	Open Technology to meet the desired outlet quality in the available land area with scope for future extension.

STP to be designed for 15 years and MPS to be designed for 30 years horizon as per CPHEEO Manual Chapter , 2013 edition chapter 2 , clause 2.5

The STP shall be designed for Average flow , pumping station shall be designed for ultimate peak flow, treated effluent channel and disinfection tank shall be designed for peak flow.
Pre-treatment Units shall be designed for Peak flow.
Note: In case of any confliction in specifications, the specifications for Process Requirements will have priority over other.

1.2 Treatment Technology

The process proposed for the Sewage Treatment Plant is Open Technology process. Bidder must provide all information necessary for complete evaluation of the technology, including drawings, design calculations, technical specifications, datasheets proposed construction/installation methodology and other relevant details. Any bid without above information will be considered as non responsive and summarily rejected. Bid must satisfy the Employer’s performance requirements as set out in the Bid documents.

Treatment Objective

Considering the raw sewage quality and the required treated sewage quality, the Contractor shall furnish a process train to achieve the following objectives –

- To achieve guaranteed treated sewage quality as per treated effluent parameter stipulated in Functional Guarantee

- Maximum guaranteed power consumption shall not be exceeded as per functional guarantees in Volume III D.
- To ensure that the offered treatment process is the most appropriate and state of the art in terms of both efficiency of treatment and cost (the Bidder shall have to produce the performance records with the same treatment systems applied elsewhere.)
- To ensure that the process is cost effective from both capital and O&M costs consideration.
- To ensure that the sludge produced is dewatered to a “spade able” or “open body truck able” consistency with dry solids content appx. 20% – so that it can be sent to reuse.
- The process preferably should utilize minimum chemical/any organic chemicals except for sludge removal process. No toxic chemical shall be used by the bidder. Bidder shall submit the toxicity test report from any govt. recognized laboratory at his own cost before using such chemical.
- Oils/lubes/fuels/media/chemicals etc. to be used will be defined by Bidder.
- The final treated sewage is to be disinfected through chlorination before its disposal.
- Provision for reuse of treated effluent shall be provided.

1.3 Incoming Sewage line to Inlet Chamber/ Receiving Chamber of STP

Incoming line shall have pumped sewage unless specified. Connecting rising main with all fittings up to the STP inlet shall be in bidder's scope of work. Bidders are required to visit the site at Borosola Beel (location plan is attached as drawing no. TCE. 10477A-CV-3000-LM-30207 R1.) and assess all the works, not limited to works given in Tender documents, to be executed for construction and successful commissioning of STP with pumping station as per tender specifications. Cost of all the works required for construction and successful commissioning of plant shall be included in the quoted price and no extra payment shall be made to contractor. Cost of all the works required for construction not limited to site levelling, foundation & successful completion of STP is deemed to be included in their quoted price.

1.4 Plant Outfall Details

The Location of outfall and the HFL in the receiving water body for disposal of treated sewage is to be obtained by the bidder/contractor for the planning and designing of the treatment plant. High Flood Level (HFL) of the receiving water body and the STP site will be approved by the client before approval of vendor drawings. Approvals shall be as per CPHEEO manual on Sewerage and Treatment Systems 2013 and other relevant codes.

1.5 Influent Wastewater Characteristics

The influent wastewater characteristics to be used as the basis of design are provided below:

Sl. No.	Parameter	Values
1	pH	5.5 - 9.0

2	Sewage Temperature	
	Min Temperature	15^{0} C
	Max Temperature	35^{0} C
3	Total BOD 5 Days @ 20°C, mg/L	250-300
4	COD, mg/L	400 - 500
5	Total suspended solids, mg/L	350-450
6	Oil and grease, mg/L	10 - 25
7	Total Kjeldahl Nitrogen (as N), mg/L	40 - 50
8	Total Phosphorus, mg/L	5 - 7
9	Faecal Coliform MPN/100 ml	$1x10^{7}$

Note: The consultants have got the preliminary tests for sewage done for estimation purposes. The parameters mentioned are tentative and indicative and the contractor shall carry out fresh independent tests for sewage quality for inlet parameters. In addition the Contractor shall coordinate with Assam Pollution control board for Sewage tests

1.6 Treated Sewage Requirements

The treated sewage quality requirements to be met shall be as per standards given in tender document as below:

Maximum limits/Type of Water usage	Unit	After Secondary Treatment	After Tertiary Treatment
Colour	-	Acceptable	Acceptable
BOD	mg/lit	<20 (less than 10 can be achieved)	<10
COD	mg/lit	<50	<50
Residual Chlorine	mg/lit	<0.5	<0.5
Faecal Coliform	MPN/100ml	<230	<100
Turbidity	NTU	<10*	<5*
pH		6.5-9.0	6.5-8.5
TSS	mg/lit	<10	<5
Total Nitrogen	mg/lit	<10	<10

Maximum limits/Type of Water usage	Unit	After Secondary Treatment	After Tertiary Treatment
Total Phosphorous	mg/lit	<2	<2

Note: These standards shall be applicable for discharge in Water resources as well as for land disposal. The standards for fecal coliform may not be applicable for use of treated sewage in Industrial Effluent.

All other parameters shall be as per present Assam State Pollution Control Board/ CPCB Norms for inland surface water whichever is stringent.

1.7 Dewatered Sludge Quality Requirements

The dewatered sludge quality requirements to be met are listed below:

Treated Sludge Quality Requirements (Dewatered Sludge)		
Parameter	**Units**	**Dry Solids content**
Dewatered Sludge	% w/w	20%

1.8 Treatment Process

The process proposed for the Sewage Treatment Plant is Sequential Batch reactor (SECONDARY BIOLOGICAL TREATMENT PROCESS) process. The process flow diagram is given in Drg. No. TCE.10477A-CV-3000-PF-30203 R1. The unit process and operation is as below:

- Screening (coarse screening)
- Sewage Transfer Pump
- Fine Screening
- Degriting system with oil and grease removal
- Secondary Aerobic Biological Treatment Process basin
- Disinfection
- Sludge dewatering system
- Tertiary treatment – Rapid Gravity sand filter
- Treated Effluent reuse tank

The treatment plant shall be designed to exclusively treat the sewage of the specified characteristics with an ability to absorb ± 10% fluctuations in the raw sewage parameters indicated above in Table 2.1.

The Contractor shall use this description together with other specific information as given below and provided elsewhere in these tender documents, all of which are integral to this Process and Facilities Description.

The design/sizing criteria, minimum number of units, and other requirements for the various unit processes and components are listed below.

Minimum Number of Units or Modules to be Provided for Unit Processes		
Unit Process	STP Design Average Capacity (MLD)	
	15	
	Number of Units (W=Working S=Standby)	
	W	S
Mechanical Screens	2	0
Manual Screens	0	1
Grit Removal (Mechanical)	2	1
Parshall Flume	1	0
Aeration/Biological Process	2	0
Chlorination with baffle	1 (Two compartments)	0
Gravity Thickening	1	0
Sludge Dewatering	1	1
Plant Specific units depending on the Process proposed in this Bid		
Anaerobic tank	2	0
Anoxic Tank	2	0
Primary Sludge Pumping	1	1
RAS Pumping	1	1
WAS Pumping	1	1 no store standby for both basins
Rapid Sand Filters and other units	As per CPHEEO	
Other tertiary Treatment Unit	As per design	

Note: The bidder shall meet the above min. Requirement.

1.9 Land Requirement

Land requirement has to accommodate the following including the future units as well.

- STP with all the process units and associated buildings and structures of proposed capacity with tertiary treatment, wherever applicable, to achieve treated sewage quality as mentioned in section 2.5, along with Compound wall and internal road of minimum 4.5 meters width. All the treatment units buildings etc shall be within the 1.22Ha of designated area of the STP .
- Green zone of shall be provided as per CPHEEO manual as required for STP area
- Deodorization of Primary and Sludge Treatment Units and UF or Cloth Media Disc Filtration for Reuse (future units).
- Sludge drying Units (in case of emergency with 3 days storage capacity)
- Additional land for 2nd Phase (if required)

Note:

a) The land requirement declared by the bidder as per Sr. No. 1 “STP with TT units” as mentioned above shall be taken into account for evaluating the price bid of the bidder.

The Bidder shall have to submit the extent of land requirement in Technical Bid duly justified in the Layout Plan. Multi-stacking of units on one another, shall not be acceptable. All the units should be on the ground floor except admin and laboratory, which can be accommodated in a building unit. All units/ buildings shall be independent with a horizontal distance of minimum 3 m between them.

Thus the STP should be designed on the technology meeting criterion of treated sewage characteristics, minimum power consumption and fit in land availability. The provision and placement of future units should be clearly marked in plant layout to be submitted with technical bid. Provision shall be made for reuse of treated effluent.

High Flood Level (HFL) of the receiving water body and at the STP site will be assessed by the bidder and the same will be approved by the client before approval of vendor drawings.

1.10 Demolition of Interfaces and Tie-Ins with Existing Facilities

All existing facilities that are to be demolished shall be properly dismantled, removed, and appropriately disposed of by the Contractor in accordance with all applicable laws, regulations, and standards. Items, components, or materials, whether buried, exposed, submerged, or otherwise, shall not be abandoned or left on site unless explicitly indicated in the Tender Documents. For facilities that are to be eventually demolished but must remain in service until alternate or replacement facilities are constructed and commissioned, whether under this contract or a different contract, the Contractor shall ensure that the facilities are protected and remain functional until such time as the alternate or replacement facilities are constructed, tested, commissioned, and accepted by Employer.

All existing facilities that must remain in service permanently shall be protected by the Contractor such that they remain fully functional, operable, and serviceable throughout the period as indicated in the Technical Bid. Contractor shall be fully responsible for installation and, if necessary, ultimate removal of any temporary facilities or connections (piping, utilities, power, controls, etc.) that may be necessary to maintain existing facilities fully operational throughout construction and commissioning. Temporary or permanent interfaces between existing and new facilities may involve making connections or “tie-ins” to existing live structures, piping, wiring, cabling, equipment or other components. Contractor shall be fully responsible for detailed design, planning, and implementation of such interfaces in a safe and secure manner.

1.11 Plant Layout and Hydraulic Profile

The Contractor shall ensure that the layouts and hydraulic profiles submitted as part of the Contractor's bid comply with the following specific constraints and all other requirements described in the Bid Documents:

- For STP where all or part of the influent flow is pumped from main pumping station to outside the plant boundary, the Contractor shall connect the incoming line to the inlet chamber of the STP. The incoming pipe length to be field verified by the bidder and to be included in financial bid.

- For all structures containing water or process liquid, the minimum freeboard shall be 0.5 m unless specified otherwise. Contractor shall provide at STP all necessary facilities for manual bypass of the process liquid at various locations in the flow path as indicated below. These facilities are included in this contract and shall be provided regardless of whether or not they are shown in any drawings included in the contract document, shall be fully functional in all respects, and shall include any and all components necessary to safely and efficiently accomplish the intended bypass. Each bypass facility shall include, but not be limited to: (i) downward opening overflow weir gates installed in the appropriate channel or structure from which the bypass is to be effected, (ii) an RCC channel or structure to receive the bypass flow over the weir gate, (iii) an appropriately sized buried (above ground piping will not be acceptable) cement mortar lined and coal tar epoxy coated ductile iron pipe to carry the bypass flow from the channel or structure in (iv) above to a manhole or junction box in the STP's main outfall pipe, (v) provision to be kept to measure and record details of all bypass events, including but not limited to date, start time, end time, continuous flow rate data for the entire duration of the event, and a totalized volume for the event.
- Bypass facilities as described above shall be provided at the following locations:
    - Grit Tank Outlet Channel to STP's main outfall pipe
    - Aeration Basin Influent Channel to STP's main outfall pipe (only in plants containing primary sedimentation units)

- Topographical survey information, benchmarks, contour maps, geotechnical/soil investigations, and treated sewage receiving water body high flood level (HFL) elevations shall be obtained by the bidder. Bidder shall be fully conversant with site conditions and all site information necessary. The information provided in these documents is for information purpose. However, Employer makes no guarantees or representations whatsoever regarding this information. Bidder's use of this information shall be at his own risk. The consultants have got the preliminary surveys done for obtaining level of the site, the contractor shall conduct own independent topographic surveys and soil investigations for constructing the plant and obtain the levels. The levels mentioned in the RFP/tender document are tentative and for

preliminary design purposes. The contractor shall conduct own independent topographical surveys to obtain final levels for design.

- Discharge level of the treated effluent shall be 0.3 m above the high flood level/full service level of the Borsola beel.
- Contractor shall independently obtain any and all site information necessary for proper planning, design, and operation of all components in the contract.

All aspects of Contractor's technical design shall also be subjected to review and approval by the Employer.

1.11.1 Plant Layout and Orientation

The STP components shall be laid out and fully contained within the respective designated site boundaries so as to logically interface with any and all existing infrastructure that may be present at the site and that must remain in service. Bidder's proposed site layout shall clearly show the space allocated for all plant components, including those components and/or unit processes that may be designated for future construction or installation. Setbacks and clearances from the site boundary shall be provided as appropriate and as required by law. All existing utilities (including water, sewer, power, or others, whether overhead or underground and whether physically located on the site or not) requiring to be relocated to accommodate the Contractor's proposed and approved site layout shall be relocated by the Contractor at no additional cost and without interrupting provision of such utility services to users and customers. Such relocations shall be fully coordinated.

The plant layout shall adhere to the following general rules:

- Minimum clear distance provided to permit safe and convenient access for operation and maintenance shall be 3 m between adjacent treatment units or fixed structures and 1 m between pieces of equipment
- An area adjacent to all mechanical equipment shall be provided as a maintenance lay down area
- Separate land for grit conveyance to be indicated
- All electrical equipment (except for motors) shall be located above the high flood level elevation for the site or for the treated sewage receiving water body, whichever is higher.
- Minimum 4.5 m of internal road width shall be provided in the STP area.
- Multi-stacking of units on one another, in any treatment technology, shall not be acceptable. All the units should be on the ground floor except admin and laboratory, which can be accommodated in a building unit.

1.12 Modular Design, Construction, and Operation for Reliability, Redundancy, Turndown, and Easy Future Expansion

The intermediate design capacity and the ultimate build-out design capacity required are both specified in Clause 2.1.

For all STP, components that are not easy to replace or expand in the future, including but not limited to header pipes, and collection and distribution and other common channels shall be designed and constructed to provide the ultimate build-out design capacity in this contract. Space for all the treatment units & sludge handling units for ultimate capacity shall be secured for future. For STP components that can be easily expanded in the future, the design and construction of the intermediate design capacity under this contract shall be performed such that future expansion to the ultimate build-out capacity can be accomplished easily and in a modular manner while maintaining the intermediate capacity fully operational at all times.

Space shall be reserved within the STP site boundary for the required future modules, and the design shall include features (including but not limited to caps or blind flanges for common header pipes and knock-out and stub walls for common channels and other structures) that will allow easy future extension/expansion with minimal disturbance to initial components. The contractor submittals and drawings shall clearly show and describe such features as well as the space reserved for future expansion. The design shall ensure that all future modules can be fully integrated with the initial modules to provide a single plant and a single process stream – multiple parallel plants will not be allowed. Such integration shall be accomplished by means of common collection and distribution channels, boxes, or header pipes in between unit processes that combine the flow from multiple modules of the upstream unit process and redistribute it to multiple modules of the downstream unit process. Designs where each future module operates independently of other modules will not be allowed and will not be accepted by the Employer.

Further, for all components under this contract, the capacity to be provided shall be designed and constructed using multiple, suitably sized unit process modules to ensure reliability, redundancy, and appropriate turndown for optimum capacity utilisation and process efficiency. The minimum number of working and standby modules or units required for each component shall be as per clause 2.7.

The Bidder shall be fully responsible to include in his bid the whole of the Works, including each individual component, designed and constructed in accordance with bid specifications and good engineering practice. The offered plant should function as a whole, a fully integrated system which is capable of achieving the required treated sewage parameters in an efficient and economical manner, and eliminate the odors and pest nuisance assignable to improper design and/or poor Operation & Maintenance. The offer shall include all buildings, plant, equipment and accessories required for the efficient, safe and satisfactory operation of the facilities. Any accessories which are not specifically mentioned in the specifications/requirement, but which are usual or necessary for completion of the Works and successful performance of the plant and facilities, shall be provided by the Bidder without extra cost to the Employer. The Bidder shall, to the maximum extent practical and feasible, endeavor to offer standardized designs and Plant and equipment keeping in view minimization of operation and maintenance requirements.

1.13 General Design Requirements

The following general design requirements shall be met for STP. These requirements shall be fully met regardless of whether or not such requirements or any related components are shown in any drawings included in the contract documents.

1. STP should be designed, such that the proposed process is meeting treated sewage requirement and with least power consumption and easy in O&M and shall fit in available land. The formation level of STP should be planned with respect to HFL of receiving water body to avoid flooding. The Formation level shall be at least 0.50 m above HFL. It is the responsibility of contractor to match the outfall chamber level with proposed disposal point of treated sewage. In case gravity disposal of treated sewage is not feasible, treated sewage pumping station shall be provided for safe disposal of treated sewage without extra cost to employer.
2. All components (including but not limited to equipment such as pumps, blowers, screens, diffusers, inline devices; instruments such as flow meters; and distribution and collection channels or pipes) shall be provided with appropriate isolation devices such as valves, gates, or other devices in order to allow isolation, drainage, cleaning, calibration, servicing, and maintenance of such components. Bypasses shall be provided around all flow meters and other in-line instrumentation such that the instrument can be isolated and removed for calibration and maintenance without interrupting the flow.
3. Where necessary, equipment shall be provided with acoustic, sound-dampening enclosures to limit ambient noise during normal operation to the limits detailed in the General Requirements.
4. All equipment shall be arranged and buildings and structures designed to permit safe and easy access to and removal of all equipment.
5. Fixed runways, lifting eyes, cranes, hoists, or other appropriate devices and means shall be provided to permit safe and easy removal of all equipment for maintenance or any other purpose
6. All liquid or sludge flow distribution shall be accomplished using one of the following options only:
    - non-submerged (i.e. with a positive free fall from weir invert to the water surface on the downstream side) overflow weirs,
    - non-submerged downward opening overflow weir gates, or
7. All structures, whether liquid-holding or not, shall be designed such that they can be fully and completely drained and will not float or move when empty, because of groundwater buoyancy or any other reason. The structures shall be designed to counteract any possible floatation without the use of any type of groundwater pressure relief valves.
8. The floors of all liquid-holding structures shall be appropriately sloped and trenches and drain sumps shall be provided at the bottoms of such slopes to facilitate complete drainage of liquid. Appropriate drain pipes and valves connected to the drain sump(s) shall be provided for all structures. Where the drain pipe connects to the structure, the

top-of-pipe elevation shall be at least 150 mm lower than the lowest floor elevation for the structure. The drain piping shall be routed from the structure being drained to the Plant Drain Pump Station and shall be continuously sloped downward in the direction of flow with a minimum slope of 1 percent. For liquid-holding structures, the drain piping and fittings shall be sized such that the entire structure can be drained by gravity in no more than six (6) hours. The Plant Drain Pump Station, Plant Drain Pumps, and other related equipment and controls shall be designed and sized to allow draining of the structure with the largest volume from full to empty within six (6) hours. The highest design water level (High High Alarm) in the Plant Drain Pump Station wet well shall be at least 300 mm lower than the lowest pipe invert elevation amongst all drain pipes connecting to the wet well.

9. Non-liquid-holding areas, structures, or buildings where leakage or other wet activities can occur, whether in normal use or during maintenance, shall be provided with covered drainage channels which shall direct the spillage either to a suitable gravity drain or to a sump equipped with standard dual submersible sump pumps discharging to the Plant Drain Pump Station.
10. All concrete structures in contact with sewage and/or sludge upstream of the Aeration Basins shall be provided with full interior corrosion protection linings and/or coatings of appropriate material and thickness – to be approved by Employer. This also applies to all concrete structures in contact with any type of sewage sludge anywhere in the plant. For Aeration Basins, interior lining shall extend from the top of wall down to 1 meter below the lowest operating water level.
11. All channels carrying process liquid shall be fully covered with solid non-skid GRP/SFRC cover plates (not grating) designed for human traffic live loads at a minimum and heavy vehicle live loads wherever the channel crosses traffic paths.
12. Inlets into tanks, reactors, or other structures via pipes, channels, valves, or gates shall be designed such that the incoming flow does not cause any damage or excessive wear whatsoever to the structure or any equipment in the vicinity under any hydraulic condition, including but not limited to the condition when the structure is empty.
13. All piping shall be of corrosion–resistant material appropriate for the service and shall be provided with interior lining, exterior coating, and other corrosion protection as appropriate. All piping shall be fully and adequately supported and braced to comply with all applicable codes and standards. All supporting hardware shall also be of corrosion-resistant material. The design of pipe supports and anchors shall fully account for static and dynamic vertical, lateral, longitudinal, and seismic loads, fluid flow, and thermal expansion. Seismic bracing, thrust restraints and/or thrust blocks, and appropriate expansion joints or loops shall be provided as needed. Pipe lengths and joints shall be assembled and arranged for ease of removal in such a way that individual runs can be changed without dismantling adjacent pipes, by providing dismantling joints at regular intervals.
14. For liquids and sludge, the maximum pipe flow velocity shall not be more than 1.5 m/s for pumped suction and not more than 2.0 m/s for pumped discharge. For gravity flow, the

minimum pipe flow velocity shall not be less than 0.6 m/s and not more than 1.2 m/s. All mixed liquor and sludge lines shall be minimum 200 mm diameter and shall be provided with appropriate cleanouts and flushing arrangements for safe and easy flushing using high-pressure water. The normal pipeline flow velocity for air shall not be more than 20.0 m/s & for biogas not more than 12 m/s.

15. All liquid service pipes shall be provided with appropriate means for safe and easy drainage of the pipes when not in service.
16. All pipes shall be colour banded and suitably labelled with the stream designation and direction of flow to enable individual lines to be identified throughout their run.
17. Particular attention shall be paid to the layout of the chemical piping, which shall be arranged without clutter and shall be functional and neat in appearance. Generally, where piping is installed in ducts, it shall be supported not less than 150 mm clear of the floor.
18. All piping routed under any type of structure or equipment shall be fully and completely encased in reinforced cement concrete, with the encasement thickness beyond the outer diameter of the pipe being at least 200 mm on all sides or D/4 whichever is more (D-diameter). The encasement shall extend along the pipe length for a minimum horizontal distance of 1500 mm in each direction beyond the footprint of the overlying structure or equipment.
19. All piping connecting to, entering, or exiting any and all structures shall be provided with appropriate restrained flexible connections and/or joints at all such interfaces with structures to allow for differential movement between pipe and structure in all directions without stressing or breaking the pipes.
20. Appropriate restrained flexible connections and/or joints shall be provided for all pipes where they connect to any and all of the following:
    - Equipment such as pumps, blowers, or inline devices
    - Valves
    - Wall, floor, or roof penetrations
21. Where piping or other materials susceptible to damage from ultraviolet radiation are employed, they shall be protected from such radiation through the use of appropriate additives and/or coatings and shall be physically shielded from direct sunlight at all times in their normal service location using enclosures, covers, canopies, roofs, and/or other similar means.
22. Platforms, handrails/guardrails, ladders, and stairs shall be provided where necessary for proper, safe, and easy access to and/or operation of valves, gates, instruments, control panels, and other devices, equipment, or structures.
23. Appropriate sampling ports and/or sampling valves shall be provided to allow easy, safe sampling of all process streams without spillage or contamination and without the need to interrupt normal operation.
24. The influent flow meter and influent sampling location shall be selected such that the true influent flow and characteristics will be measured without inclusion of in-plant recycles or

other extraneous streams. Separate flow measurement and sampling shall be provided for the recycle streams.

25. Foam, scum, fats, oil, grease, or any other floating material removed from any location in the STP shall be completely removed from the process flow path along with waste, digested, and/or dewatered solids leaving the STP and shall under no circumstances be recycled or returned to any location in the plant.
26. All units shall be interconnected by RCC overhead walkways, min. 1.2 m wide with handrail and RCC staircase.
27. Pumped sewage at required level shall be made available by the bidder. Bidder to design the hydraulics to discharge the treated sewage to suit the level of the receiving body.

1.14 Process and Facilities Description

This Process and Facilities description is intended to provide a general indication of the various unit processes and type of facilities that the Contractor shall be required to design, construct, and operate, and applies to all with sewage pumping station and STP in this contract unless specifically indicated otherwise. The Contractor shall use this description together with other specific information for each STP provided elsewhere in these bid documents, including but not limited all of which are integral to this Process and Facilities Description and are incorporated herein by reference.

The Bidder shall submit plant layout, process calculations, hydraulic calculations, hydraulic flow diagram, P&ID, mass balance calculations, electrical load list etc. along with technical bid for the technology offerred to illustrate the offer submitted with all technical details.

2.14.1 Collection Drain and Weir Arrangement before Pumping station:

1.14.1 Sewage Pumping Station

The mechanical and manual coarse screens are to be provided before the collection well of pumping station in order to remove the floating matter and grit particles from the sewage which will be diverted. Further the sewage will be pumped from the collection well of pumping station to the inlet of STP.

1.14.1.1 Receiving Chamber

Incoming gravity sewer channel/ line will discharge sewage into the receiving chamber of Sewage Pumping Station from where it will be taken into downstream screens / units. The function of receiving chamber is to reduce the velocity of incoming raw sewage. Receiving chamber shall be of adequate size to meet the requirements of workability inside it. It shall be water tight to prevent seepage of the sewage out of the receiving chamber. Isolation gate shall be provided on incoming line/box channel / duct.

1.14.1.2 Coarse Screens

Mechanical coarse screens along with manual standby shall be provided at upstream of Wet Well for removal of floating and oversized material coming with the sewage. The coarse screens should be capable to screen out most of the medium and large floating and oversized material such as plastic rags, debris, weeds, paper, cloths etc which could clog the wastewater pump impellers. The screenings removed by the screens shall be discharged at the appropriate elevation above ground on to a conveyor. A belt conveyor positioned above ground level shall convey the screenings through a galvanized steel chute to a trolley positioned at ground level.

1.14.1.3 Raw Sewage Sump, Pump & Pump House

The screened sewage will then enter into wet well of pumping station. The capacity of the Wet Well should be kept such that adequate detention time is available during average and peak flow conditions.

Suitable combination of submersible pumps shall be provided in the sump to cater to the pumping requirements at average & peak flow conditions. Based on incoming flow conditions, adequate no. of pumps shall operate automatically to cater the pumping requirements.

Pumping station should have adequate room for installing electrical & instrument panels. Bidder shall note that panel shall not be permitted to be installed above the wet well of SPS. A separate room shall be provided to house SPS panels adjacent to SPS or in nearby building. Suitable arrangement should be provided for lifting Pumps. Online flow measurement shall be done by installing a full bore electromagnetic flow meter on the common discharge header of the raw sewage pumps.

The wet well shall be provided with adequate slope towards suction pit of pump from all sides of wet well to prevent / minimize settling on wet well floor and draw all particles / grit towards the suction pit of raw sewage pumps.

Suitable number of de-silting pumps as per design calculations along with required length of cable, starter panel & other required accessories suitable to handle silt/grit/sludge settled in wet well.

1.14.2 Primary Treatment Units

1.14.2.1 Inlet Chamber

Pumped sewage shall be provided at the STP location outside the plant boundary. The Contractor for this contract shall connect the incoming line to the inlet chamber of the STP, construct the inlet chamber and coordinate the exact location of such chamber with AMC. The MWL in the inlet chamber will be decided based on plant hydraulics with respect to HFL in the receiving water body. However, the Contractor shall be fully responsible for proper coordination to ensure proper alignments and interfaces and for proper implementation of all connections.

1.14.2.2 Fine Screens

The fine Screens shall receive sewage from the upstream inlet chamber. The screenings removed by the screens shall be discharged at the appropriate elevation above ground on to a conveyor. A belt conveyor positioned above ground level shall convey the screenings through a galvanized steel chute to a trolley positioned at ground level.

For both coarse and fine screens, an area for 6 days storage of screenings shall be made available in the layout plan.

1.14.2.3 Grit Basins and Grit Washers and Classifiers

A complete grit removal facility shall be provided, with integrated fats, oil, and grease (FOG) removal. All equipment and components (including but not limited to conveyors, pumps, and blowers) necessary for a fully functional system shall be provided regardless of whether or not such items are specifically listed or described in the bid document. Dewatered grit shall be collected in a trolley positioned at ground level below the Grit Classifier discharge. De-gritted sewage shall exit the Grit Basins over the outlet weir. Liquid streams from grit washers and classifiers shall be returned to the de-gritted sewage stream or to the Plant Drain Pump Station. Any FOG skimming's removed shall be routed to the sludge storage tanks or safely disposed off. Each Mechanism shall be provided with Organic return pumps. This shall be suitably located to return organics back to Grit Chamber. The de-gritted sewage shall flow through open channels from the grit separators and confluence into a single channel of suitable width for provision of Parshall flume. Bypass facility for degritted sewage shall be provided. Separate land for grit conveyance shall be indicated in the layout.

1.14.2.4 Parshall Flume

A Parshall flume shall be provided at downstream of Grit Chamber. There will be one no. Parshall flume in R.C.C channel, which shall be designed for measuring peak flow in the STP as mentioned above in this section. There will be an approach channel, a throat, and a downstream channel. At the throat, there will be a hydraulic jump and a corresponding head loss. An Ultra sonic flow meter shall also be provided for flow measurement shall be mounted above the channel to measure the flow, record it and integrate it. Recorder and integrator will be housed in the control room. Parshall flume shall be designed as per IS: 14371:1996.

1.14.3 Secondary Treatment Units

1.14.3.1 SECONDARY BIOLOGICAL TREATMENT Basins

Secondary Aerobic Biological Treatment Process shall be designed to treat peak flow sewage for organic load reduction along with built-in nitrification-denitrification and biological phosphorus removal. Basin designs shall strictly comply with the minimum sizing and all other requirements specified in the bid documents. Process air blowers as well as air piping and valves for SECONDARY BIOLOGICAL TREATMENT PROCESSs shall be configured such that one or more blowers are dedicated to each SECONDARY BIOLOGICAL

TREATMENT PROCESS basin that is in the aeration phase at any given time. The discharge from any given blower shall be routed to no more than a single SECONDARY BIOLOGICAL TREATMENT PROCESS basin at any given time. **In case of any other type of Aeration Equipment one total set of the equipment should be provided as standby.**

For SECONDARY BIOLOGICAL TREATMENT PROCESS process, the recirculation of activated sludge (RAS) may or may not be provided depending upon bidder's design/proposal.

No. of WAS (waste activated sludge) pumps shall be minimum 1W+1S for each basin.

1.14.3.1 Return Activated Sludge (RAS) Pump Station

RAS pumps shall be provided to return settled sludge from SECONDARY BIOLOGICAL TREATMENT PROCESS Basin. A valve-controlled and metered tapping shall be provided from the RAS pump discharge header to withdraw Waste Activated Sludge (WAS) to sludge dewatering units. No separate WAS pumps shall be provided. RAS ration should be designed but not less than 50%.

1.14.3.2 Chlorine Contact Tanks

Chlorine Contact Tanks shall be provided for disinfection of treated sewage from the secondary and/ or tertiary treatment as per design. Chlorine shall be injected via an inline vacuum educator placed in the biologically treated sewage pipe just upstream of the Chlorine Contact Tanks or through diffusers in Chlorine Contact Tank. Gas chlorinator shall be provided for chlorination.

A Chlorination Building shall be provided to house all chlorination equipment including chlorine cylinders, chlorinators, and all associated equipment.

1.14.3.3 Chlorination System

A complete Chlorination system with necessary safety accessory and controls shall be provided as per IS code. A pit and absorption system shall be provided to contain and neutralise chlorine in the event of a leak.

1.14.4 Tertiary Treatment

1.14.4.1 Filter Feed Tank

The sewage from chlorine contact tank shall be collected in the filter feed tank. The wastewater will be passed through gravity sand filter for filtration. The PSF system shall be designed for Average flow.

1.14.4.2 Rapid Gravity Sand Filter/Disk Filter

The disinfected sewage from filter feed tank shall be pumped to rapid gravity sand filter to remove the residual solids and turbidity by filtration. The rapid gravity sand filter comprises of bed of sand serving as a single medium granular matrix supported on gravel layer overlying an under drainage system. When the clarified water containing suspended and colloidal matter is applied to the top of filter bed, these solids are entrapped in the granular medium matrix. The accumulation of suspended particles in the pores and on the surface of filter

medium leads to built up of head loss. When the head loss reaches at a pre-determined value, the filter is then backwashed with the help of air and water to remove the accumulated suspended matter from filter. The bidder can offer disk filtration system also in lieu of Gravity Sand filter.The bidder shall specify the same in his technical proposal. The rate for same shall be considered in his Pricebid and nothing extra shall be paid for that.

1.14.4.3 Filter Back-Wash System

Filter backwash by treated water followed by Air scouring and Backwash of clogged Filter beds shall be done at regular interval. Normally the frequency of filter backwash shall be once in a day. The rate of backwashing and air supply shall be adequate for the purpose of cleaning the bed and removing material but shall not dislodge the media layers or disturb the consistency of the bed. For backwashing of filters, water shall be drawn from filter backwash sump and air for scouring shall be provided by the blowers. A backwash water sump shall be provided for collection of dirty water.

1.14.4.4 Overhead Tank

Surface water from public water main shall be stored in sump for adequate storage and pumped to overhead tank of chlorination building or separate OHT structure for potable use. All water and plumbing connections shall be provided as per requirement.

1.14.4.5 Treated Effluent Reuse Overhead Tank

A Treated Effuent Reuse overhead tank shall be provided for provision of reuse of treated effluent after tertiary treatment. The tank shall be of minimum 5 m^3 capacity and shall be constructed over the Sludge Chlorination building or the sludge handling building, The tank shall be so placed so that tankers can be filled in the plant and take away treated effluent for reuse such as gardening or car washing or building construction etc.

1.14.5 Sludge Handling, Treatment and Disposal

1.14.5.1 Gravity Sludge Thickeners

Gravity sludge thickeners shall be provided for thickening of the sludge generated (primary and secondary clarifier sludge) from the biological treatment. Provision of dosing dewatering polyelectrolyte (DWPE) shall be made in thickener as well as dewatering facility. The thickened sludge shall be conveyed by gravity to sump of thickened sludge pump house. The overflow (supernatant) from the thickeners shall be conveyed back to inlet of STP (gravity/collection and pumping).

1.14.5.2 Thickened Sludge sump and Pump Station

Thickened sludge sump shall be provided for the collection of thickened sludge from thickeners. The sump shall be equipped with Agitator assembly to facilitate mixing of sludge content. Thickened sludge pump station and pumps shall be provided for pumping of thickened sludge from the sump to the anaerobic digesters in case of STP with digesters. In case of STP without digesters, thickened sludge shall be stored in Sludge Storage Tank to feed sludge dewatering unit

1.14.5.3 Sludge Storage Tanks

Sludge storage tanks shall be provided to store the digested sludge in case of STPs with digesters or undigested thickened sludge in case of STPs without digesters. The tanks shall be designed to provide all of the following functions:

- Thickened digested or undigested sludge by settling and decanting of supernatant
- Store sludge for periodic feeding to the dewatering facility
- Supernatant shall be recycled back to inlet of STP (by gravity/ collection and pumping)

1.14.5.4 Dewatering Building

A Dewatering building shall be provided along with mechanical dewatering units (centrifuge) and all associated/ancillary equipment, including feed pumps, a complete polymer dosing system, dewatered sludge conveyors, sludge storage/loading hoppers, and truck access and loading facilities. Sizing of the dewatering unit all related equipment shall be based on the operating schedule.

1.14.5.5 Treated Sewage and Sludge Disposal

The treated sewage, post chlorination shall be conveyed to the disposal point as per site condition to nearest receiving water body not exceeding length of 500 meters.

1.14.5.6 Plant Drain Pump Station

A Plant Drain Pump Station shall be provided to collect supernatant/ centrate/ filtrate from sludge treatment and other miscellaneous waste flows such as tertiary filter backwashing; cleaning and wash-down flows generated in the plant and pump them back up to the head works for treatment through the plant.

1.14.6 Instrumentation and Automation

SCADA based Instrumentation and Automation System shall be installed for proposed plant for various treatment units. Specification for Instrumentation, Automation and SCADA is given in Volume III C, Part 4.

1.14.7 Administration, Laboratory, Maintenance, and Other Related Buildings/Facilities

An administration building, a laboratory, a maintenance workshop, a storage facility, a guard house, and other miscellaneous buildings and related equipment and furnishings shall be provided as needed for a fully functional facility.

All units shall be interconnected by RCC overhead walkways, min. 1.2 m wide with handrail and RCC staircase.

All units/ buildings shall be independent with a minimum 3 m distance apart.

All the treatment units should be on the ground floor (no multi-stacking) except admin and laboratory, which can be accommodated in a building unit.

Compound wall as specified in section 1.23 of volume IIIB

Space for Sludge Drying Beds as specified in volume IIIB & IIIE

Minimum 4.5 meters of internal road width shall be provided in the STP area

There should be Future space provision for Second Phase along with the following;

• Deodorization of Primary and Sludge Treatment Units

• UF or Cloth Media Disc Filtration for Reuse

1.15 Design/Sizing Criteria and Other Requirements (Minimum Dimensions/sizes)

Minimum Sizes for Various Building Associated with STP (LXBXH) in Meters		
		Capacity of STP (15 MLD)
Sl. No	**Buildings**	**≤ 20**
1	Administration Building + Toilet Block :Ground Floor	6 x 5 x 3.5
	Laboratory **+ SCADA** :First Floor	6 x 5 x 3.5
2	Process Air Blower Building **(Depending on the Aeration Equipment)**	15 x 6 x 5
3	Chlorine Building Min	8 x 5 x 3.5
4	Sludge Dewatering Building – Ground Floor	10 x 6 x 4.5
	Sludge Dewatering Building – First Floor	10 x 6 x 4.5
5	Diesel Generator (DG) Room	As per the size of DG sets and other mechanical requirements
6	Maintenance Workshop	6 x 4 x 3.5
7	Guard Room	2.4 x 2.4 x 3
8	MCC Room	15 X6 X 3.5
9	HT Panel	6 x 6 x 4.5
10	Filter Feed Pump House	8 x 6 x 3.5

All units in the STP should be interconnected by overhead walkways. In addition, appropriate number of staircases should be provided for ease in O&M and there should be access to influent and treated sewage and sludge sampling.

Biological Process Requirements:

Biological Processes – Design Requirements					
Treatment Processes	**SRT (d)**	**F/M (Kg BOD / Kg MLVSS. D)**	**MLSS (mg/L)**	**Aeration Tank HRT (hr)**	**RAS (% of influent)**
SECONDARY Aerobic Biological Treatment Process Continuous Flow	15-20	0.05-0.08	3000-4000	Min 17	As per Bidders Design
SECONDARY BIOLOGICAL TREATMENT PROCESS	4-20	0.05-0.3	3500-5000	Min 17	
Anoxic Zone	Residence time- As per CPHEEO				

Items	Unit	Values
RAW SEWAGE PUMPING STATION (RSPS)		
Receiving Chamber		
Design flow	-	Peak flow
HRT	sec	30
Min. no. of unit	No.	1
Trash Rack Screen Channels		
Design flow	-	Peak flow
Screen type	-	'J' Type SS 316 removable Manual Coarse Bar Trash Rack Screen
MOC – Channel	-	RCC
MOC – Screens (all screen components)	-	SS 316
Angle of inclination of screen	deg.	**45**
Max SWD at peak flow	M	As per CPHEEO Manual
Approach velocity in channel	m/sec	As per CPHEEO Manual
Velocity through openings at peak flow	m/sec	As per CPHEEO Manual
Velocity through openings at average flow	m/sec	As per CPHEEO Manual
Minimum Bar thickness	mm	**10**
Clear spacing between bars	-	**50**
Coarse Screen Channels (Working)		
Design flow	-	Peak flow
Screen type	-	Bar screen/ Mat screen/ Step screen/ escalator type with mechanical cleaning.
MOC – Channel	-	RCC
MOC – Screens (all screen components)	-	SS 316
Angle of inclination of screen	deg.	As per CPHEEO Manual
Max SWD at peak flow	M	
Approach velocity in channel	m/sec	
Velocity through openings at peak flow	m/sec	
Velocity through openings at average flow	m/sec	
Minimum Bar thickeness	mm	
Clear spacing between bars	mm	
Coarse Screen Channels (Standby)		
Design flow	-	Peak flow
Screen type	-	Bar screen with Manual cleaning
MOC – Channel	-	RCC
MOC – Screens (all screen components)	-	SS 316
Angle of inclination of screen	deg.	As per CPHEEO Manual
Max SWD at peak flow	M	

Approach velocity in channel	m/sec	
Velocity through openings at peak flow	m/sec	
Velocity through openings at average flow	m/sec	
Minimum Bar thickeness	mm	
Clear spacing between bars	mm	20
Raw Sewage Sump (Wet Well)		
Design flow	-	Peak flow
HRT	Minutes	5 (Peak Flow)
Min. no. of unit	No.	1
Minimum SWD	M	As per bidders design with additional submergence for submersible pumps below wet well floor as recommended by pump manufacturer.
Raw Sewage Transfer Pumps		**Submersible Non-clog type**
Type of Pump	**-**	
Number of Pumps	No.	As per CPHEEO Manual
Capacity of each pump	m^3/hr	
Head	m	As per Design
SEWAGE TREATMENT PLANT (STP)		
Items	**Unit**	**Values**
Inlet Chamber		
Design flow	-	Peak flow
HRT	sec	60
Min. no. of unit	No.	1
Fine Screen Channels (Working)		
Design flow	-	Peak flow
Screen type	-	Bar screen/ Mat screen/ Step screen/ escalator type with mechanical cleaning
MOC – Channel	-	RCC
MOC – Screens (all screen components)	-	SS 316
Angle of inclination of screen	deg.	As per CPHEEO Manual
Max SWD at peak flow	m	
Approach velocity in channel	m/sec	
Velocity through openings at peak flow	m/sec	
Velocity through openings at average flow	m/sec	

Clear spacing between bars	mm	6
Fine Screen Channels (Standby)		
Design flow	-	Peak flow
Screen type	-	Bar screen with Manual cleaning
MOC – Channel	-	RCC
MOC – Screens (all screen components)	-	SS 316
Angle of inclination of screen	deg.	As per CPHEEO Manual
Max SWD at peak flow	M	
Approach velocity in channel	m/sec	
Velocity through openings at peak flow	m/sec	
Velocity through openings at average flow	m/sec	
Clear spacing between bars	mm	10
Grit Basins		
Design flow	-	Peak flow
Type	-	Mechanical Detritor or Vortex or Aerated Type with center drive, full diameter scraper
MOC – Equipment/Mechanism	-	SS 304
Design particle dia (sp gr – 2.65)	mm	0.1
Max Design SOR at peak flow	$m^3/m^2/day$	As per CPHEEO Manual
Min HRT at peak flow	sec	60
Organic return pump and organic wash pump	-	To be provided as per requirement (for each Detritor type grit chamber separately)
Grit Washer and Classifier		
Type	-	Reciprocating rake mechanism or screw conveyor
Aerated Grit Chamber		
Transverse velocity at surface	m/s	0.6-0.8
Depth-to-width ratio	-	1.5:1 to 2:1
Air supply	-	4.6-7.7 l/m/s of length 0.3-0.4 m^3/m^3
Detention time at peak flow	Min.	3-5
Quantity of grit	ml $/m^3$	7.5-75
Max Design SOR at peak flow	$m^3/m^2/day$	1,555
Vortex- Type Grit Chamber		
Minimum Velocity	m/s	0.15
Detention Time @ peak flow	sec	20-30
Parshall Flume		
Min No of Units	No.	1
MOC	-	RCC

Design flow	-	Peak flow
Minimum freeboard	m	0.5
Size	-	As per CPHEEO
Primary Removals and Primary Sewage Characteristics		
BOD Removal	%	As per CPHEEO Manual
TSS Removal	%	As per CPHEEO Manual
Aeration Basin (Refer Table above for Biological Process requirements)		
MOC – Structure	-	RCC
Min SWD	m	5
Min Freeboard	m	0.5
Specific sludge yield	kg sludge production/ kg BOD	As per CPHEEO Manual
Min HRT at Average flow	Hrs	
Recycle Configuration		
Hydraulic design of wet well	-	Minimum HRT 30 Min for upto flow of 75% of return sludge capacity
RAS Ratio ® – hydraulic design	-	As per CPHEEO Manual
Aeration System		
BOD oxidation oxygen requirement	kg/d	1 to 1.2 x Inlet BOD load avg.
Type of Aeration	-	* Type of Aeration- Diffused Aeration or Aspirator Aeration.
*Note- - The proposed aeration system shall be in successful operation in STP since last three (3) years in India.		
Diffused Aeration System		
Max Alpha Factor, α	-	0.6
Max Beta Factor, β	-	0.95
Max Fouling factor, F	-	0.8
Oxygen demand peaking factor	-	1.0
Aeration system sizing basis liquid temperature	-	Max liquid temp
Aeration system sizing basis air temperature	-	Max air temp
Aerobic basin DO (min)	mg/L	2
Diffuser type	-	Fine bubble diffuser (Disc or Tube type)
Diffuse Installation	-	Retrievable

Diffuser material	-	Only fine bubble EPDM/PolyUrethan membrane diffusers shall be acceptable with minimum membrane diffuser to floor coverage area of 5%. Diffusers shall be submerged fine bubble/fine pore, high transfer efficiency, low maintenance, non-buoyant type
Min no of diffusers – Uninstalled shelf spares	%	10
Max. SOTE per unit diffuser submergence at peak air flow (for design calculations)	%/m	5
Process Air Blowers		
Blower type	-	(Centrifugal Type Turbo blower)
Capacity	%	(All systems shall use Dissolved Oxygen/Oxygen Uptake Rate control with VFD driven Blower)
No of blowers – Working	Min.	1
No of blowers – Standby	Min.	As per CPHEEO Manual
Process Air Blower Building		
Structure	No.	1
MOC – Roof, columns, beams	-	RCC
Aspirator Aerator		
Capacity	%	110
Aerobic basin DO (min)	mg/L	2
Max Alpha Factor, α	-	0.85
Max Beta Factor, β	-	0.95
Oxygen Transfer Efficiency	Kg O_2/kWh	1.2 to 2.4
Mixing Power Requirement	W/m^3	15-26
SECONDARY BIOLOGICAL TREATMENT PROCESS Basins		
SECONDARY BIOLOGICAL TREATMENT PROCESS Basin	No.	2 (minimum)
MOC – Structure	-	RCC
Max. SWD	m	As per CPHEEO
Min Freeboard	m	0.50
Cycle time	hrs	As per CPHEEO Manual
Min. Aeration time, Settling time and Decant time	hrs	As per CPHEEO Manual
Min. HRT (excluding Anoxic /selector Zone)	hrs	17

Decanting mechanism (if proposed)	-	Rotary Weir type Stainless Steel 316 decanter
Decanting depth shall be designed to meet the specified performance standards for treated sewage. Any shortfall in meeting the performance standards due to decanting depth observed during commissioning and operation of the plant shall be corrected by successful bidder at his own risk and cost.		
No. of RAS pumps	per basin	As per CPHEEO Manual
Selector Zone HRT.	Min	
Specific Sludge Yield (for all technologies)	Kg sludge production / kg BOD	
Flash Mixer		
Detention time	sec	As per CPHEEO Manual
Velocity Gradient	s^{-1}	
Mixing Mechanism	-	Mechanical as per IS 7090- 1985
Flocculator		
Detention time	min.	As per CPHEEO Manual
Velocity gradient	s^{-1}	
Mixing Mechanism	-	Mechanical as per IS 7090- 1985 (Type C)
Total Area of Paddles	-	As per CPHEEO Manual
Max. Peripheral velocity of blades	m/sec	
Surface loading rate	liters/hour/sq.m	
SWD	m	
Tertiary Treatment		
Type	-	Rapid Gravity Sand Filter
Rapid Gravity Sand Filter		
Filtration rate	$m^3/m^2/h$	As per CPHEEO
Area per bed	m^2/ individual bed	As per Design
No. of beds	-	Minimum 2 Nos of beds shall be provided.
Min. depth of water over sand top	m	2 m (Without free board).
Min. Free board	m	0.5
Depth of Sand media	m	As per CPHEEO
Depth of Gravel media	m	
Area of orifices	-	0.3% filter bed area The perforations vary from 5 to 12 mm. In diameter and should be staggered at a slight angle to the vertical axis of pipe.
Area of laterals	-	2 x Area of Orifices

Area of Manifold	-	1.5 x Area of laterals
The inlet and outlet arrangement to RSF	-	designed at 100% over load to permit for emergency occasion
Wash Water Tank	-	Separate O/H wash water cum service water tank suitable for backwashing minimum 2 Nos. of filter beds at a time with 8 to 10 Mtr. Head
Wash Water Pumps	-	100% standby Rate 36m3/m2/h or 600LPM per Sq.m. for 10min
Air Blowers	-	Rate 45-50 m3/h per sq.m of free air flow at 0.35 to 0.4 Kg/sq.m for 5min at the under drains (100% standby)
Wash Water Recycle Pumps	-	2 x 100 % capacity pumps suitable to empty the wash water collection tank in 4 hours
Chlorine Contact Tanks		
MOC	-	RCC
Min HRT at Average flow/ Decanting flow whichever is higher	min	30
Min effective L/W ratio	-	40
SWD/Pass Width ratio	-	1
Min freeboard	m	0.5
Chlorination System		
Type	-	Chlorine Gas Feed System Hypo Dosing acceptable only for STP capacities <5MLD
Minimum chlorine dose	mg/L	5
Chlorine Ton Cylinders		
Min storage period	days	15
Max withdrawal rate per 900 kg cylinder	kg/hr	9
Min no of cylinders – total	-	As per requirement
Min no of cylinders – manifold with automatic switching-		As per requirement
Chlorinators		
Type of Chlorinator	-	Vacuum
Min no of units – Working	No.	1
Min no of units – Standby	No.	1
Chlorine Ejector		
Type	-	Inline vacuum induction or diffuser
No of units – Working	No.	1

No of units – uninstalled spares	No.	1
Chlorine Building		
Min no of units	No.	1
MOC – Roof, columns, beams	-	RCC
Gravity Sludge Thickener		
Min No of Units	No.	1 Please note, thickener not required for STP capacities <5MLD.
Type	-	Circular, center column supported with central drive
MOC – Structure	-	RCC
Conical bottom minimum slope	-	1 to 10
MOC – Center Column	-	MS Epoxy coated
MOC – Bridge	-	MS Enamel painted
MOC – Scraper	-	MS Epoxy coated
Max Surface loading rate	$kg/m^2/day$	25-35
Max center column velocity	m/sec	0.9
Minimum SWD	m	4
Min Freeboard	m	0.5
Check for Hydraulic Loading		
Max hydraulic loading rate	cum/d/sqm	20
Thickened Sludge Pumping Station		
Min no of units	No.	1
MOC – Roof, columns, beams	-	RCC
HRT in Sump	hrs	4
Type of Mixing	-	Coarse bubble/Mechanical mixers
Anaerobic Digesters		
Mixing Requirement	-	Sludge mixing by mechanical or gas mixing system
Bottom shape	-	Conical
Minimum bottom slope	-	1 : 3 to 1 : 6
MOC	-	RCC with full internal epoxy coating
SWD (max.)	m	10
Allowance for grit, scum, & foam accumulation	m	1
Min freeboard	m	1
Biogas Storage Tank		
Shape	-	Conical, Gas holder mechanism with steel bell dome
Biogas Flare		

Min no of units	No.	1
Type	-	Furnace combustion type
MOC	-	Epoxy coated MS with SS 304 flare tip
Diameter	mm	100
Height	m	5
Ignition	-	Electronic/ Auto ignition
Feed Sump & Pump (Dewatering Influent, DWI)		
Min no of Sumps	No.	1
MOC – Roof, columns, beams	-	RCC
Min. HRT	hrs	10
Type of Mixing	-	Coarse bubble/Mechanical mixers
Operation schedule	hrs/day	12
	days/week	6
Min no of pumps – Working	No.	1
Min no of Pumps – Standby	No.	1
Type of Pump	-	Progressing Cavity
Mechanical Dewatering Unit		
Min no of units – Working	No.	1
Min no of units – Standby	No.	1
Type of Sludge dewatering Equipment	-	As per bidder proposal Centrifuge
Min dewatered sludge (DWSL) TSS required	% w/w	As per CPHEEO Manual
Min solids capture required	%	As per CPHEEO Manual
Polymer System		
Type	-	Dry polymer / Liquid polymer
Minimum polymer dose	kg/ton dry solids	2
Note: Provision for dosing Dewatering Polyelectrolyte (DWPE) shall be made in thickener as well as dewatering facility.		
Dry Polymer Storage		
Type	-	Covered bin
MOC	-	GRP
Minimum storage period	days	30
Polymer Batch Tanks		
MOC	-	GRP/ HDPE
Poly solution strength	% w/w	0.10%
Min no of tanks – Working	tank	1
Min no of tanks – Standby	tank	1

Polymer Tank Mixers		
Min no of mixers per tank	No.	1
MOC - Impeller and shaft	-	SS316
Type	-	Turbine
Polymer Metering Pumps		
Type of Pump	-	Hydraulic double diaphragm
Min no of pumps – Working	No.	1
Min no of pumps – Standby	No.	1
Dewatering Facility Building		
Min no of units	No.	1
No of levels	No.	2
MOC - Roof, columns, beams	-	RCC
Plant Drain Pump Station		
Plant Drain Pump Station	Type	Wet well
MOC		RCC
Design flow	-	5% of average flow of STP
Min HRT at peak flow	min	10
Min operating depth	m	1.5
Plant Drain Pumps		
Min no of pumps – Working	No.	1
Min no of pumps – Standby	No.	1
Type of Pump	-	Submersible
Sub-Station for STP		
Min no of units	No.	1
MOC - Roof, columns, beams	-	RCC
Switch Gear Room	-	As per requirement
Min height	m	5
Transformer yard	-	As per requirement
DG Set		
DG capacity for minimum 50% electrical load or load necessary for continuous aeration process, whichever is more shall be provided to run plant successfully with desirable quality of treated sewage in case of power failure.		

End of Part 2

Request for Proposal

For

DEVELOPMENT OF BORSOLA BEEL

Design, Build and Operate Basis

Volume II A: Submission To Be Made On Award Of Contract

Client:

GUWAHATI SMART CITY LIMITED

GSCL,
Guwahati, Assam

DOCUMENT NO: 10477A-CV-3000-3102

Contents

Submission to be Made on Award of Contract

1.1 Introduction

This Part sets out the technical requirements that are general to the Contract.

1.2 Technical Standards and Regulations

Except where otherwise specified in the bid document plant, materials and workmanship shall comply with the requirements of the relevant Indian Standards (hereinafter referred to as IS) issued by the Bureau of Indian Standards (BIS). Other equivalent National or International Standard Specifications such as those issued by the International Organisation for Standardisation (ISO) or the International Electro technical Commission (IEC) may be substituted by the Contractor (so as long as they are more stringent than the equivalent IS) at the sole discretion of the Engineer or as may have been agreed in the Contract. All standards used shall be the current and latest version.

All works shall comply with all relevant statutory regulations and standards current at date of bids, unless otherwise indicated within the Employer's Requirements. Electrical installations shall, where relevant, be in accordance with the Indian Standards Code of Practice for Electrical Wiring Installations IS 732.

All materials, plant and equipment shall be new and all materials and workmanship not fully specified herein or covered by an approved standard shall be of such kind as is used in first class work and suitable to the climate in the project area.

Indian Standard Specification (I.S.) issued by the Bureau of Indian Standards, (earlier known as Indian Standards Institution), Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110 002, or to any other equivalent Standard it shall be to the latest revision of that Standard at the Tender opening date.

All details, materials and equipment supplied and workmanship performed shall comply with these Standards. If the Bidder offers equipment to other Standards, the equipment/material should be equal or superior to those specified and shall be subject to approval by the Engineer and full details of the difference shall be supplied by the Contractor. In the event of conflict between this Specification and the Codes for equipment, the most stringent provision shall govern, except as otherwise approved by the Employer.

1.3 Precedence of Employer's Requirements

The requirements specified in the Particular Requirements parts, shall be in addition to those specified in the General Requirements parts. In case of conflict between the parts, the requirements of the Particular Requirements parts shall take precedence.

1.4 Units of Measurement

All designs, drawings, specifications and manuals shall use SI units and all measurements, dimensions and performance data shall be quoted in those units.

1.5 Programme

In accordance to Conditions of Contract, the Contractor shall submit within in the stipulated time detailed contract programme for approval, which shall include details of all temporary and permanent works, construction procedures and methodologies.

In addition to the requirements set down in the Conditions of Contract the programme shall include the following details:

(a) Contractor's organisational family tree for the Contract including details of all site supervisors and their responsibilities;
(b) A statement giving the numbers and categories of supervisory and technical staff and skilled and unskilled labour to be employed on the Works;
(c) A list and type details of major constructional plant (including vehicles) which the Contractor proposes to employ on the Works, including programmed dates for order and delivery;
(d) Details of the Contractor's methods of working for all operations;
(e) A statement giving the proposals for location or locations and sizes of offices, workshops and stores at the Site;
(f) A complete resource allocation showing the number of units and allotted times for each unit of constructional plant, materials and labour allocated to each part of the Works;

The programme shall be co-ordinated to take into account the requirements of climatic, groundwater and other conditions to provide for the completion of the Works in accordance with the Contract.

The programme shall be prepared using MS Project software and shall be submitted in both electronic softcopy and paper hardcopy form.

1.6 Contract Management

The Contractor shall be responsible for administration of the Contract from award of Contract through design, manufacture, manufacturer's works testing, and delivery of Plant to Site, installation, testing and performance testing to final take over. For this purpose he shall nominate a Contractor's Representative in accordance with the General Conditions of Contract who shall be fully responsible for and undertake this administration.

Specific responsibilities of the Contractor's Representative shall be:

(a) The sole representation on behalf of the Contractor in all discussion, correspondence and matters relating to the Works.

(b) The co-ordination and monitoring of Contract progress, which shall include the preparation of the Contract programme, monitoring of progress and submission of monthly progress reports. At the discretion of the Engineer, regular meetings shall be called at which the Contractor's Representative shall give a full account of the Contract progress and programme.

(c) The co-ordination and checking of designs, drawings and submissions. The Contractor's Representative shall be responsible for co-ordinating the design, technical information and data between sub-contractors. All calculations, drawings and information submitted to the Engineer shall be checked by the Contractor's Representative and certified as having been checked before submission.

(d) Contract communication between the Engineer and the Contractor. The Contractor's Representative shall attend all meetings involving the Contractor and the Engineer.

(e) The co-ordination and programming of manufacturer's works tests and the submission of test certificates.

(f) The co-ordination and programming of Plant delivery.

(g) The co-ordination and programming of the installation of Plant on the Site, site tests and take over trials. The Contractor's Representative, although not necessarily based at the Site, shall be responsible for the various sub-contractors. At the discretion of the Engineer regular site meetings will be held during which the Contractor's Representative shall give full account of site progress and programme.

(h) The Contractor's Representative shall also be responsible for producing in advance of the work being undertaken, detailed method statements of any work, which involves or affects the performance of existing equipment, processes, or disruption to existing water supplies.

(i) The co-ordination and preparation and submission of As-Built Drawings and Operation and Maintenance Manuals.

(j) Soft copies of all submissions should be in editable form.

(k) The preparation and co-ordination of training of Employer's Personnel.

(l) The submission of applications for payment.

1.7 Meetings

From time to time the Engineer will call meetings in his office or at the Contractor's office, or at the Site, as he deems necessary, to discuss progress and any technical points requiring settlement.

The Contractor's Representative or responsible representative shall attend such meetings.

The Contractor shall prepare and submit to the Engineer a daily activity report summarising the main activities undertaken each day

1.8 Site Photographs

In accordance with the requirements of the Conditions of Contract the Contractor shall supply negatives of photographs and unmounted positive colour prints not less than 250mm x 200mm of such portions of the Works, in progress and completed, as may be directed by the Engineer and specified herein. Contractor shall submit digital photographs in electronic format on any standard digital media such as memory card or CD for every fortnightly. No prints of these soft copies shall be supplied to any other person without the written permission of the Engineer.
The photographs shall be of following categories:

- progress photographs
- record photographs
- Video (CD)

All categories of photographs shall be properly referenced to the approval of the Engineer, and on the back of each print shall be recorded the date and time of the photograph, the direction in which the camera was facing, an identifying description of the subject and the reference.

The taking of photographs of the Works by the Contractor for any other purpose whether for use in India or in any other country shall not be carried out without written approval from the Engineer.

1.9 Setting Out of the Works

The Contractor shall set out the Works, and carry out the Contractor's quality control procedures verifying the accuracy and precision of the setting out for each item of the works. The Contractor shall notify the Engineer sufficiently in advance of the setting out to enable the Employers Representative to observe the accuracy and precision of the laying out. The observations of the Engineer shall not relieve the Contractor of the responsibility under the Contract for the accuracy and precision of the setting out.

1.10 Engineer's Requirements

The Contractor shall provide the following for use by Engineer at the each proposed plant sites covered under the contract. These items are to be maintained by the Contractor in proper, safe, and clean working condition throughout the construction period and shall be returned to the Employer after completion of works.

No separate payment shall be made for the items covered here.

1.10.1 Office Facilities

A separate office for the sole use of the Engineer, his staff and Consultant shall be provided by the Contractor at STP site. The Contractor shall provide, erect, furnish, clean, maintain

and subsequently transfer the office and associated furniture/items to the Employer after the completion of works. The carpet area of the office shall not be less than 50 Sq. Meter.
The walls shall be of 230mm thick brick masonry, plastered and with oil bound distemper on the inner face and snowcem on the outer face. RCC roofing at 3 metre from floor, painted with oil bound distemper shall be provided. The doors shall be of first quality wood and steel windows of approved quality shall be provided. The flooring for the office building shall be minimum 2.5mm thick Vinyl over PCC base. Before commencing the construction of the office, the Contractor shall submit to the Engineer for his approval a drawing of the proposed building with all architectural and finishing details fully shown. The location of the office shall be as directed by the Engineer.

The Contractor shall furnish the rooms as detailed in Volume IV, Price schedule.

1.10.2 Assistance to the Engineer

The Contractor shall provide all necessary assistance to the Engineer and his staff in carrying out their duties of checking, inspecting, and measuring the Works. The Contractor shall provide, at no additional cost, chainmen, staffmen, office attendants, and labourers as may be needed from time to time by the Engineer.

The Contractor shall provide for the Engineer and his staff, consultants and their staff and visitors such protective clothing, safety helmets and rubber boots of suitable sizes, hand lamps and the like as may be reasonably required by them. These articles shall remain the property of the Contractor. No extra payment shall be made on this account

1.11 Erection of Plant

Erection of Plant shall be phased in such a manner as not to obstruct the work being done by other contractors.

Before commencing any erection work, the Contractor shall check the dimensions of structures where the various items of Plant are to be installed and shall bring any deviations from the required positions, lines or dimensions to the notice of the Engineer.
Plant shall be erected in a neat and workmanlike manner on the foundations and at the locations shown on the Approved Drawings. Unless otherwise directed by the Engineer, the Contractor shall adhere strictly to the aforesaid drawings.

The Contractor shall be responsible for setting up and erecting the Plant to the line and level required and shall ensure that all Plant is securely held and remains in correct alignment before, during and after grouting-in. This responsibility shall not be passed to any other contractor.

Any damage caused by the Contractor during the course of erection to new or existing plant or building or any part thereto, the Contractor shall at his own cost, make good, repair or

replace the damage, promptly and effectively as approved by the Engineer and to the Engineer's satisfaction.

1.12 Site Labour and Supervision

The Contractor shall provide all the skilled and unskilled labour required, and all necessary tools and equipment, to erect, test and commission the Works within the period agreed in the programme. The Contractor shall not remove any supervisory staff or skilled labour from the Site without the Engineer's prior approval.

1.13 Sub-letting

The Contractor shall not sub-let the whole of the Works. Where any design or manufacture is sub-let, the Contractor shall not be relieved of his obligation under the Contract. The Contractor shall be responsible for the acts, defaults and neglect acts in manufacture or design of any sub-contractor, as if they were his own.

Where the Engineer has consented to supply of Plant or execution of work by manufacturers or sub-contractors proposed by the Contractor, such manufacturers or sub-contractors shall not be changed without the prior approval in writing of the Engineer. A copy of every sub-order shall be sent to the Engineer at the time the order is placed each clearly marked with the title of the Contract and the Contract number.

1.14 Temporary Works

Not less than 7 days before commencing any portion of the Works, the Contractor shall submit to the Engineer for his approval comprehensive drawings and calculations for all Temporary Works which the Contractor proposes for the construction of that part of the Works.

Notwithstanding approval by the Engineer of any design for the Temporary Works, the Contractor shall be entirely responsible for their safety, efficiency, security and maintenance and for all obligations and risks in regard to such Temporary Works specified or implied in the Contract.

1.15 Languages

All drawings, instructions, signs, notices, name-plates, etc. for use in the design, construction, operation and maintenance of the Works shall be in English.

All site sign boards and warning signs shall be in Gujarati, Hindi and English Languages.

1.16 Drawings and Information to be provided

1.16.1 General

The drawings that will be prepared and issued for this Contract shall be classified as follows and where relevant shall be to a scale which is suitable for the representation of those details illustrated.

The term Drawing shall be deemed to include all drawings, schedules, lists, software documentation, descriptive text and calculations necessary for the design, construction, operation and maintenance of the Works and referred to in this clause.

Drawings and all other submittals required by this contract shall be submitted in editable electronic softcopy format on CD(s) or DVD(s) as well as in hardcopy paper format.

The softcopy format for various items shall be as follows:

- Drawings: AutoCAD version 2008
- Text Documents: Microsoft Word version 2003 or 2007
- All programmes and schedules related to the project: Microsoft Project version 2003 or 2007
- Spreadsheets, calculations, tables, technical schedules, prices schedules, and other numerical data: Microsoft Excel version 2003 or 2007
- Databases: Microsoft Access version 2003 or 2007
- All other required information not included in the above: Adobe Portable Document Format (PDF) version 7.x

The hardcopy format/sizes for various items shall be as follows:

- Drawings: Standard A1 size paper. The scale for each drawing shall be selected such that the information is presented without any clutter or ambiguity and is clearly and easily legible without the use of magnifying aids other than a reader's normal eye-glasses.
- All other information: Standard A4 or A3 paper size, except for any pre-printed standard information such as brochures or catalogue information, which may be submitted in the original size and format.

1.16.2 Drawing Format and Numbering

All drawings shall be prepared using an identical title block format. This shall be approved by the Engineer and shall identify the project, drawing title, the Employer, the Contractor, Sub-contractor, if applicable, and the Engineer.

A formalised drawing numbering system shall be adopted with digits of each number, referencing location, revision, drawing type and size. The numbering format and allocation of drawing number blocks shall be approved by the Engineer.

The Contractor shall provide a sequential numbering system for all Construction Documents. The drawing number shall not be repeated or duplicated.

All drawings shall be submitted to a formalised checking procedure prior to submission. Drawings not so checked will not be approved.

1.16.3 Bidder's Drawings

The Bid Drawings are those issued to Bidders either with the Bidding Documents for the purpose of illustrating and clarifying the Works described in the Employer's Requirements or later during the bidding period as part of an Addendum to the Contract Documents.

Such drawings shall be deemed to have been issued for the guidance of Bidders and shall, for the purpose of executing the Works, be superseded by the Construction Documents.

1.16.4 Bid Drawings and Details

The Bid drawings are those furnished by a Bidder with his Bid for the purpose of illustrating and clarifying his proposals.

The following drawings, details and specific information pertaining to the entire STP package shall be furnished by the Bidder for each STP in the technical envelope in addition to other information mentioned elsewhere in the bid. The lists provided below shall not be considered comprehensive. The bidder shall be responsible for including any and all drawings and information for any and all works that may be necessary for full and complete definition or clarification of the design, regardless of whether or not such drawings, information, or works are explicitly included in the lists below or elsewhere in these bid documents.

(a) General and Process

(i) Narrative Description of the Works
(ii) Plant Operation and Control Philosophy
(iii) Sizing and Design Calculations covering all Major Unit Processes and components of the Works
(iv) List of all structures (basins, tanks, channels, buildings, etc.) including dimensions and freeboards
(v) Complete Equipment List
(vi) All Equipment Catalogues and selection chart (with all relevant manufacturers' documentation).
(vii) Major Piping Schedule to include service (process stream), installation type (e.g., buried, exposed, submerged, etc.), size, material, coating, lining, joint type(s), gauge/thickness, pressure rating, testing protocol, design standards
(viii) Major Valve Schedule to include service (process stream), installation type (e.g., buried, exposed, submerged, etc.), size, type, material, joint type(s), pressure rating, differential pressure rating, testing protocol, design standards, operator/actuator type, and whether Open/Close or Modulating

(ix) Major Gate Schedule to include service (process stream), installation type (e.g., buried, exposed, submerged, etc.) size, type, differential head, seating or unseating, testing protocol, design standards, operator/actuator type, and whether Open/Close or Modulating

(x) Plant Layout.

(xi) Hydraulic Profile.

(xii) Process Flow Diagram.

(xiii) Piping and Instrumentation Diagrams (P&IDs)

(xiv) Electrical Load List & Power Consumption Chart.

(xv) List of Chemical Consumption on Daily/ Monthly Basis.

(b) Mechanical

(i) To-scale dimensional layout and/or installation drawings for the following Equipment, at a minimum:

- Major gates
- Fine Screens
- Grit removal equipment
- Fine Bubble Diffusers
- Process Air Blowers
- Decanters
- Return activated sludge pump sets
- Gravity Sludge Thickeners
- Thickened sludge pump sets
- Sludge Dewatering Centrifuges
- Filtration System
- Chlorination system
- Plant Water Pumps
- Plant Drain Pumps

(ii) Graphs for all major pumps and blowers (including but not limited to Return Activated Sludge Pumps, Thickened Sludge Pumps, Centrifuge Feed Pumps, Process Air Blowers)

- Pump Performance Curves : Q vs H, speed, P, Efficiency, and NPSH
- ISO-efficiency curves of the pump model proposed

(c) Electrical

(i). Equipment layout

(ii). Earthing layout

(iii). Cable routing layout

(iv). Lighting and power layout

(v). Electrical Load List

(vi). Electrical Single Line Diagram of STP

(vii). Sizing Calculations for Transformers and DG Sets
(viii). Specific Energy Consumption
(ix). Technical Schedules for Electrical Works duly filled in
(x). Instrumentation SCADA
(xi). Construction schedule

(d) Instrumentation, Control & Automation

(i) P&IDs for the complete process indicating all the local & remote /panel mounted measurements & controls, alarm & interlocking functions, using ISA symbols.
(ii) Consolidated instrument list (Instrument Index) indicating description, application, location, type, quantity, accuracy, process parameters, measuring ranges, etc.
(iii) Tentative instrumentation power (UPS & Non UPS) & air requirements, as applicable.
(iv) Automation system configuration diagram along with a write up explaining the system functions, redundancy features, interfacing with other systems, etc.
(v) Broad bill of materials for the Instrumentation & Automation equipment & peripherals.
(vi) Tentative I/O list.
(vii) Control Room Layout indicating disposition of various panels, cabinets, consoles, etc. with dimensional details (approx).Heat load in the control room shall be furnished.
(viii) List of spares and consumables with details and quantities.

1.16.5 Details of Drawings and Calculations to be submitted by the Contractor for Approval

Drawings / Calculations for approval shall be submitted by the Contractor after award of the contract in two Phases.

The first phase shall be the Preliminary Drawings / Designs. Drawings / Designs submitted during this phase shall be of sufficient detail for the Employer and Engineer to understand in outline the Contractor's proposals for the design and construction of the Works. The lists provided below shall not be considered comprehensive. The bidder shall be responsible for including any and all drawings and information for any and all works that may be necessary for full and complete definition or clarification of the design, regardless of whether or not such drawings, information, or works are explicitly included in the lists below or elsewhere in these bid documents.

The Preliminary Drawings / Designs for each STP shall comprise:

- Detailed Description of the proposed Sewage Treatment Plant and Treatment Process offered (including Raw and Treated Sewage Quality).
- Detailed Plant Operation and Control Philosophy;
- Detailed Process Design Calculations / Mass Balance Calculations covering all Units/ Equipment.
- Detailed List of Units including Unit Dimensions/ Free Boards.
- Detailed Equipment List
- Major Equipment /Instrument Specifications (with supporting Brochures).

- Major Piping Schedule to include size, material, coating, lining, gauges/thickness, and pressure rating
- Major Valve Schedule to include size, type, material, pressure rating, operator/actuator type, and whether Open/Close or Modulating
- Gate Schedule to include size, type, differential head, seating or unseating, operator/actuator type, and whether Open/Close or Modulating
- Detailed Plant Layout (including Pipe Sizes/ Pipe Routing/ Channel Size/ Channel Routing/ Site Roads/ Site Drainage)
- Detailed Hydraulic Profile including Hydraulic Calculations;
- Detailed Process Flow Diagram (inclusive of Mass Balance)
- Process and Instrumentation Diagram (P&ID) & SCADA.
- Detailed Electrical Load List for STPs, prepared based on approved Equipment list from process and Mechanical
- Transformer sizing calculation for STPs, based on approved Electrical load list
- D.G sizing calculation for STPs based on approved Electrical load list
- Detailed Chemical Consumption Calculations (Daily/ Monthly Basis).

The second phase shall be the Detailed Engineering Design phase and shall comprise the submission of the Detailed Mechanical/ Electrical/ Instrumentation/ SCADA/ Structural/ Civil Construction Drawings and Calculations. These shall be submitted after the approval of the Preliminary Drawings. The lists provided below shall not be considered comprehensive. The bidder shall be responsible for including any and all drawings and information for any and all works that may be necessary for full and complete definition or clarification of the design, regardless of whether or not such drawings, information, or works are explicitly included in the lists below or elsewhere in these bid documents.

The Construction Documents shall be used for the construction of the Works and shall comprise:

(a) Civil

Site layouts for each STP providing information on levels and detailing the location of:

- General arrangements and main sections of all plant areas;
- Plans, elevations and main sections of all structures and buildings;
- Buildings
- Storage tanks;
- Process plants;
- Transformer enclosures
- Roadways;
- Drainage (plant drainage, sanitation and storm water drainage);
- Buried pipelines;
- Cable routes for direct in ground and ducted systems;

Detail drawings of:

- Cable and pipework chambers;
- Buried pipework;
- Pipework connections;
- Contract interface;
- Reinforcement drawings;
- Bar bending schedules.

Calculations for:

- Detailed Structural Design calculation of all the units/ Structures;

(b) Hydraulic

-Detailed hydraulic profile;

-Detailed hydraulic calculations

(c) Process

Drawings:

- process flow diagram;
- comprehensive P&ID s including details of:
  - pipeline sizes and materials;
  - valve size and type;
  - Equipment detail
  - instrumentation;
  - Identification of controlling PLC.

Calculations for:

- Detailed Process Design Calculations / Mass Balance Calculations covering all Units/ Equipment.
- Detailed List of Units including Unit Dimensions/ Free Boards.
- Detailed Equipment List
- Major Equipment /Instrument Specifications (with supporting Brochures).
- Major Piping Schedule to include size, material, coating, lining, gauges/thickness, and pressure rating
- Major Valve Schedule to include size, type, material, pressure rating, operator/actuator type, and whether Open/Close or Modulating
- Gate Schedule to include size, type, differential head, seating or unseating, operator/actuator type, and whether Open/Close or Modulating
- Detailed Process Flow Diagram (inclusive of Mass Balance)
- Detailed Chemical Consumption Calculations (Daily/ Monthly Basis).

(d) Mechanical

Drawings:

Outline dimensional drawing & Cross section Drawing (with Bill of Quantity and Material of construction) for the following items for each STP but not limited to:

1.	Fine screens
2.	Belt Conveyor for screenings
3.	Sluice valve – motorised
4.	Sluice valve – manually operated
5.	Non-Return valves
6.	Knife Gate Valves
7.	Dismantling joints
8.	H.O.T & E.O.T Cranes
9.	Sluice gate – Manual & Motorised
10.	Dewatering Pumpset
11.	Grit removal equipment
12.	Fine Bubble Diffused Aerators along with Grid
13.	Process Air Blowers
14.	Decanters
15.	Return activated sludge Pumpset
16.	Chlorination system
17.	Filtration system
18.	Plant Drain Pumps
19.	Plant Water Pumps
20.	Sludge Dewatering Centrifuges
21.	Gravity Sludge Thickeners
22.	Thickened sludge pump sets
23.	Sludge conveyor system & Hopper
24.	Sludge Dewatering Centrifuge Feed Pumps
Graphs for all major pumps and blowers (including but not limited to Return Activated Sludge Pumps, Thickened Sludge Pumps, Centrifuge Feed Pumps, Process Air Blowers): • Pump Performance Curves : Q vs H, speed, P, Efficiency, and NPSH • Iso-efficiency curves of the pump model proposed	
	Motor Curve
(i)	Starting Current vs time
(ii)	Characteristics

(e) Electrical

Drawings

Single Line Diagram of Complete Electrical System for STP based on the equipments finalized by Mechanical and Process.

(1) Electrical Substation Layout of STP showing Panel locations, Transformer locations and Trench Layout.

(2) 11kV Switchgears

(a) Dimensional Drawing showing overall dimensions, plan, elevation and cable entry details.

(b) Complete assembly drawings of the Switchgear showing plan, elevation and typical sectional views, details of busbars and location of cable end boxes and control cable terminal blocks for external wiring connections, etc.

(c) Foundation plan showing the location of channel sills, anchor bolts and anchors, floor plans and openings.

(d) Schematic power and control wiring diagrams along with control & interlock details, complete bill of materials indicating make, type, rating, setting etc of Circuit breakers, relays, contactors, current transformers, potential transformers, instruments, meters, annunciations etc .

(3) Outdoor pole Structure

(a) Detail designs and Structural/ fabrication Drawings showing member sizes and their fixing details, foundation details, etc.

(b) General arrangement drawing shall indicate the overall dimensions, net weights, mounting and fixing details of insulators, lightning arrestors, disconnector, drop-out fuses, etc.

(4) Diesel Generator Set

(c) GA Drawing showing overall dimensions ,plan, elevation, sectional views, mounting arrangement, layout, make, type, rating etc of diesel engine, Alternator, Control panel, battery, battery charger etc.

(d) Single Line & Schematic diagrams showing details of Power & Control, Change over, AMF details, Synchronising details, interlocks, protections annunciations, battery, battery charger etc with make, type, rating, setting etc of various equipment, components etc.

(e) Foundation plan showing the location of channel sills, foundation, anchor bolts and anchors, floor plans and openings.

(f) Exhaust system with piping layout

(g) Day oil tank sizing with mounting arrangement details

(h) Fuel bulk storage tank sizing with mounting arrangement details

(i) Fuel supply system with pipe arrangement.

(5) Transformers

(a) General arrangement drawing of the transformer, showing plan, front elevation and side elevation complete with all accessories and fittings, detailed dimensions, net weights, quantity of oil, clearances between HV terminals, between LV terminals, between HV and LV terminals, between HV & LV terminals and ground etc.

(b) Rating, diagram and terminal marking, complete with polarity and vector group.
(c) Control wiring diagram for marshalling box.
(d) Foundation drawing with position of foundation bolts and depth.

(6) L.T Panels, Distribution Boards, Power Control Centres, Power Motor Control Centres, Motor Control Centres etc.
(a) Dimensional Drawing showing overall dimensions, plan, elevation and cable entry details.
(b) Complete assembly drawings of the switchboard/distribution board / MCC showing plan, elevation and typical sectional views ,details of busbars and location of power & control cable terminal blocks for external wiring connections, etc.
(c) Foundation plan showing the location of channel sills, anchor bolts and anchors, floor plans and openings.
(d) Schematic power and control wiring diagrams along with control & interlock details, complete bill of materials indicating make, type, rating, setting etc of Circuit breakers, relays, contactors, current transformers, potential transformers, instruments, meters, annunciations etc .
(e) Feeder Operation and Interlock logic.

(7) L.T Capacitor bank with Automatic Power Factor Correction Relay
(a) Fully dimensioned general arrangement drawings of capacitor and capacitor control panel with elevation, side view, sectional view and foundation details.
(b) Justification for number of steps for switching.
(c) Complete schematic and wiring diagrams for capacitor control panel.

(8) Variable Frequency Drives
(a) Dimensional details with mounting arrangement.
(b) Schematic power and control wiring diagrams along with control & interlock details, complete bill of materials indicating make, type, rating, setting etc of Circuit breakers, relays, contactors, current transformers, potential transformers, instruments, meters, annunciations etc .
(c) Specific details of converter, inverter and harmonic control units.

(9) Battery and Battery Charger with D.C. Distribution board
(a) Dimensioned general arrangement drawings
(b) Fully dimensioned general arrangement drawings of battery and battery charger with elevation, side view, sectional view and foundation details

(c) Complete schematic and wiring diagrams

(10) Cabling System

(a) Make and type of HT& LT Power and Control Cables.
(b) Details of Installation of Cables in Trenches, on cable trays, directly buried Etc at all locations inside the plant.
(c) Cable routing plan and section inside the plant.
(d) 11kV Cable termination and mounting Kit Layout drawing.

(11) Lighting system

(a) Make, type, rating etc of various fixtures, receptacles, switches etc in various premises.
(b) Make, type, rating etc of various fixtures, lighting poles etc for street lighting and flood lighting.
(c) Detailed Room wise Lighting Layout with Type of fixture details and Circuit diagram showing phase wise load distribution and interconnection between switches, fixtures, Lighting panel, receptacles etc.
(d) Internal road Lighting and Area lighting layout with location of poles, details of fixtures and mounting.
(e) Street Light pole details with Foundation details.

(12) Earthing System

(a) Details such as material, sizes, etc. of the earth conductor and electrode pits.
(b) Earthing layout drawing showing routing of main grid inside the plant with details of interconnection of equipment earthing to the grid and earth pits.

(13) Electrical Equipment and Panel Layout for STP.

Schedules

(1) Cable schedules & bill of quantities
(2) Electrical Load and Power consumption schedule
(3) Junction box schedule
(4) Protection relay setting schedule.

Calculations

(1) Specific Energy Consumption Calculations.
(2) Bus bar sizing calculation for 11 KV Switchgears, 415 V Switchgears etc.
(3) Co-ordinated protection study.
(4) Fault level and Voltage Dip Calculations.

(5) Sizing of Capacitor banks.

(6) Non Segregated Bus Duct

(a) Sizing of the bus bars vis-à-vis thermal capability to withstand rated Continuous current and one second short time current.

(b) Spacing of the insulators vis-à-vis mechanical strength to withstand forces due to momentary short circuit current.

(c) Heat loss and temperature rise calculations for conductor and enclosure. All formulae and other information from which the heat losses have been derived shall be enlisted.

(7) HT and LT Cable sizing.

(8) Earthing sizing calculation

(9) Room wise Lighting Calculation as per Lux level given in the specification.

(10) Building Lightning Protection and Earthing Sizing Calculation.

(f) Control and Instrumentation

Drawings:

- power supply distribution single line and schematics diagrams (see note 1) for each control panel;
- internal and external (see note 2) general arrangement for each control panel (dimensional);
- Control panel wiring diagram, , relay logic diagram along with terminal block details;
- System configuration and layout diagram along with bill of material, program listings, block logic diagram and control logic write up for PLC;
- UPS and battery sizing calculations;
- control and instrumentation loop drawings (see note 3);
- instrument installation detail drawing (hook up, see note 4);
- cable block diagrams;
- cable routing/installation drawings;
- foundation and fixing details and trenches drawings;
- Mimic general arrangement (full colour copies shall be provided).

Schedules:

- cable schedule;
- cable interconnection schedule;
- control and instrumentation load schedule for each control panel;
- I /O schedule;
- junction box schedule;
- instrument schedule with tag nos;
- instrumentation, process control set point schedule;
- instrument data sheets;

Documentation:

- functional design specification (FDS)(see note 5);
- factory acceptance test document (FAT);
- site acceptance test document (SAT).

Notes:

1. Schematic drawings shall include a comprehensive schedule of the components used in each switchboard, MCC and control panel including details of the type, manufacturer and rating of each component.
2. The external arrangement of each switchboard, MCC and control panel shall show the arrangement of all components including details of panel section, switch and instrument labels.
3. Control and instrumentation loop drawings shall show on a single drawing the complete circuit associated with an instrument or device including details and location of power supplies, cabling and terminations.
4. Hook up drawings shall detail how an instrument or device is installed.
5. See details later for requirements of the FDS.

Electrical control schematics, loop diagrams and schedules shall where practical be A3 size drawings; all other drawings shall be A1 size.

(g) Mechanical Building Services

Drawings:

- single line schematics for waste water system and drainage systems;
- general arrangement drawings showing the location of each mechanical building service plant item;
- general arrangement of ventilation systems;
- Fixing details.

Schedule:

- plant data sheets with Equipment GA dimensional drawing, Foundation detail, Calculation and Manufacturer's Quality Assurance Plan;
- pipeline schedules;
- Valve schedules.

Calculations for:

- System & Equipment sizing.

The Engineer reserves the right to ask for additional Equipment/system information apart from the above to ascertain good system design and proper selection of Equipment.

1.17 Operating and Maintenance Manuals

1.17.1 General

1.18 Submission of Documents and Drawings

The Contractor shall supply to the Engineer 5 (five) copies each of the drawings and design calculations for the process and sizing of all components of the System including architectural, structural, mechanical, electrical and instrumentation equipment, supported by flow diagrams and general arrangement drawings for approval.

The Engineer may require the Contractor to submit for approval additional drawings if they are necessary to enable him to satisfy himself that the items are well designed, that they comply with the Employer's Requirements and that they are suitable for their intended purpose. These drawings shall form the agreed basis for the execution of the Works. If an approved drawing is revised, revised copies shall be submitted for approval as above and no such revised drawing shall be used for the purposes of the Contract until it has been approved in place of the earlier issue of the drawing.

The Employer shall arrange to send observations if necessary within 28 (twenty eight) calendar days of submission of the design and drawings for modifications to the Contractor. The Contractor shall incorporate all necessary comments of the Engineer in the above design and drawings, if any, and shall re-submit further 5 (five) copies each of the revised designs and drawings within 10 (ten) days for the final approval of the Engineer. The Contractor shall thereafter submit 8 (eight) copies each of the approved designs and 8 (eight) copies each of the approved drawings together with one copy each of the reproducible tracings. The Engineer will return 2 (two) approved copies to the Contractor and retain 6 (six) for the Engineer's office and field use.

If the submissions require more then one round of revision on account of incomplete compliance from Contractor, the delay will be on account of the Contractor. If new observations are given by the Engineer, the Contractor will be entitled to take an additional 10 (ten) days period for compliance.

The Engineer will signify his approval or disapproval of the Preliminary Phase Drawings / Construction Documents within 28 (twenty eight) calendar days of each submission.

The structural designs shall be submitted along with STAAD files (input and output).

The Construction Documents are certified Drawings submitted by the Contractor to the Employer or Engineer during the course of the Contract for approval. Construction Documents shall be submitted in accordance with the timetable set down in the Work Programme.

Approval of drawings by the Engineer shall not be held to relieve the Contractor of his responsibilities under the Contract.

The construction drawings shall be submitted in A3 / A1 sized drawing papers and to readable scale.

The Engineer will not permit construction to start on a part or section of the Works unless Construction Documents for that part or section have been approved.

Draft copies of the O & M Manuals shall be submitted to the Engineer for his approval at least 56 (fifty six) calendar days prior to the commencement of Tests on Completion.

The Engineer will signify his approval or disapproval of the O & M Manuals within 28 (twenty eight) calendar days of submission.
Draft As-Built Drawings shall be submitted 56 calendar days prior to the commencement of Tests on Completion.

The Engineer will signify his approval or disapproval of the As-Built Drawings within 28 (twenty eight) calendar days of submission.

To remove doubt the submission dates referred to above shall be the dates on which the drawings and documents are received by the Engineer.

1.19 Notice of Operations

The Contractor shall give full and complete written notice of all important operations to the Engineer sufficiently in advance to enable the Engineer to make such arrangements as the Engineer may consider necessary for inspection and for any other purpose. The Contractor shall not start any important operation without the written approval of the Engineer.

1.20 Protection of Existing Installations

The Contractor shall apply to the Engineer in writing at least 28 days before starting any work that involves interference with existing structures, equipment, etc. The Contractor shall not execute such work until he has received permission to proceed, in writing from the Engineer.

The Contractor shall ensure that no earth, debris or rock is deposited on public or private roads or rights of way as a result of the Works and all vehicles leaving the Site shall be cleaned accordingly.

1.21 Protection of Existing Public and Private Services

The Contractor shall notify all public authorities, utility companies and private owners of proposed works that will affect them not less than two weeks before commencing the works.

The Contractor shall adequately protect, uphold, maintain and prevent damage to all services and shall not interfere with their operation without the prior consent of the public authorities, utility companies, private owners, or the Engineer as appropriate.
If any damage to services results from the execution of the Works, the Contractor shall immediately:

(a) Notify the Engineer and appropriate public authority, utility company or private owner.

(b) Make arrangements for the damage to be made good without delay to the satisfaction of the public authorities, utility company or private owner as appropriate. The Contractor shall be liable for all costs for making good such damage.

The Engineer may issue instructions or make other such arrangements as he deems necessary, to repair rapidly any essential services damaged during the execution of the Contract. Such arrangements shall not affect any liability to pay for making good the damage.

1.22 Reinstatement and Compensation for Damage to Persons or Property

The Contractor shall reinstate all properties whether public or private which are damaged in consequence of the construction and maintenance of the Works to a condition as specified and at least equal to that obtaining before his first entry on them.

If in the opinion of the Engineer the Contractor shall have failed to take reasonable and prompt action to discharge his obligations in the matter of reinstatement, the Engineer will inform the Contractor in writing of his opinion, in which circumstances the Employer reserves the right to employ others to do the necessary work of reinstatement and to deduct the cost thereof as certified by the Engineer from any money due or which shall become due from the Employer to the Contractor.

The Contractor shall refer to the Employer without delay all claims, which may be considered to fall within the exceptions listed in the Conditions of Contract.

1.23 Packing and Protection

Before any Plant is despatched from a manufacturer's factory it shall be adequately protected and packed to ensure that it will arrive on the Site in an undamaged condition. The methods employed for protection and packing must be suitable for withstanding the conditions which may be experienced during shipment, delivery to the Site and prolonged periods of storage in the open, whether the items are shipped in packing cases, crates or only partially protected according to their nature.

Bright parts and bearing surfaces shall be protected from corrosion by applying a rust preventive lacquer, high melting point grease or similar temporary protection. A sufficient quantity of solvent shall be supplied with the plant to enable this coating to be removed on the Site.

All machined flanges and other mating surfaces shall be protected by means of wood templates. The bolts for securing these templates shall not be reused in the final installation.

No one crate or package shall contain items of Plant intended for incorporation in more than one part of the Works.

All items of Plant shall be clearly marked for identification against the packing list, which shall be placed in a waterproof envelope inside every packing case or crate.
Every packing case and crate shall be indelibly marked to show its weight, serial number, top and bottom, shipping marks and handling instructions or sling marks.

Electrical Plant shall be enclosed in sealed airtight packages with dehydrating material, before being placed in packing cases on shock-absorbent material and secured by means of battens.

1.24 Quality Assurance

1.24.1 Policy

In accordance with Conditions of Contract the Contractor shall apply the formal requirements of Quality Assurance to the design, supply, construction and maintenance of the Works. This shall be achieved through the implementation of a Quality System compliant with the requirements of BS 5750 or an equivalent International Standard.

Positive commitment to Quality Assurance shall be expressed in a formal policy statement given in the Contractor's Quality Manual.

1.24.2 Objectives

It shall be the stated aim of the Contractor to achieve and demonstrate the achievement of quality as expressed by `due care and diligence' of the design, supply, construction and maintenance of the Works as defined by the Employer's Requirements.

The criteria to define `due care and diligence' shall be explained in the Contractor's Quality Plan and shall embody all of the design, supply, construction and maintenance requirements of the Works.

1.24.3 Quality System

The Quality System shall be fully integrated for all of the Works.

This system will be defined by the organisational structure, responsibilities, activities, resources, and events that together demonstrate the capability of the Contractor to meet the stated quality requirements.

The Contractor shall ensure that all sub-contractors and sub-consultants establish quality systems and shall supply to the Employer such evidence as is necessary to demonstrate the effective implementation of a quality system in each sub-contractor or sub-consultant organisation.

The Quality System of the Contractor and of his sub-contractor and sub-consultants will be subject to periodic audits undertaken by the Engineer. The Engineer will give two weeks' notice of such audits that will involve a full assessment of the performance and efficiency of the Quality System and will include review of the feedback and records derived from the Contractor's monitoring and internal reviews.
On a day-to-day basis the Contractor shall afford reasonable availability of staff and documentation for the Engineer to assess the implementation of the Quality System. The Contractor shall ensure that all relevant personnel and documentation are available for such audits.

1.24.4 Quality Plan

The implementation of the Quality System shall be through the establishment of a comprehensive Quality Plan issued to and approved by the Engineer.

The documented procedures shall include but not be limited to:

- Management Procedures;
- Design;
- Supply/Procurement;
- Construction;
- Putting to work/Commissioning/Reliability Trial/Performance Test;
- Operator Training and Maintenance;
- Interface Control;
- Quality Performance, Monitoring and Review.

There shall be procedures to control transmission of information across all interfaces both internally (that is, within the Contractor's Quality System) and externally. Those of the latter shall include all Statutory Bodies, Authorities and the Engineer.

Formal assessment of any non-compliance with the Quality Plan shall be achieved through periodic reviews undertaken by a team appointed by the Contractor. All deficiencies shall be

recorded and appropriate corrective measures shall be assessed, within an appropriate timescale, through subsequent formal reviews undertaken by the Contractor.

1.24.5 Quality Feedback

The system shall include for the reporting back, recording and incorporation into the system of deficiencies and remedial measures to correct them noted during the control of the project.

1.25 Environmental Protection

The Contractor shall minimize, as far as is practically possible, the effects of all his and his Subcontractors' activities upon the environment and shall implement and monitor measures to prevent:

(a) Contamination of surfaces, ground, groundwater, surface water and rivers,
(b) Emissions to air, including smells, gases, smoke, and dust.
(c) Unsanitary or unsafe storage or discharge to drain, sewer and surface waters,
(d) Unsanitary or unsafe storage or discharge of solid wastes,
(e) Noise,
(f) Visual intrusion, and
(g) Excessive energy and water consumption.

These requirements shall be met through the constant and careful attention of the Contractor's management of all Site and off-site activities, and by instruction to all staff and labour in these matters.

The Contractor shall appoint an Environmental Control Manager for the Works, who shall be responsible for preparing an Environmental Management Plan and ensuring its implementation by the Contractor after obtaining approval of the Engineer.

Implementation shall include for monitoring and reporting on the results of the above measures. Monitoring reports shall be in writing and submitted on a monthly basis as part of the monthly report referred to above. The report shall include a listing and summary of daily monitoring results on all aspects listed above.

All potentially affected areas of the Site, other areas used for or affected by the works and all adjacent or affected waterways shall be monitored and, where instructed by the Engineer, tested.

The Environmental Management Plan (EMP) shall identify the potential environmental impacts from the various construction and operations and maintenance activities to be undertaken in the Contract and set out in detail the approach he will adopt in mitigating these environmental impacts to ensure that the residual impacts are minor and confined to a short period.

The EMP shall consider but not be limited to the following:

- The methods of materials delivery, storage, usage and disposal; equipment usage; and site activities to ensure they have minimal impact on the environment,
- Only environmentally safe products and practices shall be adopted in performing his works, and
- The Contractor shall comply with all of the statutes regarding environmental effects.

The EMP shall provide separate descriptions of its proposals for minimizing any adverse environmental impacts/effects during the construction phase and the subsequent operations and maintenance phase.

The EMP shall be provided in draft form within 28 days from the Notice to Commence, and shall be updated from time to time by the Contractor as agreed or required by the Engineer to ensure the objectives of environmental protection are fully met.

1.26 Safety

The Contractor shall prepare a Safety Plan and submit the same to the Engineer for approval within 28 days of receiving the Notice to Commence.

The Safety Plan shall be followed at all times by the Contractor and shall contain adequate control measures, in accordance with the relevant protection of property and local laws and regulations as well as internationally accepted good practice, for the prevention of accidents, fires and public nuisance.

The Safety Plan shall be implemented properly and diligently throughout the execution of the Works and during the operations and maintenance period.

The Contractor's Safety Plan shall make safety provision for, among other things:

(a) Deep excavations and collapsing sides in trench excavations,
(b) Scaffolds and overhead working,
(c) Working in confined spaces,
(d) Working in water,
(e) Contractor's Equipment, especially cranes,
(f) Hand held power tools,
(g) Electrical equipment,
(h) Hazardous chemicals, gases and fuels,
(i) The use of protective clothing, and
(j) The provision of first aid facilities.

The Safety Plan shall be developed to ensure zero fatal accidents and zero hazardous incidents/occurrences in all construction works. The Safety Plan shall include descriptions of

the company's standard policies and procedures regarding its site organization and procedures, methods and frequency of conducting safety audits at the Site(s), record keeping and reporting, providing safety training for its personnel (including subcontractors), issue and mandatory use of safety equipment, and details of the qualifications and experience of the Bidder's proposed safety officers to be deployed at the Site(s). The Contractor shall provide separate descriptions in its Safety Plan covering the construction phase and the subsequent operations and maintenance phase.

The Contractor shall appoint a Full Time Safety Manager for the Works having experience in this field, who shall be responsible for implementing the Safety Plan. He shall be supported by at least two safety officers who are qualified for such safety works.

The Contractor shall ensure that his staff and labour and his Subcontractors are all fully trained in and aware of good and safe working practices.

The Contractor shall ensure that all precautions are taken to safeguard the general public and construction/operating staff from any danger.

All temporary and partially completed works shall be protected by way of barriers, lights, notices and the like.

All excavations and the like are to be protected by barriers at all times and adequately illuminated at night.

Warning and diversion signs concerning roadwork shall be suitably placed to give motorists ample warning. During the movement of heavy vehicles across roads or onto roads, men, bearing red flags, shall be in attendance to warn other road users and to generally control traffic in a safe manner.

The Safety Plan shall also consider requirements for warning and protection for other risks including overhead and underground cables, pipes or obstructions, or voids, openings, pits and trenches. The Contractor shall ensure that all appropriate measures are implemented.

The Safety Plan shall include a policy statement signed by the CEO or equivalent authority of the Organization declaring that safety and loss prevention shall be given the highest practicable priority in all aspects of the Contract. The Safety Plan shall be updated as necessary to cover the activities to be undertaken for operations and maintenance.

----------End----------

Request for Proposal

For

DEVELOPMENT OF BORSOLA BEEL

Design, Build and Operate Basis

Volume II A: Inspection, Testing & Commissioning Requirements

Client:

GUWAHATI SMART CITY LIMITED

GSCL,
Guwahati, Assam

DOCUMENT NO: 10477A-CV-3000-3102

INSPECTION, TESTING AND COMMISSIONING REQUIREMENTS

1.1 Inspection and Testing During Manufacture

1.1.1 General

(a) All inspection and testing shall be carried out in accordance with the Specification and in absence of Specification relevant Indian Standard. After award of contract, Contractor shall furnish a QA plan for approval by Employer. QA plan shall include testing for supply of raw materials and bought out items, stage inspections and tests on finished products at manufacturer's works / appropriate testing station. QA plan shall clearly indicate tests which are intended to be witnessed by the Contractor alone and those by both contractor and Employer.

(b) **Inspection and tests schedule shall be as follows;**

1) Manufacture tests
2) Acceptance inspection / Quantity checking
3) Install /site inspection
4) Site acceptance test
5) Tests on Completion
6) Process Wet Tests (by Raw Sewage)
7) Operation Test (Tests After Completion)

(c) The Contractor shall carry out at the place of manufacture tests of the Plant /Equipment at any part of the Works.

(d) The Employer and/or duly authorised and designated representative(s) shall be entitled to attend the aforesaid inspection and/or tests.

(e) The Employer and his duly authorised representative shall have access to the Contractor's premises at all times to inspect and examine the material and workmanship of the mechanical and electrical plant and equipment during its manufacture there. If part of the plant and equipment is being manufactured on other premises, the Contractor shall obtain permission for the Employer or his duly authorised representative, to inspect as if the plant and equipment was manufactured on the Contractors own premises. Testing (including testing for chemical analysis and physical properties) shall be carried out by the Contractor and certificates submitted to the Employer's Representative who will have the right to witness or inspect the above mentioned inspection /testing at any stage desired by him. Where inspection or testing is to be carried out at a subcontractor's works, a representative of the Contractor shall be present.

(f) Contractor shall provide test procedure, pre-factory test results, and calculation sheet, photo in advance and provide all of test result with necessary document including its data and photo to show Employer's Representative that test is carried out in proper condition and the its test results.

(g) The procedure for the testing and inspection to be carried out during or following the manufacture of the materials to ensure the quality and workmanship of the materials and to further ensure that they conform to the Contract in whatever place they are specified shall be as described below.

(i) The Contractor shall give the Employer at least 21 clear days notice in writing of the date and the place at which any plant or equipment will be ready for inspection/testing as provided in the Contract. The Employer or his duly authorised representative shall thereupon at his discretion notify the Contractor of his intention either to release such part of the plant and equipment upon receipt of works tests certificates or of his intention to inspect. The Employer shall then give notice in writing to the Contractor, and attend at the place so named the said plant and equipment which will be ready for inspection and/or testing. As and when any plant shall have passed the tests referred to in this section, the Employer's Representative shall issue to the Contractor a notification to that effect.

(ii) The Contractor shall forward to the Employer 6 duly certified copies of the test certificates and characteristics performance curves for all equipment.

(iii) If the Employer's Representative fails to attend the inspection and/or test, or if it is agreed between the parties that the Employer's Representative shall not do so, then the Contractor may proceed with the inspection and/or test in the absence of the Employer's Representative and provide the Employer with a certified report of the results thereof as per (ii) above.

(iv) If any materials or any part of the works fails to pass any inspection / test, the Contractor shall rectify or replace such materials or part of the works and shall repeat the inspection and/or test upon giving a notice as per (i) above. Any fault or shortcoming found during any inspection or test shall be rectified to the satisfaction of the Employer's Representative before proceeding with further inspection of that item. Any circuit previously tested, which may have been affected by the rectification work, shall be re-tested.

(v) Where the plant and equipment is a composite unit of several individual pieces manufactured in different places, it shall be assembled and tested as one complete working unit, at the maker's works.

(vi) Neither the execution of an inspection test of materials or any part of the works, nor the attendance by the Employer's Representative, nor the issue of any test certificate pursuant to (iii) above shall relieve the Contractor from his responsibilities under the Contract.

(vii) The test equipment, meters, instruments etc., used for testing shall be calibrated at recognised test laboratories at regular intervals and valid certificates shall be made available to the Employer's Representatives at the time of testing. The calibrating instrument used as standards shall be traceable to National/International standards. Calibration certificates or test instruments shall be produced from a recognised Laboratory for the Employer's Representative approval in advance of testing and if necessary instruments shall be recalibrated or substituted before the commencement of the test.

(viii) Items of plant or control systems not covered by standards shall be tested in accordance with the details and program agreed between the Employer's Representative and Contractor's Representative. If such materials or works are found to be defective or not conforming to the Contract requirements, due to the fault of the Contractor or his sub-contractors the Contractor shall defray all the expenses of such inspection and/or test and of satisfactory reconstruction.

(ix) Tests shall also be carried out such that due consideration is given to the Site conditions under which the equipment is required to function. The test certificates shall give all details of such tests.

(x) The Contractor shall establish and submit a detailed procedure for the inspection of materials or any part of the works to the Employer for approval within the date indicated in the Programme Details. The detailed procedure shall indicate or specify, without limitation, the following :

- Applicable code, standard, and regulations.
- Fabrication sequence flow chart indicating tests and inspection points.
- Detailed tests and inspection method, indicating the measuring apparatus to be used, items to be measured, calculation formula, etc.
- Acceptance criteria.
- Test report forms and required code certificates and data records.
- Method of sampling, if any sampling test to be conducted.
- Contractor's or Employer's witness points.

(xi) The Contractor shall not pack for shipment any part of the Plant until he has obtained from the Employer or his authorised representative his written

approval to the release of such part for shipment after any tests required by the Contract have been completed to the Employer's satisfaction.

(xii) The following Inspection and Testing procedures shall be carried out for the equipment as applicable.

The detailed procedure shall indicate or specify, without limitation, the following:

- Visual Inspection.
- Dimension Checking
- Dynamic balancing for all rotating parts
- Hydrostatic / Leak testing for all pressure parts, Pneumatic Leak Test wherever applicable
- Operation check
- Liquid penetrant tests or magnetic particle tests for all machined surfaces of pressure parts.

(h) The Contractor shall maintain proper identification of all materials used, along with reports for all internal / stage inspection work carried out, based on the specific job requirement and or based on the datasheets / drawings / specifications.

(i) **For inspections within and outside India, the all the expenses of Employer and Employer's Representative shall be borne by Employer.**

(j) Witnessed testing will normally be waived on standard types of equipment such as small motors made by approved manufacturers, individual standardised instruments, small mass produced components used in the manufacture of Plant items, small bore pipe work and fittings, minor installation materials and low voltage cable. In order to remove doubt this shall not relieve the Contractor of his obligation under the Contract to ensure that all Plant is tested at the manufacturer's works prior to delivery to Site.

(k) As a guide to the Contractor the Employer reserves the right to witness testing of the following but not limited to the following Plant items:

a) Electrical:

(1) Transformers
(2) 11 kV RMU.
(3) 415 V Metal enclosed switchgears (PCC)/ MCCs
(4) 415 V Power capacitor and control panel
(5) Diesel Standby Generator with AMF Control Panel and Synchronizing panel
(6) Variable Frequency Drives
(7) Power & control cables

(8) Cable carrier system
(9) Lighting system
(10) Earthing and lightning protection systems

b) Mechanical:

(1) Thickener bridges, drives, and sludge/scum mechanisms
(2) Mixers, pumps and blowers including their motors rated at greater than 18.5 kW
(3) Valve and penstock actuators
(4) Valves greater than 300 mm diameter
(5) Pipes more than 200 mm diameter
(6) Sluice Gates
(7) Weir Gates
(8) SPS Coarse Screens and STP Fine Screens, Decanters
(9) Dewatering Centrifuge ,Centrifuge Feed Pump
(10) Fine Bubble Diffuser systems
(11) Chlorination system and Gas Scrubbers
(12) Process Air Blowers
(13) EOT Cranes and Hoists
(14) Screw Pumps
(15) Grit Mechanism
(16) Clarifier Scrapper Mechanism
(17) Patented items

c) Instrumentation and Control:

(1) Level Measuring System
(2) Pressure Gauges
(3) Pressure Transmitter
(4) Flow Measuring System
(5) DO analyzer
(6) ORP analyzer
(7) Temperature Measuring System
(8) Residual Chlorine Measuring System
(9) Instrumentation and Control Cables
(10) Instrument Control Panel
(11) Programmable Logic Controller
(12) SCADA / HMI System
(13) Uninterruptible Power Supply System
(14) Wireless GPRS gateway testing
(15) FAT & SAT for complete ICA system

(l) All destructively tested samples shall be replaced with new.

(m) The Employer reserves the right to be present during the testing and inspection of all Plant items.

1.1.1 Materials, Plant, and Equipment

The Contractor shall place orders for the material and the equipment only after approval of the Employer's Representative. The Contractor shall submit the detailed drawings from the approved manufacturer and the procedure of submission, review and revision shall be as specified herein below.

The Contractor shall inform the Employer about the likely dates of manufacturing, testing, and dispatching of any material and equipment to be incorporated into the Permanent Works. The Contractor shall notify the Employer for inspection and testing, at least twenty-eight (28) days prior to packing and shipping and shall supply the manufacturer's test results and quality control certificates. The Employer will decide whether he or his representative (Employer's Representative) will inspect and test the material / equipment or whether he will approve it on the basis of the manufacture's certificate.

The following inspection and test categories shall be applied prior to delivery of the equipment, of various categories as indicated in the technical specifications for each type of the equipment:

Category A: -The drawings have to be approved by the Employer's Representative before manufacture and testing. The material has to be inspected by the Employer's Representative or a third party inspecting agency approved by the Employer at the manufacturer's premise before packing and dispatching. The Contractor shall provide the necessary equipment and facilities for tests and the cost thereof shall be borne by the Contractor.

Category B: - The drawings of the equipment have to be submitted and approved by the Employer's Representative prior to manufacture. The material has to be tested by the manufacturer and the manufacturer's test certificates are to be submitted and approved by the Employer's Representative before dispatching of the equipment. Notwithstanding the above, the Employer, after examination of the test certificates, reserves the right to instruct the Contractor for retesting, if required, in the presence of the Contractor's representative.

Category C: - Samples of the materials and/or equipment shall be submitted to the Employer's Representative for pre-construction review and approval. Following approval by the Employer, the material may be manufactured as per the approved standards and delivered to the Site.

For material/equipment under Category "A" and "B", the Employer will provide an authorization for packing and shipping after inspection.

The testing and approval for dispatching shall not absolve the Contractor from his obligations for satisfactory performance of the plant.

1.1.2 Factory Acceptance Test (FAT) Document

Fifty six (56) days prior to commencement of inspection of each Plant item / equipment the Contractor shall supply a Factory Acceptance Test (FAT) Document for approval. This shall comprise four copies of the following:

- Unpriced copy of the Contractors order for the Plant item / equipment concerned:
- Details of the inspection and test procedures to be carried out.
- Pre-factory test results and its photos.

The FAT Plan shall provide comprehensive details of the tests to be carried out, the purpose of each test, the equipment to be used in carrying out the test and the methods to be adopted in carrying out the tests. The FAT shall provide space within the documentation for results of the tests to be added and for each test and for the FAT as a whole to be signed off by the Contractor and the Employer's Representative.

On completion of the tests the Contractor shall provide four copies of all test certificates, curves etc. for the inspected Plant item. To remove doubt test certificates shall be provided for the Plant item as a whole plus certificates for the relevant component parts such as:

- Motors;
- Mixers, pumps and Blowers;
- Instruments;
- Gear boxes;
- Electrical switchgear rated in excess of 250 A;
- Integral control and switchgear panels;
- Valve gear;
- Castings.
- Actuators
- Cranes and Hoists
- Screens
- Diffusers
- Storage and process vessels
- Pumps /blowers
- Air blowers
- Centrifuge Decanters

1.1.3 Inspection and Testing Programme

The Contractor shall submit to the Employer's Representative not later than 30 days prior to the commencement of the first inspection and test during manufacture a programme detailing the inspection dates for all Plant. Those items of Plant that the Employer's Representative has specifically identified for witness testing test shall be highlighted in the programme.

The Contractor shall keep the Employer's Representative informed of any changes to the programme.

The Employer's Representative shall not be requested to inspect an item of Plant until the Contractor has satisfied himself that the equipment meets all requirements of the Employer's Requirements.

The Contractor shall inform the Employer's Representative in writing at least 21 days in advance regarding readiness for carrying out inspection of equipment/material etc. at manufacturer's works or at places of inspection. The programme for inspection shall be finalised by the Employer's Representative after the receipt of the above. In case inspection cannot be carried out due to non-readiness of equipment/material etc. a subsequent date shall be finalised for carrying out the inspection in which event all expenses incurred by the Employer for such visits shall be recovered from the Contractor. In case equipment/material etc. is found not to comply with the specification, dates for re-inspection shall be finalised and expenses incurred by the Employer for such visits shall also be recovered from the Contractor. Contractor's Representatives shall essentially be present during all inspections of Plant items. The following information shall be given in the inspection call letter mentioned above:

(a) Name of manufacturer/supplier;
(b) Address of place where inspection is to be carried out;
(c) Proposed date/s and equipment to be inspected;
(d) Name/s of contact personnel at manufacturer's/ supplier/s works with their telephone and fax numbers.
(e) Name of Contractor's Representative who will be present during the inspection.
(f) Confirmation that internal testing has been completed.

The Contractor shall provide all the necessary instruments, test facility, water / electric power, test piece, samples, Employer's Representative/ workers, all cost and others to carry out the tests after assembly. All instruments used for such tests shall be calibrated and certified by and approved by an independent testing authority not more than one month prior to the tests in which they are used. Calibration certificates with expire date and name of authorization agency for instruments used for such tests shall be produced for the approval of the

Employer's Representative and if necessary, instruments shall be recalibrated before the commencement of the tests.

No material shall be delivered to the Site without inspection having been carried out or waived in writing by the Employer's Representative.

If during or after testing, any item of plant fails to achieve its intended duty or otherwise proves defective, it shall be modified or altered as necessary and retested and re-inspected as required by the Employer's Representative.

1.1.4 Tests at Manufacturer's Premises – Mechanical Equipment

1.1.4.1 Sewage / Sludge Pumps

All pumps shall be assembled completely in the shop to ensure correct fitting of all parts and shall be match-marked before shipment.

(a) All pumps shall undergo witness performance tests at the pump manufacturer's Works. Testing shall be undertaken with the respective motors for all the pumps being supplied under the Contract.

(b) All tests such as Q/H curve, efficiency of pumps, power consumption, vibration and noise level shall be conducted, and NPSH tests one for each pumping station shall be undertaken to verify that the pumps meet the specified criteria. The pumps shall be run at constant flow capacity and speed.

(c) Pump casings shall be subject to hydrostatic pressure testing as an assembly at 150% of the pump shut-off head or 200% of the pump rated head whichever is higher. The hydrostatic pressure shall be held for not less than 30 minutes after all leaks have been stopped between attachments.

(d) Impeller and pump rotating assembly shall be dynamically balanced as per ISO 1940 / Gr. 6.3 / VDI 2060.

(e) Standard running test shall be conducted as per BS 5316 Part 2 Class B / ISO 3555 at the rated speed at manufacturer's works to measure the capacity, total head, efficiency and power. These tests shall form the basis for pump acceptance except for vibration and noise. The pump shall be tested over a range comprising shut off head to maximum flow. Minimum five readings approximately equidistant shall be taken for plotting the performance curve.

(f) The following formula shall be taken for computing the power input to the pump:

Power input to the Pump in kW: $\frac{Q \times Hx1.02}{367.2 \times \eta_p}$

Where, Q = Discharge in cum/hr
H = Total head in mwc
η_p = Efficiency of pump

(h) If the vibration, noise level readings taken during performance test show higher than that permitted, vendor shall guarantee to show that the values shall be maintained at site after erection. Any cost of rectification needed on this count shall be borne by the Contractor.

1.1.4.2 Motors

(a) Routine Tests
All routine tests shall be carried out on all motors as per the latest edition of IS 325.

(b) Acceptance Tests
Full load test to determine efficiency, power factor and slip shall be conducted on all the motors.

(c) Type tests

The following type tests shall be carried out on one motor of each rating above 18.5 kW.

(1) Isolation resistance test
(2) Temperature rise test
(3) Momentary overload test
(4) Vibration measurement test
(5) Noise level test
(6) Over speed /over load test
(7) Starting current, starting torque, and pull out torque at reduced voltage

1.1.4.3 Valves

(a) During testing there shall be no visible evidence of structural damage to any of the valve component.

(b) Motorized valves shall be tested with their actuators, with a differential head equivalent to their maximum working pressure, to prove that the actuators are capable of opening and closing the valves under maximum unbalanced head condition within the specified opening or closing period.

(c) Hydrostatically tested shall be as per relevant IS/BS standard for each type of valve.

(d) The following test shall be carried out for sluice valves, Knife Gate valves:

(1) Pressure test
(2) Leakage test
(3) Seat leakage test.
(4) Body hydrostatic test.
(5) Valve operation

(e) The following test shall be carried out for non-return valves:

(1) Pressure test
(2) Leakage test
(3) Seat leakage test.
(4) Body hydrostatic test.
(5) Valve operation

1.1.4.4 Pipe-work

Testing of pipes and fitting shall be carried out in accordance with relevant Indian Standard and internationally approved standard. Pipes, fittings and expansion bellows shall be hydrostatically tested for 1.5 times the rated pressure.

The following test shall be carried out for pipelines:

(1) Pressure test
(2) Leakage test
(3) Colour check for welding pipeline
(4) Welding beat check

1.1.4.5 Compressors and Blowers

Tests shall be carried out in accordance with the relevant international standard. All compressors and blowers shall be tested with their ancillaries to confirm design performance particularly in respect of flow and pressure. The test shall demonstrate that vibration and noise are within the specified limits and that the pressure relief valve operates correctly.

Air receiver shall be tested in accordance with the relevant section of B.S. 5169.

All pressure vessels shall be inspected and hydro water tightness tested.

1.1.4.6 Process Plant Items

All process plant items shall be tested to ensure they meet the Employer's Requirements for quality of workmanship, construction, and performance.

1.1.4.7 Crane & Hoists

The cranes shall be completely assembled in the Contractor's or subcontractor's Works and shall be subjected to the tests as specified in IS 807/IS 3177 or relevant internationally approved standard. The Contractor shall provide the test weights.

Hoists and lifting equipment shall be assembled and tested at the place of manufacture in accordance with IS 3938.

Each and every rotating part/assembly/sub-assembly shall be dynamically balanced as per grade G16 of ISO 1940/1 - 1986.

1.1.4.8 Sluice Gates

(a) Seat Clearance Check

With the gate fully closed, the clearance between seating faces when checked with the thickness gauge, shall not exceed 0.1 mm.

(b) Movement Tests

Each gate shall be shop operated three times from the fully open position to the fully closed position and return to fully open, under no flow conditions to demonstrate that the assembly is workable.

(c) Leakage Tests

With the gate in closed position design pressure shall be applied for a period not lesser than 5 minutes to the unseating side of the sluice gate and the leakage shall not exceed the maximum leakage permissible as per IS 13349.

(d) Hydrostatic Tests

Finally a differential of one and a half times the design pressure shall be applied to the unseating side of the gate. Under these tests no part shall show any deflection of deformation.

1.1.4.9 Fine Screens

(a) All screens shall be checked for overall dimensions, clearance between the bars / aperture size and its material as well as painting works.

(b) Conveyor shall be checked for dimensions and physical conditions, belt joint portion, travelling accuracy of belt, motors and its power consumption, performance of safety device.

(c) At least one screen of each type shall be tested for efficiency and operation by employing screenings. For the screen having depth of channel more than 3 metres, testing with reduced depth is acceptable. Test shall be carried out at site during commissioning of the plant.

1.1.1.10 Fine Bubble Diffusers

(a) Clean water Standard Oxygen Transfer Efficiency (SOTE) tests shall be performed for each different diffuser grid geometry/arrangement proposed in the design. These tests shall be performed by the diffuser Manufacturer at the Manufacturer's testing facility or an equivalent facility appropriately equipped with an adequately sized testing tank and other required appurtenances. The testing shall be performed in full compliance with the latest version of the applicable standard testing protocol. These tests shall be witnessed by Employer's Representative per procedures set forth for witnessing elsewhere in this document.

(b) All diffusers including 10 % spares shall be thoroughly inspected by Contractor for physical damage to the membrane or any other part of the diffuser and results of the inspection shall be reported to Employer's Representative.

1.2 Field Testing

A. All Fine bubble diffused aeration systems will be field tested.
B. Testing will verify the installation as well as the diffuser's ability to deliver the specified air flow rates at the manufacturer's stated pressure loss. Testing will also verify the uniformity of mixing provided.
C. Levelling tests:
    1. Introduce clear water into each tank to the top of the diffuser elements.
    2. Check the level of the diffusers to verify that all element horizontal surfaces are within 10 mm of a common horizontal plane and at the specified elevation.

D. Leakage and distribution of flow tests:
    1. After successful completion of the levelling tests, raise the water level to 50mm above the manifold.
    2. Visually inspect the water surface to ensure that the airflow is uniformly distributed across the tank.
    3. Repair any leaks in the elements holders, elements, pipes or the like.
    4. Repeat the test until the installation is essentially void of air leaks.

1.3 Miscellaneous Pump-sets

All the pump-sets other than sludge pumps shall be tested for performance as per IS 5120.

1.4 Reinforced Cement Concrete Pipes

Testing

(1) All pipes for testing purposes shall be selected at random from the stock of the manufacturer and shall be such as would not otherwise be rejected under the criteria of tolerances as mentioned in IS: 458.

(2) Contractor shall provide laboratory test /analysis results of cement and aggregate component and cement vs. aggregate vs. water mixing ratio and concrete mixing time and mixing method.

(3) During manufacture, tests on concrete shall be carried out as per IS:456. The manufacturer shall supply, when required to do so by the Employer's Representative the results of compressive tests of concrete cubes and split tensile tests of concrete cylinders made from the concrete used for the pipes. The manufacturer shall supply cylinders or cubes for test purposes required by the Employer's Representative and such cylinders or cubes shall withstand the tests prescribed as per IS: 458. Every pressure pipe shall be tested by the manufacturer for the hydrostatic test pressure. For non-pressure pipes, 2 percent of the pipes shall be tested for hydrostatic test pressure.

(4) The specimen of pipes for the following tests shall be selected in accordance with relevant clause of IS: 458 and tests in accordance with the methods described in IS: 3597.

(1) Hydrostatic test
(2) Three edge bearing test
(3) Absorption test
(4) Dimension and colour of surface
(5) Damage

Sampling and Inspection

(1) In any consignment, all the pipes of same class and size and manufactured under similar conditions of production shall be grouped together to constitute a lot. The conformity of a lot to the requirements of this Employer's Requirements shall be ascertained on the basis of tests on pipes selected from it.

(2) The number of pipes to be selected from the lot for testing shall be in accordance with Table 15 of IS:458.

(3) Pipes shall be selected at random. In order to ensure randomness, all the pipes in the lot may be arranged in a serial order and starting from any pipe, every r-th pipe be selected till the requisite number is obtained, r being the integral part of N/n where N is the lot size and n is the sample size.

(4) All pipes selected shall be inspected for dimensional requirements, finish and deviation from straight. A pipe failing to satisfy one or more of these requirements shall be considered as defective.

(5) The number of pipes to be tested shall be in accordance with column 4 of Table 15 of IS: 458. These pipes shall be selected from pipes that have satisfied the requirements mentioned in the above clause.

(6) A lot shall be considered as conforming to the requirements of IS:458 if the following conditions are satisfied.

(7) The number of defective pipes shall not be more than the permissible number given in column 3 of Table 15 of IS:458.

(8) All the pipes tested for various tests shall satisfy corresponding requirements of the tests.

(9) In case the number of pipes not satisfying requirements of any one or more tests, one or two further samples of same size shall be selected and tested for the test or tests in which the failure has occurred. All these pipes shall satisfy the corresponding requirements of the test.

(10) All destructively tested samples shall be replaced to new.

1.5 Steel Cylinders Pipes and Specials

Testing

a) Welding beat check Remove all scale on the welding points and welding beat and its thickness shall be checked by the Employer's Representative.

b) Penetration Test

A suitable penetrating liquid (kerosene oil/Dye) is applied to the surface of the portion under examination and is permitted to remain there for sufficient time to allow the liquid to penetrate into any defects open at the surface. After the penetrating time, the excess penetrant, which remains on the surface is removed. Then a light coloured powder absorbent called a developer is applied to the surface. This developer acts as a blotter and draws out a portion of the penetrant which had previously seeped into the surface openings. As the penetrant is drawn out it diffuses into the coating of the developer, forming indication of the surface discontinuities or flaws.

c) Each steel cylinder shall be subjected before lining/coating to a hydrostatic test under a water pressure equivalent to the test pressure in accordance with Clause 10 of IS:1916 and relevant provisions of IS:3597, provided that the whole of the area of the calculated reinforcement is used in the steel cylinder. In the case of pipes where a part of the principal reinforcement is provided in the cage, the steel cylinder shall be subjected to proportionately less hydrostatic test pressure.

d) Manufacturer's standard specials shall be hydrostatically tested before lining/coating. Where feasible, other specials shall be hydrostatically tested (before lining/coating) at factory. However, when this is not practicable, at the discretion of the Employer's Representative, the unlined specials shall be tested by penetration test as per IS: 3658 or other approved means.

1.6 Cast Iron / Ductile Iron Pipes

Mechanical Tests

Mechanical tests shall be carried out during manufacture of pipes and fittings as specified in relevant IS codes. The results so obtained shall be considered to represent all the pipes and fittings of different sizes manufactured during that period and the same shall be submitted to the Employer's Representative. The method for tensile tests and the minimum tensile strength requirement for pipes and fittings shall be as per relevant IS codes.

Brinell Hardness Test

For checking the Brinell hardness, the test shall be carried out on the test ring or bars cut from the pipes used for the ring test and tensile test in accordance with IS 1500.

Retests

If any test piece representing a lot fails in the first instance, two additional tests shall be made on test pieces selected from two other pipes from the same lot. If both the test results satisfy the specified requirements, the lot shall be accepted. Should either of these additional test pieces fail to pass the test, the lot shall be liable for rejection.

Hydrostatic test

For hydrostatic test at works, the pipes and fittings shall be kept under test pressure as specified in relevant IS codes for 15 seconds, they may be struck moderately with a 700 g hammer. They shall withstand the pressure test without showing any leakage, sweating or other defect of any kind. The hydrostatic test shall be conducted before coating the pipes and fittings.

1.7 Chlorination and Gas pipeline system

(a) All items of plant shall be tested at manufacturer's works and test certificates shall be provided.

(b) All chlorine gas piping from chlorine drums to chlorinator shall be pressure tested with dry air/nitrogen to a pressure of 15 kg/sq.cm.

(c) The chlorine gas piping from the chlorinators up to injectors shall be pressure/vacuum tested with dry air/nitrogen to a pressure/vacuum equal to 1.5 times the maximum pressure/vacuum to be encountered during operation.

(d) The motive water piping shall be hydrostatically tested for a pressure of 1.5 times the operating pressure or the maximum pump discharge pressure at pump shut off whichever is higher.

(e) After the chlorine system has been completely tested as above leak tests shall be conducted admitting chlorine gas. Leakages if any shall be identified using ammonia stick. During this test all chlorine leak detectors shall be in place and all safety procedures shall be adhered to.

(f) Gas cylinder shall provide the pressure test certificate issued by authority and manufacture year.

(g) Chlorine gas detector sensors shall be tested, and results shall provide to the Employer's Representative.

(h) Ventilation system :
The ventilation fans shall be tested at manufacturer's works to verify the design flow and pressure.

(i) Process Plant Items;
All process plant items shall be tested to ensure they meet the Employer's Requirements for inlet and outlet quality of workmanship, construction and system performance.

1.8 Tests at Site - Mechanical Equipment

(a) In addition to the progressive supervision and inspection by Employer's Representative, the Contractor shall offer for inspection to Employer's Representative, the completely erected plant/part of Plant on which tests are to be carried out. After such inspection, each equipment/sub-system shall be tested by the Contractor in accordance with the applicable standards in the presence of Employer's Representative. Such tests shall include but not be limited to the tests specified in following clauses.

(b) The Contractor shall possess during the entire working period the Electrical Contractor's licence of appropriate class from the concerned statutory authorities governing the area of work place. The Contractor shall fully comply with the relevant statutory rules and regulations. On completion of the installation or at intermediate stages, if required by the statutory authorities, the Contractor shall arrange for inspection and obtain the approval from the concerned statutory authorities. If any fees

are to be paid to statutory authorities for testing, inspection and calibration these shall be paid by the Contractor and shall be included in his erection and commissioning charges.

1.9 Pumps, piping and valves

(a) The erected pipe work shall be subjected to a hydraulic test at 1.5 times the maximum pressure or twice the working pressure whichever is higher to test the soundness of the joints. Provision of the necessary pumps, gauges, blank flanges, tappings etc. for carrying out these tests shall be included in the Contract. All gas piping shall be air tested to twice normal working pressure.

(b) Leakage tests shall be carried out on all erected pipework, pumps and valves immediately after erection and where possible before being built in.

(c) Operating tests shall be conducted on valves.

(d) The pump set shall be tested for satisfactory operation. The vibration and noise level shall be checked to be within the specified limits.

1.10 Motors

Condition of winding insulation be tested and insulation values shall be restored to required level by suitable heating arrangements locally.

1.11 Cranes

The crane and lifting tackle shall be tested to 125 % of the safe working load. The Contractor shall arrange the test load.

1.12 Screens

After erection, all screens screen shall be tested for smooth operation and capability to handle typical wastewater solids including stringy materials. Clearance between the dead plate and tines shall be checked as applicable.

1.13 Gates

(a) Leakage test shall be performed by the Contractor after installation of all Gates.

(b) Under the design seating head and unseating head the leakage shall not exceed the limit specified in IS: 13349, for shop testing.

1.14 Reinforced Cement Concrete Pipes

(a) After laying and jointing of RCC pipes is completed the pipe line shall be washing out with sufficient water and be tested at work site as per the Employer's Requirements and as directed by the Employer's Representative. All equipment for testing at work site shall be supplied and erected by contractor. Water for testing of pipes shall be

arranged by him. Damage during testing shall be contractor's responsibility and shall be rectified by him to full satisfaction of the Employer's Representative. Water used for the test shall be removed from pipes and not released to the excavated trenches.

(b) After the joints have thoroughly set and have been checked by the Employer's Representative and before back filling the trenches, the entire section of the sewer or storm water drain shall be proved by the contractor to be water tight by filling in pipes with water to the level of 1.50m above the top of the highest pipe in the stretch and heading the water up for a period of one hour.

(c) The apparatus used for the purpose of testing shall be approved by the Employer's Representative. Contractor if required by the Employer's Representative shall dewater the excavated pit and keep it dry during the period of testing. The loss of water over a period of 30 minutes should be measured by adding water from a measuring vessel at regular 10 minutes intervals and noting the quantity required to maintain the original water level. For the approval of this test the average quantity added should not exceed 1 litre/ hour/100 linear metres / 10mm of nominal internal diameter. Any leakage including excessive sweating which causes a drop in the test water level will be visible and the defective part of the work should be removed and made good.

(d) In case of pressure pipeline, the completed stretch of pipeline shall be tested for site test pressure. The site test pressure should not be less than the maximum operating pressure plus the calculated surge pressure, but in no case should it exceed the hydrostatic test pressure as specified in IS: 458.

1.15 Steel Cylinder Pipes and Specials

(a) After laying and jointing of steel cylinder pipes and specials with concrete lining and coating is completed the pipeline shall be washing out with sufficient water and be tested at work site as per the following Employer's Requirements and as directed by the Employer's Representative. All equipment for testing at work site shall be supplied and erected by Contractor. Water for testing of pipes shall be arranged by him. Damage during testing shall be Contractor's responsibility and shall be rectified by him to the full satisfaction of the Employer's Representative. Water used for test shall be removed from pipes and not released to the excavated trenches.

(b) Each section of the pipe line shall be slowly filled with clean water and all air shall be expelled from the pipeline. The pressure in the pipeline should then be raised and maintained by means of pump to the test pressure. The test pressure should not be less than 1 1/2 times the working pressure at the lowest point or the static head pressure, whichever is higher. Under the test pressure no leak or sweating shall be visible at the welded joints. The duration of test shall be not less than 24 hours. The

exposed joints shall be carefully examined and all such joints showing visible leaks shall be re-welded. Any cracked or defective pipes and specials in consequences of this pressure test shall be removed and replaced by sound material by Contractor and the test shall be repeated to the satisfaction of the Employer's Representative.

(c) Hydrostatic shop test for pipes and fittings shall be as per code/standard requirement. After erection at site, complete pipes and fittings shall be hydrostatically tested for a pressure of 1.5 times operating pressure.

(d) Where directed by the Employer's Representative welded joints on pipes larger than 675 mm diameter shall be subject to a nitrogen gas test after welding.

(e) A tapped hole (approximately 6 mm diameter) shall be made in the socket end of each pipe by the Contractor and shall be fitted with a suitable non-return valve. Nitrogen, at 400 kPa pressure, shall then be pumped into the annular space between the spigot and socket and the pump disconnected.

(f) If no drop in pressure occurs over the ensuing period of 30 minutes the test shall be deemed to be successful. If the test pressure cannot be maintained for 30 minutes all defects in the weld shall be cut back and re-welded and the test reapplied until successful. The cost of initial and subsequent testing of defective welds shall be at the Contractor's own expense.

(g) The Contractor shall provide all items necessary for the nitrogen tests including compressor, valves, gauges and tubing.

1.16 Cast Iron, Ductile Iron Pipes and Fittings

(a) After the pipes and fittings are laid, jointed and the trench partially backfilled except at the joints the stretch of pipe line as directed by Employer's Representative shall be subjected to pressure test and leakage test after washing the pipe line out with sufficient water.

Where any section of the pipeline is provided with concrete thrust blocks or anchorages, the pressure test shall not be made until at least five days have elapsed after the concrete was cast. If rapid hardening cement has been used in these blocks or anchorages, the tests shall not be made until at least two days have elapsed.

(b) Each section of the pipe line shall be slowly filled with water and all air shall be expelled from the pipe by tapping at points of highest elevation before the test is made and plugs inserted after the tests have been completed. The specified test pressure based on the elevation of the lowest point of the line or section under test and corrected to the elevation of the test gauge shall be applied by means of a pump connected to the pipe as directed by the Employer's Representative.

(c) The duration of test shall not be less than 5 minutes. The exposed joints hall be carefully examined and all such joints showing visible leaks shall be recaulked until water tight. Any cracked or defective pipes and fittings in consequence of this pressure test shall be removed and replaced by sound material by Contractor at no extra cost to the Employer's Representative and the test shall be repeated to the satisfaction of the Employer's Representative.

(d) After the satisfactory completion of pressure test, the section of pipe line shall be subjected to leakage test. The duration of test shall be 2 hours. No pipe installation shall be accepted until the leakage is less than the number of cm^3 /h as determined by the formula:

$$q_L = \frac{ND\sqrt{P}}{115}$$

Where,

q_L = the allowable leakage in cm^3/hr

N = Number of joints in the length of the pipeline

D = Diameter in mm, and

P = the average test pressure during the leakage test in Kg/cm^2

Should any test of pipe laid indicate leakage greater than that specified above, the defective joints shall be repaired by Contractor at no extra cost to the Employer's Representative until the leakage is within the specified allowance.

(e) Necessary equipment and water used for testing shall be arranged by Contractor at his own cost. Damage during testing shall be Contractor's responsibility and shall be rectified by him at no extra cost to the Employer's Representative. Water used for testing shall be removed from the pipe and not released in the excavated trenches.

(f) After the tests mentioned above are completed to the satisfaction of the Employer's Representative, the backfilling of trenches shall be done as per the Employer's Requirements specified elsewhere.

1.17 Manufacturer's Works Acceptance Tests on Electrical Equipment

The following equipment / items shall be subjected to inspection, routine /acceptance tests as per latest edition of relevant Indian / International standards in the presence of Employer/ his Employer's Representative

(a) Transformers
(b) 11 kV RMU
(c) 415 V metal enclosed switchgears (PCC) /MCC

(d) 415 V Power capacitor and control panel
(e) Diesel Standby Generator with AMF Control Panel and Synchronizing panel
(f) Variable Frequency Drives
(g) Power & control cables
(h) Cable carrier system
(i) Lighting system
(j) Earthing and lightning protection systems

Copies of test Certificates for the type tests and Special tests not later than 5 years conducted as per relevant Indian / International Standards for all the equipment /items of above shall be furnished for the perusal of Employer / his Employer's Representative. If type tests and special tests have not been conducted on any of these items, the same shall be carried out in the presence of Employer/ Employer's Representative at no extra cost.

1.18 Manufacturer's Works Acceptance Tests on Instrumentation, PLC, SCADA and Associated Equipment

A. Instrumentation:

Inspection, Testing and Setting to Work:

General

Each item of plant shall be subjected to the manufacturer's own tests which shall be certified.

Each item of plant and its installation shall be subject to inspection and testing at the place of manufacture.

The Contractor shall be responsible for the provision of all necessary test equipment. The Contractor shall demonstrate to the Employer's Representative, the correct operation of any item of plant and the Employer's Representative may witness any test. Tests which, in the opinion of the Employer's Representative, were failed or not performed correctly shall be repeated.

Calibration tests for field instruments and analytical instruments should be conducted on site after installation and the same should be witnessed by the Employer's Representative.

Before any test is made, the Contractor shall submit to the Employer's Representative a full list of test equipment & test procedures (method statements) to be used. Each item of test equipment shall have a standard of accuracy better than that stated by the manufacturer of the item to be tested. The Contractor shall provide evidence of the condition and

performance of any item of test equipment, in the form of test certificates issued by an appropriate authority independent of the Contractor and manufacturer, or as otherwise directed by the Employer's Representative. Test equipment shall be checked frequently during the period of the tests.

The Contractor's staff responsible for supervising and carrying out tests shall be fully conversant with the various items of equipment of other manufacturers and if necessary the Contractor shall arrange for his personnel to attend suitable training courses on his own expense.

Any fault or shortcoming found during any inspection or test shall be rectified to the satisfaction of the Employer's Representative before proceeding with further inspection or testing of that item. Any circuit previously tested, which may have been affected by the rectification work, shall be re-tested.

Preliminary Inspection and Testing at the Place of Manufacture

Field-mounted instruments

After the successful completion of the manufacturer's own inspection and testing of instruments supplied under the Contract, similar tests shall be carried out in the presence of the Employer's Representative and the Contractor. Such tests shall include a demonstration that an increase or decrease of the measured value at several points over the full range of the instrument produces a corresponding increase or decrease in the instrument output signal. These tests shall include checks on the specified accuracy of the instrument at all points.

Instrument panels, enclosures and mounting boards

The manufacturer shall not present instrument panels, enclosures and mounting boards (assemblies) for inspection and testing until the manufacturer's own tests and inspection has been completed. A preliminary inspection and test of these assemblies may then be witnessed by the Employer's Representative. The Contractor shall give not less than 7 days' Prior notice in writing that he has completed.

His tests and inspection and is ready for the witnessed tests and inspection. Where this notice period is different in the Conditions of Contract this shall take precedent.

The witnessed inspection and testing shall include the following:

a. A visual inspection of the panel assembly to show that the design, construction and finish are satisfactory and in accordance with the Specification;
b. A check that equipment is securely mounted, accessible for removal or calibration without damage to or undue disturbance of other components, wiring or piping;
c. That all engraving and labels are correctly positioned, fixed and designated in accordance with the Specification;
d. Panel power-distribution circuits have the correct breaker/fuse rating coordination and designation;
e. Power-isolation facilities meet the Specification;
f. The main incoming supply voltage, frequency and/or pneumatic supply pressure is within the required limits, these being checked at the beginning and end of the test and the results recorded on test certificates;
g. The output of all power supply units again at the beginning and end of the testing with results being recorded;
h. The power supply voltage or air pressure of all component instruments of the assembly(s), these voltages/pressures being recorded on the test certificate;
i. The insulation resistance of all circuits except sensitive electronic equipment which is liable to damage by application of the test voltage, such circuits being disconnected before making the insulation resistance tests and these tests being carried out in accordance with IEE Wiring Regulations;
j. That the clean earth bar is isolated from main frame of the panel.

Internal lighting and anti-condensation heaters and associated thermostats, isolators, limit switches and wiring shall be checked for compliance with the Specification.
Spare capacity within the panel(s) shall be checked to see that it complies with the Specification. This shall include future equipment space, spare terminals, space in wiring trunkings and provision for additional cable entry.

Functional Testing at the Place of Manufacture

General requirements
Once the preliminary inspection and testing is complete to the satisfaction of the Employer's Representative, functional testing shall commence. The purpose of the functional tests is to demonstrate that instrument panels enclosures and mounting boards (assemblies) conform to requirements of the Specification.

Not less than 30 days before the commencement of functional tests, the Contractor shall submit to the Employer's Representative, for approval, two copies of comprehensive test procedural documents detailing each test to be carried out. The document shall include results forms on which the results of each test will be entered. The forms shall include spaces for numerical values, where necessary, and
Witness signatures.

All applicable drawings and data shall be provided at the place of inspection by the Contractor.

The Contractor shall provide all test instruments and equipment necessary to test the assemblies in their entirety.
The following is a typical list of the equipment required:
• Switch boxes;
• Indicator light boxes;
• Analogue signal sources;
• Dummy loads;
• Meters;
• Simulators;
• Desk-top computers;
• Programmers for DCS or outstations;
• Insulation test equipment

B. Programmable Logic Controller (PLC) and SCADA

The Contractor shall carry out specified tests as follows in addition to any tests stated or implied by the foregoing sections of this clause.
The tests shall be carried out on the fully assembled control panel containing the PLC and associated equipment in order to demonstrate correct functional operation of the hardware and software systems.

Factory Acceptance Test (FAT)
The Contractor shall conduct a full programme of tests of the PLC & SCADA system at the Contractor's testing facility in the presence of the Employer's Representative to verify that all features of the system have been provided, are operating correctly and are in full compliance with the Specification. FAT shall include PLC based SCADA system for STP and PLC based control system with panel mounted HMI for SPS with wireless communication system for the

all of the above. Unless otherwise specified or agreed by the Employer's Representative, the entire PLC & SCADA system shall be assembled and tested together as an integrated system, including all master station equipment, all operators' consoles, all outstations and telemetry equipment all instrumentation panels and uninterruptible power supplies included in this Specification. The scheduled date for the factory acceptance test shall be as agreed by the Contractor and the Employer's Representative at least four weeks before the test.FAT shall be conducted with a hardwired simulation panel connected to the PLC based SCADA system. Contractor shall note the importance of the requirement. No software based simulation testing shall be accepted or allowed.

Not less than one month before the scheduled factory acceptance test, the Contractor shall submit to the Employer's Representative for approval two copies of a comprehensive manual detailing each test to be conducted. The manual shall include a results form on which the results of each test will be entered, including spaces for numerical values where appropriate and witness signatures.
Not less than 7 days before the scheduled factory acceptance test, the Contractor shall give written notification to the Employer's Representative that a complete dry-run of the factory acceptance test has been performed successfully and that, in the opinion of the Contractor, the system exhibits stable operation and is ready for the formal factory acceptance test.

The factory acceptance test will be considered successfully completed only when the system has successfully passed all factory tests. The system shall not be delivered to Site until the successful completion of the factory acceptance test is certified by the Employer's Representative or unless otherwise approved by the Employer's Representative. Delay in the delivery of the system due to failure of the factory acceptance test shall not constitute an unavoidable delay. If the system fails the factory acceptance test, the test shall be extended or rescheduled at the discretion of the Employer's Representative.

All hardware to be used in the testing of the system shall have passed an agreed preliminary hardware performance test to ensure known hardware operability before software testing begins.

After successful completion of the factory acceptance test, no software changes shall be made to the system without written authorisation by the Employer's Representative. Any changes to the system which effect the system software documentation, such as input scale modifications or changes to the control logic, shall be entered into the system documentation

before delivery of the system to Site. All instruments under IC&A scope has to be tested 100%.

FACTORY ACCEPTANCE TEST PROCEDURES

General

The scope of the tests shall include the proving of every aspect of hardware and software operation and functions as detailed below.

Hardware tests

(a) Verify the correct inventory of hardware including cables and printed circuit boards;

(b) Demonstrate that all spare-memory, disk-capacity and system-expansion requirements have been met;

(c) Demonstrate all hardware and software diagnostics;

(d) Verify all power supply voltages are within tolerance;

(e) Verify proper earth connections and isolation of instrumentation earth for all equipment;

(f) Demonstrate operation of test simulation and indication equipment and its Suitability for adequate functional testing of all system functions.

Software tests

(a) Demonstrate the editing of all system parameters including set-points, timers and the like;

(b) Demonstrate system configuration capabilities including the addition and deletion of input and output points, outstations, and all data base parameters;

(c) Demonstrate the addition, deletion and modification of mimic displays and report formats;

Functional tests

The functional tests shall verify proper operation of every specified system function as an integrated system. These tests shall be conducted in conjunction with functional tests of instrumentation and control panels as specified elsewhere. All failures or discrepancies found shall be documented in the test manual.

Following a failure of any functional test, should software or hardware modifications be required it shall be the decision of the Employer's Representative whether the factory acceptance test is to continue, re-start or be aborted. If testing is allowed to continue, any changes which are required shall be described in a system modification document, signed by both Contractor and Employer's Representative and be incorporated into the final factory acceptance test documentation. The failed test shall be re-conducted and the Employer's

Representative may require the retest of functions which may be affected by the modification.

The functional tests shall include, as a minimum, the following:

(a) Demonstration that the system meets the requirements of the Specification for response time and speed of screen update

(b) Verification of the accuracy of all analogue input points in the system. The procedure shall include applying the appropriate signal to each analogue input at a minimum of three points within the range of the input, checking for expected numerical results, and verifying appropriate update of related mimic displays. Proper sensing and action by the system to high and low out-of-range inputs shall also be verified

(c) Verification of the proper logic sense, pulse accumulation and rate computation where appropriate, of all digital inputs and verifying appropriate update of related mimic displays;

(e) Verification of all control and sequencing operations and proper operation of all digital and analogue outputs. The procedure shall include simulation of all related process variables for both normal and abnormal conditions, including instrument and component failure, and demonstration of fail-safe response of the system. System outputs shall be indicated with appropriate lamps and indicators;

(f) Simulation of outstation communications errors and failures and demonstration of error detection and handling, failure detection and handling, and appropriate changes to control actions as designed and specified;

(g) Verification of fault detection and diagnostics by inducing a sufficient variety of fault conditions in the system to ensure that detection processes and fail-safe operation are adequately tested;

(h) Demonstration of proper operation of all mimic displays, help pages, reports, operator procedures and historical data accumulation;

(j) Demonstration of proper operation of all outstations following a simulated master station central processor failure;

(k) Demonstration of proper operation of all equipment during both a system wide or isolated power failure, and following power restoration. The procedure shall include the demonstration of battery backup of both master station and outstation for the full length of time specified, and proper operation of power fail, low voltage warning and all associated alarms.

Reliability test

After successful completion of the functional tests a 48-hour continuous run of the system shall be performed. The test shall be passed if no system function is lost or no hardware or

software failure occurs. Hardware failure is defined for this test as the loss of a major component such as the computer, an outstation, a VDU or a peripheral device. Non-repetitive mechanical failures of loggers, push-buttons and the like are excluded.
During this test, the system shall be exercised with simulated inputs and conditions in a manner which approximates the on-site operational environment. Unstructured testing by the Employer's Representative shall be included during this test. Upon any system failure during this period, it shall be the decision of the Employer's Representative whether the reliability test is to continue or be aborted. If testing is allowed to continue any changes to the system which are required shall be described in a system-modification document, signed by both Contractor and Employer's Representative and the document shall be incorporated into the final factory acceptance test documentation.

Factory acceptance test documentation
As a minimum, the following information shall be included in the factory Acceptance test manual for each test:
• Test identification number;
• Test name and description;
• List of all equipment to be tested including any special test equipment required;
• Description of the test procedure broken down into logical steps;
• Description of the expected system response verifying the completion of each logical step;
• Space for recording the results of the test and the time and date of the test;
• Space for signatures of the Contractor and the Employer's Representative.

In addition, the Contractor shall provide a method for recording and tracing all problems, discrepancies, queries and suggestions regarding the system and software, and for formalised control of any modifications to the system.

Pre-commissioning tests
The Contractor shall perform pre-commissioning, or preliminary, testing of the SCADA system in accordance with that specified for instrumentation. The purpose of pre-commissioning tests is to confirm readiness of the system for commissioning.

The scope of pre-commissioning tests shall be generally as specified for factory acceptance tests but real field inputs and final control elements shall be used wherever practical to provide inputs to the system and to confirm proper outputs.

Where this is impractical, simulation signals shall be injected as near as possible to their ultimate sources so as to include in the tests as much of the cabling system as possible.

Each process system shall be set to work under manual control and the system tested to confirm proper operation. After proper operation of manual control mode has to be verified, tests of automatic controls of each process system shall be conducted wherever practical.

Commissioning

Site Acceptance Tests (SAT)

The Contractor shall submit all relevant draft operating manuals for the PLC & SCADA System to the Employer's Representative for approval prior to commissioning tests.

Any faults or failures of the system detected during the previous tests shall be noted and corrected to the satisfaction of the Employer's Representative before commissioning is allowed to commence.

As part of commissioning, the PLC & SCADA system shall be tested for availability for a continuous period of 60 days. During this period, the system will perform the normal functions according to the procedures described in the SAT documentation approved by the Employer's Representative.

The system shall have passed the SAT if all major components have been free from fault or failure and exhibit full error-free functionality for 100 % of the total duration of the test, unless otherwise agreed by the Employer's Representative. Major components include all master station equipment, outstations, communications facilities and instrument panel components, excluding push-buttons, switches and lamps and any equipment not supplied by the Contractor.

During SAT, no modifications to the system shall be made by the Contractor without the written approval of the Employer's Representative. Erroneous functioning which requires software modifications or re-configuration to correct, other than set-point or parameter changes, shall constitute a failure of the availability test. Any changes to the system which are required and approved shall be described in a system-modification document, signed by both Contractor and Employer's Representative and the document shall be incorporated into the final test documentation. The test shall be restarted after corrections have been made.

1.19 Manufacturer's Works Acceptance Tests on Uninterruptible Power Supplies

The Contractor shall carry out further specified tests as follows in addition to any tests stated or implied by the foregoing sections of this clause.

The tests shall be carried out on the fully assembled unit utilising the batteries that are to be supplied with the unit.

The Contractor shall demonstrate the following:

(1) Change-over from full load with mains present to full load on battery supply
(2) Carry out a discharge test on the system at full load and for the specified duty bridging time period.
(3) Carry out recharge test after operation for the specified duty bridging time at full load. The UPS shall supply the full load during the recharge cycle.

1.20 Inspection at Site

During erection of the Plant the Employer's Representative will inspect the installation from time to time in the presence of the Contractor's Supervisor to establish conformity with the requirements of the Specification. Any deviations found shall be corrected as instructed by the Employer's Representative.

1.21 Plant protection on Site

Factory finished plant shall be adequately protected both before and during installation against damage to finished surfaces, fitted components, and the ingress of dust. It may be necessary for structural finishing operations to be carried out in the vicinity of installed plant before it is taken over and the Contractor shall take this into consideration in complying with the requirement of this clause.

1.22 Erection staff

The Contractor shall provide at least two approved senior Gujarati/Hindi/English speaking working erectors to supervise the erection of all Plant in the Contract and in each case to act as the Contractor's Representative as set out in contract of the general conditions of contract.

In the case of a foreign firm based overseas the Contractor's Representative shall be thoroughly conversant with the manufacturer's Plant and equipment, and its erection and shall be an expatriate.

The Contractor shall also provide sufficient erectors skilled in electrical, mechanical and instrument engineering, with such skilled, semi-skilled and unskilled labor as are necessary to ensure completion of the various sections of the Contract in the time required. The Contractor shall not remove any supervisory staff or labor from the site without the prior approval of the Employer's Representative.

The Employer's Representative will give the Contractor at least one month's notice in writing of the date on which the erection staff will be required on site, and the Contractor shall confirm the date of arrival in writing to the Employer's Representative. The Contractor shall make all the necessary arrangements to ensure that sufficient plant has been or is about to be delivered to site, so that there shall be no delay to the start of erection.

It shall be the responsibility of the contractor to obtain necessary License / Authorization n/Permit for work from the Licensing Boards of the Locality/State where the work is to be carried out. The persons deputed by the Contractor's firm should also hold valid permits issued or recognized by the Licensing Board of the Locality/State where the work is to be carried out.

1.23 Erection and Building-in

The installation work shall comply with the latest applicable Standards, Regulations, Electricity Rules and Safety Codes of the locality where the installation is to be carried out. Nothing in this specification shall be construed to relieve the Contractor of this responsibility.

It will be the Contractor's responsibility to obtain approval/clearance from local statutory authorities including Electrical Inspector, wherever applicable for conducting of any work or for installation carried out which comes under the purview of such authorities.

The Contractor shall carry out the complete erection of all plant, including the provision of all necessary skilled and unskilled labor, material, transportation, supplies, power and fuel, Contractor's Equipment and appurtenances necessary, for the complete and satisfactory erection of the Plant.

The Contractor shall have a separate cleaning gang to clean all equipment under erection and as well as the work area and the project site at regular intervals to the satisfaction of the employer. In case the cleaning is not up to the employer's satisfaction, he will have the right to carry out the cleaning operations and any expenditure incurred by the employer in this regard will be to the Contractor's account.

Erectors

The Contractor's employees shall include skilled erection staff in sufficient number, who shall arrive on the site on or before the respective dates set out in the approved work programmed and prior to delivery of any item of Plant to the Site. The Employer's Representative will not entertain any claim by the Contractor in respect of delayed erection due to a delay in the delivery of any items of Plant to the site.

Contractor's Equipment, materials and appurtenances

The Contractor shall have available on the Site sufficient suitable equipment and machinery, as well as all other materials and appurtenances required by him, of ample capacity to ensure the proper erection of Plant and to handle any emergencies such as may normally be expected in work of this character.

The Contractor shall be responsible if any installation materials are lost or damaged during installation. All damages and thefts of equipment/component parts, after takeover by the Contractor, till the installation is taken over by Employer shall be made good by the Contractor to the satisfaction of Employer's Representative.

Workmanship

Plant shall be erected in a neat and workmanlike manner on the foundation and at the locations and elevations shown on the approved drawings and other Employer's Engineering documents. Unless otherwise directed by the Employer's Representative the Contractor shall adhere strictly to the aforesaid drawings and no departures there from will be permitted.

All plant shall be correctly aligned, leveled and adjusted for satisfactory operation and shall be installed so that the proper and satisfactory connection can be made readily between the various units and pipe work and equipment installed under the Contract. The mounting arrangements for pump-sets and blowers shall be such that the alignment offset between motors and the driven equipment shall be well within 0.1 mm.

Building-in

Erection of Plant shall be phased in such a manner so as not to obstruct the work being done by other contractors. Before commencing any erection work, the Contractor shall check the dimensions of structures where the various items of plant are to be installed, and shall bring any deviations from the required positions, lined or dimensions to the notice of the Employer's Representative and shall take such measures as are necessary for their correction.

The Contractor shall take particular care for the correct positioning and alignment of all puddle pipes which are required through concrete structures prior to, and during the pouring of concrete.

The Contractor shall pin and plug in the holes prepared, all small clips, plugs, screws, nails, sleeves, inserts, etc., required for fixing electric wires and conduits, small pipe work and all other apparatus.

The Contractor shall align all equipment and holding down bolts and shall inform the Employer's Representative before proceeding with grouting-in the item or item concerned. The Contractor shall ensure that all equipment is securely held and remain in correct alignment before, during and after grouting-in.

The Contractor shall properly bed in cement grout each item of plant or its supporting base resting on foundations, and shall grout-in where required holding down bolts placed in the holes prepared in the foundations. The materials and workmanship used in grouting shall be such as will result in a solid anchoring of foundation bolts and complete filling of the gaps between the Plant or its base and the foundations, without shrinkage or cracking.

During erection of the Plant the Employer will inspect the installation from time to time in the presence of the Contractor's Site representative to establish conformity with the requirements of the Specification. Any deviations and deficiencies found or evidence of unsatisfactory workmanship shall be corrected as instructed by the Employer.

All plant shall be installed in accordance with the recommendations or instructions of the manufacturer, for the particular application. Each mounting position shall be chosen to give correct operation of the equipment, ease of operation, access for maintenance and servicing and freedom from any condition which could have adverse affects.

Precautions

The approval by the Employer's Representative of the Contractor's proposals for rigging and hoisting of any item of plant into its final position shall not relieve the Contractor from his responsibility for avoiding damage to completed structures, parts or members thereof or other installed equipment. He shall at his own cost make good, repair or replace any damaged or injured items whether structural, mechanical, electrical, architectural, or of any other description, promptly and effectively to the satisfaction of the Employer's Representative.

No plant or other loads shall be moved across the floors of structures without first covering the floors with timber of sufficient size so that applied loads will be transferred to floor beams and girders of steel or concrete. If it is required to reduce bending stresses or deflection, the beam and girders shall be provided with temporary supports. Any movement of Plant and other loads over the floor structures shall be subject to the prior approval of the Employer's Representative.

1.24 Civil Inspection (Water Leakage Test)

1.24.1 All liquid retaining Structures

(a) Water retention test of tanks (Refer Volume III 3B - Technical Specification for Civil Works)

1.24.2 Field Control Inspection

Contractor shall be conduct periodic field control inspection to prevent any field accident. The Employer's Representative shall joint field inspect or conduct unannounced inspections.

1.24.3 Inspection after Erection

After the erection of any item of Plant and its associated equipment has been completed, it shall be offered to the Employer's Representative for inspection in its static state prior to commissioning the item.

Completion of erection and procedure prior to setting to work.

The mechanical completion of plant under erection shall be deemed to occur if all the units/systems of the Works are structurally and mechanically complete as noted below:

All rotary, static, structural equipment, piping, electrical/instrumentation and other equipment under the scope of the Contract have been erected, installed and grouted and are as per the specifications.

All systems have been washed/flushed/drained/boxed up where necessary.

All system testing including pressure, vacuum and nondestructive tests, no load tests and such other tests are completed with safety valves/relief valves set to operating conditions installed in position.

All panels, local control desks erected with power/control cable terminations with all continuity checks, insulation checks and other installation checks are carried out.

Prior to pre-commissioning checks, the Contractor shall erect the entire Plant and ensure readiness of civil works to the satisfaction of Employer, so that the Works are physically ready to undergo pre-commissioning checks. Pre-commissioning checks will include checks like no-load running of machinery, checks on instruments and electrical including calibration and loop checks, functional checks, inter-lock checks etc.

At the stage of mechanical completion of erection, the Contractor shall ensure that all the physical, aesthetic and workmanship aspects are totally complete and the Plant is fit and sound to undergo pre-commissioning checks.

The following documentation shall be completed before the Contractor notifies Mechanical Completion of Erection to the Employer

(a) All shop inspection records compiled and bound in 4 (four) copies.
(b) All erection and commissioning procedures duly approved.
(c) All instruction manuals in draft form - with each sheet bearing a stamp to indicate "DRAFT FOR REVIEW ONLY" submitted in 4 (four) copies.

Upon achieving mechanical completion, the Contractor shall notify the Employer of such completion of section/units/systems and readiness for inspection for acceptance of

mechanical completion of erection. The Employer/ Employer's Representative shall proceed with inspection of such sections/units/systems within 10 days of such notice.

Consequent to inspection, the Employer will inform the Contractor a list of deficiencies for rectification and the Contractor shall complete the rectification work within a jointly agreed period prior to start of pre- commissioning tests. The erection period allowed by the Contractor shall include all activities of mechanical completion as noted above.

1.25 Site Acceptance Test Document

Fifty six (56) days prior to commencement of Tests on Completion the Contractor shall supply a Site Acceptance Test (SAT) Document for approval. This shall comprise four copies of the details of the inspection and test procedures to be carried out in testing the Works.

The SAT Plan shall provide comprehensive details of the tests to be carried out, the purpose of each test, the equipment to be used in carrying out the test and the methods to be adopted in carrying out the tests. The SAT shall provide space within the documentation for results of the tests to be added and for each test and for the SAT as a whole to be signed off by the Contractor and the Employer's Representative.

The SAT shall categorise tests as follows:

a) Dry tests

Dry tests are those tests carried out without process fluid being present.

b) Wet tests which can be further sub-divided into

(1) Hydraulic tests

Hydraulic wet tests are those tests carried out with potable water in order to prove the hydraulic capability of the Works.

(2) Process tests /System tests

Process wet tests are those tests carried out with raw Sewage as the feed stock to prove the process capability of the Works.

The Contractor shall make his own arrangements for water supply, chemical, electric power, fuel, instrument and labour during hydraulic wet tests.

It shall be assumed that the co-operation of other contractors in the carrying out of Tests on Completion will not be unreasonably withheld.

1.26 Tests on Completion

1.26.1 General

Prior to the commencement of Tests On Completion the Contractor shall submit for approval the following:

(1) Site Acceptance Test Documents
(2) As-Built Drawings
(3) Operation and Maintenance Manuals
(4) Site test results / data sheet and photo

Tests on Completion shall not be commenced until the aforementioned documents are approved.

The initial charges of oil, grease, electrolyte, generator fuel / oil, chemical, disposal of cake, etc. necessary for Tests on Completion shall be provided by the Contractor. Raw Sewage and electricity required for Tests on Completion will be provided by the Employer free of charge. If necessary, Contractor shall create design loading conditions for testing purposes by testing fewer than the total number of installed units of process tanks or equipment at a time. In such cases, multiple tests shall be conducted to ensure that all installed units are tested. In the event that raw sewage/influent wastewater is not available at the plant, the Contractor shall defer testing until such time as sewage becomes available for treatment as described elsewhere in these Bid Documents. The Contractor shall provide adequate notice (this notice period shall be determined by the normal lead time for locally purchased chemicals plus at least 28 days) of his chemical requirements prior to commencement of the Tests on Completion involving their use.

The cost of chemicals used for the Tests on Completion shall be met by the Contractor.

The inspection and tests procedure which will be carried out are provided under the general conditions of contract and shall also consist of the following:

a) Manual Commissioning Tests (Clause i)
Manual Commissioning Tests shall be such preliminary trials, tests and retests on individual items of Plant or complete systems as are required by the Employer's Representative in order to demonstrate that the Plant as a whole is ready to undergo the Manual Operation Tests and that these will take place with a minimum of interruption.

The Manual Commissioning Tests shall demonstrate not only the items of Plant under normal operation, but also their response to abnormal and emergency conditions.
The Employer's Representative will notify to the Contractor which items of Plant will be tested and the extent to which they will be tested in order to fulfill the requirements of the Specification.

Leakage tests at 1.5 maximum working pressures shall be carried out on all erected pipe work prior to the Manual Commissioning Tests.

Pump curves shall be available for the Manual Commissioning Tests and all instruments essential for the tests shall have been calibrated.

b) Manual Operation Tests (Clause ii)

When the Manual Commissioning Tests have been completed so that the items of Plant have been demonstrated to the satisfaction of the Employer Representative, the Contractor shall commence the Manual Operation Tests.

These tests shall demonstrate the correct operation of the whole Plant whilst using the minimum quantity of automatic control and monitoring equipment. Such equipment shall be at least that required both for the maintenance of safety and for the normal mode of operation of the Plant.

The Plant will be required to demonstrate satisfactory operation at all design flow rates.

The tests shall be of seven consecutive days' duration; if the supply of water should fail or other matters interfere outside the Contractor's control, the tests may be of such number of broken days as the Employer's Representative considers is the equivalent.

The exact date of commencement shall be subject to the approval of the Employer's Representative and shall be dependent on the following conditions having been met

(1) All relevant items of Plant in approved working order
(2) All items of Plant correctly identified with labels

c) Automatic Commissioning Tests (Clause iii)

The Automatic Commissioning Tests shall be such preliminary trials, tests and retests on individual items of Plant or complete system as are required by the Employer's Representative in order to demonstrate that the Plant as a whole is ready to undergo the Tests of Completion and that these will take place with a minimum of interruption.

At least one week before the commencement of these tests, the Employer's Representative will notify the Contractor which items of Plant will be tested and the extent to which they will be tested in order to fulfill the requirements of the specification.

The Tests on Completion as provided under the general conditions of contract shall not be carried out until the completion of the above tests.

(1) All pipe work shall be hydrostatically tested at site to a pressure equal to 1.5 times the maximum working pressure likely to be encountered in the system.

(2) The Contractor shall carry out all tests on the Plant and shall supply four copies of all test results to the Employer's Representative.

(3) All tests shall be to the approval of the Employer's Representative who may require them to be repeated, prolonged or modified as may be necessary to ensure that any or all items of Plant conform to the Contract.

(4) The Employer's Representative shall be permitted to inspect all Plant which is undergoing tests and may themselves conduct tests.

Where it is necessary for the Employer's Representative to make arrangements for the supply of water, chemicals, power, etc., for any testing, the Contractor shall not commence the tests until after these arrangements have been made on or after a date agreed by the Employer's Representative and the Contractor shall make no claim for delay to such testing on this account except as provided under the General Conditions of contract.

If any item of plant fails during or after testing to achieve its intended duty or otherwise proves defective, it shall be modified or altered as necessary and re-tested and re-inspected as required by the Employer's Representative.

Vibration/noise level tests shall be carried out at site which will form basis for acceptance of the equipment. If the Contractor is not in a position to meet the requirements given below as per ISO 10816 – 1995, the equipment may either be rejected or the Contractor shall carry out all necessary modifications to keep vibrations within the acceptable limits specified.

Equipment	Noise Level (dBA at 1.86 m from equipment)	Velocity of vibration (mm/sec)
All rotating equipment not having reciprocating parts with motor kW less than or equal to 15 kW	85	1.12
All rotating equipment not having reciprocating parts with motor kW more than 15 kW and less than or equal to 75 kW	85	1.8
All rotating equipment not having reciprocating parts with motor kW greater than 75 kW	85	2.8
All equipment having reciprocating parts viz. compressors, dosing	85	-

pumps sampling pumps		

The Contractor shall have a minimum of three commissioning Employer's Representative, one for process and plant and the other for mechanical/electrical/instrumentation works on site during all tests in order to both demonstrate the Plant and to correct any faults which may occur.

1.27 Dry Test Requirements

As a minimum requirement the following dry tests shall be carried out as a general requirement:

(1) A general inspection to check for correct assembly and quality of workmanship

(2) A check on the presence of lubricant, cooling medium, electrolyte, etc.

(3) A check on adequacy and security of Plant fixing arrangements.

(4) A general check to ensure that all covers, access ladders, water proofing, guard railings etc are in place.

(5) A check on damp-proofing, rust-proofing and vermin-proofing and particularly the sealing of apertures between building structures, chambers etc and the outside.

a) Civil and Building Works

As a minimum requirement the following dry tests shall be carried out on the civil engineering and building works:

- Check for the presence of foreign bodies in pipe work and structures.

b) Mechanical Works

As a minimum requirement the following dry tests shall be carried out on the mechanical systems:

- Carry out preliminary running checks as far is permitted by circumstances in order to ensure smooth operation of Plant.

c) Electrical Works

As a minimum requirement the following dry tests shall be carried out on the electrical systems:

(1) Check phasing and polarity.

(2) Carry out point to point check on all cables.

(3) Check on security of cable terminations.

(4) Check on completeness and adequacy of earthing systems.

(5) Check setting on protection relays, sizes of fuses and motor overload settings.

(6) Carry out checks on cabling systems in accordance with the requirements of the relevant standards.
(7) Check operation of main circuit breakers by secondary injection methods.
(8) Check rotational direction of Plant.
(9) Check instrument loop integrity, functionality and calibration.
(10) Check operation of standby generator installation and mains / generator changeover procedures; a 4 hour load test (using the normal load of the Works) shall be carried out on the generator when the load is available.
(11) Check plant functionality.
(12) Check functionality of the central MMI and its power supply.

d) Process Plant Item / Equipment

All process plant items / equipment shall be tested to ensure they meet the Employer's Requirements for quality of workmanship, construction and performance.

e) Hydraulic Wet Test Requirements

Hydraulic wet tests shall be carried out on completion of dry tests.

Clear Water shall be used for hydraulic wet tests. The purpose of the tests is to prove the hydraulic performance of the Works. In order to demonstrate this, the Contractor shall ensure that each part of the Works is hydraulically loaded to its rated throughput for a period of at least four hours.

In order to ensure a sufficient supply of water to carry out these tests the Contractor shall provide all required facilities, including but not limited to any temporary facilities that may be required for storage and recycle of Clear Water or facilities for the disposal of the water off Site in an approved manner.

The following tests inter alia shall be carried out:

(1) Pressure testing of all piped systems laid direct in ground in accordance with the relevant standards.
(2) Fill all structures and check for leaks.
(3) Filling of all storage vessels to check for leaks and distortion.
(4) Running of all pumped systems in order to check for.
i) Correct functionality.
ii) Absence of leaks.
iii) Correct running temperatures.
iv) Smoothness of running and the absence of undue vibration or stress.
v) Check drive running currents.
(5) Carry out calibration of instruments where appropriate.

(6) Carry out valve operation, diversions etc. to fully hydraulically load each process element (or where there is a requirement to withstand an over load), overload each process element.
(7) Demonstrate correct functionality of electrical, control and instrumentation systems.

The Contractor shall simulate the conditions that will prevail when operating as a process in order to demonstrate the correct functionality of process control loops etc.

During these tests a check on the performance of Plant shall be made to compare its site performance with the factory test data and to identify any constraints on performance due to site conditions.

1.28 Safety Audit

After satisfactory completion of hydraulic wet tests and prior to introduction of process fluid to the plant a safety audit shall be carried out to ensure compliance with the necessary requirement for safety and for operation of Plant. The safety audit shall be documented. The safety audit document shall be approved by the Employer's Representative prior to commencement of Plant commissioning.

1.29 Process Wet Tests (with Raw Sewage)

On approval by the Employer's Representative the Contractor shall carry out process wet tests. Raw Sewage shall be used as the main feed stock for process wet tests. These tests shall be carried out to demonstrate the process performance of the Works. In order to demonstrate this, the Contractor shall ensure that each part of the Works is loaded to its rated throughput (including a period of overload if required in order to demonstrate compliance with the Employer's Requirements) for a continuous stable operating period of not less than 48 hours. If necessary, Contractor shall create design loading conditions for testing purposes by testing fewer than the total number of installed units of process tanks or equipment at a time. In such cases, multiple tests shall be conducted to ensure that all installed units are tested

The Contractor shall provide all required facilities for the disposal off Site in an approved manner.

The following tests inter alia shall be carried out:

(1) Check for leaks on vessels, structures, pumps and pipe work.
(2) Running of all pumped systems in order to check for.
- ✓ Correct functionality.
- ✓ Absence of leaks.
- ✓ Correct running temperatures.

- ✓ Smoothness of running and the absence of undue vibration or stress.
- ✓ Check drive running currents where the solution pumped is different from that pumped during hydraulic wet tests.

(3) Carry out calibration of instruments.

(4) Carry out valve operation, diversions etc. to fully hydraulically load each process element (or where there is a requirement to withstand an over load), overload each process element.

(5) Demonstrate correct functionality of electrical, control and instrumentation systems not checked during dry or hydraulic wet tests or which may have changed as a result of the different operating conditions now prevailing.

On completion of the tests on the various parts of the works the Contractor shall run the plant as a whole in order to demonstrate the full functionality and performance of the Works at various throughput rates for a continuous period of not less than 15 days.

During the various process tests the Contractor shall perform sampling and analysis of all the process streams (locations) and parameters listed in the "Sampling/Analysis Locations and Frequencies" table provided in the "Tests after Completion" Section below. The frequencies listed in this table shall be followed for the Tests after Completion. However, for the Process Wet Tests performed as part of the Tests on Completion, the sampling frequency for all locations and all parameters shall not be less than once every hour. The Contractor shall demonstrate to the Employer's Representative that the Works is functioning in accordance with the Employer's Requirements. Each sample shall comprise two 1 litre (minimum) quantities and shall be labelled to identify the contents, where taken and time and date. The flow recorded at the time of sampling shall also be indicated in the log book or record. One sample shall be used by the Contractor for his analysis; the other shall be handed over to the Employer's Representative.

The Employer's Representative reserves the right to take additional samples and to carry out his own tests or to check the samples taken by the Contractor.

The Employer's Representative shall be given reasonable access to the premises where analysis is taking place in order to check on working practices and the procedures being adopted.

1.30 Effluent Quality Criteria for Passing the Tests on Completion

The Works shall be considered to have achieved the required effluent quality standards for passing Tests on Completion if all samples taken during a 15 day continuous operational period comply with the criteria set down for passing the Tests after Completion. This includes criteria relating to the reliability of the plant.

The Effluent quality Tests on Completion shall not be commenced until all tests associated with the civil/building, electrical and mechanical works and individual process tests have been completed to the satisfaction of the Employer's Representative.

1.31 Co-operation with other Contractors in the Execution of their Tests

The Contractor shall, where required, assist other contractors in carrying out their tests on completion and or tests after completion.

Where this assistance does not constitute part of the Contractors own work associated with Tests on Completion or Tests after Completion the Contractor shall be reimbursed at the rates approved by the Employer's Representative.

1.32 Tests after Completion

General

On successful completion of "Test on Completion" the Contractor shall carry out over a period of time not exceeding two months two separate 30 days operational tests. These tests shall be used to prove the operation of the Works at varying flows and with varying raw Sewage quality. During these tests Effluent produced by the Works will be entering the disposal system.

The timing of the tests shall be determined by the Employer who shall give notice to the Contractor in accordance with the General Conditions of Contract. The total time for carrying out the tests shall not be less than two calendar months. One of the tests for each part shall be carried out in a period of high raw Sewage BOD and suspended solids.

On commencement of each 30-Days test the Employer shall allocate a continuous period of not greater than 60 days to complete the test. Any failure to perform during the 60 days period shall restart the '30 day clock'. If the part of the Works fails to pass the test in the 60 days period the test shall be deemed as a failure and the Contractor shall carry out any necessary remedial work to the satisfaction of the Employer's Representative before the Contractor restarts the test.

During the tests the Contractor shall take samples to demonstrate that the part of the Works is performing in accordance with the Employer's Requirements. The procedure for taking the samples shall follow the pattern adopted for Test on Completion. Samples shall be taken at locations and intervals detailed below. The results of the Tests after Completion shall be compared and evaluated by the Employer and Contractor.

The Contractor will not be held responsible for interruptions to the sewage treatment process as a result of Grid power failures (unless as a result of a Plant failure) interruptions in the raw Sewage supply etc. which are out of his control. However, the Contractor shall be required to demonstrate that the Works can cope with these inevitable interruptions in an orderly fashion and recover to a normal operational state with the minimum of manual intervention.

All consumables except power needed for operation of the Works and transportation of sludge off site shall be provided by the Contractor.

The Contractor shall provide all facilities and equipment not supplied under the contract and which are deemed necessary for the Contractor to carry out and monitor the Tests after Completion.

1.33 Sampling and Analysis (for Test on Completion and Test after Completion)

Sampling and analysis shall be performed to measure the parameters indicated in the table below, at the locations and frequencies indicated in the table. In case of multiple units (such as multiple aeration basins or thickeners), the indicated sampling and analyses shall be performed for each individual module.

Sampling/Analysis Locations and Frequencies

Sample Location and Parameters to be Measured	Frequency	Sampling Method
Plant Effluent (outlet of chlorine contact tank): All parameters specified in volume - IIIA, Part-2. BOD, TSS, TKN, pH	3 times per week	Flow-weighted 24-hour composite
Dewatered Sludge: All parameters specified under the “Dewatered Sludge Quality Requirements” sub-section of Volume IIIA, Part 2	Daily	Composite of samples from each container or vehicle filled during the day
Raw Sewage Influent, Plant Effluent, RAS, WAS, Thickened Sludge, Dewatering Influent, Plant Recycles: Flow	Continuous	Continuous instantaneous flow from recorder
Raw Sewage Influent and Effluent: TSS, VSS, Temperature, pH	Daily	Flow-weighted 24-hour composite
Raw Sewage Influent: BOD, COD, TKN	3 times per week	Flow-weighted 24-hour composite
Aeration Basins: MLSS, MLVSS, Temperature, SVI	Daily	Grab
RAS, WAS	Daily	Grab

Sample Location and Parameters to be Measured	Frequency	Sampling Method
Chemicals/Scum/Screenings/Grit: Specific weight, volume, weight, Chemical consumption	3 times per week	Grab

All costs associated with the taking and analysis of samples shall be met by the Contractor.

The analysis shall be carried out by chemical certified laboratory (Pollution Control Board Certified) and as approved by the Employer's Representative, and shall be performed in strict compliance with appropriate analytical methods published in Indian Standards, or in "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, or as published by the US Environmental Protection Agency. The Contractor shall submit to the Employer's Representative a comprehensive report of the above sampling and analysis, including details of each analytical test as well as a summary of all the data and results in a Microsoft Excel spreadsheet.

Criteria for Passing the Test after Completion

(1) Treated Effluent and Dewatered Sludge Quality Criteria

The Works shall be deemed to have met the Treated Effluent and Dewatered Sludge Quality Criteria if:

(i) at least 95 percent of the plant effluent samples described above meet the requirements specified under the "Effluent Quality Requirements" Volume III-A, Part 2 at least 95 percent of the dewatered sludge samples described above meet the requirements specified under the "Dewatered Sludge Quality Requirements" sub-section of Volume III-A Part 2.

(2) Operational Cost Criteria

The plants shall have fulfilled the operating cost criteria if the operating costs determined during the Tests After Completion are in agreement with or less than those detailed in the Contractor's Functional Guarantee or an amount of liquidated damages are agreed by the Contractor and the Employer's Representative to compensate for any short fall in performance up to an agreed maximum amount if stated.

(3) Plant Reliability Criteria

A part of the Works shall be deemed to have failed its test if:

(1) A single item of Plant / equipment fails more than twice during the test.
(2) More than four individual Plant items / equipment fail.

An item of Plant / equipment shall be deemed to have failed if manual intervention is required in order to restore the Plant / equipment to its fully operational state: i.e. the failure of a duty drive will be considered as one failure, if the standby drive fails to start that will be considered as a second failure.

1.33 Performance Certificate

The conditions for issuance of a Performance Certificate as detailed in Clause 12 of the Conditions of Contract shall inter alia comprise:

a) The completion of the two months operation of the Works (Tests after Completion) to the satisfaction of the Employer's Representative.
b) The O & M Manuals have been updated following one year's operational experience and approved by the Employer's Representative.
c) All defects identified prior to Taking Over and defects identified during one year operation of the Works have been rectified.
d) All Tests "After Completion" have been completed to the satisfaction of the Employer's Representative.
e) All training detailed in the Employer's Requirements has been completed.

End of Part 4

Request for Proposal

For

DEVELOPMENT OF BORSOLA BEEL

Design, Build and Operate Basis

Volume II A: Operation and Maintenance Requirements

Client:

GUWAHATI SMART CITY LIMITED

GSCL,

Guwahati, Assam

DOCUMENT NO: .10477A-CV-3000-3102

Operation & MAINTENANCE requirements OF the plant and all Items for Borsola Beel

The operator is required to run the STP and the Beel and all the items such as MPS and Inlet works and the Beel for 5 years.

OPERATION AND MAINTENANCE MANUAL AND AS-BUILT DRAWINGS

The submission of the As–built drawings and the operation and maintenance manual for the system is the precondition for the final payment.

OPERATION AND MAINTENANCE MANUAL

The Contractor has to submit as operation and maintenance manual after the physical completion of the work. This manual will be submitted as draft at the date of physical completion and as final version one month after commissioning. It shall include all the experience made during the tests and the training given to the operators during the commissioning period. The Contractor will prepare this manual in cooperation with his suppliers and subcontractors and after consultation with the Employer's representative for detailed contents. It will at least contain the following items.

General description of the STPs/SPS and their functioning

Step- by step procures for all the each plant functioning.

Architectural, mechanical electrical, instrumentation, piping drawings, sections, details, charts.

Nomenclature of all the equipment (mechanical, electrical, instrumentation, power and signal cables, electrical and sanitary fixtures)

- For each item of the equipment
- Drawing charts (if required)
- Operational Instructions
- Calibration charts (if required)
- Fault identification and location guides and charts
- Repair instructions (if repair by operations if possible)
- Maintenance instructions including type and quantity of lubricants
- Spare parts list with addresses of suppliers and procedures for ordering.
- Preventive maintenance schedules for all the equipment, showing the type and frequency of maintenance of different items
- Type and quantity of the recommended consumables (lubricants, fuels etc.,)
- Emergency management for specimen emergency situation which might occur due to external or internal factors
- Logs for the operator of the system
- Operating hours
- Salient indicators of the operation
- Maintenance operations

- Fault and actions taken
- Other events

Address and telephone number to contact in case of operation problems shall be provided. It is emphasized that a collection of standard literature of a general nature, unaccompanied by specific drawings and descriptive matter relating to the work as commissioned, shall not be acceptable. The operation and maintenance manual shall be bound in one or several loose-leaf binders designed to prevent loss and damage of the contents. The binders shall be tilled, numbered, and have a table of contents of all information contained.

General Requirements for Operation and Maintenance (For STP& SPS)

All necessary repairs, maintenance, overhaul, replacements etc., shall be made during the O & M to maintain the STPs & SPS at the status of formal handing over after the commissioning. At the end of O & M period the plant shall be handed over to the Employer in fully functional and new condition except normal wear and tear.

Following shall include but not limited to the following items (except power charges).

Operation and Maintenance including Civil, Electrical, Mechanical and all allied works

Sampling and testing of influent sewage based on the tests and frequency desired by the Employer's representative and in general in accordance with the CPHEEO manual on Sewerage and Sewage Treatment.

Sampling and testing of additional samples for the day to day O & M of the STP and as mutually agreed from time to time between the Contractor and the Employer's representative.

Sampling of final treated effluent to ensure that the guarantee parameters are as stipulated in the bid document. The sampling frequency to be as per relevant norms of Assam Pollution Control Board or higher as decided by Employer's representative. The Employer reserves right to collect samples at random at the will of the Employer through any agency nominated by him. Employer shall have right to seek part of sample collected by the Contractor without any prior intimation to cross check the results on random basis. However the analysis charges of such samples shall be borne by Employer.

O & M of all functional and utility buildings, infrastructure and common areas Within the Plant campus.

Proper maintenance of Water Supply, Sewerage, Roads, Paths, lawns including trimming and upkeep of gardens etc.,

Maintenance of Proper records of sampling as per approved Performa.

Loading, Unloading and Transportation of screenings, Wet sludge and wet grit out of treatment Plant site at his cost as directed by Employer's representative within 20 km from the Plant at the place as directed by the Employer's representative from time to time. The wet sludge shall be

collected and disposed of by the contractor. Any revenue accruals by sale of sludge shall be to the benefit of the Contractor.

Maintenance of log books of all the machinery not connected to the PLC / SCDA shall be done separately & collectively, at the STP fortnightly and monthly reports of all such machinery and parameters monitored by the PLC shall be generated and hardcopy along with soft copy shall be got approved by the Employer's representative. These reports shall contain sufficient appropriate and adequate data to make the records meaningful and amenable to analysis for evaluating the performance of the Plant as well as to help in O & M decisions.Security of the campus and contents therein shall be Contractor's responsibility. The records maintained by the Contractor shall be produced periodically to the Employer's representative for proper monitoring. The Employer's representative's remarks shall be attended to on next submission. Consolidated summary reports shall be furnished to the Employer monthly, quarterly and yearly containing salient features. The Contractor shall also maintain history sheets of overhauling, maintenance, replacement of all the important electrical and mechanical equipment. The O & M shall include the appropriate preventive maintenance of equipment as per the manufacturer's recommendation. The operation, maintenance and repairs services shall be performed according to the following.

Down time:

The Plant shall never be operated at less than 50% of its design capacity due to maintenance and repair reasons. The period of such exceptional operation shall not exceed two consecutive days and shall not be more than three days a week. The maximum downtime of the whole Plant shall not exceed 8 hours. The periods for repairs and maintenance have to be communicated to the Employer's representative at least one month in advance. For machinery and equipment which requires maintenance to be carried out by manufacturer/ manufacturer's authorized representative, the down time shall not exceed 30 days. Employer reserves the right to impose penalty, should there be any default by Contractor on this account. The penalty amount will be deducted in the next O & M bill if adequate reasons are not furnished by the Contractor for delay.

Operation of the Plant as per O & M Manual:

The Plant shall be operated according to the rules and procedures of State Pollution Control Board. The Plant must be in position to work at the design capacity at any time.

Awareness & Cleanliness

The Contractor and his staff shall maintain a high degree of awareness in operation and maintenance of the Plant and all relevant safety codes and procedures. At all times the Plant, its equipment and surrounds shall be kept clean and in order' including the buildings, floors, walls, roofs, windows, and garden etc.

Frequency of Preventive maintenance

The preventive maintenance shall be carried out according to the preventive maintenance schedule of the Plant. The regular staff may be reinforced with short-term specialists by the Contractor for special maintenance tasks, after duly informing the Employer's representative of the need and the schedule.

Repairs

Repairs shall be made as and when needed very promptly on the spot or at the Contractor's / Manufacturer's workshop. The need of repair on the spot or at the Contractor's workshop has to be defined in co-ordination with the Employer's representative and according to the status of spare parts availability.

Spare parts

The Contractor shall keep a reasonable stock of spare parts so that the down time of equipment can be kept within the limits specified. The contents of the stock and the reorder level of the inventory have to be approved by the Employer's representative.

Transportation

All necessary transportation shall be arranged and made by the Contractor at his own expense.

Consumables

The Contractor has to ensure that there is always there is sufficient stock of 15 days of consumables, laboratory chemical, glass ware etc.,

Chemicals

The Contractor has to ensure that there is always there is minimum stock of 30 days requirement of Polyelectrolyte.

GENERAL OBLIGATION

The Contractor shall operate and maintain the entire Plant under this contract for the period specified in this contract which shall be extendable for a further period at the Employer's option.

The Contractor will submit a detailed operation and maintenance plan for approval of Employer's representative. All operation and maintenance activities shall be carried out strictly in accordance with the approved plan.

The services shall include but not be limited to the following items.

Operation and maintenance of the sewage treatment plant from the inlet chamber up to disposal point,

Training for the O & M staff of designated by Employer's requirement.Generation and maintenance of periodic reports.

Operational services

The Contractor shall operate the complete sewage treatment Plant/ SPS and associated services on a continuous 24-hour basis.

The Contractor shall operate and utilize the control and monitoring systems provided. If found necessary, he shall make adjustments (within the operation range) of the control system and equipment, so that the Plant operation matches the treatment process requirements.

If it is determined that the facility is not capable of meeting the design parameters for any reason beyond the Contractor's control and not attributable to him, the Contractor shall determine the specific cause of failure/ abnormality in the Plant functioning and report to the Employer's representative and seek his directives on the necessary corrective action to be taken/adopted.

The Contractor will be required to furnish the details of electricity consumption in the format prescribed by the Employer's representative.

All consumables, Polyelectrolyte, and spare required operating and maintaining the Contractor shall provide the Plant in good condition. The grit, Screenings, Wet sludge and other garbage generated in the plant shall be removed from the site on daily basis. No accumulation of such residues shall be permitted within the Plant campus without express application by Contractor giving adequate reasons as well as permission of Employer's representative. The Contractor shall such residues in conformity to Environmental regulations/ rules in force. The Employer's Representative may, if required, decide the mode and timing of disposal of such residues in consultation with concerned Environmental and Civic Authorities. Such directions shall be followed by the Contractor promptly, both in letter and spirit, without any reservations and without any increase in O&M /other costs. The loading, unloading and transportation cost of these shall be borne by the Contractor and shall be included in the price quoted by the Contractor for O&M.

The Contractor at his own expense shall provide all tools, cleaning, and house keeping equipment, security and safety equipment

Laboratory services

The Contractor shall perform all tests, sampling and analyses regularly as approved by the Employer's requirement and as per the O & M standards

The Contractor will submit a complete list of laboratory equipment and materials in accordance with the analysis program required..Manpower

The Contractor shall provide experienced managerial, technical, supervisory, laboratory, administrative, and non-technical personnel and labour necessary to operate and maintain the treatment Plant(separate to all STPs & SPS) and works properly, safely and efficiently on a

continuous 24 hour basis for the full term of the O & M period. While doing so due consideration shall be given to the labour laws in force.

The qualification and capability of Contractor's personnel shall be appropriate for the tasks they are assigned to perform. The staff provided shall be fully trained in the operation of the works before being given responsibility. If, in opinion of the Employer's representative, a member of Contractor's staff is considered to be insufficiently skilled or otherwise inappropriate for the assigned task, and Employer's representative informs the Contractor in writing, the Contractor shall replace him with a person of appropriate skills and experience for the task, approved by the Employer's representative, within one month of being so informed.

The bidder shall propose in his tender a staff management structure for the operation and maintenance of works. The suggested structure (minimum) shall be as follows for three SPS &STP

Plant Manager cum Chemist	1
Operator	3
Electrical Technician	2
Mechanical technician	2
Instrumentation Technician	2
Sewerman+Labour	5
Mali cum Chowkidar	2

The Employer may require a suitable change in the structure on the basis of design, automation and other relevant parameters it deems fit.

The Contractor shall provide all secretarial support, printing and publishing services, office furniture and office supplies as required. It shall also ensure that all labor welfare laws and regulations are followed, including weekly rests, rotation of duties

The C V resumes of the Contractor personnel shall be submitted to the Employer's representative for acceptance at least two months before anticipated commencement of the pre-commissioning of test. Normal time duty hours for the Contractor's O & M personnel may be modified as necessary and agreed by the Employer's representative. A rotating shift schedule shall be established by the Contractor and approved by the Employer's representative who will ensure that an adequate number of the Contractor's staff will be available for duty at Plant 24 hours each day, 7 days week, including national holidays.

In the event that it is necessary for more than one of the Contractor 's O & M personnel to be absent from the Plant , for whatever reason, the Contractor shall provide a qualified replacement at his own expense and ensure that specified project duty coverage is maintained. If substitute key personnel are required for a period longer than 15 days, their CV must be approved in advance by the Employer's representative.

The O & M personnel shall be dedicated solely to the specified duties and responsibilities and shall not be diverted to perform Contractor's administrative duties, construction arrangement, office management, or other non- O & M activities. Adequate support staff shall be provided by the Contractor in order avoid any such diversion.

The bidder shall provide justification of the labour cost proposed by him for all personnel

The Contractor shall include in his cost medical and accident insurance expenses of all the staff employed by him along with all provisions of the labour welfare acts prescribed from time to time by the State and Central Government. Adequate insurance cover shall also be maintained during O & M period for all short-term employees, as well as casual, temporary employees and visitors.

Employer is not liable for any situation arising due to any accident/mishap of whatever nature occurring in the Plant premises.

Safety

The Contractor shall be responsible for safety of his staff during O & M of the Plant and shall procure, provide and maintain all safety equipment necessary for satisfactory O & M such as gasmasks, gloves, boots, mats etc.,

1. The Contractor shall utilize safety awareness procedures in every element of operation and maintenance.

The Contractor shall emphasize site safety including adoption of

Safe working procedures

Cleanliness and care of the plant as a whole

Accident and hazardous conditions prevention and reporting.

Safe practice while working near digester / gas holder areas

The Contractor shall impart safety training to all members at regular intervals, especially for new comers.

The Contractor shall provide Notice boards and display boards at appropriate locations detailing precautions to be taken by O & M personnel to work in conformity to regulations and procedures and by the visitors to the Plant.

The Contractor shall notify the Employer's representative immediately if any accident occurs whether on-site or off site in which Contractor is directly involved and results in any injury to any person, whether directly concerned with the site or a third party. Such initial notification may be verbal and shall be followed comprehensive report within 24 hours of the accident.

Reporting

The Contractor shall prepare consolidated daily reports, weekly and monthly reports on Plant operation and maintenance and submit to the Employer's representative. The daily reports are to be submitted within first working hour of the next day. The monthly reports shall be submitted on the first day of the next month and within two working hours.

Overall reporting formats shall be approved by Employer's representative and may have to be modified from time to time as required and approved by Employer's representative. Contractor may have to prepare and submit additional reports on particular matters and incidents as and when required by the Employer's representative for each significant occurrence.

MAINTENANCE

Maintenance of Installed Plant

The Contractor shall ensure the continuity of the Plant operations and the breakdown or the deterioration in performance of the Plant under normal operating conditions of any items of the Plant and equipment and component parts thereof shall be minimized.

The classes of maintenance provided shall comprise full Operational maintenance and standby Maintenance.

Full operational maintenance comprises the planned and regular maintenance carried out by the Contractor on a day-to-day basis, including cleaning, lubricating, minor adjustment, together with the preventive and corrective maintenance plan for those items of the Plant and equipment within the treatment works which have been commissioned and made operational.

Standby maintenance comprises the planned and regular maintenance carried out by the Contractor including cleaning, lubricating, periodic, and minor adjustment of all items of Plant and equipment within the treatment works which have been installed but have not yet been made operational.

The Contractor shall carry out the maintenance of the Plant installations in accordance with the requirements of the O & M Manual and to the approved maintenance plan. The Contractor shall strictly adhere to the manufacturers' recommendations with respect to equipment maintenance, and only use types and grades of lubricants to be used. The frequency of lubrication, adjustments to be made regularly, and recommended spare parts by the equipment/machine/instrument manufacturer/supplier shall be carried out and appropriate inventory shall be held in store.

Building and Site Maintenance

The Contractor shall be responsible for:

The full maintenance of building and all electrical, ventilation, plumbing and drainage installation in the building.

Building and housekeeping maintenance.

- Full maintenance of the site water and wastewater services, cabling and earthing systems, and the site road lighting system.
- Site maintenance including the upkeep of landscaped areas/ tree Plantation etc.,
- The telephone installations in all buildings.

The building services and housekeeping maintenance shall be undertaken on all buildings and services installations.

Routine housekeeping maintenance shall be carried out in accordance with procedures specified in the Operation and Maintenance Manual which shall be approved by the Employer's representative.

Preventive Maintenance

The Contractor shall plan the day-to-day and the preventive maintenance. This planning must include for each equipment the estimated necessary hours in preventive maintenance and break down maintenance. It shall also include the qualification of the foreseen maintenance personnel. The Contractor shall provide the yearly requirement of spare parts and consumable needed for the maintenance of each piece of equipment for the day-to-day maintenance, preventive maintenance, and foreseen break down maintenance/overhaul, if any.

TRAINING

General

(a) The Contractor shall be responsible for instruction and training of all his personnel in all aspects of Plant operation and maintenance till the end of the operation and maintenance period. The Contractor shall also be responsible for training personnel designed by the Employer who will operate the Plant at the expiry of the contract.

The Contractor will make available for this purpose competent staff and as well as propose schedule information that may be necessary for effective execution of the training programs.

The training shall be organized in two (2) stages as follows:

- Basic technical training education to be carried out during the final stages of the erection period of the contract through literature, manuals, handouts demonstration at site, etc.
- Intensive on-the- job training during commissioning and maintenance period.

(b) By the end of this training period these personnel should be able to carry out their respective duties efficiently under the supervision of Employer's representatives and supervisory staff of the Employer.

The Contractor shall provide at his cost all local transportation, literature, computers, CDs and other related hardware and stationery to be used by trainers and trainees during the training period.

Towards end of O & M contract period, training shall be conducted once again to Employer's personnel or their authorized personnel. This training shall be for a duration of 10 working days.

Operation and Maintenance records

The following are a typical sample form of records (not an exhaustive and comprehensive) that are required to the maintained by the O & M Contractor. The details of complete records shall be prepared and submitted by the O & M Contractor to the Employer's representative for approval prior to commissioning.

Performance data of BIOLOGICAL TREATMENT Basin of STPs &SPS

The performance data sheet shall contain the records of the analytical results at the inlet and outlet all the parameters. These parameters are pH, Dissolved Oxygen, BOD & COD, TSS, VSS, N, P, Sulphate and Temperature.

Month:

Year:

Date	BIOLOGICAL TREATMENT Basin					Chlorination				Centrifuge				Officer on duty	Operator
	a	b	c	d	e	a	b	c	d	d	f	g	h		

a- BOD

b – COD

c- Suspended solids/ MLSS

d- pH

e - Dissolved oxygen

f – VSS content

g –solid concentration in the underflow

h- if any

Other Records

The contractor shall maintain detailed record of consumption of Polyelectrolyte and other scrubbing chemicals (if used). Record of wet sludge transported out of the plant site shall be maintained. Similarly record of material movement shall also be maintained as appropriate and approved by Employer's Representative.

These records shall be available to the Employer's Representative for scrutiny and copies shall be furnished on demand.

Request for Proposal

For

DEVELOPMENT OF BORSOLA BEEL

Design, Build and Operate Basis

Volume II B Part-1: Technical Specifications for Civil Works

Client:

GUWAHATI SMART CITY LIMITED

GSCL,
Guwahati, Assam

DOCUMENT NO: 10477A-CV-3000-3102

1.1 Design Submissions

Complete detailed design calculations of foundations and superstructure together with general arrangement drawings and explanatory sketches shall be submitted by the Contractor to the Engineer. Separate design calculations for foundations or superstructures submitted independent of each other shall be deemed to be incomplete and shall not be accepted by the Engineer.

Submissions of detailed design calculations and Good for Construction drawings shall include the following as a minimum:

A. Detailed Design Calculations

1. One (1) Copy of a Compact Disc (CD) containing electronic files relevant to the structure's modelling, analysis and design calculations (Microsoft Excel, Staad Pro, etc.). Files submitted shall be in editable format.

2. Print copy (6 Copies) of the contents as submitted in the Compact Disc.

B. Good for Construction Drawings

1. One (1) Copy of a Compact Disc (CD) containing AutoCAD files (Civil General Arrangement, Structural Dimensions and Reinforcement Details) pertaining to the structure. Files submitted shall be in editable format.

2. Print copy (6 Copies) of the contents as submitted in the Compact Disc. Prints to be submitted on A1 Size Sheet as a minimum or A0 Size Sheet when required by the employer.

3. Bar-bending schedule indicating the number, shape and size of the re-bars shall be submitted as part of the Reinforcement Details

4. Detailed drawing showing the location, number and depth of inserts shall be included for any structural steel inserts/Metal inserts in the structure such as rungs, bolted connections for ladders/railings, etc.

5. Location of Construction Joints and pour sequence shall be included on the drawing for base slabs, walls and top slabs.

6. Revised drawings shall be submitted by clouding at the location with the latest revision number and also show the history of revisions in a table format just above the title block.

The design considerations described hereunder establish the minimum basic requirements of plain and reinforced concrete structures, masonry structures and structural steel works. However, any particular structure shall be designed for the satisfactory performance of the functions for which the same is being constructed. The Contractor shall also take care of all

mandatory statutory requirements, codal provisions and shall check the stability of partly completed structures and/or for the construction methodology adopted..

1.2 Design Standards

All the designs shall be based on the latest Bureau of Indian Standard (BIS) Specifications or Codes of Practice. The design standards adopted shall follow the best engineering practice. In case of any variation or contradiction between the provisions of the BIS Standards or Codes and the specifications given along with the tender document, the provision given in this Specification shall be followed.

All reinforced concrete structural design shall generally conform to the following publications of the Indian Standards Institution:

(i) I.S. 456 : Code of Practice for plain and reinforced concrete

(ii) I.S. 875 : Code of Practice for design loads for buildings and structures (Part I to V)

(iii) I.S. 3370 : Code of Practice for concrete structures for the storage of liquids (Part I to IV)

(iv) I.S. 1893 : Criteria for earthquake resistant design of structures (Part-1)

(v) I.S. 2974 : Code of Practice for design and construction of machine foundations

(Part 1 to 4)

(vi) I.S. 4326 : Code of Practice for Earthquake Resistant Design and Construction of Buildings

(vii) I.S. 13920 : Ductile Detailing of Reinforced Concrete Structures subjected to Seismic forces- Code of Practice

(viii) IRC: 6 : Standard specification and Code of Practice for road bridges Loads and Stresses

(ix) IRC: 21 : Standard specification and code of practice for road bridge, section III Cement Concrete

(x) IRC 78 : Standard specification and code of practice for road and bridge, section VII Foundation & Sub-Structures

All structural steel design shall generally conform to the following publications of the Indian Standards Institution:

(i) I.S. 800 : Code of Practice for general construction in steel

(ii) I.S. 806 : Code of Practice for use of steel tubes in general building construction

1.3 Design Life

The design life of all structures and buildings shall be 60 years.

1.4 Design Loadings

All buildings and structures shall be designed to resist the worst combination of the following loads/stresses under test and working conditions; these include dead load, live load, wind load, seismic load, stresses due to temperature changes, shrinkage and creep in materials, and dynamic loads, test loads, water pressures, soil pressures, uplift forces as applicable:

1.4.1 Dead Load

This shall comprise all permanent construction including walls, floors, roofs, partitions, stairways, fixed service equipments and other items of machinery. In estimating the loads of process equipment all fixtures and attached piping shall be included, but excluding contents, shall be considered.

The following minimum loads shall be considered in design of structures:

(i)	Weight of water	:	9.81 kN/m3
(ii)	Weight of soil (irrespective of strata available at site and type of soil used for filling etc). However, for checking stability against uplift, actual weight of soil as determined by field test shall be considered	:	20.00 kN/m3
(iii)	Weight of concrete	:	24.00 kN/m3
(iv)	Weight of reinforced concrete	:	25.00 kN/m3
(v)	Weight of brickwork (exclusive of plaster)	:	22.00 N/m2 per mm thickness of brickwork
(vi)	Weight of plaster to masonry surface	:	18.00 N/m2 per mm thickness
(vii)	Weight of granolithic terrazzo finish or rendering screed, etc.	:	24.00 N/m2 per mm thickness
(viii)	Weight of MS chequered plates	:	78.5 N/m2 per mm thickness of plates

1.4.2 Live Load

Live Load (LL) shall include the superimposed loads due to the use/occupancy of the structure/building not including dead, wind or earthquake load. Live loads shall be in general as per I.S. 875 Part (II). However, the following minimum loads shall be considered in the design of structures:

(i) Live load on roofs : 1.50 kN/m^2

(ii) Live load on floors supporting

	Equipment such as pumps, valves etc.	:	10.00 kN/m^2
(iii)	Live load on all other floors		
	Walkways, stairways and	:	5.00 kN/m^2
	Platforms		

In the absence of any suitable provisions for live loads in BIS Codes or as given above for any particular type of floor or structure, assumptions made must receive the approval of the Engineer prior to starting the design work. Apart from the specified live loads or any other load due to material stored, any other equipment load or possible overloading during maintenance or erection/construction shall be considered and shall be partial or full whichever causes the most critical condition.

1.4.3 Wind Load

Wind loads shall be as per I.S. 875 Part (III).

Basis wind speed=50 m/s

K1=probability factor(risk coefficient)=1.0

K2=Terrain height and structure rise factor as per table 2 of IS875 Part 3

K3=Topography factor, as per appendix C of IS 875 Part 3

Vz = K1 * K2 * K3 and Design Wind Pressure

Calculate Pz

Where P_z = Design wind pressure in N/m^2 at height Z

1.4.4 Earthquake Load

This shall be computed as per I.S. 1893. The site falls in Zone V as per IS: 1893. An importance factor appropriate to the type of structure shall be considered for design of all the structures. Environmental condition shall be considered appropriate as per IS 456, IS 800 and IS 3370.

1.4.5 Dynamic Load

Dynamic loads due to working of plant items such as pumps, blowers, compressors, switch gears, travelling cranes, etc. shall be considered in the design of structures.

1.4.6 Water Pressure:

Water pressure is the horizontal pressure of the water acting on the structure. The water pressure shall be calculated

1.4.7 Earth Pressure:

Earth pressure means the horizontal pressure of the soil acting on the underground structure and foundation. Earth pressure for all underground structures (walls of basement / tanks) shall be calculated as per IS Guidelines.
The earth pressure of submersed soil shall be calculated as follows:

1.4.8 Uplift pressure:

Ground water table shall be considered appropriately based on findings of geotechnical investigation and considering the local conditions. Appropriate seasonal variation shall be considered while calculating ground water table.. Uplift pressure due to ground water on foundation is calculated as follows:

1.4.9 Surcharge Load:

Minimum surcharge of 10KN/m2 shall be considered for design of all underground structures to take into account the construction load and vehicular movement in the vicinity of structure. Fire tender load shall be added at applicable locations. The soil pressure and ground water table shall be considered as applicable.

1.4.10 Wheel Load

For any structure or pipeline below the roads, Class A loading of IRC 6 shall be taken.

1.5 Joints

Movement joints such as expansion joints, complete contraction joints, partial contraction joints and sliding joints shall be designed to suit the structure. However, contraction joints shall be provided as per standards.

Expansion joints of suitable gap at suitable intervals not more than 30 m shall be provided in walls, floors and roof slabs of liquid retaining structures.

Construction joints shall be provided at right angles to the general direction of the member. The locations of construction joints shall be decided on convenience of construction. To avoid segregation of concrete in walls, horizontal construction joints are normally to be provided at every 2 m height. PVC water-stops of 150 mm width shall be used for walls and 230 mm width for base slabs.

1.6 Design Conditions for Underground or Partly Underground Liquid Retaining Structures

All underground or partly underground liquid containing structures shall be designed for the following conditions:

(a) Liquid depth up to full height of wall: no relief due to soil pressure from outside to be considered;
(b) Structure empty (i.e., empty of liquid, any material, etc.): full earth pressure and

surcharge pressure wherever applicable , to be considered ;

(c) Partition wall between dry sump and wet sump : to be designed for full liquid depth up to full height of wall on one side;

(d) Partition wall between two compartments : to be designed as one compartment empty and other full;

(e) Structures shall be designed for uplift in empty conditions with the water table as per geotechnical investigation carried out by contractor.

(f) Underground or partially underground structures shall also be checked against stresses developed due to any combination of full and empty compartments with appropriate ground/uplift pressures from below to base slab. A minimum factor of safety of 1.2 shall be ensured against uplift or floatation.

(g) All the liquid retaining structures shall be designed for maximum design crack widths of 0.2mm for direct tension and flexure.

(h) All the structures wherever applicable shall be checked for overturning. Minimum factor of safety of 1.4 against overturning shall be considered. Overturning shall be checked for empty condition

(i) All the structures wherever applicable shall be checked for sliding. Minimum factor of safety of 1.4 against sliding shall be considered. Sliding shall be checked for empty condition.

1.7 Structural Analysis

General: The structural analysis shall be carried out as three dimensional space frames with finite elements using commercially available software STAAD Pro/Etabs Mathematical Modelling of Structure: All structures shall be modelled analysed and using STAAD.Pro. Tank Structures shall be modelled analysed and designed using Finite Element Method. Pump house, buildings shall be modelled, analyse and design as frame structures.

Analytical Result: Bending moments, Axial forces, Shear forces, Support reactions, Support displacements, Base pressures etc shall be considered while extracting force envelope.

1.8 Foundations

(j) The minimum depth of foundations for all structures, equipments, buildings and frame foundations and load bearing walls shall be as per IS 1904.

(k) Maximum safe bearing capacity of soil strata shall be taken as indicated in geotechnical reports.

(l) Care shall be taken to avoid the fouling with the foundations of adjacent buildings or structure foundations, either existing or not within the scope of this Contract. Suitable adjustments in depth, location and sizes shall have to be made depending on site conditions. No extra claims for such adjustments shall be accepted by the Employer.

(m) Special attention is drawn to danger of uplift being caused by the ground water table. All underground structural slabs shall be designed for uplift forces due to ground water pressure.

1.9 Design Requirements

The following are the design requirements for all reinforced or plain concrete structures:

All blinding and levelling concrete shall be a minimum 100 mm thick in concrete grade M15.

a) All liquid retaining reinforced concrete structures, concrete shall be of a minimum M30 grade with a maximum 40 mm aggregate size for footings and base slabs and with a maximum 20 mm aggregate size for all other structural member. All other structures, reinforced concrete shall be of a minimum M25 grade with a maximum 40 mm aggregate size for footings and base slabs and with a maximum 20 mm aggregate size for all other structural member.

b) The reinforced concrete for all structures shall have a minimum cement content of 375 kg/m^3 with a maximum 20 mm size aggregate and 350 kg/m^3 with a maximum 40 mm size aggregate**(with Sulphate Resisting Portland Cement (SRPC) / Slag Cement)**. Reinforced concrete shall have maximum slump of 100mm with maximum water cement ratio of 0.48.

c) As a design consideration to control crack, though general requirements of IS 3370 shall be followed, All liquid retaining structures shall be designed based on the serviceability crack width limit state (i.e. 0.2 mm crack width) and other limits including the ultimate limit states.

d) The minimum cover to the main reinforcing bars for different members for non–liquid retaining structures shall be as follows unless stated otherwise:

Slab (Floor, Roof, Canopy, and Staircase)	30 mm
Beams (Sides, Bottom & Top)	40 mm
Columns	50 mm
Pedestals (in contact with earth)	50 mm
Basement wall, retaining walls	
i) Face in contact with earth	40 mm
ii) Interior face	30 mm
Foundations	50 mm

NOTE: The minimum clear cover to all reinforcement including stirrups and links shall be 50 mm for all liquid retaining structures.

e) In general, reinforcement for buildings and sewage treatment units shall be HYSD-CRS **(Corrosion Resistant Steel)** of Grade Fe 500. All physical and chemical properties of

this Fe 500 grade steel shall conform to IS: 1786-2008. Welded wire fabric shall conform to IS: 1566 as shown or specified on the drawing. The CRS (corrosion resistant steel) index shall be at least 1.35 when tested for Salt Spray test as per "ASTM B 117 – 2009 test procedure for 120 hours when compared with the Fe 500 normal reinforcement bars and with same bar diameter. All test results (including physical and chemical properties and salt spray tests) have to be produced for the respective bar diameter for each consignment of steel delivered at site and at a frequency of every 20 Metric Tons.

f) Reinforcement produced using iron ore as the raw material only shall be accepted. Reinforcement produced from scrap metal shall not be accepted.

g) The amount of reinforcement in each of the two directions at right angles within each surface zone should not be less than 0.35% of the surface zone cross section (As per cl. 2.6.2.3 of BS: 8007-1987). For slabs, minimum of 10 mm dia bars shall be used to avoid any deformation of lesser diameter bars under loads prior to construction.

h) All buildings shall have a minimum 1 meter wide, 100 mm thick plinth protection paving in M15 grade concrete or stone slabs/tiles. All plinth protection shall be supported on well compacted strata.

i) All pipes and ducts laid below the structural plinth and road works shall be surrounded with concrete of grade M15 having minimum 150 mm thick concrete or D/4 (D = outer dia. of pipe) thickness whichever is more.

j) Use of pressure relief valves to reduce uplift pressure due to ground water table shall not be allowed.

k) Detailing of the reinforcement shall be done as per latest IS-13920 considering Earthquake Seismic Zone-V.

l) Sliding layer or slip layer shall be provided between sub base and structural slab (Raft). Polythene sheets of 500 gauge shall be provided as sliding layer as per IS specification.

m) Water tightness testing of water retaining structures shall be done in accordance with IS: 3370, Part I. It is described in **Clause 1.22**. The depth of water for testing shall be up to the soffit of the covering slab.

The following minimum thicknesses shall be used for different reinforced concrete members, irrespective of design thicknesses:

(i)	Walls for liquid retaining structures	:	250 mm
(ii)	Roof slabs for liquid retaining structures (Other than flat slabs)	:	200 mm
(iii)	Bottom slabs for liquid retaining structures	:	250 mm

(iv)	Floor slabs including roof slabs, walkways,		
	Canopy slabs	:	125 mm
(v)	Walls of cables / pipe trenches,		
	Underground pits etc.	:	200 mm
(vi)	Column footings	:	300 mm
(vii)	Parapets, chajja	:	100 mm
(viii)	Precast trench cover	:	75 mm
(ix)	Column Dimensions	:	300 mm

1.10 General Arrangement of Plant

The following general guidelines shall be followed in the preparation of general arrangement of Plant:

- Sufficient room shall be allowed between items of plant and adjacent Plant or fixed structures to permit safe and convenient access for operation and maintenance;
- An area adjacent to all mechanical Plant shall be provided as maintenance lay down area;
- fixed runways, lifting eyes or other means shall be provided to permit the removal of Plant that shall be required to be removed during the course of its normal operational life for maintenance or any other purpose;
- areas where leakage is likely to occur whether in normal use or during maintenance shall be provided with covered drainage channels which shall direct spillage either to a suitable plant drain or to a sump from where it can be pumped to plant drain;

1.11 Orientation

The works shall be laid out within the confines of the Site in order to interface to the existing infrastructure of roadways and inlet and outlet pipe work. Underground services requiring to be relocated in order to accommodate the proposed site layout shall, with the approval of the Engineer, be relocated by the Contractor.

1.12 Buildings and Structures

All the building and structure works shall generally comply with the following Employer's Requirements unless otherwise specified elsewhere:

All building works shall be of reinforced concrete framework.

All internal and external walls shall be in solid cement concrete blocks of concrete grade M15 and shall be provided as per IS: 2185 (Latest Revision) and shall be 200 mm thick or 230 mm thick brick masonry walls.

Toilet partition walls shall be in 100 mm thick solid concrete block or 115 mm thick brick masonry walls.

(a) Finishes to concrete liquid retaining structures shall be :

F1 - External surfaces, buried

F2 - External surfaces exposed and up to 300 mm below ground level

F2 - Internal surfaces

(b) Finishes to other concrete structures shall be :

F1 - Buried

F1 - Exposed, where plastering is specified

F2 - Exposed

4. All internal masonry surfaces finish shall have 12 mm thick plain faced cement plaster in cement mortar (1:4) with neat cement finish on top. Over this, one coat of primer and two coats of plastic emulsion paint of approved quality and shade shall be provided.

5. All external masonry and concrete with rough board finish shall have 20 mm thick sand faced cement plaster in two coats, base coat 12 mm thick in cement mortar 1:4 and finishing coat 8 mm thick in cement mortar 1:4. Waterproofing compound of approved make and quality shall be added to the cement mortar in proportions as specified by the manufacturer.

6. All external surfaces above ground level shall have one coat of primer and two coats of waterproof cement based paint of approved quality and shade. A coat of silicone water repellent paint shall also be applied thereon.

7. Toilet areas, walls and ceilings, shall have one coat of primer and two coats of plastic emulsion paint.

8. Toilet floor slab shall be filled with brick bat coba (broken bricks in lime) and provided with waterproofing as per the specifications of an approved specialist waterproofing company.

9. The finished floor level in toilet areas shall be 25 mm below general finished floor level elsewhere in the building.

10. The flooring in all areas except toilets, staircases, pumping stations, chlorination building, centrifuge building, workshop, D.G.Room shall be in standard tiles of approved make unless otherwise specified, shade and pattern and placed in cement

mortar 1:4 to give overall thickness of 50 mm. Half tile skirting shall also be provided in these areas.

11. The flooring in the pumping stations, chlorination building, sludge dewatering building, maintenance workshop, D.G. Room shall be 60mm thick cement flooring with Metallic concrete hardener topping, under layer of 42mm thick cement concrete 1:2:4 (1 cement : 2 coarse : 4 graded stone aggregate 16mm thick nominal size) and top layer of 18mm thick metallic concrete hardener consisting of mix 1:2 (1 cement : 2 stone aggregate 6mm nominal size) by volume & mixed with metallic hardening compound of approved quality @ 3 kg/m^2. Including cement slurry and rounding off edges.

12. Chlorine and chemical buildings should be acid resistant.

13. The flooring in operator's room, loading/unloading bay, MCC cum Panel room shall be in 25mm thick Kota stone slab of approved shade and pattern and placed over 20 mm thick base of cement mortar 1:4 to give overall thickness of 45 mm. Half tile skirting shall also be provided in these areas.

14. Toilet areas shall have 450 mm x 450 mm x 25 mm thick polished Kota stone tiles placed in cement mortar 1:4 to give an overall thickness of 50 mm. 2100 mm high dado, in 150 mm x 150 mm x 6 mm thick glazed tiles (approved make, shade and pattern) placed in cement mortar 1:3 shall also be provided in these areas.

15. The flooring along with skirting in administration cum laboratory building shall be 20 mm thick mirror polished, machine cut granite slab of approved shade and pattern placed in cement mortar (1:4). 150mm high skirting shall be provided in these areas. Granite stone shall be provided for laboratory platforms fixed over double sandwiched cuddappah support as directed and the edges of granite is to be embedded into the wall.

16. The toilet facilities shall include at least :

    (i) 2 Nos. Water closets with white porcelain Orissa pan minimum 580 mm long with low level flushing cistern of 10 litres capacity.

    (ii) 2 Nos. Urinals of sizes 600 mm x 400 mm x 300 mm flat back type in white porcelain separated by a marble partition of size 680 mm x 300 mm.

    (iii) 2 Nos. wash basins of size 510 mm x 400 mm in white porcelain with inlet, outlet and overflow arrangements.

    (iv) 2 Nos. mirror of size 400 mm x 600 mm wall mounted type fitted over wash basins.

    (v) 2 Nos. plastic liquid soap bottles

    (vi) 2 Nos. chromium plated brass towel rails minimum 750 mm long.

(vii) All stopcocks, valves and pillar cocks shall be heavy duty chromium plated brass.

(viii) All fittings such as `P' or `S' traps, floor traps, pipes, down take pipes etc.

(ix) The sewage from toilet blocks shall be led to the wet well of terminal sewage pumping station if present or included under this contract or to the closest gravity sewer.

17. All staircases shall have 25 mm thick chequered mosaic tiles for treads and 25 mm thick plain mosaic tiles for risers of approved make and shade and half tile skirting set in cement mortar in 1:4 to give an overall thickness of 50 mm.

All concrete stairs shall have aluminium nosing over 2 mm thick rubber strip of width same as nosing for the full length of the tread. Nosing shall be fixed with countersunk screws.

18. Stairways shall be provided to permit access between different levels within buildings. Staircase shall be minimum 1000mm wide unless specified otherwise. Staircases in general shall not be steeper than 40°. Staircases having space constraints shall be steeper than 40^0. The maximum vertical run for a single flight of stairs shall be 3.0 M.

19. All roof tops and overhead tanks shall be made accessible with ladder provision. Vertical step ladders fitted with landing point extensions shall be permitted where considered appropriate by the Engineer to access areas not frequently visited.

Steel staircases shall be constructed of standard channel stringers with M.S. grating treads 25mm thick with non skid nosing. Steel Ladders shall be minimum 600mm wide and shall not exceed 6m of straight run. The ladders shall be painted with epoxy paint.

20. All hand railing (3-rail) shall be provided with 6063-T6 Aluminium Alloy with an ultimate tensile strength of at least 207 MPa and yield strength of at least 172 MPa. The minimum height of hand railing shall be 1m and maximum spacing of verticals shall be 1.5 m.

21. The reinforced concrete roofs shall be made waterproof by application of an approved roof polythene / bitumen membrane / brick bat coba. The finished roof surface shall have adequate slope to drain quickly the rain water to R.W down take inlet points.

22. All roof floors shall have minimum 750 mm height solid concrete block parapet wall where accessible is provided and shall have minimum 300 mm height solid concrete block parapet wall where accessible is not provided.

23. For roofing drainage, cast iron or uPVC rainwater down takes with C.I. bell mouth or uPVC bend and C.I. or uPVC grating at top shall be provided. For roof areas up to 40 sq m minimum two nos. 100 mm diameter down take pipes shall be provided. For

every additional area of 40 sq m or part thereof, at least one no. 100 mm dia. down take pipe shall be provided.

24. Top surfaces of chajjas and canopies shall be made waterproof by providing a screed layer of adequate slope or application of an approved roof membrane and sloped to drain the rain water.

25. Building plinth shall be minimum 600 mm above finished ground level around building.

26. All doors, windows, rolling shutters shall have lintels above. Chajja protection to lintels on external walls shall be such as to prevent the rain water splashing into the building. Chajja projection of minimum 750 mm for rolling shutters, 600 mm for doors and 450 mm for windows shall be provided to prevent the rain water splashing into the building. Chajja shall be projected 150 mm on either sides from size of doors/windows/rolling shutters.

27. All windows and ventilators shall have 25 mm thick Kota stone sills bedded in cement mortar (1:3).

28. All doors and windows shall be painted with two coats of synthetic enamel paint over a priming coat (ready mixed Zinc Chromate Yellow primer of approved brand and manufacturer confirming to I.S.: 127-106, 341 and 340).

29. All doors, windows and ventilators shall be made of aluminium confirming to latest version of IS: 1948. All fixtures for doors, windows and ventilators shall also be of aluminium. Aluminium grills shall be provided in all the windows. Doors shall be in two panel and both panels shall be glazed/unglazed. Minimum weight of aluminium doors & windows shall be as follows

I. Single Glazed Window : (Weights indicated shall be aluminium)

a) Openable

Outer Frame	:	Weight 0.70 kg/Rmt
Shutter Frame	:	Weight 0.97 kg/Rmt
Intermediate Mullion	:	Weight 0.97 kg/RMt
Beading	:	Weight 0.31 kg/Rmt

Fixing Louvers windows/ventilators

Outer Frame	:	Weight 0.46 kg/Rmt

II. Double Glazed Window

Outer Frame	:	Weight 0.72 kg/Rmt
Shutter Frame	:	Weight 0.97 kg/Rmt
Intermediate Mullion	:	Weight 0.98 kg/Rmt

Beading : Weight 0.31 kg/Rmt

III. Sliding Windows

Bottom & Top Frame : Weight 0.70 kg/m

Shutter Frame : Weight 0.42 kg/m

Interlocking Section : Weight 0.47 kg/m

IV. Aluminium Door

Outer Frame : Weight 2.508 kg/Rmt

Shutter Frame : Weight 2.508 kg/Rmt

Bottom Stile : Weight 2.508 kg/Rmt

Glazing shall be 5.5 mm thick glass.

30. Openings of the windows & ventilators shall be minimum 25% of the external wall area.

31. Ventilator shall be provided where height of floor is more than 3m.

32. All windows and ventilators shall have wire mesh. Frame of doors, windows and ventilators shall be of aluminium of standard rolled section. Doors, Windows and Ventilators shall be of size as per schedule to be submitted by the Contractor for approval of Engineer. The minimum size shall be as per below:

Door of opening size 1.2m x 2.1m

Door of opening size 0.75m x 2.1m for toilets

Glazed windows of minimum size 1.2m x 1.2m

Ventilators of minimum size 0.6m x 0.6m

33. Rolling shutters shall be made of 80 x 1.25 mm MS laths. Rolling shutter shall be of minimum size 3m wide x 3.0m high. Rolling shutter shall be provided in MCC cum panel room, chlorine tonner shed, at entry and exit of the pump house for access to pumps, motors, valves, panels and as wherever required.

34. All concrete channels and ducts used for conveying liquid shall have inside finish of type F2. The width of concrete channels shall not be less than 500 mm. All open channels shall be provided with Aluminium hand railings (3-rail) or concrete walls to a minimum height of 1 m from the access surface elevation. All concrete surfaces of structures conveying raw sewage or primary effluent upstream of the aeration tanks shall be protected from corrosion with an approved internal epoxy lining.

35. Kerbs to be provided below the hand railing on the catwalks/pathways should be as per relevant sections of Factory Act. It shall not be less than 150mm.

36. All exposed surfaces of inserts embedded in concrete shall be painted with two coats of enamel paint over one coat of red oxide zinc chrome primer. Surfaces in contact with concrete shall not be painted.

37. All structural steel members shall be painted with two coats of enamel paint over one shop and one field coat of red oxide zinc chrome primer.

38. All rooms in the treatment plant buildings shall be provided with appropriate sign boards indicating the function of the rooms involved written in Assameese and English Languages.

39. The design of buildings shall reflect the climatic conditions existing on site. Process buildings shall as far as possible permit the entry of natural light , and the use of glazed panelling shall be kept to a minimum and preference given to wall openings protected by weather canopies.

40. Emergency exit doorways shall be provided from all buildings in order to comply with local fire safety regulations .Stairways and paved areas shall be provided at the exit points.

41. Toilet blocks in process buildings and control blocks shall be provided with a sink with two drinking water taps of 20 mm size with adequate inlet and outlet connections.

42. All the walkways shall have minimum 1 m width and shall be covered with mosaic tiles. Walkways to be provided with 6063-T6 Aluminium Alloy hand railings.

43. Anaerobic Sludge Digesters and Sludge Tank shall be built in RCC.

44. All water retaining structures shall be provided with full Polyurethane Corrosion protection lining for all walls and floors

45. For structures containing water or process liquid, the top of the wall shall be at least 0.5m higher than the maximum water surface level calculated at peak plant flow.

1.13 Roadways, Pathways & Hard standings

A comprehensive network of roadways shall be provided around the treatment plant to link in with the existing road network and permit access to the plant for necessary maintenance, delivery of consumables and personnel access. All roads shall be of asphalt macadam/concrete and internal roads minimum 4.50 metres wide. Approach road and main road shall be minimum 6.0m wide. Vehicular access shall be provided for all Plant structures and buildings. All roads shall be provided with drainage and shall be constructed to prevent standing water.

Paved pedestrian access ways shall be constructed to provide a network of logical routes interlinking plant areas. Damage to any existing roads on account of their use by the Contractor shall be made good to the satisfaction of the Engineer.

Hard standing areas with shading facility shall be provided to permit the parking of vehicles involved in the delivery of consumables from blocking site roadways during unloading or loading. The road system shall be designed such that vehicles involved in the delivery of consumables can follow a continuous route through the works and out again.

1.14 Site Drainage

The Contractor shall provide a site drainage system. The system shall comprise of the following:

- Storm Water Drainage
- Foul Drainage

1.15 BRIDGES

1.15.1 DESIGN CODES AND STANDARDS

Design of all proposed structures is in accordance with the provisions of the following IRC Codes:

IRC: 5-1998 - Section I- General Features of Design (Seventh Revision)

IRC: 6-2014 - Section II- Loads and Stresses (Revised Edition)

IRC: 112-2011 - Code of Practice for Concrete Road Bridges

IRC: 22-2008 - Section IV- Composite construction for Road Bridges

(Second Revision)

IRC: 24-2001 - Section V- Steel Road Bridges (Second Revision)

IRC: 78-2014 - Section VII- Foundations and Substructure (Revised Edition)

IRC:83 (Part I)-1999- Section IX (Part I), Metallic Bearings

IRC:83 (Part II)-1999- Section IX (Part II), Elastomeric Bearings

IRC:83 (Part III)-2002 - Section IX (Part III), POT, POT cum PTFE, PIN and Metallic Guide Bearings

IRC: 87-1984 - Guidelines for the Design and Erection of False work for Road Bridges

IRC: 89-1997 - Guidelines for Design and Construction of River Training and Control Works for Road Bridges (First Revision)

IRC:SP:64-2005 Guidelines for the Analysis and Design of Cast-in-Place Voided Slab Superstructure

IRC:SP:66-2005 Guidelines for Design of Continuous Bridges

IRC:SP:69-2005 Guidelines & Specifications for Expansion Joints

IRC:SP:70-2005 Guidelines for the Use of High Performance Concrete in Bridges

MORTH Specifications for Road and Bridges Works, 2013 (Fifth Revision)

Whenever IRC codes are silent, relevant BIS codes shall be followed. In case where even BIS

codes are silent, other suitable international codes of practices like BS: 5400, AASHTO and

EURO codes shall be adopted.

The design criteria / method applied for important components of the project are as follows:

Structure Design: IRC Bridge Standards and MORTH Manual & circulars on Structures

Geometric Design: IRC Standards and MORTH Manual & circulars on National Highways.

Pavement Design: New Pavement - IRC 37 and AASHTO Design guide for design of flexible pavement - IRC 58 for Design of Rigid Pavement

Road Furniture & Road side Facilities: Related standards of IRC & MORTH publications

1.15.2 DESIGN STANDARDS FOR BRIDGES

Material:

Cement

For construction of structures 43 grade Portland Pozzolana Cement conforming to IS:8112 and 53 grade ordinary Portland cement conforming to IS: 12269 shall be used.

Admixtures

To improve workability of concrete, admixtures conforming to IS: 9103 shall be used.

Aggregates

Aggregates shall consists of clean, hard, strong, dense, non-porous and durable crushed stone for coarse aggregates and natural particles for sand. The aggregates shall conform to IS: 383 and shall be tested to conform to IS: 2386 parts I to VIII. Size of coarse aggregate shall be selected as per mix design requirement.

Water

Water used for mixing and curing shall be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that shall be deleterious to concrete or steel. The pH value of water shall not be less than 6.

Concrete

The grade of concrete shall be as per design requirement and mentioned in execution drawings for each component of the structure. Cement and water content shall be as per mix design requirement.

Reinforcement

Deformed or Corrosion Resistant Steel (CRS) bar conforming to IS: 1786 shall be used for components of the structures. The reinforcement grade shall be Fe500.

1.16.3 Design Methodology

I. Pile Foundation

In general, the design of pile and pile cap shall conform to provisions of IRC:78. The various specific assumptions to be made for the design of pile and pile cap shall be as follows:

(a) The vertical load carrying capacity of the pile shall be determined based on static formula given in Appendix-5 of IRC:78-2014. The following limiting values shall be considered for computation of safe load:

 Results of sub-soil investigation shall be used for adopting the value of angle of internal friction “Ø” and cohesion “C” of the soil.

 Angle of wall friction ‘Ø’ to be taken as equal to Angle of internal friction ‘Ø’.

 The coefficient of earth pressure, ‘K’ shall be taken as 1.5 while calculating the safe load carrying capacity.

 The entire overburden shall be assumed fully submerged for the purpose of calculation of safe load.

 Maximum overburden pressure at the bottom of pile for the purpose of calculation of shaft friction and end bearing shall be limited to 20 times the diameter of the pile.

 Factor of safety shall be taken as 2.5

(b) The vertical load carrying capacity as calculated by static formula shall be verified by conducting initial load tests on piles conforming to IS:2911 (Part 4).

(c) The lateral load carrying capacity of the pile shall be determined by using empirical formula given in IS:2911 (Part-1/Sec-2) by limiting the lateral deflection of 5mm at its tip considering it as fixed headed pile under normal conditions. The capacity so evaluated shall be used purely for the purpose of arriving at the upper bound of lateral load capacity. This deflection limitation shall not be applicable in load combination with seismic conditions for which the resulting stresses and the structural capacity of the section would be the governing criteria.

(d) Soil stiffness for lateral loads shall be taken from IS:2911 (Part-1/Sec-2), Appendix – C.

Unconfined compressive strength shall be calculated from the results of Geotechnical Investigation Reports. Cohesion as calculated using unconsolidated un-drained test with required modification of angle of internal friction shall be used for working out unconfined compressive strength.

II. Pile Cap

 The minimum thickness of pile cap shall be kept as 1.5 times the pile diameter.

 Top of the pile shall project 50mm into the pile cap.

 The top of pile cap shall be kept at least 300mm below the ground level in case of urban interchange structures or road over bridges. For bridges on rivers / streams / canals, the bottom of pile cap shall be kept at LWL.

 Pile cap shall be designed either by truss analogy or by bending theory, depending upon the spacing and number of piles in a pile group. Truss analogy shall be used for pile caps with a maximum of 5 piles in a pile group. Beyond 5 piles, bending theory shall be used.

 Pile cap shall be provided with an offset of at least 150mm beyond the outer face of the outer piles.

III. Piers & Pier Caps

 The piers are to be designed for combined axial load and biaxial bending as per the provisions of IRC:112.

 Pier cap is checked as either as a flexural member or as a bracket, depending upon the span / depth ratio.

 In case it is a flexural member, the bending moments are checked at the face of pier support. Shear force shall be checked at a distance deff away from the face of support.

 In case the pier cap acts as a bracket, the design shall conform to provisions of IS:456 in absence of any specific provision in IRC code for bracket design.

 Analysis, design and detailing shall in general conform to the stipulations of relevant IRC codes and good engineering practice.

IV. Superstructure

Design of RCC T Beam and Slab (Precast Girder and in-situ slab)

 The design of such type of structure economical for smaller spans only.

 The design therefore shall be done with only the girder section being effective upto the stage of casting of deck slab and diaphragm and composite section shall be considered for all subsequent loads (i,e for SIDL and live loads).

 The deck structure shall be analyzed using grillage analogy method for SIDL and Live Loads. Self weight of girder and Dead Load of slab shall be applicable on girder section alone and hence the design forces for DL and SW shall be calculated separately and results superimposed. The superstructure shall be idealised into a criss cross set of discrete members which are able to resist the loads applied in a plane perpendicular to the plane of assemblage, through bending shear and torsional rigidities of the members.

 The minimum dimension of various elements shall be provided conforming to the latest IRC codes and standards. The minimum deck slab thickness shall be kept as not less than 200mm.

 For obtaining maximum shear stress, the section at a distance equal to effective depth from the face of the support shall be checked and the shear reinforcement calculated at the section shall be continued up to the support.

 The design of deck slab supported transversely on the precast girder shall be carried out assuming un-yielding support at the girder points.

 Effect of differential shrinkage and creep between precast girder and in-situ slab shall be considered.

1.15.4 Seismic Design & Detailing

I. Seismic Analysis & Design

The project corridor falls under seismic zone – v, which is a high seismic zone. In general, Seismic analysis of the bridge structure is proposed to be carried out in 2 steps.

Step-1: To carry out single mode analysis to obtain the fundamental vibration period of the bridge in two orthogonal directions (i.e. longitudinal & transverse direction).

Step-2: To estimate seismic forces using the spectrum response, defined in IRC:6.

The calculation for fundamental period can be done either by using the simplified expression given in Appendix – D of IRC:6-2014 or else by modeling the structure in STAAD/Pro and carrying out dynamic analysis.

Vertical seismic coefficient shall be taken as “2/3rd ” of the horizontal seismic coefficient.

The vertical seismic shall be combined with the horizontal seismic in any one direction.

The seismic combination to be considered are as follows:

 ± SX ± SY

 ± SZ ± SY

Where SX & SZ are seismic forces in 'longitudinal' & 'transverse' direction respectively while SY is the seismic force in vertical direction.

II. Seismic Detailing

Superstructure

 The superstructure shall be designed for the design seismic forces for the load combinations as specified in IRC:6

 Under simultaneous action of horizontal and vertical accelerations, the superstructure shall have a factor of safety of at least 1.5 against overturning. In this calculation, the forces to be considered on the superstructure shall be the maximum elastic forces generated in the superstructure.

1.15.5 Bearings

Type of bearings to be adopted depends upon the length of the span, loads, forces, movement and seismic zone in which the project road falls. Since the proposed bridges fall in high seismic hazardous zone, Elastomeric type bearings with longitudinal and transverse seismic arrestors are proposed.

Elastomeric bearings if used for transferring in plane horizontal forces shall be checked using minimum frictional value and minimum vertical load, including combined effects of horizontal and vertical component of earthquake. Anchored elastomeric bearings shall be used in case it is not possible to satisfy the above criteria.

Elastomeric bearing can accommodate translation movements in any direction and rotational movements in any axis by elastic deformation. They should not be used in tension or when rotation is high and vertical load small. The basis of design is that the elastomer is an elastic material, the deflection of which under a compressive load is influenced by its shape (shape factor). Reinforcing plates should be bonded to the elastomer to prevent any relative movement at the steel/elastomer interface. The dimension and the number of internal layers of elastomer chosen shall satisfy the following clauses of IRC: 83(Part-II).

Design Criterion	**Clause no of IRC: 83 (Part-II)**
Dimensional	916.3.3
Translational	916.3.4
Rotational	916.3.5
Frictional	916.3.6

IRC: 83 (Part-II) recommends that chloroprene (CR) only shall be used in the manufacture of bearing. The elastomer shall conform to all the properties specified in table 1 of IRC: 83 (Part- I), and tolerances in dimensions specified in table2 of IRC: 83 (Part-II).

1.15.6 Substructure & Foundation

 The scour to be considered for design shall be based on mean design flood. In the absence of detailed data the scour to be considered for design shall be 0.9 times the maximum design scour depth. The designer is cautioned that the maximum seismic scour case shall not always be governing design condition in case of deep foundations as the time period of the structure greatly reduces with the reduction in the free standing length of piles.

 In loose sands or poorly graded sands with little or no fines, vibrations due to earthquake shall cause liquefaction or excessive total and differential settlements. For the bridges of this project, which is in seismic zone V, liquefaction potential shall be assessed. If found necessary, remedial measures shall be undertaken to mitigate liquefaction potential.

 Minimum grade of concrete should be M25 (fck = 25 MPa).

Steel reinforcement of grade Fe 500, having elongation more than 14.5 percent and conforming to other requirements of IS 1786 : 1985 shall be used for the reinforcement.

1.15.7 LOADING

Superimposed dead load (SIDL)

Loads corresponding to the dimensions given for bridge details shall be considered as SIDL for design of structure.

Differential Settlement

If the riding quality permits, clause 706.3.2.1 of IRC:78 specify that the calculated differential settlement between the foundations of simply supported span shall not exceed l in 400 of the distance between the foundations, where l is distance between two foundations. In case of structure sensitive to differential settlement such as continuous structures the value of differential settlement shall be taken as 10 mm.

Temperature Gradient

Effective bridge temperature shall be taken from the isothermal of shade air temperature given in fig 8 and fig 9 of IRC: 6. Difference in temperature between the top surface and other levels through the depth of the structure, where ever applicable shall be taken in accordance with clause :218.3 of IRC:6.

Other Loads

The loads which are not mentioned in this Clause, shall be as per IRC:6.

Cover

Minimum clear cover to any reinforcement bar closest to concrete surface for different component shall be as follows.

Component	Minimum Cover in mm
Superstructure	40
Substructure	40
Foundation	75

Minimum Diameter of Bar

Diameter if any reinforcing bar including transverse ties, stirrups etc. shall not be less than 10 mm. Diameter of any longitudinal reinforcement bars in columns/ vertical member shall not be 12 mm. However diameter of the reinforcing bars shall not exceed 25 mm in slabs and 32 mm in other member.

Concrete grades

The grades of concrete for different bridge components are as follows.

Retaining Wall - M30

Abutment Cap, Bearing Pedestals – M35

Deck Slab – M30

Pile and Pile cap - M35

Substructure - M35

Super structure of RCC Bridges – M35

Abutment, Dirt Wall – M 30

Reinforcement

Corrosion Resistant Steel (CRS) conforming to IS: 1786 shall be used for reinforcement of super-structure, sub-structure and foundations. The minimum lap length of reinforcement bars shall be kept as 63 times the diameter of bar and not more than 50% of the bars shall be lapped at one location.

Drainage spouts

Drainage spouts shall be provided in accordance with MORTH standard. The minimum spacing shall be kept preferably as 5.0m c/c which shall be adjusted to suit span length. The drainage spouts at nala/canal Bridge are proposed with free down fall.

MAJOR STRUCTURAL COMPONENTS

1. GIRDER BRIDGE ACROSS BORSOLA BEEL FOR WALKWAY

Foundation

In view of the depth at which Soft / hard strata is available it is not possible to provide open foundations. Deep foundations either well type or pile type is required to be provided. Considering the location of the bridge and loading suitable foundation to be designed.

Substructure

The substructure consists of RCC solid piers supporting deck slab of carriage way (walkway) of 5m at top and sufficient width at bottom to transmit the forces to pile foundation. The abutment is also proposed in RCC. Elastomeric bearings shall be provided between cast in situ girder and pier cap.

Superstructure

Considering in view the methodology of construction of superstructures which involves pre casting of RCC girders and hoisting the same into position to seat on Elastomeric bearings span suitable arrangements to be given. The entire bridge consists of 3 Nos of precast girders at regular spacings. The girders are connected by total 13 Nos of cross girders. Deck slab and walkway shall be in cast-in-situ construction. Finishing works like wearing coat and railings shall be cast-in-situ.

2. DIVERSION WEIR

No.	Component	Remarks
1	Type of overflow section	Gated weir with ogee profile
2	Type of energy dissipation	Hydraulic jump with cistern floor
3	Spillway capacity (cumecs)	44.50
4	Type of non-overflow section	Concrete gravity type
5	Provision of Gates	2 gates

Type of the structure

The structure proposed shall be an gated flow weir. Two number of gates shall be provided at a suitable location in the length of the weir, to allow for release of water to downstream as well as to clear the silt accumulation to the extent feasible. The structure shall be therefore designed as a weir on suitable foundation with a body wall, cistern floor for energy dissipation and cutoffs to safeguard against exit gradient failures.

Weir Details

The Weir shall be designed for a Maximum discharge of 44.50 Cumecs. The HFL works to be 50.25. The length of Weir proposed shall be 25m. Ogee Spillway shall be proposed to minimize afflux. Hydraulic jump calculation shall be done and Floor level works out to 47.00.

However with a small depression of 0.3m and level fixed shall be fixed at 47.00m. Jump length works out to 5.0m.

Body wall shall be designed assuming the section rests on concrete floor. No joint shall be proposed. The design shall be done treating as weir on permissible foundation as it rests on Soft Rock. Stability Analysis of Body Wall shall be done for corresponding uplift pressure.

Crest thickness of 0.60m shall be provided and Scour level works out to 46.00. But the stratum met with at this level is loose soil.Ground Improvement shall be done here and Pile Foundation shall be proposed for foundation.

Gravity section shall be proposed for upstream weir section and downstream training walls.

3. ARCH BRIDGE

Foundation

In view of the depth at which soft / hard strata is available it is not possible to provide open foundations. Deep foundations either well type or pile type is required to be provided. Considering the location of the bridge and loading RCC bored cast-in-situ piles shall be proposed.. Two pier support and abutments are provided at the both the ends.

Substructure

The substructure consists of RCC solid piers supporting deck slab of carriage way / walkway of 3m at top and sufficient width at bottom to transmit the forces to pile foundation. The abutment is also proposed in RCC.

Superstructure

Deck slab shall be designed for Pedestrian Loadings.

Design Parameters:

Materials:

For Pile and Pile Cap:

a) Grade of concrete M = 30
b) Grade of steel = Fe 500

For Pier:

a) Grade of concrete M = 30
b) Grade of steel = Fe 500

Clear Cover:

i. Pile: 75mm
ii. Pile Cap: 75mm
iii. Pier: 40mm

For Girder and Deck Slab:

a) Grade of Concrete M=30 (For Deck Slab)

b) Grade of steel = Fe 500

Clear Cover:

i. Deck Slab: 25mm

4. RETAINING WALL:

Retaining walls are relatively rigid walls used for supporting the soil mass laterally so that the soil can be retained at different levels on the two sides. Retaining walls are structures designed to restrain soil to a slope that it would not naturally keep to (typically a steep, near-vertical or vertical slope).

Cantilever retaining walls are made of reinforced concrete that consists of a thin stem and a base slab. Retaining wall is proposed all along the Beel for a length of 2600m. Height of retaining Wall is varying from 6m to 4.0m.. A cantilever portion is provided for pedestrian walking / Jogging Track. Foundation is proposed is Pile Foundation. Cantilever portion is kept above the Maximum Water Level.

Materials:

a) Grade of concrete M = 30

b) Grade of steel = Fe 500

Construction Joints and Keys:

Concrete shall be placed without interruption until completion of the part of the work between predetermined construction joints, as specified therein after. Time lapse between the pouring of adjoining units shall be as specified in the drawing or as directed by Engineer-in- charge. If stopping of concreting becomes unavoidable anywhere, a properly formed construction joint shall be made where the work is stopped. Joints shall be either vertical or horizontal, unless shown otherwise in drawings. In case of an inclined or curved member, the joints shall be at right angles to the axis of the member.

Vertical joints in walls shall be kept to a minimum. Vertical joints shall be formed against a stop board, horizontal joints shall be level and wherever possible, arranged, so that the joint lines coincide with the architectural features of the finished work. Battens shall be nailed to the form to ensure a horizontal line ad if directed, shall also be used to form a grooved joint. For tank walls, similar work joints shall be formed as per IS 3370. Concrete that is in the process of setting shall not be disturbed or shaken by traffic either on the concrete itself or upon the shuttering, horizontal and vertical construction joints and shear keys shall be located ad shall conform in detail to the requirements of the plans unless otherwise directed by Engineer-in-charge.

Vertical construction joints in watertight construction shall not be permitted unless indicated on the drawings. Where a horizontal construction joint is required to resist water pressure, special care shall be taken in all phases of its construction to ensure maximum water tightness.

Concreting shall be carried out continuously upto construction joints. The position and arrangement of construction joints shall be as shown in the structural drawings or as directed by the Engineer-in Charge. Number of such joints shall be kept minimum. Joints shall be kept as straight as possible. Construction joints should comply with IS 11817.

When the work has to be resumed on a surface which has hardened, such surface shall be roughened. It shall then be swept clean and thoroughly wetted. For vertical joints, neat cement slurry, of workable consistency by using 2 kgs of cement per sqm shall be applied on the surface before it is dry. For horizontal joints, the surface shall be covered with a layer of mortar about 10-15 mm thick composed of cement and sand in the same ratio as the cement and sand in concrete mix. This layer of cement slurry of mortar shall be freshly mixed and applied immediately before placing of the concrete.

Where the concrete has not fully hardened, all laitance shall be removed by scrubbing the wet surface with wire or bristle brushes, care being taken to avoid dislodgement of particles of coarse aggregate. The surface shall be thoroughly wetted and all free water removed. The surface shall then be coated with neat cement slurry @ 2 kgs of cement per sqm. On this surface, a layer of concrete not exceeding 150 mm in thickness shall first be placed and shall be well rammed against old work particular attention being paid to corners and close spots; work, thereafter, shall proceed in the normal way.

WATER STOPPER

Water bars are performed strips of impermeable material which are to be embedded in the concrete during construction so as to span across the joint and provide a permanent watertight seal during the whole range of joint movement. The most useful forms of water bars are strip with a central longitudinal corrugation and a central longitudinal hollow tube with thin walls with stiff wings. The material used for the water bar are synthetic rubbers and plastics have very considerable advantage in handling, splicing and in making intersections.

With all water bars, it is important to ensure proper compaction of the concrete. The bar should have such shape and width that the water path through the concrete round the bar should not be unduly short. The water bar should either be placed centrally in the thickness of the wall or its distances from either side of the wall should not be less than half the width of the bar. The full concrete cover to all reinforcement should be maintained.

Joint sealing compound: Joint sealing compounds are impermeable ductile materials which are required to provide a watertight seal by adhesion to the concrete throughout the range of joint movement. The commonly used materials are based on asphalt, bitumen, or coal tar pitch with or without filters, such as lime stone or slate dust, asbestos fibre, chopped hemp, rubber or other suitable material. These are usually supplied after construction or just before the reservoir/delivery chamber are put into service by pouring in the hot or cold state. These shall also be applied during construction such as by packing round the corrugation of water bar. For detailed specification refer IS 3370 (Part-I) – 1965.

Measurement and Payment:

Measurement and Payment as per payment schedule.

MISCELLANEOUS GENERAL REQUIREMENTS

- Dense concrete with controlled water cement ratio preferable 0.45 shall be used for all underground concrete structures such as pump house. Tanks water retaining structure, cable and pipe trenches etc. For achieving water tightness.
- All joints including construction and expansion joints for the water retaining structures shall be made watertight by using PVC ribbed water stops with general bulb. However kicker type (externally placed) PVC water stops shall be used for the base slab and in other areas where it is required to facilitate concreting. The minimum thickness of PVC water stops shall be 5mm and minimum width shall be 230mm.
- All mild steel parts used in the water retaining structures shall be hot-dip galvanized, the minimum coating of the zinc shall be hot-dip galvanize. The minimum coating of the zinc shall be 750 gm/sq. for galvanized structures and shall comply with IS: 2629 and IS:2633 . Galvanizing shall be checked and tested in accordance with IS:2629. The galvanizing shall be followed by the application of an etching printer and dipping in black bitumen in accordance with BS:3416.
- A screed concrete layer not less than 100mm thick and of grade not weaker than M10 conforming to IS:456-1978 shall be provided below all water retaining structures. A sliding layer of bitumen paper or craft paper shall be provided over the screed layer to destroy the bond between the screed and the base slab concrete of the water retaining structures.
- Bricks having minimum 75 kg/cm2 compressive strength can only be used for masonry work. Bidder shall ascertain himself at site regarding the availability of bricks of minimum 75 kg/cm2 compressive strength before submitting his affer.
- Monorails, monorail girders and fixtures shall be provided where ever required.
- Doors and windows on external walls of the buildings (other than areas provided with insulated metal claddings) shall be provided with RCC sun-shade over the openings with 300mm projection on either side of the openings. Projection of sunshade from the wall shall be minimum 450mm over window openings and 750mm over door openings.
- Stairs shall have maximum riser height of 150mm and minimum tread width of 300mm . Minimum width of the stairs shall be 1500mm.
- Angles 50x50x6 mm (minimum) with lugs shall be provided for edge protection all around cut outs/openings in floor slab. Edges of drains supporting grating covers. Edges of RCC cable/ pipe trenches supporting covers, edges of manholes supporting covers, supporting edges of precise cover and any other place where breakage of corners of concrete is expected.

- Anti termite chemical treatment shall be given to column pits, wall trenches, foundations of buildings, filling below the floors etc, as per IS :6313 and other relevant Indian standard.

- Hand-railing minimum 900mm high shall be provided around all floor/roof openings projections/balconies, walk-ways, platforms, steel stairs etc. All handrails and ladder pipes shall be 32mm nominal bore MS pipes (medium class) and shall be galvanized(medium class as per IS:277). All rungs for ladder shall also be galvanized as per IS:277 medium class.

8 For RCC stairs: Hard railing with 20mm square MS bars. Balustrades with suitable MS flats and aluminium handrails shall be provided.

1.15.7 Storm Water Drainage

Storm water drains adjacent to the existing and proposed roads (under this Contract) shall be sized for a rainfall intensity of 50 mm/hr, allowing for 100% runoff. Drains adjacent to roads shall be in stone masonry in CM (1:4) of appropriate thickness, topped with 75 mm thick M10 concrete and internally flush pointed in cement mortar (1:4), 20 mm thick. The minimum width of drain shall be 450mm.

The storm water drainage system shall also be designed to cater the run-off from the existing plot areas and structures, if necessary depending upon the site topography.

1.15.8 Foul Drainage

The foul drainage system shall accept discharge from toilets, washrooms, offices and the laboratory. The foul drainage system shall be conveyed to either wet-well of the terminal sewage pumping station wherever exist or proposed under this contract or nearest public sewer wherever exist.

1.15.9 Cable and Pipe work Trenches

Cable and pipe-work trenches shall generally be constructed in reinforced concrete. However, 500 mm x 500 mm size or smaller trenches, not on fill shall be constructed in 200 mm thick solid cement concrete blocks over 150mm thick M 15 PCC base. The trenches shall be 20mm thick plastered internally with cement mortar (1:4) and externally in cement mortar (1:3).

All floor cut-outs and cable ducts, etc. shall be covered with M20 precast concrete covers (Heavy Duty) or MS grating as per direction of Engineer in outdoor areas and M.S. chequered plates, suitably painted of adequate thickness in indoor areas. All uncovered openings shall be protected with hand railing. The pipe, cable trenches shall be suitably sloped to drain off rainwater to a suitable location.

Layout of trenches outside the buildings shall allow space for construction of future trenches where necessary with due consideration for planning for future developments. This aspect shall be brought to the notice of the Engineer while planning the works.

1.15.10 Pipes and Ducts

R.C.C ducts for drainage shall have minimum 1 metre pre-cast cover (M20 concrete, Heavy duty) while laid under roads. Access shafts of size not less than 600 mm x 1000 mm shall be provided.

All drains (except storm water drains adjacent to roads) shall be covered and designed structurally for appropriate loads.

1.15.11 Main Gate

Each proposed treatment plant shall have one main gate to access the plant irrespective of existing gate at the premises of existing plant site. Minimum width of main gate shall be 6m. Main gate shall have 1.5m wide wicket gate. Main gate shall have as external framework of GI pipes and internal framework of MS flats. Gate shall be fixed on RCC columns. The design and pattern of gate with drawing shall be submitted for approval of the Engineer. The gate shall have all necessary hinges, locking arrangement, rolling arrangement and painting complete, as approved by the Engineer.

1.15.12 Landscaping

The site shall be landscaped once the Works are substantially complete. Landscaping area shall be marked in the layout plan of STP site. The area of landscaping shall not be less than 33% of the proposed plant layout area.

Landscaping shall include planting of suitable trees and development of lawn/grassed areas. Landscaping in general shall meet ecological and environmental conditions of the site. Road widths shall determine the size of the tree height and spread to be selected for planting. Trees suitable for local conditions shall be selected as approved by the Engineer. Medicinal and fruit trees shall be avoided. Landscaping shall be maintained in good condition till the completion of the contract.

1.15.13 Tree Planting

Pits dug a few days in advance of actual planting shall be allowed to weather and be filled with top soil mixed with manure. Size of the pit shall be as per standard requirement. Only one tree shall be planted in each pit. A guard made of bamboo with wire mesh or bricks or M.S. ring as approved by Engineer, shall be provided.

1.15.14 Applications for Anti-Corrosive Internal Lining (Epoxy Coating) protection of Concrete Surfaces

Application limits of Anti-Corrosion Internal Lining for Concrete Surfaces:

1. All units upstream of and including Primary Clarifiers shall have to be provided with internal lining for the full internal surface area (Walls and base slab)
2. For the Aeration units - internal lining shall be provided on the walls only from the top of the structure to 1.0 m below the lowest operating liquid level

For the units handling the solids part such as: Gravity Sludge Thickener, Anaerobic Sludge digester and Digested Sludge Storage tank, internal lining shall be provided for the entire internal surface area.

1.15.15 Hydraulic Testing of Liquid Retaining Structures

In addition to the structural test of structures, the liquid retaining structures shall also be tested for water tightness test at full supply level as described in 10.1.1,10.1.2 and 10.1.3 of latest revision of IS 3370 (Part I).

On completion of the structure and before its commissioning, the Contractor shall carry out a water tightness test for the maximum water head condition i.e. with the water standing at Full Supply Level (FSL). This test shall be carried out preferably in dry season and prior to internal lining in accordance with the procedure given below:

The water tightness test shall be carried out when the construction of liquid retaining structure is done and when it is possible to fill the structure and ensure that uniform settlement of the structure as a whole or as directed by the Engineer. Before the filling operations are started the structure shall be inspected by the Engineer and the Contractor's Representative and the condition of surfaces of walls, contraction joints shall be noted and it shall be ensured that the jointing material filled in the joint is in position and all openings are closed. The Contractor shall make necessary arrangement for ventilation and lighting of the structure by way of floodlights, circulators etc. for carrying out proper inspection of the surfaces and inner conditions if so desired by the Engineer. Records of leakages starting at different levels of water in the reservoir, if any, shall be kept.

The liquid retaining structure once filled shall be allowed to remain so for a period of seven days before any readings of drop in water level are recorded. The level of the water shall be recorded against the subsequent intervals of 24 hours over a period of seven days. The total drop in surface level over a period of seven days shall be taken as an indication of the water tightness of the structure, which for all practical purposes shall not exceed 40 mm. Also there shall be no indications of the leakages around the opening or on the walls.

If the structure does not satisfy the condition of test and the daily drop in water level is decreasing, the period of test shall be extended for a further period of seven days and it the specified limit is then reached the structure shall be considered as satisfactory.

The external faces of structure shall not show any signs of leakage and shall remain apparently dry over the period of observation of seven days after allowing a seven day period for absorption after filling.

In case the drop in level exceeds the permissible level limit and signs of leakage with the stipulated period of test, the Contractor shall carry out such additional works and adopt such measures as shall be directed by the Engineer to reduce the leakage within the permissible limits. The entire rectification work that shall be carried out in this connection shall be at the

Contractor's cost. The water required for subsequent testing shall be supplied to the Contractor free of cost, if the same is available near the site. Contractor shall have to make arrangement for filling emptying the structure at his own cost.

If the test results are unsatisfactory, the Contractor shall ascertain the cause and make all necessary repairs and repeat the water retaining structures test procedures, at his own cost. Should the re-test results still be unsatisfactory after the repairs, the structure shall be condemned and the Contractor shall dismantle and reconstruct the structure, to the original specification, at his own cost.

Water tightness test / hydraulic testing to be carried out after installation of mechanical equipment and interconnecting piping.

During testing and during defect liability period the impression marks created due to seepage shall be rectified and made good.

No separate payment shall be made for water tightness test and the cost thereof shall deem to be covered in the price quoted of different items of work of Sewage Treatment Plant.

TESTING: WATERTIGHTNESS OF STRUCTURES

Water retaining structures shall be tested for water tightness as stated below points. Each compartment of structures, which incorporate division walls, shall be tested separately with adjoining compartments empty. The complete structure shall also be tested.

- The structure shall be filled with water at an approximately uniform rate not exceeding 2 m depth in 24 hours to the levels stated in the below. The water used for testing water retaining structures for potable or fresh water shall be fresh potable water. The permission of the Engineer shall be obtained before filling starts. The structure or each compartment of the structure being tested shall be kept full for 7 days before testing allow for absorption.

- After the period for absorption, the water shall be topped up to the specified level and the test shall begin. During testing, the oscillatory motion of the water surface shall be dampened. The test period shall be 7 days.
- The equipment for recording water levels shall be installed in a temporary enclosure of minimum dimensions 2 m x 2 m x 2.5 m high with a lockable door. The enclosure shall be located over stilling wells, manhole openings or other points of recording water levels. The temporary enclosure shall be removed on completion of the test.

The equipment shall be calibrated before testing starts and at regular intervals agreed by the Engineer and shall be readable and accurate to 0.5 mm.

- The fall in water level in water retaining structures shall be measured at hourly intervals between 8 a.m. and 5 p.m. each day. The total fall shall be measured at the end of the test period.
- Structures shall be emptied after completion of testing and maintained in a clean and dry condition. The water shall be removed at an approximately uniform rate not exceeding 2 m depth in 24 hours. The permission of the Engineer shall be obtained before emptying starts.
- Unless otherwise instructed by the Engineer, the water used for the final tests on water retaining structures for potable or fresh water shall be retained in the structure and shall not be wasted or contaminated.

Compliance criteria: water tightness of structures

The results of tests for water tightness of water retaining structures shall comply with the following requirements:

(a) The total fall in water level at the end of the test period, after adjustment for evaporation and rainfall, shall not exceed 1/500 times the maximum specified depth of water in the test or 10 mm, whichever is less.

(b) There shall be no leaks or damp patches visible on the surface of the structure, including any division walls, during or at the end of the test.

Non-compliance: water tightness of structures

If the result of any test for water tightness of a water retaining structure does not comply with the specified requirements for the test, the Contractor shall investigate the reason. Remedial or replacement work approved by the Engineer shall be carried out and the structure shall be retested.

Table : Tests on water retaining structures

Type of structure	Part of structure tested	Test water level
Water retaining structures other than for sewage	Structure with division wall - each compartment of structure	100 mm below top of division wall
	Structure with division wall - complete structure	Top water level of structure

	Structure without division wall	
Water retaining structures for sewage	Structure with division wall - each compartment of structure	Top water level of structure
	Structure with division wall - complete structure	
	Structure without division wall	

SPECIFICATIONS FOR DISMANTLING AND DEMOLITION

SCOPE OF WORK:

The work envisaged under this sub-head is for dismantling and demolition of brick masonry in cement/lime mortar, reinforced cement concrete works, removing wooden chowkhats of doors, wooden or steel windows.

GENERAL:

The term Dismantling implies carefully taking up or down and removing without damage. This shall consist of dismantling one or more parts of the building as specified or shown on the drawings.

The term Demolition implies taking up or down or breaking up. This shall consist of demolishing whole or part of work including all relevant items as specified or shown on drawings.

PRECAUTIONS:

Necessary propping, shoring and/or underpinning shall be provided for the safety of the adjoining work or property, which is to be left in tact, before dismantling and demolishing is taken up and the work shall be carried out in such a way that no damage is caused to the adjoining work or property.

Wherever required, temporary enclosures or partitions shall also be provided.

Necessary precautions shall be taken to keep the dust- nuisance down as and when necessary.

Dismantling shall be commenced in a systematic manner. All materials which are likely to be damaged by dropping from a height or demolishing roofs, masonry etc., shall be carefully dismantled first. The dismantled articles shall be passed by hand where necessary and

lowered to the ground and not thrown. The materials then be properly stacked as directed by the Engineer-in-charge.

All materials obtained from dismantling or demolition shall be the property of the employer unless otherwise specified and shall be kept in safe custody until handed over to the Engineer-in-charge.

Any serviceable material, obtained during dismantling or demolition shall be separated out and stacked properly as indicated by the Engineer-in-charge within a lead of 150 m. or as specified in the item. All under serviceable materials, rubbish etc. shall be disposed off as directed by the Engineer-in-charge.

TREATMENT:

All the dismantled area shall be rendered clean off all debris, dust etc. The sides of jambs, sills, soffits etc. of the openings if any, after taking out doors and window chowkhats, unless and otherwise to be treated, shall be plastered in C.M. 1:3 with neeru finish to render true sides, corners, edges etc.

1.16.15 STATUTORY RULES:

1 Contractor shall comply with all the applicable statutory rules pertaining to enquire act (as applicable for the state). Fire safety rules of Tariff Advisory committee's water act for pollution control etc.

2 Preventions for fireproof doors of staircases fire separately we plastering on structural members (in fire prone at case) etc., shall be made according to the recommendations of Tariff Advisory Committee.

3 Statutory clearance and norms of state pollution control board shall be showed as per Water Act for effluent quality from plant.

Request for Proposal

For

LANDSCAPING OF BORSOLA BEEL

Design, Build and Operate Basis

Volume II B Part-2: SCOPE OF WORK & SPECIFICATIONS FOR LANDSCAPE WORK

Client:

GUWAHATI SMART CITY LIMITED

GSCL,
Guwahati, Assam

DOCUMENT NO: 10477A-CV-3000-3102

Contents

1 LANDSCAPING OF BORSOLA BEEL

The city has number of beels and wetlands. Being physically constrained by hills and natural *beel* areas, the city has sprawled in a curvilinear fashion surrounding the central area, along the main corridors towards the east and the south. The city lacks good neighborhood parks and gathering spaces.

It is required to design a conservation strategy with supporting infrastructure that will transform BORSOLA Beel to a **vibrant neighbourhood public place for all age groups** which will have direct environmental physical and social benefits.

The project will be designed to mitigate flood, improve access and manage recreational, cultural and ecological assets and reconnect the city to its riverine ecosystem. Eco-restoration, bio-remediation techniques will be explored to transform the degraded water bodies into performing ecological landscapes and tourist attraction.

Borsola Beel has the potential to be developed as an eco-tourism site with facilities like boating, water sports and waterways recreation activities. The project aims to promote the use of solar-operated battery boats, canoes, pedal boats as a form of non-motorized transport.

1.1 PROJECT BRIEF AND LANDSCAPE ELEMENTS

1.1.1 The Garden of Five Senses : SIGHT : Colour Garden

Colour Garden to spread awareness and promote the conservation of the biodiversity and flora Assam state. Nature lovers and flower enthusiasts can converge to admire the variety and beauty of the native flowers and plants of Assam

The entrance one will lead to the Color garden. The Entrance Mist Fountain will not only refresh the visitor once he enters the site but also the lighting in the fountain will depict the theme.

•The circular entry Plaza will have different layers of flowering shrubs with vibrant local species of flowers and seasonal which change every season.

•The floor fountain with changing lights assembled highlights the fountain and makes the water feature user friendly

1.1.2 Sight : Water Front

Development of viewing decks along river bank to enjoy the nature as well as the beautiful scenes of Borsola Beel and development across the bank.

1.2 The Garden of Five Senses : Hearing

Plantation of various types of Bamboo species and installation of wind chimes made of various materials along the wind direction to fill the atmosphere with varying sounds.
The trees will have small chimes which produce gentle sounds.

- The Trees like Ficus religiosa, bamboo sways with the gentle breeze to produce sounds.
- The central Water feature creates water sounds soothing to the ears
- Sound Wall will produce gentle sounds when touched or moved.
- Trees with berries attract birds which produce soothing sounds.
- Other garden elements in sound garden produce sounds with wind too.

1.3 The Garden of Five Senses: Taste/ Edible and Fragrance Garden

There are many native aromatic flowers and trees in Assam. The garden showcases beautiful shrubs, ground covers and trees which have fragrance which intern attracts butterflies and local birds.
The flowers of Millingtonia hortensis create a beautiful bed of fragrance flower fall on the lawn. Aromatic trees and shrubs are used near the Yoga garden and seating areas.

Aroma Garden

Trees and shrubs with aromatic inflorescence planted along wind direction for user to enjoy aroma while seating at the rectangular seaters. Each court in Aroma garden will also contain aromatic herbs, and plants that engage the senses.

Edible Garden:

Herbs and fruit trees form the main plating scheme of this part of the garden. These trees also attract native birds.
Herb Wall can be used with different edible herbs which encourages the visitor to use and taste the herbs.
Herbs like tulsi (Ocimum Sanctum) etc are planted with signage explaining the use of these shrubs.
Fruit trees with nested trunk structure will attract lot of local birds.

Yoga and Meditation Pavilion

Yoga Pavilion to be designed with a covered patio that will serve not only as a yoga practice area but also for meditation area amidst aromatic vegetation.

1.4 The Garden of Five Senses : Touch Garden

The Touch garden encourages the visitor to touch and feel different shrubs and plants. The acupressure path in the touch garden made with different materials encourage the visitors of all ages to explore the park. The seaters are cladded with different materials and textures. Use of different foliage plants to create texture in the look of the touch garden too.

Fitness Zone

Provision for a place for installation of outdoor gym equipments and play courts to encourage fitness drive in the visitors along the enlightenment of the soul with other zones of garden.

Children's Play area

Children's Play area will have different play equipments for all ages:

1.Swings

2.Slides

3.Rock Climbers

4.Rope Climbers

5.Floor Games etc.

Children's Play area shall design & built as best in practices to keep all safety factors in mind, Targeting age groups- 2 to 15 years. The surface shall have sand pit and rubberized flooring as required along with playing equipments, lights , signages etc. but not limited to this .

1.6 Pedestrian bridges/walkways/ Traffic Circulation Plan

The Water front development of the Beel is designed so as to form an iconic lake development area in Guwahati. The deck runs all along the 1500m Beel edge which would eventually attract many visitors for jogging, walking, seating and relaxing etc. The Deck is carefully designed considering the accessibility, safety and activities. The Deck has Ghaat Pavilions and Trellis.

1.7 Seven Sisters Walkway-Deck:

The Cultural Deck represents the rich cultural heritage of the 7 seven sister states of North East India. The Walkway takes the visitor through a fascinating journey showing the ethnic and cultural diversity of the 7 states. The 1.5km Deck Walkway will have 7 Arches or Gates which

represent each of the 7 states. Notheast India is ethnically diverse and a heterogeneous region which boosts 209 tribes and many languages.

Just like the people of Northeast the cultural walkway also forms a beautiful mosaic representing the culture and the tradition with the help of motifs, tribal gods and the specialities which are depicted on the arch gateways.

1.8 Elements of the Deck- Walkway

Deck-The Walkway

The Walkway is an interesting deck which has elements like Ghaat Pavilions, Trellis with seatings, Access areas to Bridges (connects both the banks of the Beel), Solar Trees and Planters.

Ghaat Pavilions

The 1500 mts long deck area has 10 Ghat Pavilions which gives accessibility to the Beel. The Ghaat Pavilions steps down of the Beel and also creates a Beautiful view to the Beel.

1.9 Pathway, Deck , Bridges and Road:

- The circulation scheme shall have of the Road, the pathway and the Walkway/Deck.
- This is so designed so as to create a limited access to the Deck and the Beel.
- Elements of the section are listed below:
  - ❖ Road, cycle track
  - ❖ Deck (as per drawings)
  - ❖ Bridges (Three pedestrian and one for vehicle) .
  - ❖ Footpath, jogging track

    All type of circulation shall design to keep in mind the norms and specification for handicapped person.

1.10 Site Access and Entrance

At the downstream side of the Beel a parking bridge has been proposed. It will be used for public parking as well as visitors for Beel. The parking capacity of the bridge is 40+2 cars. On the upper stream side the approaching road and entrance gate with 22 car parking and 30 two wheeler parking is proposed .

Entrance 1:

State of art Entrance plaza and gate is proposed which give the welcome ambience to the visitors. The Park will have parking areas at the entries with two-wheeler, four-wheeler and cycle parking areas. Apart from parking the entry areas will have Guard room/ ticket counter ,Toilet Blocks, Gardeners storage rooms and can accommodate a Food Kiosk in the parking area too.

Entrance 2: From Srimanta Sankardeva road/Paltan Bazar

State of art Entrance plaza and gate is proposed which give the welcome ambience to the visitors. The Park will have parking areas at the entries with Two- wheeler, Four- wheeler and cycle parking areas. Apart from parking the entry areas will have Guard room/ ticket counter, Toilet Blocks, Gardeners storage rooms and can accommodate a Food Kiosk in the parking area too.

Entrance 03: From Rahbari Road

The Park will have parking areas at the entries with Two- wheeler, Four- wheeler and cycle parking areas. Apart from parking the entry areas will have Guard room/ ticket counter.

1.11 Design consideration

The following points to be covered on while design the Landscape areas

- Sustainability: Land, vegetation and water sensitive design options to be explored during the design stage . The ecological design approach and sustainable solutions are expected.
- Accessibility: The planning and design of open spaces may be accessible for a wide range of users, including pedestrians, cyclist, transit riders and those using private modes of transport. The emergency evacuation plan shall be submitted to respective agency.
- Design for Safety and Security w.r.t

a) Details of Hard landscape materials

b) Plant materials may be selected taking into consideration the possible issues of allergic reactions or toxicity.

c) Level differences in the open spaces

d) Durable, easy to repair equipment and safety surfacing may be considered for play areas.

e) Planning of exits in play areas.

f) The density of vegetation and height of the understory planting may be decided so as to keep the view-lines clear.

g) Lighting in the landscape.

- Integration of structures and elements related to external services.

a) Storm water drainage

b)Sewage disposal system

c) Fire lines

d) Electrical works

- Specification : The specifications for design elements for outdoor spaces shall be included under the following categories as part of hardscape specifications :

a) Pavement and other pedestrian movement spaces, covering

- Footpath with heavy pedestrian traffic
- Footpath with light pedestrian traffic
- Plaza and public assembly spaces
- Kerbs ,Steps and ramps.

b) Parking and vehicular movement corridor covering

- Parking, Median, Road marking,

c) Traffic management units, covering

- Bollards, Barriers, Crash guard ,Gate/Access control, Vehicular height restrictors etc.

d) Outdoor public conveniences, covering

- Seating, pergolas
- Drinking fountains
- Toilet/Wash rooms.

e) Shelter and kiosks, covering

- Information desk, stalls

f) Outdoor illumination, covering

- Street light
- Façade light
- Ambient light

g) Tree protection units, covering

- Tree guard ,Tree grate ,Planter.

h) Garbage collection units, covering

- Litter bin- for different types of garbages

k) Display and signage

- Location of the street furniture shall be coordinated with the traffic

flow pattern of vehicles and pedestrians and external services.

1.12 Design for Disabled People.

The Design of Landscape and building areas shall be barrier free built environment for disabled and elderly persons.

Note: Contractor shall do the designing of the areas as describe above but not limited to this only.

Contractor shall do all necessary co-ordination activities with OWNER & PMC for seamless implementation of the said works.

2 SCOPE OF WORK

2.1 Broad Scope of Work.

The broad scope of work for Development of Landscape garden and River front, area around 1.91 Ha under Guwahati Smart City Proposal Implementation shall include execution of all Civil, Architectural Landscape work (including Softscape /Horticulture and Hardscape), Electrical works, Plumbing and Irrigation works as per the local CPWD specification, Schedule of Rates (S.O.R), Engineering Standards and construction Drawings .

The work include the design, build and operated the parks, Water feature,fountain parking areas, deck ,children play area, Toilets etc. as approved by client and PMC.

Contractor shall have to do all the relevant survey viz, topographical ,geotechnical, infrastructural survey etc.

Contractor shall have to take all the necessary approvals, if any, from respective authorities.

Contractor shall do all necessary co-ordination activities with client & PMC for seamless implementation of the said works.

2.2 Scope Of Concept & Drawings

The bidder shall have to appoint a well experience landscape consultancy firm (selection of consultancy firm is given in selection criteria).

The bidder shall have to submit the concept design , design development, specifications and working drawings in all sense and get the approvals from client/ PMC.

2.3 Cope Of Supply

Note: The contractor has to make all effort to save energy and water.

2.3.1 Client's Scope of Supply

Client and/ or PMC shall not be liable to supply any machine ,equipment and material.

2.2.2 Contractor's Scope of Supply

All materials (consumables & non-consumables), tools tackles etc. as required for satisfactory completion of the job shall be supplied by the contractor.

Prior approval from Owner/ Engineer In-charge shall be obtained prior to use of all material at site.

2.4 Specifications

The works shall be performed conforming to the Indian Standard codes, NBC,P.H.D & P.W.D. specifications of the State Government. Wherever such specifications are not available, CPWD specifications, relevant references, manuals etc. shall be followed as directed by Owner. For Horticulture and landscaping works CPWD-Delhi/Assam Schedule of Rates, Analysis of Rate and Specifications (Horticulture & Landscaping) .

2.5 Applicable Codes and Specifications

The following codes, standards and specifications are made a part of this specification. All standards, specifications, codes of practice referred to herein shall be the latest version on the date of offer made by the Bidder.In case of discrepancy between this specification and those referred to herein, this specification shall govern.

IS: 110	-	Ready mixed paint, brushing, grey filler, for enamels for use over primers.
IS: 280	-	Specification for mild steel wire for general engineering purposes.
IS: 412	-	Expanded metal steel sheets for general purposes.
IS: 426	-	Paste filler for Colour coats.
IS: 428	-	Distemper, oil emulsion, Colour as required.
IS: 1077	-	Specification for common burnt clay building bricks.

IS: 1081	-	Code of practice for fixing and glazing of metal (steel & aluminium) doors, windows and ventilators.
IS: 1124	-	Method of test for determination of water absorption, apparent specific gravity and porosity of natural building stones.
IS: 1200	-	Method of measurement of building and civil engineering works.
IS: 1237	-	Specification for cement concrete flooring tiles.
IS: 1346	-	Code of practice for water-proofing of roofs with bitumen felts.
IS: 1443	-	Code of practice for laying and finishing of cement concrete flooring tiles.
IS: 1542	-	Specification for sand for plaster.
IS: 1597	-	Code of practice for construction of stone masonry: Part 1 Rubble stone masonry.
IS: 1661	-	Code of practice for application of cement and cement-lime plaster finishes.
IS: 1834	-	Specification for hot applied sealing compound for joint in concrete.
IS: 1838	-	Specification for preformed fillers for expansion joint in concrete pavements and structures (non extruding and resilient type) : Part 1 Bitumen impregnated fibre.
IS: 2116	-	Specification for sand for masonry mortars.
IS: 2185	-	Specification for concrete masonry units (Parts 1, 2 & 3).
IS: 2212	-	Code of practice for brickwork.
IS: 2250	-	Code of practice for preparation and use of masonry mortars.
IS: 2339	-	Aluminium paint for general purposes, in dual container.
IS: 2395	-	Code of practice for painting Concrete, masonry and plaster

		surfaces (Part 1 & Part 2).
IS: 2571	-	Code of practice for laying in-situ cement concrete flooring.
IS: 2690	-	Specification for burnt clay flat terracing tiles: Part 1 Machine made.
IS: 2691	-	Specification for burnt clay facing bricks.
IS: 2750	-	Specification for steel scaffoldings.
IS: 3036	-	Code of practice for laying lime concrete for a water-proofed roof finish.
IS: 3067	-	Code of practice of general design details and preparatory work for damp-proofing and water-proofing of buildings.
IS: 3068	-	Specification for broken brick (burnt clay) coarse aggregates for use in lime concrete.
IS: 3384	-	Specification for bitumen primer for use in water-proofing and damp-proofing.
IS: 3495	-	Method of test for burnt clay building bricks : Part 1 to 4.
IS: 3696	-	Safety code of scaffolds and ladders (Part 1).
IS: 3696	-	-DO- (Part 2).
IS: 5410	-	Cement paint, colour as required.
IS: 6248	-	Specification for metal rolling shutters and rolling grilles.
IS: 8042	-	Specification for white Portland cement.
IS: 8112	-	Specification for 43 grade ordinary Portland cement.
IS: 8543	-	Methods of Testing Plastics (Part 4 / Section 1)
IS: 15058	-	PVC water stops at transverse contraction joints – specification.

3 SPECIFICATIONS FOR SITE DRESSING AND LAND MODULATION

3.1 SCOPE

- The Scope consists of clearance of the Site of Works and preparation of the same to commence the proposed landscape execution activities. Wherever applicable, this is deemed to include all preliminary works like Dismantling/Demolition, Site Clearance, and General Leveling etc.

- The drawings shall be read in conjunction with the specifications and matters referred to, shown or described in one are not necessarily repeated in the other.

- In the event of any element of specification not available in any of the documents the instructions of the Engineer-in-Charge in writing shall be followed by the Contractor.

- The work shall be carried out in accordance with the drawings and designs as would be issued to the Contractor by the Landscape consultant duly signed and stamped by him.

- The work shall be executed and measured as per metric dimensions given in the Schedule of Quantities, drawings etc.

3.2 GENERAL ITEMS

The more important Codes, Standards and publications applicable to this section are listed hereinafter.

3.2.1 Setting out the works

- The Contractor shall supply without additional charges the requisite number of persons with the means and material necessary for the purpose of setting out works and checking, weighing and assisting in the measurement or examination at any time and from time to time, of the work or the materials. Failing this, the same may be provided by the client's designated representative In-charge at the expense of the Contractor and the expenses shall be deducted from any money due to the Contractor under the contract or from his security deposit.

- The Contractor shall arrange for a qualified surveyor to set out the works and obtain certification of its accuracy from the surveyor. The Contractor shall then set out the works and shall be responsible for the true and perfect setting out of the same and for the correctness of the positions, levels, dimensions, and alignment of all parts thereof

and for provision of all necessary instruments, appliances and labour in connection therewith. The Contractor shall submit to the client and the Landscape Architects, margins and the verifications of layout within seven days from the date of getting site layout from Landscape Architects / client.

- Mark the layout on the site. All bench marks, levels should be properly established and preserved for future use.

- Clearly check the surveyed map provided by the client and mark all drainage lines, water pipe lines, electrical lines, etc. It needs to be checked by Contractor to satisfy him / herself from safety point of view before starting of work.

- The checking of any setting out or of any line or level by the Landscape Architects and CLIENT's representative or their representative shall not in any way relieve the Contractor of his responsibilities, for the correctness thereof. The Contractor shall carefully protect and reserve all benchmarks and other things used in setting out of the work.

3.2.2 Site Clearing / Excavation / Site Grading

- Light irrigation, by flooding the whole site with water. The water should penetrate up to depth of 15-20 cm only so that the weeds can germinate. Remove all grasses, small shrubs/weeds etc. with roots. Excavating the site as marked on the drawing/as instructed at the site, up to any lead and lift.

- Verify the levels and bench-marks from the up-dated surveyed drawing made available by the client. If there are any discrepancies between the site and the survey drawing, the same are to be brought to the client's notice by addressing a letter to the client and copy marked to the Landscape Architects.

- Grading and levelling of site as shown in drawing / specified on site by Landscape Architects. This will include spreading manually or by help of soil unloaded at different working areas in the site so as to obtain basic datum levels and grades.

- Excavated material shall be stacked off in the manner indicated at the site including stacking of excavated material up to any lead and lift. The rate shall only cover the cost of excavation, stacking and/or spreading of the material, if required at the site.

- Clearing the area of unwanted materials including the weeds, stones, masonry pieces etc. and all such matter that may cause damage to growth of the plant materials immediately or in future.

3.2.3 Topographic Survey & Geotechnical investigation

Contractor to conduct detail topographical site survey and Geotechnical investigation before execution of work and submit the same to the Engineer in charge for approval.

3.3 Earth Works

- Earthworks shall involve the grading of soil for earth mounding, the excavation of trenches and soil for formation levels of pathways and foundations, and the fine grading of earth banks and landscape areas roughly graded by others.

- Excavation shall be carried out to the depth shown on or implied in the drawings or to such greater or lesser depths as the Landscape Architect may direct. The Contractor shall supply and fit all shoring, sheeting, strutting and walling required to maintain the sides of excavations as long as necessary and to remove them as required. The Contractor is to allow for making all necessary adjustments to existing manholes in accordance to bring them to the same level as the required profiled grades. No claim shall be entertained for either bulking or compacting and all other quantities shall be measured net from the drawings.

- The stripping and replacement of the subsoil shall only be done in dry weather and ground conditions unless in exceptional circumstances the Landscape Architect authorizes otherwise. Subsoil in heaps or dumps shall not be sited so as to damage or impede water courses or other drainage so long as they are capable of remaining in operation. Any weeds which may grow on the heaps of subsoil shall be sprayed with an approved selective weed-killer to prevent seeding.

- Notwithstanding the general description for the type of material to be excavated, if original bed rock is encountered during these operations which can only be removed by blasting or compressed air tools this work will be paid for separately as an extra over item for that given for normal excavation. This work shall only be undertaken when authorized in writing by the Landscape Architect.

- During excavation it is expected that the Contractor will take every prudent step or precautions such as tests or borings in order to prove the nature or type of material underneath or the ground bearing capacity in order to protect his workmen, plant or machinery employed in these operations.

- In the event of the Contractor excavating below the proper levels or otherwise in excess of the dimension given, he shall at his own expenses, remove all loose excavated material and replace the soil excavated in error.

- If, in the opinion of the Landscape Architect the bottoms of any excavation or any material to be excavated become unsuitable due to the Contractor's operations, the Contractor shall, at his own expenses, carry out any necessary excavation and make up in a similar manner to the above.

- If, in the opinion of the Landscape Architect the weather conditions are such as to preclude the satisfactory completion of any operation or cause unnecessary nuisance or disturbance to other parties, the Contractor shall, on receiving directions from the Landscape Architect suspend operations on that particular portion of the work until the Landscape Architect considers that weather conditions are satisfactory, or issues a direction to re-commence operations. The absence of such a direction shall in no way constitute the basis of a claim for delay or remedial work to a formation which is unsuitable.

3.3.1 Major Grading

- Site shall be complete with rough dressing including the base levels by civil contractor before handed over to landscape contractor for execution.

- Role of Landscape contractor involves major grading forming earth mounds / hillocks from imported fill materials where specified, or from the site debris and soil generated by excavations. The soil shall be graded using suitable earth moving machinery to the contoured earth forms indicated on the drawings. Soil, when in a dry enough state for easy working, shall be distributed to the correct areas and laid in layers not exceeding 100mm thick and compacted by at least 2 passes of the earth moving machine in each direction for each 100mm layer.

- Earth slopes are to be formed from the compacted mounds to the gradients and levels shown on the drawings, accounting for the topsoil depths to be included after subsoil formation is complete. If insufficient fill is available to complete the levels shown, additional suitable subsoil is to be imported to make up the required quantities. Importation of additional fill shall only be carried out with written permission of the Landscape Architect.

- Earthworks levels are to be carried out to the contours shown on the drawings to a maximum tolerance of 150mm measured vertically, and to a maximum gradient of 1:2. All subsoil levels are to account for the later additional of specified depths of topsoil.

- The Contractor shall be responsible for protection of completed subsoil mounds and shall take preventative measures to control erosion and siltation restore or replace any portion of the earthwork areas which erodes, slumps, silts or is otherwise damaged by the out-washing of soil.

3.3.2 Excavation for Formation Levels and Trenches

- For footpath areas or other paving areas, excavate subsoil to create a smooth formation for taking the sub-base for the paved area, to levels shown on the drawings accounting for the depth of the paving build up.

- Firmly compact sub-grade with a smooth wheeled vibratory roller to achieve an even level. Finished sub-grade is to be protected until the path sub-base or other construction such as pool sub-base is laid. If sub-grade is too dry to be compacted, water shall be added until suitable texture is achieved. If sub-grade is too wet, the material shall be left to dry out until workable.

- A completed sub-grade/formation on which there is standing water, soft spots or slurry shall be deemed to be unsuitable and shall be rectified at the Contractor's expense including making up of additional material as required to bring the formation to line and level again.

- Where soft or wet ground is encountered prior to preparation of the sub-grade and this soft or wet ground cannot satisfactorily be compacted, the Contractor shall submit a written request for this to be inspected and the area to be dug out and replaced with

suitable material shall be evaluated by the Landscape Architect and directed accordingly.

- Surplus material resulting from excavations for path formation or drainage trenches shall be taken off site at Contractor's own expense unless otherwise directed by the Landscape Architect in writing.

- Excavation of drainage or formation trenches shall be carried out after the major grading has been completed and approved. Trenches shall be cut to lines and gradients shown on the drawings. Planking and strutting shall be carried out as required to make the sides of the trenches safe. The Contractor will be responsible for ensuring that drainage trenches are kept free from mud and water and side slippage.

3.3.3 Fine Grading and Shaping

- Slight unevenness, ups and downs and shallow depressions shall be removed by fine dressing the surface to the formation levels of the adjoining land, as directed by Landscape consultant and adding suitable quantities of Good earth, brought from approved source, if necessary.

- Fine grading shall be carried out using small sized earth moving equipment or by hand, and shall involve final modeling of the earth contours produced by the major grading exercise. The shaping will follow the contours shown on the plans in general terms, but the final forms will be developed by eye to create smoothly flowing and pleasing contours.

- The Fine Grading will provide the detailed earth contouring prior to cultivation of soil. Soil cultivation and the application of topsoil mixes shall not take place until the Fine Grading is completed.

3.4 DRAINAGE

There is existing storm water drain which shall be used for drain. The existing drain shall be covered and remodel as per requirement.

3.4.1 Field Drains ,Subsoil, and Trench Drains

- Before beginning installation of drain lines establish invert elevation of city storm drains at points where tree drains will tie in and prepare schematic layout for approval of Landscape Architect before digging trench.

- Surplus material resulting from excavations shall be carted to other fill areas within the site. If no additional fill sites are available the Contractor shall remove all surplus material from site and deposit it in a Local Authority approved tip.

- The Contractor shall survey the gradient levels of all trench bases to ensure that all falls are continuous from the highest point down to the outlet point at the sump. These findings shall be submitted to the Landscape Architect for verification before any further work is undertaken, either pipe laying or backfilling.

- All trenches when completed and approved shall be lined with approved filter membrane laid over the base of the trench and up the sides with sufficient membrane to wrap over the top of the gravel backfilling with a minimum overlap of 300mm.

- The base of each drainage trench shall have a layer not less than 30mm and not more than 50mm depth of fine stone chippings 8-12mm diameter or coarse sand laid to accurate falls for bedding the perforated pipes.

- The drainage pipes to the sizes shown on the drawings shall be prefabricated subsoil drainage system or similar approved type. PVC pipes with drilled holes will not be permitted. Drainage pipes shall be laid to the lines to the falls shown on the drawings and accurately boned in to correct gradients before backfilling.

- All pipe junctions shall be as supplied by the selected manufacturer and shall be fitted to the manufacturer's instructions to provide smooth flow and to fit the correct pipe sizes. Where changes in pipe diameters occur the correct junctions shall be used to match the changed pipe diameters.

- Connect drainage system to percolation pits.

- Where subsoil drainage pipes pass under paths or structure the pipe shall be of non perforated pipe joined at either end to the perforated pipe, and be surrounded by 100mm of concrete haunching.

- Trenches shall be backfilled to within 100mm of the finished level with clean coarse grained sand or crushed stone chippings 8-12mm diameter free of any fine particles. The gravel backfill shall be lightly compacted in 100mm depth layers.

- All drains shall be tested on completion to ensure a satisfactory water flow. Any pipes that do not flow are to be taken up and re-laid at the Contractor's expense.

- After testing has been approved, remaining depth of the trench shall be filled with a layer of coarse grained sand up to the finished soil level (after final settlement). Where the top layer is specified as such, clean graded gravel 20-40mm stone chippings free from fine particles shall be placed up to the finished surface mix, free from clay lumps or any item likely to inhibit drainage.

4 SPECIFICATIONS FOR SOFTSCAPE WORKS

4.1 SCOPE

- The scope of services covers all horticultural operations and services including, labour, equipment, services and transport for all plant materials, Good earth, top soil conservation, manures, pesticides etc. completing the entire work within the scheduled time, maintaining the entire Softscaping work for five years after virtual completion of the work.
- The Contractor shall refer to Specifications provided in this document for relating to formation levels, sub-bases, concrete footings, foundations and all associated works. The specifications are to be read along with necessary specifications from other consultants.
- Vendors' shop drawings shall be submitted for all such items where the Contractor will procure and install items from/by a reputed vendor. Execution of all such items shall be done after such drawings are approved by the Employer/ Employer's representative.
- Contractor shall prepare and issue all required working drawings and get them approved by Employer/ Employer's representative with required number of revisions till the details provided do not satisfy the Employer/ Employer's representative.
- DLP shall be of five year after completion of Landscape Execution. The Contractor will maintain the entire landscape development area free of cost for a period of five years after completion of all above works as certified by the Employer/ Employer's Representative's in consultation with the Landscape Architect.

4.2 SPECIAL CONDITION

The Contractor will have to provide the following items at no extra cost to Employer:

- The Contractor will supply and install 2.0 metres high barricades for safeguarding landscape development area and works, as indicated in the drawing. He may also install the barricades in the landscape development area according to his own understanding if he feels that any part of the landscape area is bound to be damaged for any reason, after taking prior permission from the Employer/ Employer's Representative.

- The Contractor will supply, install and maintain at his own cost, the most modern, automated watering system for the landscape, which will take care of the requirement for particular plants, save water and does not waste water, including any requirements specified by the Landscape Architect appointed by contractor. He will give full details of the layout, size of the pipe, size of the sprinklers, bubblers, etc and their warranty period. All equipment must conform to international standards and / or Indian Standards if available. The design of the irrigation system has to be approved by Employer/ Employer's representative.
- All equipment required for development shall be made available by Contractor, and its maintenance shall be his responsibility. This includes Tagara, Phawdas, Hose Pipes, Ground Roller, Manual and/or Electric lawn Mowers, Sprinklers, etc.
- Contractor will ensure that all plants remain free of diseases, pests, etc during development and maintenance periods. The contractor shall, without any additional charge renew any dead or defective plant material and shall fully maintain including watering, de-weeding etc. of the whole landscape as mentioned above.
- Contractor shall follow pre construction and during construction soil erosion control measures as per the NBC Part 10, section 1, Chapter 4 – Protection of Landscape during Construction.
- The contractor in co-ordination with the Employer as applicable shall ensure conservation and storage of top soil: Topsoil shall be stripped to a depth of 200 mm from areas proposed to be occupied by buildings, roads, paved areas and external services. It shall be stockpiled to a height of 400 mm in designated areas and shall be re-applied to site during plantation of the proposed vegetation. Topsoil shall be separated from sub-soil debris and stones larger than 50 mm diameter. The stored topsoil may be used as finished grade for planting areas. It is the landscape contractor's responsibility to conserve top soil that is not disturbed by the civil contractor.
- The Contractor shall:
    - Furnish the source of top soil to Employer/ Employer's Representative.
    - Contractor to carry out a detail soil report, providing soil details such as pH, alkalinity, total soluble salts, porosity, sodium content and organic matter and submit the same to Engineer in charge for approval.

- Use the restored soil at site for landscape purpose, manure mixture, Neemcake, weedicide shall be added if required.
- Not consider any external soil source unless the existing soil conserved from site is lacking in quality and/or quantity.

Soil Analysis for Top Soil fertility determination

- To determine the fertility of top soil for conservation, soil investigation shall be carried out by an NABL accredited laboratory.
- Adequate number of test samples of soil from a depth of 10-200mm below ground level shall be collected from at least 5 representative locations from site, preserved and transported (as per standard procedures specified by the laboratory) carefully to the laboratory for carrying out necessary tests.
- All relevant Indian Standards for sampling and conducting laboratory tests shall be followed.
- This soil samples shall be analyzed to determine soil type, texture, total organic content, pH, extractable nutrients such as nitrogen, phosphorus, potassium, salinity, cation exchange capacity, % base saturation and extractable heavy metals.
- The soil analysis report from the laboratory shall also include a statement on the fertility and suitability of the soil for plant growth based on the analysis, in addition to the test results.

Top Soil conservation

- Topsoil shall be removed for conservation to a depth of 200 mm (not more than 400 mm) and shall be separated from subsoil debris and stones larger than 50 mm diameter.
- It shall be stockpiled to a height of 400 mm in designated areas. The stockpiled topsoil shall be protected from erosion during storage by installing earthern berms/solid walls, temporary seeding (using native grass), covering with mulch or plastic, etc.
- The topsoil shall be protected with sand bags/solid walled enclosures (2 feet high) on all sides for containment.
- Appropriate drainage channels shall be dug around the storage area to prevent flooding of the top soil storage area.
- The top soil shall be reapplied to site during plantation of the proposed vegetation as finished grade for planting areas.
- Seeding will take place immediately after respreading topsoil and decompacting, unless timing is inappropriate (for e.g., not in mid-summer).

a) The contractor to identify erosion prone areas on site and protect them from construction activities throughout the construction period. Prevent / mitigate the disturbances caused to site due to construction activity.

b) The contractor shall execute a sedimentation and erosion control plan that conforms to the best management practices highlighted in the National Building Codes of India (NBC) Part 10, section 1, Chapter 4 – Protection of Landscape during Construction. This standard describes two types of measures that can be used to control sedimentation and erosion. Stabilization measures include temporary seeding, permanent seeding and mulching. Structural control measures include earth dikes, silt fence, sediment trap, and sediment basin. All of these measures are intended to stabilize the soil to prevent erosion.

c) The erosion and sedimentation control plan must be approved by Employer/ Employer's Representative and the erosion sedimentation control plan must be maintained throughout the execution period.

d) The contractor shall execute measures of protection and preservation of existing landscape on site during entire construction time.

e) Design, execute and maintain a temporary storm water management layout for the duration of construction activity. The storm water management layout should conform to National Building Codes of India (NBC) Part 10, section 1, chapter 4 – Protection of Landscape during Construction.

f) Contractor should take measures to prevent entry of any soluble/ insoluble construction waste to enter the water table/ water ways/ ravines on site.

5 SPECIFICATIONS FOR HORTICULTURE WORKS

5.1 Provision of Site Utilities

The Contractor is to allow for the provision at his own cost of all site utilities for the duration of the contract including but not limited to water, electricity and telephone.

5.2 Landscape Development Technique

- The contractor will not be allowed to use different techniques or quality criteria or materials unless his alternative system has been confirmed in writing by the Employer/Employers representative.
- No cost increases for alternative specifications will be entertained unless formally submitted in writing as an improvement in the quality of a product and accepted in writing, following Employer/Employer's Representative approval, by the Employer/Employers representative.

5.3 Quality of Workmanship and Materials

- All materials and workmanship shall be of the high standards and quality demanded by this specification. Sub-standard work and materials identified by the Employer/Employer's representative will be rejected and will be required to be rebuilt or replaced at the Contractor's costs.
- All plant material shall be of the genus, species and variety specified and substitutions will not be permitted unless authorized in writing by the Employer/Employer's representative. The sizes and plant description set out in the section headed Plant Material.
- All trees and shrubs supplied for the contract shall be free of pest, disease, discolouration and damage. Plants shall be well branched with vigorous shoots. The root system of each plant shall contain a good proportion of fibrous roots.
- All materials are to be approved by the Employer/Employer's representative prior to use on site. Materials shall be obtained from approved sources/manufacturers and/or suppliers. All guarantees and warranties shall be copied and submitted to the Employer/Employer's representative prior to requests for approval.
- Where particular products are specified, the Main contractor's specialists subcontractors if he wishes to use similar products from other manufacturers must seek prior confirmation from the Employer/Employer's representative.

5.4 Site Responsibilities

From the commencement of the works until the Certificate of virtual Completion has been issued by the Employer/Employer's representative, the Main contractors specialists subcontractors shall, in respect of all areas of soft landscape works, adjacent areas and parts of the site used by him, be responsible as follows:

- For adequate protection to grassed areas, planted areas and trees and for making good Softscape works on removal of any protective measures at completion.
- For any damage to existing works and features and any necessary rectification work required to obtain approval from Employer/Employer's Representative.
- For keeping all paved surfaces used by him in a clean and tidy condition.
- For periodic removal of all surplus excavations and waste matter produced by his operations to a Local Authority registered tip off site, to be found by the Main contractors specialists subcontractors.
- For keeping all Softscape areas in a weed-free and tidy condition and adequately watered.
- The Main contractor's specialist subcontractors shall make appropriate allowance for these requirements in his rates.
- The Main contractor's specialist subcontractors shall, within 24 hours of notification and as directed by the Employer/Employer's representative, undertake at his own expense any remedial works arising from the stated requirements.

5.5 Tree conservation:

- All trees to be conserved shall be protected with a 3-4 foot high enclosure constructed using brick/fencing (with an access gate for tree maintenance) .
- This tree enclosure shall be erected before demolition, grading, or construction begins and remain until final inspection of the project. A 'Warning" sign of size 8.5"x 11" shall be prominently displayed on each protective enclosure to state the following:
- The following activities are prohibited within and in the vicinity of the tree protection zone throughout the entire duration of the construction project:
- Cutting of tree roots by utility trenching, foundation digging, placement of curbs and trenches, or other miscellaneous excavations

- soil disturbance or grade change
- drainage changes
- storage of material, topsoil, vehicles, or equipment
- Activity including but not limited to compaction, grading, construction etc.
- dumping of any material including but not limited to paint, petroleum products, concrete, mortar, dirty water, waste
- use of the tree trunks as a backstop, support or anchorage as
- a temporary power pole, signpost or other similar function
- The following activities are permitted or required within the Tree Protective Zone with approval from Landscape Architect:
- Mulching with wood chips (unpainted/untreated) or approved material to a four to six inch depth, leaving the trunk clear of mulch to prevent inadvertent soil compaction and moisture loss.
- Irrigation, Aeration, fertilization indicated by Landscape Architect for the healthy growth/maintenance of the tree
- if tree is adjacent to or in the immediate proximity to a grade slope of 8% or more, e rosion control measures shall be installed outside the Tree Protection Zone to prevent siltation and/or erosion within the zone

5.6 Plant Protection

- All plant material is to be carefully protected and if necessary wrapped in the nursery during lifting, awaiting transportation, during transportation, unloading and during storage on site.
- Any evidence of unsatisfactory protection to roots, stems, branches and leaves will result in plants being rejected.
- Unprotected plants must not be transported during very hot weather, and all plants must be kept moist during transportation and storage. No plant material shall be left on site unplanted for more than two days.

5.7 Work by Machine or Hand

- All operations herein described shall be carried out by suitable approved machines or by hand.
- Any work around the base of existing trees, in confined spaces or which is impractical to carry out by machine for any reason shall executed by hand and the contractor shall include for this in his rates.

5.8 Notice of Intentions

The contractor shall give forty-eight hours written notice to the Employer/Employer's representative of his intention to commence any of the following operations:

- Setting out, Planting,Topsoiling,Turfing,Sprigging,Maintenance visits,etc.

5.9 Heavy Machinery

Heavy machinery, which would excessively consolidate the sub-soil, shall not be used during any operations nor shall heavy machinery be taken over areas prepared for planting or grassing.

5.10 Substitutions

- If the Main contractor's specialist subcontractor is unable to supply a particular species of plant he is to notify the Employer/Employer's representative in advance of his intention to make a substitution. No substitution will be allowed without prior written agreement of the Employer/Employer's representative.
- Notices of substitutions are to be made sufficiently for in advance of installation to ensure that the substituted material conforms to specifications. Substitutions requested by the Main contractor's specialist subcontractor after work has started on site will not be entertained.

5.11 Setting Out

- The Contractor shall be responsible for accurately setting out all the works prior to the commencement of the works and shall rectify errors in setting out at his own expense.
- Any discrepancy in site area between that shown on the drawings by Landscape Architect appointed by contractor and the actual area on the ground shall be notified to the Employer/ Employer's representative.

- The Contractor shall supply all necessary materials, equipment and labour to enable the Landscape Architect to check the setting out, levels and dimensions on the site along with the Employer/ Employer's representative.

5.12 Tools and Equipment

The Contractor shall use proper tools and equipment for the carrying out of the works and is to ensure that the work force is fully and properly equipped with the correct equipment and experience for the job at hand.

5.13 Failures of Plants (Pre-practical completion)

- Any trees, shrubs, grass or other plants (other than those found to be missing or not in accordance with the Contract Documents as a result of theft or malicious damage and which shall be replaced), which are dead, dying, missing or found not to be have been in accordance with the Contract Documents at practical completion of the Works shall be replaced by the Contractor entirely at his own cost unless the Contract Administrator shall otherwise instruct.
- The Contract Administrator shall certify the dates when in his opinion the Contractor's obligations under this clause have been discharged.

5.14 Plants Defects Liability and Post Practical Completion Care by Contractor

- Any grass which is found to be defective within 12 months, any shrubs, ordinary nursery stock trees or other plants found to be defective within 12 months and any semi-mature, advanced or extra large nursery stock trees found to be defective within 12 months of the date of virtual completion due to materials or workmanship not in accordance with the Contract Documents shall be replaced by the Contractor entirely at his own cost unless the Contract Administrator shall otherwise instruct.
- The Contract Administrator shall certify the dates when in his opinion the Contractor's obligations under this clause have been discharged.
- Malicious Damage or Theft (Before Practical Completion): All loss or damage arising from any theft or malicious damage prior to practical completion shall be made good by the Contractor at his own expense.

5.15 Submittals

- The Contractor shall submit for review drawings by Landscape Architect appointed by contractor completely dimensioned, indicating any pattern layouts, special

installation procedure, cutting, fitting, sinking and adjacent equipment materials for coordination.

- The Contractor shall submit samples of all materials and samples of workmanship for approval by Employer/Employer's representative.
- The Contractor shall be responsible for producing and submitting for comment and approval to the Employer/Employer's representative the shop drawings and samples of all elements indicated in this section. All should be based on the drawings provided by Landscape Architect appointed by contractor. All submissions should be reviewed, approved and endorsed by the PMC.

5.16 Handling, Storage And Delivery

- The Contractor shall:
- Coordinate delivery with suppliers, to minimize handling.
- Handle and store equipment and materials in such a manner that no damage will be done to the materials or the work of other trades.
- Store packaged materials, undamaged in their original wrappings, or containers with manufacturer's labels and seals intact.
- Stack equipment and materials on wooden platforms at least 150mm clear of the ground and protect with weatherproof covers.
- Damaged equipment, material or works will be rejected by the Employer/Employer's representative whether built-in or not.
- For equipment, materials and work, covering shall be of suitable material containing nothing that may injure or stain the materials.

5.17 Protection of Work

- The Contractor shall protect all equipment, materials and completed work from damage until final completion of the work.
- The Contractor shall remove and replace damaged work at no extra cost.

5.18 Reference Standards

- The Contractor shall comply with all relevant Indian Standards, ASTM,NBC, British Standard Code of Practice, Draft BS or DIN Standard applicable to elements indicated in this section, the recommendations and requirements of such

documents shall be considered a minimum standard of such work described and must be complied with.

- Nothing shall relieve the Contractor of his responsibility for providing a higher standard than the relevant Code or Standard where it is required to comply with other sections of the Specification.

5.19 PLANT MATERIALS AND PLANTING OPERATIONS

The following plant descriptions cover the different categories of plant material to be used on the site. These descriptions and their accompanying drawings requirements must be studied carefully and adhered to.

Plants that do not reach the specified dimension or quality, characteristics in this section or in the sizes and descriptions set out in the Bill of Quantities will be rejected and will have to be replaced at the Contractor's cost.

Trees and palms and large feature plants that are growing in open ground are to be prepared for transplanting at least 2 months before moving, either to containers in the nursery or direct to the site.Preparation of in-ground trees and palms shall be by root pruning to the stated rootball dimensions.

Trenching around the outer edge of the rootball using pruning and a sharp spade shall be done in four separate stages trenching in quarters, with one quarter of the tree roots being cut and backfilled each week, the next quarter the following week, with all of the ball being cut in one month.

If roots over 25mm are encountered these are to be cleanly cut with large secateurs or pruning saw.

For trees and palms that are to be containerised or root wrapped, the lifting and placing in containers or being wrapped is to be done immediately after the root trenching operation is complete.

Rootballs are to be wrapped and tied with Gunny sack or hessian sacking if not containerised.

Exposed trunks are to be wrapped in rice straw including the lower parts of the branch system.

Damaged trees will automatically be rejected on arrival at site.

All trees and palms are to be purchased, stored and grown on in suitable nursery conditions within one month of the contract and made ready for direction by the Landscape Architect appointed by Contractor.

Failure to procure within this time and to reveal the source of supply and location will result in the Employer/Employer's representative sourcing the plant materials for the Contractor, and the cost of this sourcing operation will be deducted from the Contractor's payments.

All dimensions shown with tolerances (that is 120 - 150mm) refer to maximum and minimum dimensions that will be accepted. Measurement of all plants of one species shall, as a minimum, average between the upper and lower figures (that is in the above case 135mm).

All trees and palms specified for containerising or root wrapping after root pruning operations are to be well furnished with leaves over the crown of the tree. Thinning of leaves to reduce transpiration to give a 50% cover is permissible providing due notification is given that thinning is required to ensure that the trees can be inspected before thinning work is done. Bare crowned trees will not be permitted.

5.19.1 Trees

a. Heavy Standard Trees

These are large size nursery grown trees pruned during growth to produce a tight well rounded head, and a straight stem clear of leafs or twigs.

Trees shall be 120 - 150mm (5" - 6") circumference of stem when measured 1.0m (3') from ground level and shall have a clear straight stem of minimum 1.8 metres.

The head shall be well balanced and rounded and contain at least four main branches with a well developed secondary branch system and a central leader, giving an overall height of 3.5 - 4.0cm (10' - 13') at the time of planting.

Pruning at the time of removal from the nursery will not be permitted.

In dry weather conditions, trees are to be sprayed with approved Anti-transpirant.

Rootball dimensions: diameter 600mm (2') x 450mm (1'6") deep minimum. Branching/leaf spread to be of 1.8 - 2.0m diameter.

b. Standard Trees

These are nursery grown trees pruned during growth to produce a tight well rounded head, and a straight stem clear of leaves or twigs.

Trees shall be 100 - 120mm circumference stem when measured 0.9m from ground level and shall have a clear straight stem of minimum 1.5mm.

The head shall be well balanced and rounded and contain at least four main branches with a well developed secondary branch system and a defined central leader that has not been pruned, giving an overall height of 2.5 -3.0m at the time of planting.

Pruning at the time of removal from the nursery will not be permitted.

In dry weather conditions, trees are to be sprayed with approved Anti-transpirant.

Rootball dimensions: diameter 500mm (1.6") x 300mm (1') deep minimum. Branching/leaf spread shall be of 1.5 - 1.8m diameter.

c. Standard Feathered Whips

These are medium sized nursery grown trees having a single straight stem and unbroken leader giving an overall height of 2.5 - 3m.

The stem shall be fully furnished with evenly spread and balanced lateral branches down to ground level and shall be 80 - 100 mm circumference of stem when measured 1m from ground level.

The tree shall have a strongly developed fibrous root system and shall be container grown. Leaves or branches shall not be cut off before planting.

Rootball dimensions 450 x 300mm minimum. Branching/leaf spread shall be of 1.5 - 1.8m diameter.

c. Palms

All palms shall be single stem. Single Stem Palms shall have clear straight trunks of heights as stated in the Bill of Quantities as measured from the root collar to the base of the lowest leaf sheath. The stem girth shall be of dimension normally found for palms for the stem height and species specified.

Acceptable tolerances to variations in stem height shall be +200mm or -200mm from the height specified in the Bills of Quantities.

The heads of palms shall be well balanced with at least 7 leaves and a healthy growing apical shoot all free from pest and disease.

Rootball dimensions shall be in proportion to stem heights as follows:

Stem height	Rootball diameter	Depth
1m	400mm	400mm
2m	750mm	600mm
3m	900mm	600mm
4m	1200mm	750mm

Contractor shall provide well grown tree with height more than 1.8 mt.

5.19.2 Shrubs

These are woody perennials of generally multi stemmed and bushy habit ranging from 3 - 4.5m down to 500mm height.

Shrubs shall have no less than three main stems and shall be well balanced and bushy, with strongly developed fibrous root systems, and shall be pruned in advance as required to achieve the specified height tolerances.

Branches shall break from the base of the plant just above the root collar, and shall be well furnished with leaves right down to ground level.

All plants are to be container grown in containers of suitable dimensions for the species.

5.19.3 Herbaceous Plants

These are non-woody perennials usually of a clump forming habit.

Plants shall have a well developed main stem or stems with good symmetry, a healthy root system, free from pest or disease.

Clumps of herbaceous plants shall include rhizomes, corns, tubers or roots and soil undisturbed by lifting with evidence of growing shoots emerging above soil level.

All herbaceous plants are to be grown in containers unless specified as being produced by alternative method.

5.19.4 Groundcover plants

These are low growing, 500mm or less, or prostrate shrubs or herbaceous plants whose habit is to totally cover the soil.

All groundcover species shall be evenly balanced to allow equal growth in all directions.

Plants shall have fully developed roots and leaves.

Rooted cuttings will not be accepted. All plants to be container grown.

Rooted shoots of certain spreading ground cover plants shall be used only where specified, planted as 'sprigs' as opposed to established plants in soil.

Plants shall be rooted shoots and shall have at least one and evidence of vigorous root growth.

Recent cuttings with no root development shall not be acceptable.

5.19.5 Climbers

Climbers are plants whose growth habit is to climb upwards by means of twinning stems, tendrils or clinging roots.

Plants shall be grown to reach the recommended size using stocks no less than one year old, and no more than five years old at the time of the start of the contract.

Plants shall have at least two leader shoots up to the recommended height and a vigorous root system. All plants to be container grown.

5.19.6 Hedging Plants

Hedging Plants shall be shrubs such as Lawsonia, Ixoras, etc as per design requirements of Landscape Architect appointed by contractor as suited to regular clipping, previously prepared to establish a uniform height and complete foliage cover to the stem from ground level upwards.

Plants shall be a minimum overall height of 500mm with a minimum of 4 branches arising from ground level and a strongly developed fibrous root system.

Branches shall be well clothed in leaves down to ground level. All plants to be container grown in suitably sized containers.

Hedging plants shall be prepared by root and branch pruning to achieve the 'box' shape shown, at least 3 months before transplanting.

5.20 Planting Techniques and Accessories

All plants shall be planted to accommodate the spreading root system of the plant to the same soil depth as in the nursery and shall be well watered before removing them from containers. Plants are to be positioned upright and the soil firmed around the roots.

Planting shall be carried out in accordance with the schedule of plants and drawings supplied by Landscape Architect appointed by contractor. The number of each species and variety shall be evenly distributed over the area as indicated on the drawings by Landscape Architect appointed by contractor.

For large areas the outer rows are to be set out first to ensure the correct shape to the bed is established. The remaining plants are then to be evenly distributed to cover the planting area. The Landscape Architect is to be notified in advance if there are too many or too few plants to fill the area required and an assessment of setting out adjustments will be directed accordingly.

Setting out of plants is to be completed and approved by Landscape Architect appointed by contractor before planting into the soil bed can commence.

5.20.1 Staking and Supports

Stakes shall always be used when planting instant trees, standards and single stem palms and for tall shrubs when directed by the Landscape Architect appointed by Contractor.

Stakes shall be in sawn timber of an approved type and be carried out according to the size of plant to be supported. The types of approved staking methods are:

a) Tripod or Quadropod staking for large trees or palms

Three or four stakes each 50 x 50mm section shall be positioned equidistantly around the tree and firmly driven into the ground at angles of between 30 - 40 degrees.

The inner ends of the stakes shall extend beyond the tree stem by not more than 150mm and shall not be higher than 300mm below the lowest branch.

The tree stem shall be wrapped in hessian or gunny sacking at the point where the tree stakes are to be fastened in order to prevent bark damage.

The stakes shall be neatly and firmly fastened to the tree stem using rubber hose or cord; String are not be used.

The stakes are to be adjusted and the position of the protective wrapping is to be altered up or down every month.

The hessian wrapping is to be sprayed with an approved horticultural pesticide.

b) Climber wires

Wires for training climbing plants against walls shall be approved lightweight PVC mesh, fixed at 600mm intervals to screw eyes supplied under the sub contract.

Maximum mesh coverage shall be 180mm high x 240mm wide.

The climbing plants shall be trained through the wire mesh with the shoots directed upwards and tied.

5.20.2 Turfing :Fine Turf

Fine Turf shall consist of fine bladed rhizomatous grass such as Bermuda grass or cultivar specified by Landscape Architects appointed by the Contractor.

Fine Turf shall be a live grass sod or mat at least 300mm square with a well developed root system growing in a minimum of 25mm soil bed, free from stones or extraneous roots, cut mechanically or by hand to give an even thickness and texture.

A sample of one square metre of Fine Turf or both types shall be submitted to the Employer/Employer's representative for approval before fine Turf is brought in for use on site. The source of the material shall be stated by the Contractor.

Fine Turf shall be free from weeds, fungus, pest or disease and contaminants or pollutants. Fine Turf sods shall be kept moist and in shade and shall be planted within 24 hours after lifting.

a. Fine Turfing Operations

Subsoil mix shall be hand raked to provide an even and fine tilth to an even and accurate level matching kerb edge levels. Any lumps or stones over 25mm in diameter brought up in this operation shall be removed from site.

Soil areas shall be lightly sprinkled with water to moisten surface in dry weather before laying turf.Pre-Turfing fertiliser shall be applied to all areas to be turfed prior to turfing at the rate of 40gm per square metre evenly spread over the whole area and lightly worked into the soil. The turves shall be laid on the prepared soil bed and firmed into position in consecutive rows with broken joints, closely butted and to the correct levels. The turf shall be laid off planks working over turves previously laid.

Where necessary, the turves shall be lightly and evenly firmed with wooden beaters, the bottom of the beaters being frequently scraped clean of accumulated soil and mud.

A dressing of finely sifted topsoil/sand/compost mix shall be applied and well brushed into the joints to give an overall even surface.

Watering shall take place over the area that has been turfed immediately after planting. Watering shall be undertaken by use of a fine spray to avoid disturbance of soil particles.

Fine turfing shall only be accepted as complete when new growth has caused turves to knit together and adhere by rooting to the soil bed. Any areas not covered by green healthy grass to the satisfaction of the Landscape Architect within 28 days after fine turfing shall be re-laid as specified at the Contractor's own expense.

If shrinkage occurs or the joints open, finely sifted topsoil/ sand/ compost mix shall be brushed into the gaps and shall be watered in.

Any inequalities in finished levels owing to variation in turf thickness or uneven consolidation of soil shall be adjusted by lifting turves and by re-spreading fine soil mix to correct levels and relaying turves as specified.

The finished level of the Fine Turf shall be 25mm above adjoining paved surfaces or other hard edges after allowing for final settlement.

Turf edges and margins shall be laid with whole turves and uneven edges trimmed to give an even line.

b. Maintenance of Fine Turfing before Completion

Watering shall be carried out as often as necessary before completion to allow a satisfactory green sward to develop over the whole fine turfed area.

Cutting before completion shall be carried out as necessary to keep the grass to a maximum height of 25mm.

One extra fertiliser application is to be allowed for before completion, to be used if directed by the Landscape Architect appointed by Contractor.

Completed fine turfed areas are to be kept in a weed free inset free, fungus free and tidy condition until completion (that is start of maintenance period).

Edge cutting shall be carried out as required along edges of paths, plant beds or other junctions with other materials. Only sharp edge cutting tools are to be used for this operation.

Over cutting or ragged edges will require the relaying of the turf edge strip as specified (that is 300mm wide).

c. Specification for Sourcing of Turf Types

Fine Turf is to be specially prepared horticultural turf, re-lawn or turf-carpet, mechanically cut to specified tolerances.

5.20.3 Slope retention work with Coir Mat Turfing

a) Site Preparation

Sub-grade shall be excavated to proper lines and grades based on construction plans.

The sub-grade shall be fairly smooth and free of sharp objects and debris that may damage the Coir Mat. The soils should be proof rolled prior to Coir Mat and backfill placement.

The soils should be compacted to 95 Percent of the relative density based on the Site Engineer's recommendations.

Above the compacted soil, Top soil mix 'A' to be laid upto 150 mm thick layer for planting turf. Coir mat to be laid first and then planting operation should take place.

b) Laying of Coir Mat

Coir Mat should be placed in correct orientation as shown on the construction plans and approved by the Engineer.

The Contractor should verify the orientation. The orientation of the Coir Mat should be such that it is rolled in the direction of the slope – not perpendicular to it.

The Coir Mat should be cut to length based on construction plans using an Engineer approved cutting tool.

Each sheet of Coir Mat should be pulled taut by hand to get rid of any wrinkles.

Adjacent sheets should be overlapped for minimum width of 0.30 M.

Each sheet may be secured in place using staples, pins, sandbags, backfill, or by other Engineer approved methods to help prevent disruption during the installation of adjacent sheets

Turfing should be done as per procedures mentioned above once Coir mat is installed.

5.20.4 Watering of all Plants

After planting all plants are to be thoroughly watered to soak the ground all around the rootball.

After watering and the water has percolated away leaving e surface relatively dry the soil is to be lightly cultivated to give an even soil tilth.

5.20.5 Mulching

After completion of planting and watering and light cultivation operations a 50mm deep layer of approved mulch shall be spread and forked in over all cultivated planting areas.

Around each tree and palm and around the base of each climber, additional mulch is to be applied to a 50mm depth to a diameter of 600mm.

Mulching is to be done within 2 days of completing planting and watering in.

5.20.6 Fertilising

After a period of settling in of at least one month, all pit planted materials shall be fertilised with an approved slow release fertiliser at the rate of:

Trees : 250gm per tree

Shrubs/climbers : 50gm per plant

Ground Cover/Herbaceous : 100gm per square meter spread

Rooted Shoots : around the base of the plants - 40gm per square meter

All fertilised areas are to be watered immediately after fertiliser application.

5.20.7 Disease Control

The Contractor shall take all necessary precautions to prevent or eradicate any outbreak of disease or insect attack.

5.20.8 Planting into Turf Areas

Where planting is to be carried out in areas of turf, the turf shall be carefully cut to the size of the tree or shrub pit, rolled and stored for re-use, being kept moist and in shade.

After planting is complete stored turf shall be re-laid around the base of the plant.

The Contractor shall replace at his own expense, any turf which is damaged during planting operations.

5.20.9 Protection of Planted Areas

The contractor shall be responsible for protecting all planted areas.

If it is necessary for the Contractor to erect protective fencing, the Contractor shall be responsible for keeping the fencing in position and in good repair until the end of the maintenance period.

Fencing proposals shall be submitted to the Employer/Employer's representative for approval.

Post and string fences shall not be acceptable.

5.20.10 Maintenance prior to Completion

After planting and prior to the onset of the maintenance period, the Contractor shall be responsible for carrying out all necessary measures to ensure that the plant material thrives and becomes established and that the landscape areas are kept in a clean and tidy condition.

The Contractor shall allow for carrying out the following maintenance operations when necessary prior to the onset maintenance period.

The Contractor shall be responsible for replacing any plants which fail to survive as a result of inadequate maintenance operations, poor workmanship or poor quality of plant material prior to completion.

The Virtual Completion Certificate will not be issued until all plants scheduled on the Drawings and Schedule of Works are installed in a healthy condition in the manner specified.

6 SPECIFICATIONS FOR MAINTENANCE WORKS

6.1 General

The Contractor shall maintain the landscape for five years period after the date certified by the Landscape Architect / Engineer in charge that the work has been satisfactorily completed (issue of Certificate of Completion).

The extent of the landscape to be maintained by the Contractor shall be deemed to cover and include all soft landscape areas within the overall project boundaries as shown on the drawings including all existing soft landscape not affected by the contract works and retained intact or nearly so through the end of the contract period as well as all the landscape works covered in the contract scope of works. No additional maintenance charges will be allowed unless specifically agreed to by the Landscape Architect in writing.

- The Contractor shall ensure that a senior qualified supervisor is made available for organising and running the maintenance programme. The Contractor shall also have available an experience foreman who can supervise the workers on a day-to-day basis. An adequate trained labour force of at least 3 workers must be available for routine work and they must be on site for at least half a working day, 5 days per week during the maintenance period. Additional grass cutting operators will be needed to ensure adequate cutting and cleaning.
- The Contractor's Supervisor shall inspect the site once per week during the maintenance period and shall prepare a brief schedule of operations required for the coming week. The format for the schedule of operations will cover each distinct areas of the site such as frontage, rear, courtyard, roof, interior, etc. The schedule shall describe the operations the Contractor intends to carry out in the coming week to cover the items listed in the specification and to ensure that the current weather conditions and growing performances, insect attack, etc is taken into account.
- A copy of this schedule is to be submitted to the Landscape Architect and Employer every week so that a running record of proposed operations can be checked at the maintenance inspections each month. If in the opinion of the Landscape Architect the maintenance works have not been satisfactorily carried out according to site conditions and the specifications, part of the monthly payment will be withheld until the works have been satisfactorily carried out.

- The contractor shall carry out all necessary measures to ensure that all pot plants, trees and shrubs and other plants shall thrive and become established within this period. All landscape areas will be inspected monthly and lists of remedial works issued after each inspection. All items on the remedial lists are to be carried out by the time of the next inspection, ie within one month.
- The Contractor shall keep the landscape areas clean and tidy at all times and dispose of all waste materials arising from the cleaning.
- Fresh water only shall be used for the Works. Water shall be supplied to the Contractor from agreed points on the site. However, it will be only to necessary for the Contractor to supply his own means of transport from the watering points to the plant beds.
- An inspection of watering requirements is to be made by the Contractor at least two times a week in dry weather.
- Water shall be supplied using an approved hose or sprinkler so as not to cause compaction or wash-outs of the soil or loosening of plants. The Contractor shall immediately make good any such damage, soil erosion or outwash and plants loosened by erosion are to replanted or if damaged, replaced.
- All plant beds are to be kept in a weed free condition with a weeding operation once a month. All weeds, stones and rubbish collected from this operation shall be removed from the site to a tip to be found by the Contractor. Herbicides may not be used on this site unless a specific application in writing is made by the Contractor with full back up data on the performance of the chemicals and the particular need for the chemicals use. Approval will in all cases be subject to the Landscape Architect's decision.
- After weeding, at least once per month the soil surface is to be lightly broken up between plants using a pronged fork upto maximum depth of 100mm. Contractor shall Take care not to disturb the root systems of plants. After forking the soil loose, the mulch and loosened soil are to be raked to give an even re-distribution of the mulching materials
- Firming up and adjusting of stakes/ties shall be carried out monthly to ensure that the trees and shrubs are firmly held in the ground. If required guy ropes or tree pits

shall be adjusted, tightened or loosened. If tree ties or ropes are rubbing the bark of the trees, the ties are to be taken off and retied. Any damaged branches are to be carefully pruned and the wounds sealed.

- All protective fencing is to be maintained and kept in good condition and in position until the end of the maintenance period.

6.2 Pruning of Tree/ Shrub

- Trees shall be pruned if dead, rotten or crossed branches are present or to maintain a clear stem up to the specified height using the methods described below. Tree pruning is to be reviewed monthly.
- All shrubs and ground covers are to be reviewed monthly and pruned as and when required during the Maintenance Period to promote bushy growth and good flowering characteristics. The shrubs shall be checked and all dead wood, broken, damaged or crossed branches shall be cut back, depending on species. Pruning and removal of branches is to be carried out using sharp clean implements to give a clean sloping cut with one flat face. Ragged edges of bark or wood are to be trimmed with a sharp knife.

Pruning for all plants shall be carried out as follows:

- Pruning is to be done with the cut just above and sloping away from an outward facing health bud.
- Removal of branches is to be done by cutting flush with the adjoining stem and in such a way that no part of the stem is damaged or torn.Ragged edges of bark are to be trimmed with a sharp knife.
- Any cuts or wounds over 25mm diameter are to be painted with an approved sealant after trimmed. All pruning to be cleared up and removed from site after pruning.
- All hedges, mat forming herbaceous plants and ground cover plants shall be clipped with shears as often as necessary (at least monthly) to maintain a tidy appearance. Tall hedges are to be cut to forms shown on the drawings. Fertiliser is to be applied to clipped areas around 1-2 weeks after clipping.
- Selective pruning of flowering plants shall be done where special flowering characteristics are required such as for Ixoras, Hibiscus, Allamanda where

flowering takes places on twig ends. Heavy clipping must not be used for these species since this will remove future flower buds. Selective pruning by clipping non flowering twigs and leaving flowering twigs is necessary for these plants, and this operation must be done by experienced workers.

- The Contractor shall allow for monthly fertiliser operations during the Maintenance Period. An approved slow release fertiliser shall be applied to each plant at the rate of 50gm per shrub and 200gm per tree, one month after planting and thereafter monthly. After spreading the fertiliser around the base of the plant the granules shall be lightly forked into the soil, and the plant well watered. Herbaceous and ground cover areas shall receive 25mm of approved soil conditioner, evenly spread and mixed with 50gm/m2 of approved slow release fertiliser, evenly spread over entire area and lightly forked into the soil to break up the top layer, and the area well watered on a month by month basis.
- The horticultural requirements of different plants or areas may involve variations to those techniques (such as the use of organic liquid fertilisers for sensitive plants) and variations in method will be authorised as required.
- Heavy feeding plants such as Canna, Heliconia and Lantana shall be dressed with a 25mm mulch of approved organic compost or similar approved compost every 2 months, lightly forked in around the base of the plants.
- Additional mulching layer, 25mm deep to be spread and forked in over all planted areas at 3 monthly intervals.
- The Contractor shall make regular weekly checks to ensure that the plant material is insect and pest and fungus free. No pesticides may be used unless approval from the Landscape Architect is given from the Contractor stating the chemical intended for use; concentration, spraying programme and including full technical details of the product.

6.3 Maintenance of Lawn Areas

- The Contractor shall mow all lawn areas using approved cutting equipment to maintain a close sward to a height of not less than 20mm and not more than 30mm for all grass types.

- Mowing shall be carried out generally weekly, except in dry weather and grass shall not be allowed to flower between cuts.
- Weekly inspections are to be made to ensure adequate planning of grass cuts to suit growth and weather conditions. All clippings to be gathered up and removed from site.
- All grass areas are to be watered by means of sprinklers during dry weather as often as is required to keep the grass green and the soil moist.
- The Contractor shall provide hoses and sprinklers for use from water points provided. Weekly inspections are to be made to determine the need for water and, in dry weather watering must be done to moisten the soil to a depth of 100mm.
- Fertiliser of NPK value 10-15-15 or similar approved be spread at a rate of 40gm/sq m over all grass areas at monthly intervals, using approved spreading equipment to give an overall even spread. Grass areas that have been fertilised shall be watered if no rain falls within 24 hours.
- The Contractor shall apply top-dressing of not more than 15mm depth fine sand and granulated compost raked and spread evenly over the lawn areas. The next top-dressing shall be applied only after the grass has grown through to a mowable height.
- There shall be at least two applications of topdressing during the maintenance period, to be directed by the Landscape Architect appointed by Contractor.
- If depressions or bumps over 25mm deep or high in turf areas during the maintenance period these are to be levelled out by lifting the turf and raising the soil level with sand/compost mix or trimming to level grades, followed by re-turfing.
- Grass areas are to be kept free of weeds, annual grasses, fungus and insect attack and free of stones or other debris throughout the maintenance period as often as is required.
- All chemicals used shall be to the approval of the Employer/Employer's representative. Assessment of these operations is to be prepared on the basis of the weekly maintenance inspection chart.
- If compaction or consolidation takes place or hard passing or baking of the soil occurs, the soil areas are to be well watered first and lightly loosened by mechanical

means such as spiking, slitting or hollow tinning using equipment approved by the Employer/Employer's representative.

6.4 Replacement Planting

- If during the course of the Maintenance Period trees or shrubs or other plants die because of a fault by the Contractor, the Contractor shall replace the plant at no cost to the Employer.
- All questions related to responsibility for the replacement planting will be subject to site inspection and agreement of the appointment of responsibility.
- This will be done very month at the monthly maintenance inspections.

6.5 Final Handover

- Two weeks before the end of the Maintenance Period a joint inspection shall be held with the Maintenance Agency, Contractor and the Employer/Employer's representative review the requirements for alteration or replacement in order to gain approval for Final Handover.
- In order to ensure satisfactory handover procedures, the site meetings held each month between the Contractor and Employer/Employer's Representative will be used to inspect and approve the maintenance works which will be reviewed to ensure adequate work has been done.
- At the time of the final inspection, all areas under this contract shall be free of weeds, neatly cultivated and raked, and all plant boxes in good order.
- Grass shall be neatly cut and all clippings removed. No bare patches of earth shall be visible in turf or planting areas unless specified (that is rings around tree trunks).
- If, after this inspection, the Employer/Employer's representative is of the opinion that all work has been performed in accordance with the drawings and specifications, the Employer/Employer's representative will give written letter of acceptance and completion of the project.
- If, all or certain portions of the work are not acceptable under the terms and intent of the drawings and specifications, the formal maintenance period for all the work shall be extended at no cost to the Employer/Employer's representative until the defects in the work have been corrected and the work is accepted by the Employer/Employer's representative.

7 LIST OF PLANTS

List Of Plants Envisaged For Gardening

Sr. No.	Plant Type & Zones	
	Large Shrubs - General	**Common Name**
1	*Bougainvillea glabra*	*Bougainvillea*
2	*Bougainvillea shrubhra (White)*	*Bougainvillea*
3	*Caesalpinia pulcherrima*	*Sandhesharo*
4	*Nerium oleander (White and Pink)*	*kaner*
5	*Tecoma gaudi chaudi*	*Piliya*
6	*Thevetia peruviana*	*Peeli kaner*
	Trees, Shrubs & Bulbs for Fragrance garden	
1	*Millingtonia hortensis*	*Ākāsh Limbdo*
2	*Nyctanthes arbor-tristis*	*Parijat*
3	*Cestrum diurnum*	*Din Ka Raja*
4	*Jasminum sambac*	*Mogra*
5	*Nerium oleander dwarf*	*kaner*
6	*Plumeria pudica*	*Champa*
7	*Murraya paniculata*	*Jaswanti / Kamini*
8	*Cestrum nocturnum*	*Raat ki Rani*
9	*Polianthes tuberosa*	*Rajanigandha*
	Groundcovers	
1	*Wadelia trilobata*	*Pila Bhangara*
2	*Asparagus meyerii*	*Shatavari*
3	*Phyllanthus Niruri*	*Bhuiamla*
4	*Hedera helix*	*English ivy*
5	*Aegopodium podagraria*	*Bishop's weed*
	Plants for Shrubbery & Hedge Preparation	
1	*Golden Duranta*	*Duranta*
2	*Duranta varigated*	*Duranta*
3	*Ficus nitida*	*Ficus*
	Trees & Shrubs for Colour Garden	
1	*Canna generalis lineata Red*	*Canna*
2	*Ixora duffi*	*Ixora*
3	*Lantana Yellow*	*Wild Sage*
4	*Lantana camara depressa*	*Wild Sage*
5	*Plumbago capensis blue*	*Nila chitrak*
6	*Lantana blue*	*Wild Sage*
7	*Verbena bipinnatifida*	*Purple verbena*
8	*Hamelia patens dwarf*	*Hummingbird bush*
9	*Lantana red variegated*	*Wild Sage*
10	*Delonix regia*	*Gulmohar*

11	*Cassia fistula*	*Garmalo / Amaltash*
12	*Spathodea campanulata*	*African Tulip*
13	*Lagerstroemia speciosa*	*Crape Myrtle*
14	*Erythrina indica variegated*	*Pangara*
	Tree List: General Plantation	
1	*Albizia lebbeck*	*Siris*
2	*Alstonia scholaris*	*Saptaparni*
3	*Azadirachta indica*	*Neem*
4	*Bauhinia purpurea*	*Kachnar*
5	*Cassia fistula*	*Garmalo / Amaltash*
6	*Cordia sebestena*	*Lal Lasora*
7	*Delonix regia*	*Gulmohar*
8	*Erythrina indica variegated*	*Pangara*
9	*Lagerstroemia speciosa*	*Pride of India / Crape Myrtle*
10	*Peltophorum pterocarpum*	*Pila Gulmohar*
11	*Plumeria alba*	*Champa*
12	*Plumeria rubra*	*Champa*
13	*Samanea saman*	*Rain Tree*
14	*Spathodea campanulata*	*African Tulip*
15	*Roystonea regia*	*Royal palm*
	Tree List: Medicinal Garden	
1	*Azadirachta indica*	*Neem*
2	*Emblica officinalis*	*Amla*
3	*Aegle marmelous*	*Bel*
4	*Commiphora wightii*	*Guggul*
5	*Terminalia chebula*	*Hirada*
6	*Terminalia bellerica*	*Behda*
7	*Saraca Asoca*	*Ashoka*
8	*Mesua Ferrea*	*Nag Champa*

Note : These are the tentative plant list the bidder shall submit the planting plan in consult with Landscape architect . The proposed plant list shall have native trees and shrubs and grow well in local climate.

8 SPECIFICATIONS FOR HARDSCAPE WORKS

8.1 TECHNICAL SPECIFICATION OF MATERIALS

Materials shall be of the approved quality best obtainable. A list of materials of approved

a) brand(s) is indicated in the annexure. Testing of materials of approved brand(s) may have to be done at the discretion of Architect/Employer. The cost to be borne by the contractor.

b) In case, for some reason or other materials are required to be obtained from any manufacturer other than those listed, then prior approval from Architects will be necessary supported by a relevant test certificates qualifying the required standard.

c) Further tests as directed by the Architects/PMC shall also be carried out by the contractor at their own cost, if required.

d) Samples of all materials including the sources shall be got approved before placing order and the approved sample shall be carefully preserved in an appropriate manner at the site office for verification from time to time.

e) For standard bought out times, the sizes manufactured by the firms listed, shall prevail when there is discrepancy in the sizes mentioned in the schedule without any financial adjustment.

f) Materials shall be tested in any approved Testing Laboratory conforming to the requirements and frequency indicated in the list of Mandatory test. The test certificate in original shall be submitted to the Architects and entire charges connected with testing including charges for repeated tests if ordered, shall be borne by the contractor.

g) It shall be obligatory for the contractor to furnish certificates(s), if demanded by the Architects, from the manufacturer or the material supplier that the work has been carried out by using their material and as per their recommendations.

h) All materials supplied by the Employer/any other specialist firms shall be properly stored and the contractor shall be responsible for its safe custody until they are required on the works and till the completion of work.

i) The contractors without any extra cost shall provide all equipment and facilities for carrying out field tests on materials.

j) Unless otherwise shown on the drawings or mentioned in the Schedule of quantities or special specifications, the quality of materials, workmanship, dimensions etc. shall be followed hereunder.

8.2 PLAIN CEMENT CONCRETE WORK

For foundations shall be mixed in proportion and with ingredients as specified in the schedule of quantities. The concrete shall be mixed in a mechanical mixer. No more concrete shall be mixed than can be consumed within half an hour. It shall be deposited gently in the trenches in horizontal layers not more than 30 cm. thick and rammed and consolidated with steel rammers of 5 to 6 kg. Weight. After laying and consolidation is completed watering twice a day for a week from the next day shall be done.

8.3 Bricks Masonry:

- All bricks used on the works shall be burnt clay building bricks of second class quality having minimum crushing strength of 35 Kg/Sq.cm. and shall conform to IS: 1077 latest. All bricks shall be uniform in quality and size. The bricks shall be got tested as per IS: 3495 latest at the Contractor's cost.
- Bricks shall be unloaded by hand and carefully stacked and all broken bricks shall be removed from site. - All bricks shall be subject to inspection on the site and shall be to the approval of the Engineer who may reject such consignments as are considered by him to be inferior to the quality specified.

8.4 Mortar: (DDK)

All mortar shall be prepared in accordance with IS: 2250 latest. The sand used shall conform to IS: 2116 latest and the water shall conform to relevant clauses of Concrete of this specification. Only river sand should be used. Re-stamping of set mortar will not be permitted

Unless otherwise specified in the Schedule of Quantities, the cement mortar proportion shall be asfollows:

i) 115mm thick brickwork and hollow brickwork 1:4

ii) 230 mm thick brickwork and hollow brickwork 1:6

8.5 Construction

- All masonry work shall comply with the requirements of IS: 2212 latest. It shall be of English Bond. All closure bricks, etc. necessary to comply with the requirements of the bond specified or to brick joints effectively shall be procured by the Contractor and used for the work.

- Ordinarily there shall be four courses per 0.3 m height or in other words, the horizontal bed joints shall be on average 10 mm thick, and the vertical joints 6 mm wide. The mortar shall be worked up to all joints and no hollow space shall be left in any portion of the work. All joints shall be laid truly horizontal and all vertical joints shall be truly vertical. Masonry work shall be raised in a uniform manner so that no one portion is being raised more than 1.0 m above another portion at one time.
- For half brick-walls (115 mm thick) which exceed 2.0 m in height, a reinforced concrete band 75 mm thick (concrete band M-15/i0) shall be provided at intervals not exceeding 1.0m. the reinforcement in these bands shall consist of 2 no 6 m. mild steel rounder with 6 mm binders spaced at 150 mm centre to centre. Such band shall also be provided at the free edge of all masonry work including window sills and top of free standing walls.
- All bricks shall be thoroughly soaked by keeping them under water for at least 12 hours before use; the practice of dipping bricks in water just before use will not be allowed. All necessary water cisterns for this purpose shall be constructed or tubs brought by the Contractor to the satisfaction of the Engineer to ensure proper soaking of bricks.
- No bats or broken bricks are to be used otherwise than as closures. No under burnt or over burnt bricks shall be used.
- All concrete block work shall conform to IS: 2572. Well dried blocks shall be laid dry and shall only be moistened to the extent required to compensate the absorption of water from the mortar. Pieces of blocks shall not be used except where they are absolutely necessary to make a closure.
- Un-coursed Random Rubble Masonry

Un-coursed Random Rubble Masonry Foundation, Plinth and Superstructure

a) Materials

Stones for the works shall be of the specified varieties which are hard, durable, fine grained and uniform in colour (for superstructure work) free from veins, flaws and other defects. Quality and work shall conform to the requirements specified in IS: 1597 (Part-1). The percentage of water absorption shall not exceed 0.5 percent as per test conducted in accordance with IS: 1124. The CONTRACTOR shall supply sample stones to the ENGINEER for approval. Stones shall he laid with its grains horizontal so that the load transmitted is always perpendicular to the natural bed.

Cement-sand mortar for stone masonry works shall be in the proportion of 1:6 unless otherwise specified in the respective items of work. Materials and preparation of mortar shall be as specified in clause 3.1.

b) Workmanship

For all works below ground level the masonry shall be random rubble un-coursed with ordinary quarry dressed stones for the hearting and selected quarry dressed stones for the facing.

For all works above ground level and in superstructure the masonry shall be random rubble un-coursed, well bonded, faced with hammer dressed stones with squared quoins at corners. The bushings on the face shall not be more than 40 mm on an exposed face and on the face to be plastered it shall not project by more than 12 mm nor shall it have depressions more than 10 mm from the average wall surface.

Face stones shall extend back sufficiently and band well with the masonry. The depth of stone from the face of the wall inwards shall not be less than the height or breadth at the face. The length of the stone shall not exceed three times the height and the breadth on base shall not be greater than three-fourths the thickness of wall nor less than 150 mm. The height of stone may be upto a maximum of 300 mm. Face stones or hearting stones shall not be less than 150 mm in any direction.

Chips and spalls shall be used wherever necessary to avoid thick mortar joints and to ensure that no hollow spaces are left in the masonry. The use of chips and spalls in the hearting shall not exceed 20 percent of the quantity of stone masonry. Spalls & chips shall not be used on the face of the wall and below hearting stones to bring them to the level of face stones.

The maximum thickness of joints shall not exceed 20 mm. All joints shall be completely filled with mortar. When plastering or pointing is not required to be done, the joints shall be struck flush and finished as the work proceeds. Otherwise, the joints shall be raked to a minimum depth of 20 mm by a raking tool during the progress of the work while the mortar is still green.

Through or bond stones shall be provided in walls up to 600 mm thick and in case of walls above 600 mm thickness, a set of two or more bond stones overlapping each other by at least 150 mm shall be provided in a line from face to back. In case of highly absorbent types of stones (porous lime stone and sand stone, etc.) the bond stone shall extend about two-thirds into the wall and a set of two or more bond stones overlapping each other by at least 150 mm shall he provided. Each bond stone or a set of bond stones shall be provided for every 0.5 sq.m of wall surface.

All stones shall be sufficiently wetted before laying to prevent absorption of water from the mortar. All connected walls in a structure shall be normally raised uniformly and regularly. However if any part of the masonry is required to be left behind, the wall shall he raked back (and not saw toothed) at an angle not exceeding 450. Masonry work shall not be raised by more than one metre per day.

Green work shall be protected from rain by suitable covering. Masonry work shall be kept constantly moist on all the faces for a minimum period of seven days for proper curing of the joints.

Type of scaffolding to be used shall be as specified in clause 3.2.

Installation of miscellaneous inserts in the masonry shall be as specified in clause 3.2.

8.6 Concrete Block Masonry

a) Materials

Masonry units of hollow and solid concrete blocks shall conform to the requirements of IS: 2185 (Part 1).

Masonry units of hollow and solid light-weight concrete blocks shall conform to the requirements of IS: 2185 (Part 2).

Masonry units of autoclaved cellular concrete blocks shall conform to the requirements of IS: 2185 (Part 3).

The height of the concrete masonry units shall not exceed either its length or six times its width.

The nominal dimensions of concrete block shall be as under.

- Length 400,500 or 600 mm.
- Height 100 or 200 mm.
- Width 100 to 300 mm in 50 mm increments

Half blocks shall be in lengths of 200, 250 or 300 mm to correspond to the full length blocks. Actual dimensions shall be 10 mm short of the nominal dimensions.

The maximum variation in the length of the units shall not be more than ±5mm and maximum variation in height or width of the units shall not be more than ±3mm.

Concrete blocks shall be either hollow blocks with open or closed cavities or solid blocks.

Concrete blocks shall be sound, free of cracks, chipping or other defects which impair the strength or performance of the construction. Surface texture shall be as specified. The faces of the units shall be flat and rectangular, opposite faces shall be parallel and all arises shal1 be square. The bedding surfaces shall be at right angles to the faces of the block.

The concrete mix for the hollow and solid concrete blocks/light weight concrete blocks shall not be richer than one part of cement to six parts of combined aggregates by volume i.e. (1:6).

Concrete blocks shall be of approved manufacture, which satisfy the limitations in the values of water absorption, drying shrinkage and moisture movement, as specified for the type of block as per relevant IS code. CONTRACTOR shall furnish the test certificates and also supply the samples, for the approval of Engineer.

b) Workmanship

The type of the concrete block, thickness and grade based on the compressive strength for use in load bearing and/or non-load bearing walls shall be as specified in the respective items of work. The minimum nominal thickness of non-load bearing internal walls shall be 100 mm. The minimum nominal thickness of external panel walls in framed construction shall be 200 mm.

The workmanship shall generally conform to the requirements of IS: 2572 for concrete block masonry, IS: 6042 for light weight concrete block masonry and IS: 6041 for autoclaved cellular concrete block masonry works.

From considerations of durability, generally concrete block masonry shall be used in superstructure works above the damp-proof course level.

Concrete blocks shall be embedded with a mortar which is relatively weaker than the mix of the blocks in order to avoid the formation of cracks. Cement mortar of proportion 1:6 shall be used for the works unless otherwise specified in the respective items of work. Preparation of mortar shall be as specified in clause 3.1 to 3.1.

The thickness of both horizontal and vertical joints shall be 10 mm. The first course shall he laid with greater care, ensuring that it is properly aligned, levelled and plumb since this will facilitate in laying succeeding courses to obtain a straight and truly vertical wall. For the horizontal (bedding) joint, mortar shall be spread over the entire top surface of the block including front and rear shells as well as the webs to a uniform layer of 10 mm. For vertical joints, the mortar shall be applied on the vertical edges of the front and rear shells of the blocks. The mortar may be applied either to the unit already placed an the wall or an the edges of the succeeding unit when it is standing vertically and then placing it horizontally, well pressed against the previously laid unit to produce a compacted vertical joint. In case of two cell blocks with slight depression on the vertical sides these shall also be filled up with mortar to secure greater lateral rigidity. To assure satisfactory bond, mortar shall not be spread too far ahead of actual laying of the block as the mortar will stiffen and lose its plasticity. Mortar while hardening shrinks slightly and thus pulls away from the edges of the block. The mortar shall be pressed against the units with a jointing tool after it has stiffened to effect intimate contact between the mortar and the unit to obtain a weather tight joint. The mortar shall be raked to a depth of 10 mm as each course is laid to ensure good bond for the plaster.

Dimensional stability of hollow concrete blocks greatly affected by variations of moisture content in the units. Only well dried blocks should be used for the construction. Blocks with moisture content more than 25% of maximum water absorption permissible shall not he used. The blocks should not be wetted before or during laying in the walls. Blocks should be laid dry except slightly moistening their surface on which mortar is to be applied to obviate absorption of water from the mortar.

As per the design requirements and to effectively control cracks in the masonry, RCC bond beam/studs, joint reinforcement shall he provided at locations as per details indicated in the construction drawings. Joint reinforcement shall be fabricated either from mild steel wires conforming to IS: 280 or welded wire fabric/high strength deformed bass as per the drawings.

For jambs of doors, windows and openings, solid concrete blocks shall he provided. If hollow units are used, the hollows shall be filled with concrete of mix 1:3:6. Hold fasts of doors/windows should be arranged so that they occur at block course level.

At intersection of walls, the courses shall laid up at the same time with a true masonry bond between atleast 50% of the concrete blocks. The sequence for construction of partition walls and treatment at the top of load bearing walls for the RCC slab shall be as detailed under clause 3 for the brick work.

Curing of the mortar joints shall be carried out for atleast 7 days. The walls should only be lightly moistened and shall not be allowed to become excessively wet.

Double scaffolding as per clause 3.2 shall be adopted for execution of block masonry work.

Cutting of the units shall be restricted to a minimum. All horizontal and vertical dimensions shall be in multiples of half length and full height of units respectively, adapting modular co-ordination for walls, opening locations for doors, windows etc.

Concrete blocks shall be stored at site suitably to avoid any contact with moisture from the ground and covered to protect against wetting.

9 WATER PROOFING

INTEGRAL CEMENT BASED WATER PROOFING TREATMENT OF UNDER GROUND WATER TANKS, SWIMMING POOLS, BASEMENTS ETC. FROM OUTSIDE:

9.1 On Horizontal Surfaces

a) **Preparing the Surface**

The water proofing treatment over the lean concrete/levelling course surface should adhere to the surface firmly. The surface of levelling course should be roughened when the concrete is still green. In case the surface is not made rough in the initial stages itself (i.e. before the concrete is set, the work of water proofing shall not be permitted till proper key is provided for

the 25 mm thick base layer. This key cannot be achieved by hacking the already set concrete surface, instead a spatter-dash key should be provided without any extra cost, as it is the respon sibility of the contractor to roughen the surfaces properly over which plaster or similar coat is to be laid.

b) Blending Cement/Water with Water Proofing Compound

Mixing water-proofing compound in powder or liquid form, to already prepared cement mortar shall not be allowed. **Blending Cement** with water-Proofing Compound shall be prepared as followed:

i.The required quantity of cement bags to be used for a particular portion of work should be sorted out and the contents of each bag should be emptied on a suitable dry platform. Water proofing compound in powder form manufactured by reputed approved manufacturer, bearing ISI mark, conforming to IS 2645 should be mixed with the contents of each bag. The quantity of water proofing compound to be mixed should b e as prescribed by the manufacturer but not exceeding 3% by weight of cement.

ii. The quantity of cement (50 kg) and water -proofing compound in powder form should be mixed thoroughly, blended by employing skilled labourers and the cement thus blended should ag ain be packed in gunny bags so that the material can be readily used for preparing mortar/slurry for the water proofing works, to achieve best results.

Note: Unless otherwise specified, all waterproofing works shall be carried out using blended / PPC cement.

a) Blending Water with Liquid Water Proofing Compound.

- In case the water proofing compound to be used is in liquid form then instead of blending cement with water-proofing compound the water to be used in the particular mix should be blended with water proofing compound.
- This shall be done by taking just required quantity of water to be mixed in the particular batch of dry cement mortar. The required quantity of water thus collected per batch of dry cement mortar to be prepared should be mixed with liquid water-proofing compound from sealed tins with ISI mark and manufactured by reputed approved manufacturer.
- The water thus mixed with water -proofing compound shall be stirred so that the water is blended with water proofing compound well.

- The quantity of blended water thus prepared should only be used per batch of dry cement mortar/dry cement to make slurry to be used for water -proofing works to achieve the best results.

Note: Use of cement mixed with water -proofing compound is referred as “blended c ement” in this chapter which shall mean use of water proofing compound in powder/liquid form for use in cement mortar/slurry.

b) Rough Shahabad stone:

The stone slabs to be used for this item shall be carefully selected for uniform thickness. Stones with varying thicknesses shall not be permitted to be used. Unless otherwise specified, the size of rough Shahabad stone shall not be less than 300x300mm and thickness 22mm (+/ -) 3mm.

c) Preparation of Cement Slurry

Cement slurry normally prepared and used on general building works with just 1.50 to 2 kg of cement to cover an area of one sqm shall not be applicable for such works instead it should have thick honey like consistency. Each time only that much quantity of slurry shall be prepared which ca n be covered on the surface **and** the surface in turn would be covered with 25 mm thick cement mortar base within half an hour. Slurry prepared and remained un -used for more than half an hour shall be totally rejected.

d) Preparation of Cement Mortar

The cement mortar 1:3 (1 blended cement : 3 sand) shall be prepared with cement / water duly blended. Each time only that much quantity of cement mortar that can be consumed within half an hour, shall be prepared. Any quantity of cement mortar that is prepar ed and remains unused for more than half an hour shall be totally rejected.

e) Laying Water Proofing Course

First layer : 25 mm thick Base Course in Cement mortar 1:3

- Before laying the first course of cement mortar 1:3 base the lean concrete surface s hall be cleaned neatly with water and cement slurry shall be applied only on the area of the concrete surface, that can be covered with the cement mortar (1:3) base course within half an hour.

- The cement slurry should cover every spot of the surface and no place shall remain uncovered.
- Just after the application of cement slurry on the surface, the cement mortar should be used for laying the base course.
- For laying base course to a perfect level at least 3 Nos. 25mm high wooden strips with 3 legs shall be placed on the concrete surface at suitable distances and the cement mortar shall be laid to the exact level of the strips and tamped gently. The top surface should be finished neatly and later scratched when green with a suitable instrument.
- Before the base course dries and gets hard that is just before the base course takes up initial set, the 2nd layer of Shahabad stone/slab cladding shall be taken up immediately.

Note : As far as possible work of different layers of this water proofing treatment shall be taken up in immediate succession without allowing any time gap in between the layers, otherwise it would be difficult to achieve homogenous treatment, which is the basic necessity.

Second layer : Shahabad stone.

- When the 25 mm thick base course is just getting set the cement slurry should be spread over the base course up to the area that shall be covered with just two to three stone slabs.
- The Cement slurry shall be spread in such a way that the area of base course to be covered immediately shall be covered with slurry without any gap, or dry spots.
- Each time only the area that is required to clad two to three stone slabs shall be taken up for spreading the slurry and only after fixing the stone slabs over the slurry further area shall be taken up.
- Immediately on applying cement slurry on the base course the Shahabad stone slabs shall be laid over the base course and pressed gently so that the air gap can be removed.
- The slurry applied on the surface which gets spread when the stone slab is pressed shall get accumulated in the joints of adjacent stone slabs and if any gap still remains between the stone slabs the same should also be filled with additional quantity of cement slurry.
- For laying the stone slabs in perfect level, two slabs at adjacent corners/en ds shall be fixed firmly to the required level and a string stretched over the two slabs, the intermediate slabs shall then be set to the level of the string.

Third layer : 25 mm thick course in cement mortar 1:3

- On filling all the joints of the Shahabad s tone slabs with cement slurry and after a gap of 6 to 8 hours the area of stone slabs shall be cladded with cement mortar 1:3.
- The surface of stone slabs shall be cleaned and lightly watered. The cement mortar (1:3) shall be used for laying this course, no cement slurry need be used and the mortar can be laid on the slab surface directly.
- For laying this course in perfect level, 25mm high wooden strips with legs used for laying base course shall be used and the top surface shall be finished smooth without u sing additional cement or slurry.

Fourth Layer : Top Finish with Stone Aggregates 10 to 12 mm Size

- Immediately after laying 3rd course and before the cladded mortar takes the initial set, stone aggregate of 10mm to 12mm nominal size shall be pressed into t he finished surface @ 8 cudm/sqm.
- The aggregates though embedded shall be clearly visible on the surface, i.e. the stone aggregates shall not be embedded totally inside the mortar.

Note: This treatment is provided over the surfaces which are originally in slope or in level & no attempt under any circumstances shall be made to provide any slope by altering the 25 mm thickness of base course, to lay the water -proofing course in slope.

In case a slope is to be provided for the water proofing layer on a surface which is in perfect level, grading with additional cement concrete/cement mortar shall be provided and then the water-proofing layer shall be laid on the graded surface.

f) Curing

i. **Water Proofing on Lean Concrete Surface**

Immediately after completing the fourth layer, arrangements shall be made to lay the top RCC slab as quickly as possible and in the mean time till the top slab is concreted the water proofing treatment shall be kept wet continuously. In case the concreting of slab gets delayed for more than 2 weeks the curing can be stopped after 14 days.

ii. Water Proofing on Horizontal Surface of the offset of floor slab.

The water proofing treatment done on the offset of the floor slab shall be kept wet continuously for 14 days minimum.

9.2 On Vertical Surfaces

The vertical water proofing treatment either from inside or outside shall be undertaken only when the entire work is structurally complete.

a) **Preparing the Surface and Providing Ancillary Arrangements.**

- The surface of the structure to be treated shall be roughened properly either by raking joints when the mortar is still green in case of brick/stone masonry structures, or by hacking the cement concrete surface with a specially made hacking tool just after removing the shuttering.
- In case the raking joints/hacking concrete surface is not done properly the only alternative method to make the surface rough by **"Spatter dash key"** (a special hacking tool), which shall be done by the contractor without any extra cost.
- For doing the water proofing treatment from outside or inside, al -round scaffolding shall be erected which shall be strong enough to support the stone slabs . Also proper strong scaffold boards, strong ladders and coir ropes shall be made available for using while erecting the stone slabs. Similarly, while doing the water proofing to vertical faces from inside, a particular care shall be taken to see that the water proofing layer of floor slab is not get damaged while resting the vertical props of scaffolding. As a precaution it is advised to rest the bellies on the strong and proper size sole piece placed on the horizontal water proofing treatment of the floor slab.
- Alternatively water proofing for vertical surface shall be provided before horizontal floor slab water proofing. In order to arrest any leakage through junction of vertical/horizontal water proofing, a proper haunch in cement concrete shall be provided.
- For the stone slabs that are used for arresting the leakages, while executing this type of water proofing treatment , the first and foremost mandatory condition is that the number of joints in the portion covered by the stone slabs shall be minimum and this condition can be achieved only by using the maximum possible size of stone slabs. Normally the size of stone slabs used for the purpose is 600 x 600mm x 900mm each stone slab weighing approximately 16 kg and 25 kg respectively.
- The Rough Stone slabs used for such works though are basically rough on the surface still that much roughness will not be sufficient for the stone slabs to remain in vertical position held by cement slurry. Therefore the grip for the stone slabs has to be increased and this can easily be done by planting 12mm to 15mm nominal size stone aggregate fixed with araldite on the face of each stone slab.

- A 20mm thick clear gap has to be formed between the masonry/concrete surface and the stone slabs erected in vertical position for pouring the cement slurry. This gap can be maintained by fixing with araldite the 20mm x 20mm cover blocks made out of rich cement mortar on the four corners of the stone slabs and also at centre.

b) Preparation of Cement Mortar (1:4)

Cement mortar shall be prepared as explained above except that the proportion shall be 1:4 (1 Blended Cement : 4 Coarse sand) instead of 1:3 .

c) Fixing Water Proofing Courses on Vertical Surfaces. Note:

- Normally the item of work prescribes executing the first layer as base course with Cement slurry, second layer fixing rough Shahabad stone slab, third layer as plastering the surface and the fourth layer as finishing surface with neat cement punning, but in actual execution, a gap of 20mm width has to be formed for pouring cement slurry. The 20mm wide gap can be formed by erecting the 20 mm thick Shahabad slab at a distance of 20 mm from t he Masonry/concrete surface, over which the cement slurry is to be cladded and can be termed as first step for construction.
- Hence for all practical purposes, chronology of layers shall be considered as per actual construction i.e. as laid in particular se rial and not as actually formed later. To avoid confusion and to distinguish between the two different layers laid and the actual work executed, actual working is termed as Step I, Step II etc.

Step I: Erecting Shahabad Stone Slab forming 20mm wide gap.

- The Shahabad Stone slab duly fixed with 20 x 20 mm cover blocks and 12 to 15mm size stone aggregate on the surface shall be erected against the masonry/concrete surface to be treated by abutting the 20mm thick cover block against the surface, thus forming a clear gap of 20 mm.
- The stone slabs thus erected shall be supported with ballies/pipes to the scaffolding already erected for the purpose.
- The joints of stone slabs shall be temporarily closed from outside with cement mortar so that the cement slurry poured in the gap does not escape through the joints. The bottom portion of the stone slabs shall also be closed with cement mortar.
- While erecting the stone slabs, proper care shall be taken to see that stone slabs are of uniform size. In case similar width slabs are used, it shall be ensured that these are not fixed at the corners but the same should be at the middle portion.

- Interlinking of the Shahabad Stones of horizontal layer of water proofing with this vertical layer of water proofing shall be done very carefully, as per standard practice.
- The Stone slabs shall be erected in perfect plumb and fixed in position and it will be considered as 2nd layer of water proofing on completion.
- Further lifts of Shahabad Stone slabs up to the full height of the masonry/ concrete wall shall be erected only after filling the gap of each lift erected, with cement slurry.

Step II : Filling Cement Slurry in the gap formed by erecting Shahabad Stone Slabs:

- When the first lift of stone slabs are erected and checked to be in per fect plumb, cement slurry shall be poured in the gap till the gap is filled completely.
- The further filling of slurry in the second lift shall be done when the second lift of stone slabs are erected in position and thus the work on 2 nd and 1st layer of the item shall be completed simultaneously till the cladding over the entire height of the wall is complete.
- Thus on completion of filling cement slurry and erecting stone slabs for the entire height of the wall, it can be considered that the first layer (i.e the layer of cement slurry) and the second layer (i.e. the layer of erecting Rough Shahabad Stone Slabs) is complete as per the item.

Step III : 3rd Layer: Plastering Over 2nd layer with Cement Mortar 1:4 (1 Blended Cement : 4 Sand)

- Immediately on completion of the work of cladding the entire masonry/ concrete wall with Shahabad Stone slabs, the cement mortar applied over the joints shall be removed and the joints exposed. The entire surface shall be cleaned with water neatly to start the plastering work.
- Cement mortar 1:4 (1 blended cement : 4 coarse sand) shall be used for the purpose. Care shall be taken to see that the 20mm thickness of cement plaster over the entire surface is maintained correctly.
- The work of plastering shall be taken up immediately o n completion of cladding the wall surface, rather it should be a continuous process from the day of starting the erection of stone slabs till the finishing work of plastering is done.
- The plastering shall be done from top to bottom without leaving any join t. As far as possible the joints in plaster shall be minimum. In case a joint has to be left to continue the

work on the subsequent day, cement slurry shall be applied over the entire joint, and then only the further work of plastering shall be taken up.

Step IV:4th Layer: Finishing with Neat Cement Punning:

When the surface of plastering is still green, the cement slurry shall be applied over the plastered surface and the surface shall be finished neatly to a smooth surface with specially made semi rounded thapis. The surface should show a smooth and neat finish without any undulations.

Curing and Testing: On completion of water proofing course from outside, the tank shall be cleaned from inside, scaffoldings shall be removed and tank is gradually filled with water for testing, which shall commence within two or three days. The exposed faces of the water proofing course shall be kept wet for 14 days. No back filling shall be done before expiry of 14 days from the date of completing the water proofing course from outside

Horizontal Surfaces	**Vertical Surfaces**				
Layers	**Details of Layer**	**Thickness**	**Layers**	**Details of Layer**	**Thickness**
First Layer	25mm thick base course in C.M 1:3	25mm	First layer	Base course with cement slurry	20mm
Second Layer	Shahabad Stone Slab	22(+/-) 3mm	Second Layer	Shahabad Stone Slab	22(+/-) 3mm
Third Layer	Finishing with CM 1:3	25mm	Third Layer	Plastering II Layer with CM 1:4	20MM
Fourth Layer	Embedding 10 to 12mm Aggregates in third layer	----	Fourth Layer	Punning with neat cement	---
	Total Thickness	**72 (+/-) 3mm**		**Total Thickness**	**62 (+/-) 3mm**

10 FINISHING WORKS

FINISHING WORKS	
IS 1542	Sand for plaster
IS 1661	Code of practice for cement and cement-lime plaster finishes on walls and Ceilings
IS 1625	Code of practice for preparation and use of lime mortar in buildings
IS 2250	Code of practice for preparation and use of masonry mortars
IS 712	Building limes
IS 1635	Code of practice for field slacking of lime and preparation of putty.
IS 427	Distemper, dry colour as required
IS 428	Distemper, oil emulsion, colour as required
IS 6278	Code of practice for white washing and colour washing
IS 106	Ready mixed paint, brushing, priming for enamels for use on wood.
IS 102	Ready mixed paint, brushing, red lead, non- setting, priming
IS 123	Ready mixed paint, brushing, finishing, semi-gloss, for general purposes
IS 1477	Code of practice for painting of ferrous metals in buildings
IS 2074	Ready mixed paint, red oxide-zinc chrome priming
IS 2339	Aluminium paint for general purposes in dual container
IS 2932	Enamel, synthetic, exterior, type 1
	(a) under coating,
	(b) finishing, colour as required

IS 137	Specification for ready mixed paint, brushing, matt or eggshell flat finishing interior to Indian Standard colour as required
IS 1131	Specification for enamel, interior
	(a) under coating
	(b) finishing.
IS 129	Specification for ready mixed paint, brushing, grey filler for enamel for use over primers
IS 533	Specification for gum spirit of turpentine (oil of turpentine)
IS 101	Methods of tests for ready, mixed paint, & enamels
IS 118	Specification for ready mixed paint, brushing finishing semi glossy for
(Part I) general purposes	
IS 2933	Enamel, Exterior (a) Under Coating, (b) Finishing
IS 5410	Cement Paint
IS 5411	Plastic emulsion, Paint Part- I for interior use
IS 419	Specifications for putty for use in window frames

11 CEMENT PLASTERING & POINTING WORK

a. Materials

The proportions of the cement mortar for plastering shall be 1:4 (one part of cement to four parts of sand) unless otherwise specified under the respective item of work. Cement and sand shall be mixed thoroughly in dry condition and then water added to obtain a workable consistency. The quality of water and cement shall be as per relevant IS. The quality and grading of sand for plastering shall conform to IS: 1542. The mixing shall be done thoroughly in a mechanical mixer unless hand mixing is specifically permitted by ENGINEER. If so desired by the ENGINEER sand shall be screened and

washed to meet the specification requirements. The mortar thus mixed shall be used as soon as possible preferably within 30 minutes from the time water is added to cement. In case the mortar has stiffened due to evaporation of water this may be re-tempered by adding water as required to restore consistency but this will be permitted only upto 30 minutes from the time of initial mixing of water to cement. Any mortar which is partially set shall be rejected and removed forthwith from the site. Droppings of plaster shall not be re-used under any circumstances

b. Workmanship

Preparation of surfaces and application of plaster finishes shall generally confirm to the requirements specified in IS: 1661 and IS: 2402.

Plastering operations shall not be commenced until installation of all fittings and fixtures such as door/ window panels, pipes, conduits etc. are completed.

All joints in masonry shall be raked as the work proceeds to a depth of l0mm/20mm for brick/ stone masonry respectively with a tool made for the purpose when the mortar is still green. The masonry surface to be rendered shall be washed with clean-water to remove all dirt, loose materials, etc., Concrete surfaces to be rendered shall be roughened suitably by hacking or bush hammering for proper adhesion of plaster and the surface shall be evenly wetted to provide the correct suction. The masonry surfaces should not be too wet but only damp at the time of plastering. The dampness shall be uniform to get uniform bond between the plaster and the masonry surface.

Interior Plain Faced Plaster - This plaster shall be laid in a single coat of 13mm thickness. The mortar shall be dashed against the prepared surface with a trowel. The dashing of the coat shall be done using a strong whipping motion at right angles to the face of the wall or it may be applied with a plaster machine. The coat shall be trowelled hard and tight forcing it to surface depressions to obtain a permanent bond and finished to smooth surface. Interior plaster shall be carried out on jambs, lintel and sill faces, etc. as shown in the drawing and as directed by ENGINEER. Rate quoted for plaster work shall be deemed to include for plastering of all these surfaces.

Plain Faced Ceiling plaster - This plaster shall be applied in a single coat of 6mm thickness. Application of mortar shall be as stipulated in clause 30.2.

Exterior plain faced plaster - This plaster shall be applied in 2 coats. The first coat or the rendering coat shall be approximately 14mm thick. The rendering coat shall be applied as stipulated in clause 30.2 except finishing it to a true and even surface and then lightly roughened by cross scratch lines to provide bond for the finishing coat. The rendering coat shall be cured for atleast two days and then allowed to dry. The second coat or finishing coat shall be 6 mm thick. Before application of the second coat, the rendering coat shall be evenly damped. The second coat shall be applied from top to bottom in one operation without joints and shall be finished leaving an even and uniform surface. The mortar proportions for the coats shall be as specified in the respective item of work. The finished plastering work shall be cured for atleast 7 days.

Interior plain faced plaster 20mm thick if specified for uneven faces of brick walls or for random/coursed rubble masonry walls shall be executed in 2 coats similar to the procedure stipulated in clause 30.2.

Exterior Sand Faced Plaster - This plaster shall be applied in 2 coats. The first coat shall be 14mm thick and the second coat shall be 6mm thick. These coats shall be applied as stipulated in clause 30.2. However, only approved quality white sand shall be used for the second coat and for the finishing work. Sand for the finishing work shall be coarse and of even size and shall be dashed against the surface and sponged. The mortar proportions for the first and second coats shall be as specified in the respective items of work.

Wherever more than 20mm thick plaster has been specified, which is intended for purposes of providing beading, bands, etc. this work shall be carried out in two or three coats as directed by ENGINEER duly satisfying the requirements of curing each coat (rendering/floating) for a minimum period of 2 days and curing the finished work for atleast 7 days.

In the case of pebble faced finish plaster, pebbles of approved size and quality shall be dashed against the final coat while it is still green to obtain as far as possible a uniform pattern all as directed by ENGINEER.

Where specified in the drawings, rectangular grooves of the dimensions indicated shall be provided in external plaster by means of timber battens when the plaster is still in green condition. Battens shall be carefully removed after the initial set of plaster and the

broken edges and corners made good. All grooves shall be uniform in width and depth and shall be true to the lines and levels as per the drawings.

Curing of plaster shall be started as soon as the applied plaster has hardened sufficiently so as not to be damaged when watered. Curing shall be done by continuously applying water in a fine spray and shall be carried out for atleast 7 days.

When the specification items of work calls for waterproofing plaster the CONTRACTOR shall provide the waterproofing compound as specified while preparing the cement mortar. Payment for water-proofing compound will be made separately if it is not included as a combined item of work.

Where lath plastering is specified, it shall be paid for at the same rate as for plaster work except that separate payment for metal lath will be made.

For external plaster, the plastering operations shall be commenced from the top floor and carried downwards. For internal plaster, the plastering operations for the walls shall commence at the top and carried downwards. Plastering shall be carried out to the full length of the wall or to natural breaking points like doors/ windows etc. Ceiling plaster shall be completed first before commencing wall plastering.

Double scaffolding to be used shall be as specified in clause 3.2.6.

The finished plaster surface shall not show any deviation more than 4mm when checked with a straight edge of 2m length placed against the surface.

To overcome the possibility of development of cracks in the plastering work following measures shall be adapted.

(a) Plastering work shall be deferred as much as possible so that fairly complete drying shrinkage in concrete and masonry works takes place.
(b) Steel wire fabric shall be provided at the junction of brick masonry and concrete to overcome reasonably the differential drying shrinkage/thermal movement. This steel item shall be measured and paid for separately.
(c) Ceiling plaster shall be done, with a trowel cut at its junction with wall plaster. Similarly trowel cut shall be adopted between adjacent surfaces where discontinuity of the background exists.

11.1 PAINTING OF CONCRETE MASONRY & PLASTERED SURFACES

a) Materials

Oil bound distemper shall conform to IS: 428. The primer shall be alkali resistant primer of the same manufacture as that of the distemper.

Cement paint shall conform to IS: 5410. The primer shall be a thinned coat of cement paint. Acrylic emulsion paint shall be of an approved manufacture. Plastic emulsion paint shall conform to IS: 5411. Lead free acid, alkali and chlorine resisting paint shall conform to IS: 9862.

White wash shall be made from good quality fat lime conforming to IS: 712. It shall be slaked at site and mixed with water in the proportion of 5 litres of water to 1 kg of un-slaked lime stirred well to make a thin cream. This shall be allowed to stand for a minimum period of one day and strained through a clean coarse cloth. Four kg of gum dissolved in hot water shall be added to each cum of cream. 1.30 kg of sodium chloride dissolved in hot water shall then be added per 10 kg of lime used for the white wash to be ready for application.

Colour wash shall be made by addition of a suitable quantity of mineral pigment, not affected by lime, to the prepared white wash to obtain the shade/tint as approved by ENGINEER.

All the materials shall be of the best quality from an approved manufacturer. CONTRACTOR shall obtain prior approval of the ENGINEER for the brand of manufacture and the colour/shade. All materials shall be brought to the site of works in sealed containers.

b) Workmanship

CONTRACTOR shall obtain the approval of the ENGINEER regarding the readiness of the surfaces to receive the specified finish, before commencing the work on painting.

Painting of new surfaces shall be deferred as much as possible to allow for thorough drying of the sub-strata.

The surfaces to be treated shall be prepared by thoroughly brushing them free from dirt, mortar droppings and any loose foreign materials. Surfaces shall be free from oil, grease and efflorescence. Efflorescence shall be removed only by dry brushing of the growth.

Cracks shall be filled with Gypsum. Workmanship of painting shall generally conform to IS: 2395. Surfaces of doors, windows etc. shall be protected suitably to prevent paint finishes from splashing on them.

c) White Wash

The prepared surfaces shall be wetted and the finish applied by brushing. The operation for each coat shall consist of a stroke of the brush first given horizontally from the right and the other from the left and similarly, the subsequent stroke from bottom upwards and the other from top downwards, before the first coat dries. Each coat shall be allowed to dry before the next coat is applied. Minimum of 2 coats shall be applied unless otherwise specified in the item of work. The dry surface shall present a uniform finish without any brush marks.

d) Colour Wash

Colour wash shall be applied in the same way as for white wash. A minimum of 2 coats shall be applied unless otherwise specified in the item of work. The surface shall present a smooth and uniform finish without any streaks. The finished dry surface shall not show any signs of peeling/powdery and come off readily on the hand when rubbed.

e) Cement Paint

The prepared surfaces shall be wetted to control surface suction and to provide moisture to aid in proper curing of the paint. Cement paint shall be applied with a brush with stiff bristles. The primer coat shall be a thinned coat of cement paint. The quantity of thinner shall be as per manufacturer's instructions. The coats shall be vigorously scrubbed to work the paint into any voids for providing a continuous paint film free from pinholes for effective water- proofing in addition to decoration. Cement paint shall be brushed in uniform thickness and the covering capacity for two coats on plastered surfaces shall be 3 to 4 kg/sq.m. A minimum of 2 coats of the same colour shall be applied unless otherwise specified in the item of work. Atleast 24 hours shall be left after the first coat to become sufficiently hard before the second coat is applied. The painted surfaces shall be thoroughly cured by sprinkling with water using a fog spray at least 2 to 3 times a day. Curing shall commence after about 12 hours when the paint hardens. Curing shall be continued for atleast 2 days after the application of final coat. The operations for brushing each coat shall be as detailed in 34.2.5.

f) Oil Bound Distemper

The prepared surfaces shall be dry and provided with one coat of alkali resistant primer by brushing. The surface shall be finished uniformly without leaving any brush marks and allowed to dry for atleast 48 hours. A minimum of two coats of oil bound distemper shall be applied unless otherwise specified in the item of work. The first coat shall be of a lighter tint. Atleast 24 hours shall be left after the first coat to become completely dry before the application of the second coat. Broad, stiff, double bristled distemper brushes shall be used for the work. The operations for brushing each coat shall be as detailed in 34.2.5.

g) Plastic Emulsion Paint

The prepared surface shall be dry and provided with one coat of primer which shall be a thinned coat of emulsion paint. The quantity of thinner shall be as per manufacturer's instructions. The paint shall be laid an evenly and smoothly by means of crossing and laying off. The crossing and laying off consists of covering the area with paint, brushing the surface hard for the first time over and then brushing alternately in opposite directions two or three times and then finally brushing lightly in a direction at right angles. In this process, no brush marks shall be left after the laying off is finished. The full process of crossing and laying off constitutes one coat. The next coat shall be applied only after the first coat has dried and sufficiently become hard which normally takes about 2 to 3 hours. A minimum of 2 finishing coats of the same colour shall be applied unless otherwise specified in the item of work. Paint may also be applied using rollers. The surface on finishing shall present a flat velvety smooth finish and uniform in shade without any patches.

h) Acrylic Emulsion Paint

Acrylic emulsion paint shall be applied in the same way as for plastic emulsion paint. A minimum of 2 finishing coats over one coat of primer shall be provided unless otherwise specified in the item of work.

i) Acid, Alkali Resisting Paint

A minimum of 2 coats of acid/alkali resisting paint shall be applied over the prepared dry surfaces by brushing. Primer coat shall be as per manufacturer's instructions.

11.2 PAINTING & POLISHING OF WOOD WORK

a) Materials

Wood primer shall conform to IS: 3536E.

Filler shall conform to IS: 110 or IS: 345.

Varnish shall conform to IS: 337.

French polish shall conform to IS: 348.

Synthetic enamel paint shall conform to IS: 2932.

All the materials shall be of the best quality from an approved manufacturer. CONTRACTCOR shall obtain prior approval of the ENGINEER for the brand of manufacture and the colour/shade. All materials shall be brought to the site of works in sealed containers.

b) Workmanship

The type of finish to be provided for woodwork of painting or polishing, the number of coats, etc. shall be as specified in the respective items of work.

Primer and finish paint shall be compatible with each other to avoid, cracking and wrinkling. Primer and finish paint shall be from the same manufacturer.

Painting shall be either by brushing or spraying. CONTRACTOR shall procure the appropriate quality of paint for this purpose as recommended by the manufacturer. The workmanship shall generally conform to the requirements of IS: 2338 (Part I).

All the wood surfaces to be painted shall be thoroughly dry and free from any foreign matter. Surfaces shall be smoothened with abrasive paper using it across the grains and dusted off. Wood primer coat shall then be applied uniformly by brushing. The number of primer coats shall be as specified in the item of work. Stopping as per IS: 426 shall be used to fill up large holes & cracks on the surface. For small holes or minor cracks, fillers as per IS: 110 should be used. Any slight irregularities of the surface shall then be made up by applying an optimum coat of filler conforming to IS: 110 and rubbed down with an abrasive paper for obtaining a smooth surface for the undercoat of synthetic enamel paint conforming to IS: 2932. Paint shall be applied by brushing evenly and smoothly by means of crossing and laying off in the direction of the grain of wood. After drying, the coat shall be carefully rubbed down using very fine grade of sand paper and wiped clean before the next coat of finishing is applied. Atleast 24 hours shall elapse between the applications of successive coats. Each coat shall vary slightly in shade and this shall be got approved by

ENGINEER. The number of coats of paint to be applied shall be as specified in the item of work.

All the wood surfaces to be provided with clear finishes shall be thoroughly dry and free from any foreign matter. Surfaces shall be smoothened with abrasive paper using it in the direction of the grains and dusted off.

Any slight irregularities of the surface shall be made up by applying an optimum coat of transparent liquid filler conforming to IS: 345. The Surface when hard shall be rubbed down with fine abrasive paper. All dust and dirt shall be cleaned and on this surface water or spirit stains shall be applied to enhance the natural grain or figuring effect of wood. After the surface is dry, a suitable seater shall be applied to prevent bleeding of stain and filler into the finish coat. The surface shall be rubbed down lightly, wiped off and allowed to dry. Over this prepared surface, varnish conforming to IS: 337 shall be applied by brushing. Varnish should not be retouched once it has begun to set. Staining if required shall be provided as directed by ENGINEER. When two coats of varnish is specified, the first coat should be

a hard-drying undercoat or flatting varnish which shall be allowed to dry hard before applying the finishing coat. The number of coats to be applied shall be as per the item of work. For works where clear finish of French polish is specified the prepared surfaces of wood shall be applied with the polish using a pad of woollen cloth covered by a fine cloth. The pad shall be moistened with polish and rubbed hard and the surface in a series of overlapping circles to give an even finish over the entire area. The surface shall be allowed to dry before applying the next coat. Finishing shall be carried out using a fresh clean cloth over the pad, slight dampening with methylated spirit and rubbing lightly and quickly in circular motions. The finished surface shall have a uniform texture and high gloss. The number of coats to be applied shall be as per the item of work.

12 FLOORING & PAVING

FLOORING	
IS 1200 (Part-XI)	Method of measurement of Building and Civil Engineering work (Part 11) paving, floor finishes, dado and skirting
IS 1237-Edition 2.3	Specification for 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 finish
IS 3622	Specification for sand stone (Slab & Tiles)
IS 4457	Acid and / or alkali Resistant tiles
IS 5318	Code of practice for laying of hard wood parquet and wood block floors
IS 5766	Code of practice for laying of burnt clay brick floor
IS 13630 (Part-1 to 15)	Methods of Testing for ceramic tiles
IS 13712	Specification for ceramic tiles, definition, classification characteristic and marking
IS 15622	Specification for pressed ceramic tile.

12.1 CEMENT CONCRETE FLOORING (IPS) :

12.1.1 SCOPE OF WORK :

The work covered under this specification consists of providing and laying at all levels and floors, flooring of different types, strictly in accordance with these specifications and relevant drawings.

12.2 CEMENT CONCRETE FLOORING (INDIAN PATENT STONE) :

12.2.1 Materials :

The specifications for materials, grading, mixing and the quantity of water to be added shall generally conform to their relevant specifications described under plain and reinforced concrete. The maximum size of coarse aggregate shall be 10 mm. The fine aggregate shall consist of properly graded sand. Concrete shall be mixed preferably by machine, and hand mixing shall be avoided as far as practicable.

12.2.2 Preparation of Base :

The base concrete surface shall be thoroughly chipped to remove laitance, caked mortar, loose sand, dirt etc. cleaned with wire brush and washed clean and watered until no more water is absorbed. Where the base concrete has hardened so much that roughening the surface by wire brushes is not possible, the same shall be roughened by chipping or hacking at close intervals. The surface shall be soaked with water for at least 12 hours and surface water removed and dried before laying the topping. Before laying the concrete, cement slurry at 2.75 kg./ sqm. of surface shall be applied for better bond. Concrete flooring shall then be laid in alternate bays in pattern and joints, wide/ flush as per drawing. The edge of each panel into which the floor is divided shall be supported by wooden or metal strips duly oiled to prevent sticking. The panels shall be of uniform size and, unless otherwise specified, no dimension of panel shall exceed 2 m. and the area of a panel shall not be more than 2 sqm. However, the exact size of panel shall be decided by the Engineer-in-Charge to suit the size of the room. The joints in the floor finish shall extend through the borders and skirting/dado. The border shall have mitred joints at the corners of the room. Where glass/ aluminium dividing strips are proposed to be provided, the same shall be fixed in cement mortar 1:2 @ 600 mm. centres or as specified in the schedule for full depth of the finished floor.

The depth of dividing strips shall be the thickness as proposed for the finished floor in the item. In the case of flush joins, alternate panels only may be cast on same day. At least 48 hours shall elapse before the concreting of adjacent bay is commenced.

12.2.3 Mixing

The topping concrete shall be of mix of one part of cement, two parts of sand and 4 parts of well graded stone chips of 10 mm. maximum size. The ingredients shall be thoroughly mixed with just sufficient water to the required plasticity, having water cement ratio not more than 0.4.

12.2.4 Laying :

The free water on the surface of the base shall be removed and a coat of cement slurry to the consistency of thick cream shall be brushed on the surface. On this fresh grouted base, the prepared cement concrete shall be laid immediately after mixing. The concrete shall be spread evenly and laid immediately after mixing. The concrete shall be spread and levelled carefully. The concrete shall be completed and brought to the specified levels by means of a heavy straight edge resting on the side forms and down ahead with a sawing motion in combination with a series of lifts and drops alternatively with small lateral shifts, either mechanically or manually as directed by the Engineer-in-Charge.

While concreting the adjacent bays, care shall be taken to ensure that the edges of the previously laid bays are not broken by carelessness or hand tamping. Immediately after laying the concrete,the surface shall be inspected for high or low spots and any needed correction made up by adding or removing the concrete and whole surface is again levelled. When the layer is made even, the surface shall be completed by ramming or beating and then screed to a uniform line and level. Before the initial set commences, the surface shall be trowelled to smooth and even surface free from defects and blemishes and tested with straight edges. No dry cement or mixture of dry cement and sand shall be sprinkled directly or empty gunny bags spread over the surface of the concrete to absorb excess water coming on top due to floating.

12.2.5 Finishing the Surface :

After the concrete has been fully compacted, it shall be finished by trowelling or floating. Finishing operations shall start shortly after the compaction of concrete and shall be spread over a period of one to six hours depending upon the temperature and atmospheric conditions. The surface shall be trowelled intermittently at intervals for several times so as to produce a uniform and hard surface. The satisfactory resistance of floor to wear depends largely upon the care with which trowelling is carried out. The object of rowelling is to produce as hard and close knit a surface as possible. The time interval allowed between successive trowelling is very

important. Immediately after laying only just sufficient trowelling shall be done to give a level surface. Excessive trowelling in the earlier stages shall be avoided as this tends to work a layer rich in cement to the surface, some time. After the first trowelling, the duration depending upon the temperature, atmospheric conditions and the rate of setting of cement used, the surface shall be retrowelled many times at intervals to close any pores in the surface, and to bring to

surface and scrap off any excess water in concrete or laitance (it shall not be trowelled back into the topping).

The final trowelling shall be done well before the concrete has become too hard but at such a timethat considerable pressure is required to make any impression on the surface. Trowelling of rich mix of dry cement and fine aggregate on to the surface shall not be permitted. Trowel marks should not be seen on the finished surface. Where broom finish is specified, after the concrete has been thoroughly compacted, and when most of the surface water has disappeared, the surface shall be given broom finish wit h an approved type of brass or M.S. fiber. The broom shall be pulled gently over the surface from edge to edge in such a manner that corrugation shall be uniform in width and depth, the depth shall be not more than 1.5 mm. Brooming shall be done when the concrete is in such a condition that the surface will not be torn or unduly roughened by the operation. Coarse or long bristles which cause irregularities or deep corrugation shall be trimmed out. Brooms which are worn or otherwise unsatisfactory shall be discarded.

After the concrete in the bays has set, the joints of the panels should be filled with cement cream and neatly floated smooth or jointed. Care should be taken that just the minimum quantity of cream for joint is used and excess spilling over the already finished surface shall be removed when the cream is still green. In case of wide joints the same shall be filled with pigmented cement concrete (1:2:4) using approved pigment and the joint shall be finished in perfectly straight line.

12.2.6 Steel Trowel Finish :

Areas where Marblex tiles are proposed to be used are required to have base concrete finished smooth by steel trowel.

12.2.7 Curing :

The completed flooring shall be protected from sun, wind and rain for the first two days and movement of persons over the floor is prohibited during this period. The finished surface shall be covered and cured continuously form the next day after finishing, at least for a period of 7 days. Bunding with murrum for curing is prohibited as it will leave permanent stain on the finished floor.

Curing shall be done by spreading sand and kept damp throughout the curing period of seven days minimum. The surface shall be protected from any damage to it whatsoever. The surface

shall then be allowed to dry slowly. All corners, junctions of floor with plastered wall surface shall be rounded off when required at no extra cost.

12.3 KOTAH STONE FLOORING/ SKIRTING/ FACIA / SHELVES :

12.4 Materials

The stone shall be hard, sound, durable, homogeneous in texture and resistant to wear. These shall be without any soft veins, cracks or flaws and shall have uniform colour. They shall have natural surface free from broken flakes on top. Hand cut/ machine cut for exposed edges and machine polished. Kotah stone shall be of the best quality and of the specified thickness, size and the shade, which shall be got approved by the Engineer-in-charge. The slabs / tiles shall be

rectangular or square in shape or as per pattern shown in drawing and as directed by the Engineer-in-charge. The sizes given in schedule of quantities are tentative and can vary only slightly as per the availability in the market. The thickness of the slab after it is dressed shall be 20, 25, 30 or 40 mm as specified in the item. Tolerance of (+/-) 2 mm shall be allowed for the thickness. In respect of length & width, tolerance in length & width shall be permissible upto (+/-) 5 mm for hand cut slabs & (+/-) 2 mm for machine cut slabs. At its thinnest, no stone shall be thinner than the specified thickness.

Uniformity of size and colour / shade shall generally be maintained for the stones used in any one room. The exposed surface shall be machine polished to a smooth, even and true plane and the edges hand cut and dressed true and squares. The evenness of the surface of slabs and edges of the slab shall not be marred by careless dressing or handling and no patching up shall be allowed for the slab. The edges shall be quite straight. The under face may be left as required or rough dressed. Before taking up the work, samples of stone slabs to be used and their dressing and polishing shall be got approved by the Engineer-in-charge and kept in his office as approved sample and the stone slabs to be used shall conform to the same.

12.4.1 Bedding/ Backing Coat

In case of flooring / skirting / dado, the mortar bedding / backing shall be of cement mortar of thickness and mix specified in the schedule of work.

12.4.2 Cement Mortar

Cement mortar bedding shall be as specified under relevant specification for terrazzo / plain cement tile flooring.

12.4.3 Construction Details

Cement mortar as specified for bedding shall be uniformly mixed. The amount of water added shall be the minimum necessary to give just sufficient plasticity for laying and satisfactory bedding. Care shall be taken in preparing the mortar to ensure that there are no hard lumps that would interfere with the even bedding of the stones. Before spreading the mortar, the sub-floor or base shall be cleaned of all dirt, set mortar scum or laitance and of loose materials by hacking and brought to original levels and then well wetted without forming pool of water on surfaces.

12.4.4 Fixing the stone slab/ tile :

Before laying, the stone shall be thoroughly wetted with clean water, neat cement grout (2.75 kg/ sqm.) of honey like consistency shall be spread on the mortar bed over as much areas as could be covered with the slabs within half an hour. The specified type of stone shall be laid on the neat cement float and shall be evenly and firmly bedded to the required level and slope in the mortar bed. Each stone shall be gently tapped with wooden mallet till it is firmly and properly bedded.

There shall be no hollows left. If there is a hollow sound on gently tapping off the sla b, such slab shall be removed and reset properly. The joints shall be grouted with matching cement slurry. Approved pigment shall be used in cement slurry to match with shade of stone. Pigment required to match the shade of stone shall be supplied by the contractor at no extra cost. The stone adjoining the wall shall go about 12mm. under the plaster, skirting or dado for the wall. All stone slabs, tiles shall be so laid as to have continuous lines from various rooms to the corridors. No change of lines shall be permitted at junction between rooms and corridors. Only one piece machine cut, Kotah stone shall be used for treads and risers, unless otherwise specified in the tender schedule..

12.4.5 Curing

The work shall be kept well wetted with damp sand or water for seven days.

12.4.6 Polishing and cleaning

When the bedding and joints have completely set and attained required strength, the surface shall be machine polished to give smooth, even and true plane to the flooring. All flooring shall be thoroughly cleaned and handed over free from any mortar stains etc. Polishing shall be done as per relevant IS and IS-14223 (Specification for polished building stones).

12.4.7 Skirting and Dado/ Facia

The quality and type of stone shall be same as mentioned for flooring except of their height and thickness or backing coat which shall be as mentioned in item schedule. The backing shall conform to the specifications for cement mortar specified for item of terrazzo tiles. Contractor should take into consideration the fact that touching up of the plaster at the junction of skirting / dado is invariably done after the skirting/ dado/ facia work is completed and quote rates accordingly. Nothing extra for the same shall be entertained.

Fixing, curing, polishing and cleaning shall be as specified herein before under cement/ terrazzo tile skirting. Polishing may be done by hand, but a smooth surface and fine polishing shall be obtained. Joints shall be finished in neat matching cement slurry. The junction of plaster and the upper edges of the dad o/ skirting shall be finished smoothly as directed by the Engineer-in-charge without any extra cost.

12.5 CERAMIC TILE FLOORING, DADO / SKIRTING / FACIA.

12.5.1 Materials

12.5.2 Ceramic Tiles

The tiles shall be of approved make and shall generally conform to IS : 13712 -1998. They shall be flat and true to shape and free from cracks, blisters, welts, crawling, crazing spots, chipped edges, corners or other imperfections detracting from their appearance. The glazing shall be of uniform shade.

The tiles shall be of square or rectangular of nominal sizes as mentioned in schedule of quantities and as directed by the EIC. The length of all four sides shall be measured correct to 0.1 mm and average length & breadth shall not vary more than (+ / -) 0.8 mm from specified dimensions. The variation of individual dimensions from average value of length/breadth shall not exeed (+ / -) 0.5 mm. Tolerance in thickness shall be (+ / -) 0.4 mm. Size of tiles different form the specified one, may be allowed to be used with prior approval of the EIC.

The thickness of the tiles shall not be less than 6 mm or as specified in the items and shall confirm to I.S. 13712 in all respects. Samples of tiles shall be got approved by the Engineer-in-charge before use on the work. Top surface of tile shall be glossy or matt as specified. The underside of tiles shall not have glaze on more than 5% of the area in order to have proper adherence to the back .

12.5.3 Preparation of surface & laying

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 for terrazzo tile flooring.

The bedding/backing for the tile shall be of C.M. 1.3 or as specified and shall be applied and allowed to harden. The mortar shall be roughened with wire brushes or by scratching diagonal lines 1.5mm. deep at 7.5mm. centre both ways.

The back of tiles shall be buttered with a coat of grey cement slurry paste and edges with cement slurry and set in the bedding mortar. The tiles shall be tapped gently with wooden mallet and corrected to proper planes and lines. The tile shall be butt jointed in pattern and joints shall be as fine as possible. The t op of skirting/ dado shall be truly horizontal and joints truly vertical.

After a period of curing of 7 days minimum, the tiles shall be cleaned and shall not sound hollow when tapped.

The surface during laying shall be checked with a straight edge 2 m. long. Where full size tiles cannot be fixed, these shall be cut/sawn to the required size & their edges rubbed smooth to ensure straight and true joints.

Tiles shall enter not less than 10mm. under side skirting.

After the tiles have been laid, surplus cement grout shall be cleaned off.

12.5.4 Mortar and Bedding

Cement mortar for bedding shall be of proportion specified in items schedule and shall conform to the specification for materials, preparations etc. as specified under cement mortar. The amount of water a dded 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 withe even bedding of the tiles. Before spreading the mortar bed the base shall be cleaned of 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 even & smoothly spread over the base by use of screed battens to proper level or slope.

Cement mortar of thickness and proportion as specified in the schedule for dado shall be applied to the wall after preparing the wall surface as specified under cement plaster as

specified in schedul e of quantities and brought to correct line and plumb and the surface left rough to receive the tiles.

12.6 Fixing Of Tiles For Flooring

The tiles before laying shall be soaked in water for atleast 2 hours. 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. Neat cement mortar grout 1:2, using fine sand (table III, zone-IV and as per I.S. 383) of honey like consistency shall be spread over the bedding mortar just to cover as much area as can be tiled within half an hour. The edges of the tiles shall be sm eared with neat 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. The surface of the flooring during laying shall be frequently checked with a straight edge about 2M long to obtain a true surface with the required slope. The joints between tiles shall not exceed 1.00 mm. in width. The joint shall be grouted with /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.

12.7 Fixing Tiles For Dado & Skirting/Facia

The dado work, shall be done only after fixing the tiles/slabs on the floor. The approved ceramic tiles before laying shall be soaked in water for atleast 2 hours. Tiles shall be fixed when the cushioning mortar is still plastic and before it gets very stiff.

The back of the tile shall be covered with this layer of cement mortar 1:2 using fine sand (table III, zone IV, I.S. 383-1963) and the edge of the tile smeared with neat cement slurry. The tile shall then be pressed in the mortar and gently tapped against the wall with a wooden mallet. The fixing shall be done from bottom of wall upwards without any hollows in the bed of joints. Each tile shall be as close as possible to one adjoining. The tiles shall be jointed with cement slurry. Any thickness difference in the thickness of the tiles shall be arranged out in cushioning mortar so that all tiles faces are in one vertical plane. The joints between the tile shall not exceed 1.00 mm. in width and they shall be uniform.

While fixing tiles in dado work, care shall be taken to break the joints vertically. The top of the dado shall be touched up neatly with the rest of the plaster above.

After fixing the dado/skirting etc. they shall be kept continuously wet for 7 days.

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 contractor will not be entitled to any extra claims on this account for cutting of tiles if required.

12.8 Cleaning

After the tiles have been laid in a room or the days fixing work is completed, the surplus cement grout that may have come out of the joints shall be cleaned off before it sets. After the complete curing, the dado or skirting over shall be washed thoroughly clean. In the case of flooring, once the floor has set, the floor shall be carefully washed clean and dried. When dry, the floor shall be covered with oil free dry saw dust. It shall be removed only after completion of the construction work and just before the floor is used.

12.9 Pointing and finishing :

The joints shall be cleaned off with wire brush to a depth of 3 mm. and all dust and loose mortar removed. Joints shall then be flush pointed with cement and floor kept wet for 7 days and then cleaned. Finished floor shall not sound hollow when tapped with a wooden mallet.

12.10 Paver Blocks / Interlocking Concrete Block Pavement:

- The concrete pavers should have perpendiculars after release from the mould and the same should be retained until the laying. The surface should be of anti-skid and anti-glare type. The pave should have uniform chamfers to facilitate easy drainage of surface run off. The pavers should have uniform interlocking space of 2mm to 3mm to ensure compacted sand filling after vibration on the paver surface.
- The concrete mix design should be followed for each batch of materials separately and automatic batching plant is to be used to achieve uniformity in strength and quality.
- The pavers shall be manufactured in single layer only.
- Skilled labour should be employed for laying blocks to ensure line and level for laying, desired shape of the surface and adequate compaction of the sand in the joints.
- The pavers are to be skirted all round with kerbing using solid concrete blocks of size 100mm x 200mm x 400mm or as directed by the Engineer. The kerbing should. be embedded for 100mm depth. The concrete used for kerbing shall be cured properly for 7 days minimum.

12.11 Bedding Sand Course

The bedding sand shall consist of a clean well graded sand passing through 4.75mm sieve and suitable for concrete. The bedding . should be from either a single source or blended to achieve the following grading.

Bedding Sand Requirement

In Sieve Size	% Passed
9.52mm	100
4.75mm	95-100
2.36mm	80-100
1.18mm	60-100
600 Microns	25-60
300 Microns	10-30
150 Microns	5-15
75 Microns	0-10

- Contractor shall be responsible to ensure that single-sized, gap-graded sands or sands containing an excessive amount of fines or plastic fines are not used. The sand particles should preferably be sharp not rounded as sharp sand possess higher strength and resist the migration of sand from under the block to less frequently areas even though sharp sands are relatively more difficult to compact than rounded sands, the use of sharp sands is preferred for the more heavily trafficked driveways. The sand use for bedding shall be free of any deleterious soluble salts or other contaminants likely to cause . efflorescence.
- The sand shall be of uniform moisture content and within 4% - 8% when spread and shall be protected against rain when stock piled prior to spreading. Saturated sand shall not be used. The bedding sand shall be spread loose in a uniform layer as per drawing. The compacted uniform thickness shall be of 45mm and within +/- 5mm thickness variation shall not be used to correct irregularities in the base course surface.
- The spread sand shall be carefully maintained in a loose dry condition and protected against pre-compaction both prior to and following screeding. Any pre-compacted sand or screeded sand left overnight shall be loosened before further laying of paving blocks take place.

- Sand shall be slightly screeded in a loose condition to the predetermined depth only slightly ahead of the laying of paving unit.

13 VITRIFIED TILE FLOORING, DADO / SKIRTING / FACIA :

13.1.1 MATERIALS :

Vitrified Tiles: The tiles shall be of approved make like Marbonite / Granamite or equivalent and shall generally conform to the approved standards. They shall be 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 tender schedule / drawings or as directed by the Engineer -in-Charge. Thickness shall be as per recommendations of the approved manufacturers.

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.

13.1.2 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 for terrazzo tile flooring.

- Mortar and bedding: Cement mortar for bedding shall be prepared of mix 1:4 or as specified in the schedule of items, 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 sqm. 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.

13.1.3 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. A 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 be come 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.

13.1.4 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 contractor will not be entitled to any extra claims on this account for cutting of tiles if required.
- 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.

13.1.5 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.

13.1.6 Cleaning

As directed by the Engineer-in-Charge, the tiles shall be cleaned by mild acid (However, Hydrofluoric acid and its derivatives should 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.

13.1.7 Cleaning Agents For Vitrified Tiles

Vitrified tiles are resistant to all chemicals (except hydrofluoric acid and its derivatives), hence commerciall y 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.

14 DOORS & WINDOWS

Contractor to shall submit the design opening schedule of all architectural block like, toilets guards room store etc.

ALUMINIUM WORK	
IS 733	Wrought Aluminium Alloys, Bars, Rods and Sections (For General Engineering Purposes) – Specification
IS 737	Wrought Aluminium and aluminium alloy sheet
IS 1285	Wrought Aluminium and Aluminum Alloy, Extruded Round Tube and Hollow sections (for General Engineering Purposes) – Specification
IS 1868	Anodic coating on Aluminium and its alloy – Specification
IS 1948	Specification for Aluminium Doors, Windows and Ventilators
IS 5523	Method of testing anodic coating on aluminum and its alloys
IS 6012	Measurement of coating thickness by Eddy Current Method
IS 6315	Floor springs (Hydraulic regulated) for heavy doors – Specifications

IS 6477	Dimensions of extruded hollow section and tolerances
IS 14900	Transparent Float Glass – Specifications

14.1 SPECIFICATIONS FOR ALUMINIUM DOOR, WINDOW, VENTILATOR WORKS

Extent and intent : The work shall be carried out through an approved specialist contractor who shall furnish all materials, labour, accessories equipment tool and plant and incidental required for providing and installing anodised aluminium doors, windows, claddings, louvers and other items as called for in the drawings. The drawings and specifications cover the major requirement only. The supplying of additional fastenings, accessory features and other items mentioned specifically herein but which are necessary to make a complete installation shall be a part of the contract

14.1.1 General

Aluminium doors, windows, etc. shall be of sizes, section details as shown on the drawings. The details shown on the drawings location gives generally the sizes of the components parts and general standards. These may be varied slightly to suit the standards adopted by the manufacturer. Before proceeding with any manufacturing the contractor shall prepare and submit complete manufacturing and installation drawings for approval of the Engineer-in-Charge and no work shall be performed until the approval of these drawings is obtained.

14.1.2 Shop Drawings

The contractor shall submit the shop drawings of doors, windows, louvers claddings and other aluminium work, based on architectural drawings to the Engineer-inCharge for his approval. The drawings shall show full size sections of doors, windows etc. thickness of metal (i.e. wall thickness) details of construction, sub frame/rough ground profile anchoring details, hardware as well as connection of windows doors, and other metal work to adjacent work. Samples of all joints and methods of fastening and joining shall be submitted to the Engineer-in-Charge for approval well in advance of commencing the work.

14.1.3 Samples

Samples of doors, windows, louvers etc. shall be fabricated, assembled and submitted to the Engineer-in-Charge for his approval. They shall be of sizes, types etc. as decided by Engineer-in-Charge. All samples shall be provided at the cost of the contractor

14.1.4 Sections

Aluminium doors and windows shall be fabricated from extruded section of profiles as detailed on drawings. The sections shall be extruded by the manufacturers approved by the Engineer-in-Charge. The aluminium extruded section shall conform to IS designation 63400-WP(HV9WP old designation) with chemical composition and technical properties as per IS: 733 and IS: 1285. The permissible dimensional tolerance of the extruded sections shall be such as not to impair the proper and smooth function/operation and appearance of doors and windows.

14.1.5 Fabrication

Doors, windows etc. shall be fabricated to sizes as shown at factory and shall be of section, sizes combinations and details as shown in the Architectural drawings. All doors, windows etc. shall have mechanical joints. The joints shall be designed to withstand a wind load of 150 kgs per sqm. The design shall also ensure that the maximum deflection of any member shall not exceed 1/175 of the span of the member. All members shall be accurately machined and fitted to form hairline joints prior to assembly. The joint and accessories such as cleats, brackets, etc. shall be of such materials as not to cause any bimetallic action, the design of the joints and accessories shall be such that the accessories are fully concealed. The fabrication of doors, windows etc. shall be done in suitable sections to facilitate easy transportation, handling and installation. Adequate provision shall be made in the door and windows members for anchoring to support and fixing of hardware and other fixtures as approved by the Engineer-in-Charge.

14.1.6 Anodising

All aluminum sections shall be anodised as per IS: 7088 and the required colour as specified in the item as per IS: 1868 grading as specified in items schedule after cuttings the member to the required & requisite sizes before the final assembly. Anodising to specified grade with minimum average thickness of 15 microns when measured as per IS:612. The anodic coating shall be properly sealed by steams or in boiling water or cold sealing process as per IS: 1856/IS:6057. Polythene tape protection shall be applied on the anodised section before they are brought to site. All care shall be taken to ensure surface protection during transportation and storage at site and installation. The tape protection shall be removed on installation. The sample will be tested in the approved laboratory and cost of samples, cost of testing, shall be borne by the contractor.

Powder Coating The powder used for powder coating shall be polyester powder made by Berger or Jenson & Nicholson or equivalent. The thickness of powder coating shall not be less than 50 micron at any point measured with micron-meter.

14.1.7 Protection of Finish

All aluminium members shall be wrapped with approved self adhesive non-staining PVC tapes.

14.1.8 Handing and Stacking

Fabricated materials shall be created in an approved manner to protect the material against any damage during transportation. The loading and unloading shall be carried out with utmost care on receipt of materials at site, they shall be carefully examined to detect any damaged pieces. Arrangements shall be made for expeditious replacement of damaged pieces/parts. Materials found to be acceptable on inspections shall be repacked in crates and stored safely.

In the case of composite windows, and doors the different units are to be assembled first. The assembled composite units should be checked for line, level and plumb before final fixing is done. Units may be serial numbered and identified as how to be assembled in their final location if situation so warrants.

Where aluminum comes into contact with masonry brickwork, concrete planter or dissimilar metals, it shall be coated with approved insulation lacquer paint or plastic tape to ensure that electro-chemical corrosion is avoided. Insulation materials shall be trimmed off to a clear flush line on completion.

14.1.9 Silicon Sealant

The peripheral gaps between plastered faces /RCC and aluminium sections shall be sealed both from inside and outside to make the windows watertight. Gaps upto 10 mm between the peripheral aluminium member and masonry/RCC/Stone shall be sealed by inserting Backer Rod manufactured by HT TROPLAST or Supreme Industries and by application of weather silicon/sealant of DOW Corning/GE Silicon make.

The contractor shall be responsible for doors, windows etc, being set straight plumb, level and for their satisfactory operation after fixing is complete.

14.1.10 Installation:

- .Just prior to installation the doors, windows etc. shall be uncrated and stacked on edge on level bearers and supported evenly. The frame shall be fixed into position true to line and level using adequate number of expansion machine bolts, anchor fasteners of approved size and manufacture and in an approved manner. The holes in concrete/masonry members for housing anchor bolts shall be drilled with an electrical drill.

- The doors, windows assembled as shown on drawings shall be placed in correct final position in this opening and marks made on concrete members at jambs, sills and heads against the holes provided in frames for anchoring. The frame shall then be removed from the opening and laid aside. Neat holes with parallel sides of appropriate size shall then be drilled in the concrete members with an electric drill at the marking to house the expansion bolts. The expansion bolts shall then be inserted in the holes, struck with a light hammer till the nut is forced into the anchor. The frame shall then be placed in final position in the opening and anchored to the support through cadmium plated machine screws of required size threaded to expansion bolts. The frame shall be set in the opening by using wooden wedges at supports and be plumbed in position. The wedges shall invariably be placed at meeting points of glazing bars and frames.

14.1.11 Neoprene Gaskets

The contractor shall provide and install Neoprene Gaskets of approved size and profile at all locations as shown and as called for to render the doors windows etc. absolutely air tight and weather tight. The contractor shall produce samples of the gaskets for approval and procure after approval only.

14.1.12 Fittings

Hinges, stays, handles, tower bolts, locks and other fittings shall be in quality and manufacturer as approved by the Engineer-in-Charge.

14.1.13 Manufacturer's Attendance

The manufacturer immediately prior to the commencement of glazing shall adjust and set all windows and doors and accept responsibility for the satisfactory working of the opening frames.

Details of Test:

- The various tests on aluminium section shall be conducted in accordance with the relevant IS
- The minimum number of tests for anodic coating and corrosion resistance shall be as given below: as given below:

Sl. No.	Details	No. of Tests
1	Doors, windows & ventilators	5% of Nos. manufactured

- The sample of major member of each unit of doors/windows shall be selected at random by Engineer-in-Charge such as that all the aluminium section shall be got tested.
- The cost of samples, carriage of the samples and testing charges if any shall be borne by the contractor

14.1.14 Acceptance Criteria

The aluminium section shall be conform to the provisions of the relevant item in the schedule of quantities. For payment purpose only actual weight of sections shall be taken into account. If however, the sectional weight of any aluminium section is higher than the permissible variation then the weight payable shall be restricted to the weight of the section including permissible variation.

14.1.15 Guarantee Bond

All aluminium work shall carry two years guarantee to be reckoned from the date after the expiry of maintenance period prescribed in the contract of the work against structural unstability, leakage, unsound materials and workmanship and defective anodising, colouring, sealing and finishing as per guarantee bond attached in this tender document.

Two years guarantee in prescribed Performa attached must be given by the specialized firm, which shall be counter signed by the contractor in token of his over all responsibility. 10% (Ten Percent) of the cost of these items would be retained as guarantee to the performance of the work done. The guarantee against this item of work shall be in addition to the security deposit mentioned else where in the contract form. If any defects or deficiencies are noticed during the guarantee period the same shall be rectified by the contractor within seven days of issue of the written notice by the Engineer-in-charge, failing which the defects/deficiencies would be got removed by the Engineer-in-charge from another agency at the risk and cost of the contractor. However this amount of the guarantee can be released in full, if bank guarantee of equivalent amount for the required period is produced and deposited with the department.

15 SPECIFICATIONS FOR SIGNAGES

15.1 Scope of Work and Services

Contractor to design, fabricate and install of interior and exterior signages which consist building/ area identification signs, regulatory signs and direction always finding signs information and History about place). The design shall be approved by Landscape architect and client. Contractor to submit drawings of the same and take the approval before execution of the work.

15.2 Design Requirements

The following are the design requirements:

- The signs shall be attractive and exhibit a professional quality of workmanship, which will reflect positively on Guwahati smart city project.
- Signage should incorporate client's branding standards, as appropriate.
- Signage should leverage the spatial organization of the facility and utilize architectural design features, destinations zones, landmarks, shape, color, lighting, etc.
- Signage should be easy to recognize, consistent, clear, distinctive, and easy to read.
- Signage shall be compliant with CPWD Standards or relevant norm for signages Design.

15.3 Considerations - Services And Products

- Perform a site review to verify locations, determine available areas for signage, confirm dimensions and identify potential conflicts with architecture or landscape designs.
- Finalize all elements of the sign system design including materials, fabrication specifications, graphic design and installation details.
- Prepare sign lay outs based on actual sign messages to determine sign and letter sizes and to determine the need for variations to the way finding/signage program.
- Provide final fabrication submittals based on approved design.
- Be responsible for fabricating the exterior signage program in accordance with the approved design.
- Develop an installation schedule to assure timely, accurate and code compliant installation.
- Be responsible for the installation of the exterior signage program in accordance with the design intent of the approved program.

16 SPECIFICATIONS FOR MECHANICAL WORKS FOR IRRIGATION SYSTEM

16.1 Pumping Requirement for irrigation

- For gardening: Total Landscape area approx. 11000 sqm. Water requirement for garden is calculated @ 5litre/sqm , hence total water requirement for gardening = 11000 sqm x 5 = 55,000 lrs.

Hence total water requirement for Irrigation will be around 55000 lrs. per day. STP treated water will be used for irrigation work in garden.

Thus, it is proposed to provide 1w+1S Horizontal monoblock type pumping set for irrigation purpose in garden.

Type of Pump	Horizontal monoblock type
Volume to be transferred	55 m3
Working Hours	8 hrs
Capacity of pump required	6.875 m3/hr
Capacity of pump provided	7 m3/hr (1W+1S)
Head of pump required	63 meter
Head of pump provided	65 meter

16.2 Assumptions:

- We are considering working hours for pumping is 8 hours for Irrigation.
- Velocity through Ring main for irrigation is min 0.98 m/sec.
- Distance between two consecutive sprinklers is 10 meter.

Irrigation Detail:

Total length of pipe	1500 meter
MOC of pipe	G.I. Medium duty
Distance between two sprinklers	10 meter
Total number of sprinklers required	150
Total no of sprinklers provided	160 Nos
Type of sprinklers	full rotating sprinklers
Range of sprinkler	35-40 feet
Velocity through ring main	0.52 m/sec (Min.)
Head of pump required	63 meter

Head of pump provided	65 meter
Size of Pump main Header	50 mm
MOC of Pump main Header	G.I. Medium duty
MOC of sprinklers	Brass/Stainless steel
Type of irrigation	semi-automated sprinkler system

16.3 Approach of working:

STP Treated water form Treated water collection tank of STP will be transferred in the entire park for the irrigation purpose. Water form that tank will be lifted by 2 nos (1W+1S) Horizontal monoblock pumps capacity 7m3/hr @ 65 m head with the help of foot valve for Irrigation Purpose. Discharge line of that will be laid in the park for irrigation and number of Sprinklers will be provided for irrigation. The distance between the two consecutive Sprinklers will be 10 meters.

16.4 Horizontal Centrifugal Pump Set

16.4.1 SCOPE:

This specification covers the design, manufacturer, testing performance guarantee and supply of horizontal centrifugal pumps. The pump shall be directly coupled with electric motors. A common base plate shall be provided for the pump motor with all accessories.

16.4.2 STANDARDS & CODES:

The horizontal centrifugal pumps as specified herein shall comply with requirement for all applicable codes, regulation and safety codes in the locality where the pump sets will be installed and the pump data sheet attached.

The latest editions of the following standard shall be followed.

a) IS – 6595 (part-I): 1993 Horizontal Centrifugal Pump for clear, cold and freshwater.

b) IS – 11346:1985 Tests for agricultural & water supply pumps code of acceptance.

c) IS – 9137:1978 & IS – 5120:1977 code for acceptance test for centrifugal, mixed flow and axial pumps - Class C

d) IS 9079:2013 - Electric monoset pumps for clear, cold water for Agriculture and water supply.

16.5 SPECIFIC REQUIREMENT:

- The contractor shall make his own assessment of the friction losses under all conditions of operation and suitable head shall be selected dta given in the data sheets is indicative.
- Details of pump and motors such as discharge, efficiency, head, B.H.P., R.P.M. etc. shall be worked out and filled up by the contractor in the enclosed data sheets.
- Pumps shall have a continuous rising head characteristic form the operating point towards shut off without any zone of instability. Pump with dropping curves shall not be acceptable. The contractor shall submit system resistance curve superimposed on solo and parallel operation curves. The head capacity curve shall be continuously rising towards shut-off with the highest at shut-off head shall be minimum 120 % of the duty point head.
- Pumps of each category shall be identical in all respect and shall be suitable for parallel operation and from the same manufacturer.
- The power rating for motor thus selected should be higher than the power consumption on any point of the Characteristic curve.
- Material of construction of pumps shall be as per data sheets enclosed.

16.6 General requirement:

The calculation for system resistance is to be furnished along with offer. The Head vs Flow characteristic of pump to be super imposed on system resistance curve for solo and parallel operation & to be enclosed with bid. The pump model shall be the one from the existing regular production range of the manufacturer.

16.6.1 Construction features:

Construction features shall be generally as specified here under.

16.6.2 Casing

Casing shall be robust construction and shall be tested to withstand 1.5 times maximum discharge pressure for 2 minutes.

16.6.3 Impeller

The impellers shall be dynamically balanced to ensure freedom from vibrations. It shall be positively locked on shaft and shall not loosen under reverse rotation. In case of pumps up to 2000 rpm the impeller shall be statically and dynamically balanced. In case

of pumps above 2000 rpm impeller shall be balanced as per grade G6.3 of IS 11723:1985 (Part 1)

16.6.4 Wearing Rings

It shall be or renewable type and these shall be held in place by screwing against rotation, press fit and locked with pins, flanged and screwed. Material construction shall be as per data sheet

16.6.5 Shaft & Shaft Seals

A single piece shaft shall be designed for 0.05 mm maximum deflection at stuffing box face under worst condition of shut off head. Renewable shaft sleeves shall be provided with suitable packing to prevent leakages. Shaft shall be properly balanced so as not to cause any vibration during operation. The shaft shall be of adequate size to transmit the required power over the entire range.

The design of the shaft shall also take into consideration the critical speed of the shaft which shall be all tested 20% above/below the operating speed. Mechanical seal to be provided for shaft sealing.

Material of construction shall be as per data sheet

16.7 GI PIPE, MEDIUM DUTY

16.7.1 Scope:

Providing and Supplying ISI mark G I pipes with couplings of following class and diameter including all taxes, freight , transportation, insurance, loading, unloading, conveyance to department stores, stacking etc, complete.(IS 1239). Jointing GI pipes with GI specials of following diameters in proper positions grade and alignment as directed by Engineer in charge, including conveyance from stores to site of work, labor, giving hydraulic testing etc

16.7.2 Applicable Codes

The laying of pipes and fittings/specials shall comply with all currently applicable status, regulation, standards and codes. In particular, the following standards, unless otherwise specified herein, shall be referred to. In all cases, the latest revision of the standards/codes shall be referred to. If requirements of this specification conflict with the requirements of' the standards/codes, this specification shall govern.

16.7.3 Carting & Handling

Pipes and fittings/specials shall be transported from the factory to the work sites at places along the alignment of pipeline as directed by Owner/Engineer and as specified by manufacturer. Contractor shall be responsible for the safety of pipes and fittings/specials in transit, loading/unloading. Every care shall be exercised in handling pipes and fittings/specials to avoid damage. While unloading, the pipes and fittings/specials shall not be thrown down from the truck on to hard surfaces. They should be unloaded on timber skids with steadying ropes for by any other approved means. Padding shall be provided between coated pipes, fittings/specials and timber skids to avoid damage to the coating. Suitable gaps between pipes should be left at intervals in order to permit access from one side to the other. As far as possible pipes shall be unloaded on one side of the trench only. All pipes shall be checked for any visible damage (such as broken edges, cracking or spalling of pipe) while unloading and shall be sorted out for recantation. Any pipe which shows sufficient damage to preclude it from being used shall be discarded. Dragging of pipes and fitting/specials along concrete and similar pavement with hard surfaces shall be prohibited.

16.7.4 Storage

Each stack of pipes shall contain only pipes of same class and size, with consignment or batch number marked on it with particulars of suppliers wherever possible. Storage shall be done on firm level and clean ground and wedges shall be provided at the bottom layer to keep the stack stable. The stack shall be in pyramid shape or the pipes laid lengthwise and crosswise in alternate layers. The pyramid stack shall be made for smaller diameter pipes for conserving space in storing them. The height of the stock shall not exceed 1.5 m. Fittings/specials, shall be stacked under cover and separated from pipes.

16.8 BUTTERFLY VALVE

Resilient seated butterfly valve shall be as per IS 13095-1991/ BS 5155. Valve shall be suitable for mounting in any position.

The valve seat shall be of integrally cast or replaceable design. When the valve is fully closed, the seal shall seat firmly so as to prevent leakage. The seat surfaces shall be machined smooth to provide a long life for the seal.

All fasteners shall be set flush so as to offer the least resistance possible to the flow through the valve.

Valve shall be suitable for throttling purpose.

All valve, spindles and hand wheels shall be positioned to give good access for operational personnel.

All hand wheels shall be arranged to turn in a clockwise direction to close the valve, the direction of rotation for opening and closing being indicated on the hand wheels. Specification & M.O.C. of Butterfly valve :

16.8.1 General

a	Type	-	Threaded
b	Rating of valves	-	PN 1.0
c	Manu. Standard	-	IS-13095:1991 / BS 5155
d	Sizes and quantity	-	As per Price schedule

16.8.2 Material of construction

a	Body	-	CI IS 210 FG 260
b	Bush	-	PTFE
c	Disc	-	SS ASTM A 536
d	Liner	-	EPDM
e	Lock Plate	-	CS
f	Internal & External Hardware	-	SS-304
g	Lever & Lever lock screw	-	CS
h	Upper & Lower stem	-	SS
j	Dowel pin	-	CS

16.9 BALL VALVE

The ball valve shall confirm to API 6D. The flange end shall be ANSI B 16.5 150#.

The valves shall be three pieces, full bore bi directional type.

16.9.1 Material of construction shall be as follows:

a. Body & body connector	:	ASTM A 216 GR WCB
b. Ball	:	ASTM A 351 Gr. CF8M
c. Seat	:	PTFE.
d. Stem	:	AISI 316
e. Body Seal	:	PTFE.
f. Stem seal	:	35% Carbon-filled PTFE

16.9.2 Design parameters

a. Size (mm)	:	As per priced BOQ
b. Rating (bar)	:	150#

16.9.3 Testing

a. Shell	:	31.5 kg/cm2
b. Seat	:	5.6 kg/cm2

16.10 NON-RETURNS VALVE

The valve shall be suitable for mounting on a horizontal pipeline and flow direction shall be clearly embossed on the valve body.

Valves shall possess high speed closing characteristics and be designed for minimum slam condition when closing.

Non Return valves shall conform to IS 778. They shall have metal to metal sealing. The spring action shall optimize the equal closing rates of each plate especially when the friction coefficients are uneven due to one plate resting upon one another. The plates shall not drag on the seat while opening. The plates shall not vibrate under full or partial flow condition.

16.10.1 Specification for Reflux Valve (Non Return Valve)

Standard	:	IS 778 with latest edition
Ends	:	Threaded.
Type	:	Swing type

Body, Disc, bonnet	:	Leaded tin Bronze LTB 2 (IS 318)
'O' ring	:	Nitrile rubber (IS 5192 - 1

16.11 SPRINKLERS

The full- or part-circle sprinkler shall be a single stream, water lubricated, gear drive type. The sprinkler shall be capable of both full circle and part circle operation in the same unit. The mode of operation shall be selected by inserting a flat blade screwdriver in the top of the rubber cap and turning a selector approximately 45º. The Sprinkler shall not reverse in direction during continuous operation in the full circle mode.

The part-circle sprinkler shall have adjustable arc coverage of 50º to 330º. Arc adjustment should be possible to be performed with or without the rotor in operation and shall require only a flat blade screwdriver. The arc adjustment should be possible to be performed on both the right and left trip of the sprinkler. The sprinkler shall have a rotating nozzle turret independent of the riser stem. The portion of the riser stem that is in contact with the wiper seal shall be non-rotating. The sprinkler shall have a non-strippable drive mechanism and permit manual rotation of the pop-up stem in any direction. This shall have no effect on either the drive or the set arc. Once the manual rotation is terminated, the sprinkler shall automatically return the water stream to its preset arc. The sprinkler shall have a pressure activated, multi-function, soft electrometric wiper seal. This wiper seal shall prevent the sprinkler from sticking in the up position, and be capable of sealing the sprinkler riser stem to the sprinkler cap under normal operating pressures. The sprinkler shall have a screen attached to the drive housing to filter inlet water, protect the drive from clogging and simplify its removal for cleaning and flushing of the system. The sprinkler body shall have a 1"(26/34) female (NPT or BSP) bottom inlet. The sprinkler shall have a standard rubber cover which designates each adjustment opening from the top. The sprinkler shall have a two piece, front-load nozzle assembly which will allow the nozzle to be installed without a stator bushing change. The primary and secondary nozzle ports shall be contained in one of the parts and shall biunique to each nozzle size. The tertiary nozzle port shall be common to all of the other primary/secondary nozzle assemblies. The sprinkler shall have a selection of eight color-coded nozzles. All nozzles shall have three ports for optimal close-in, mid-range and long-range water distribution. The sprinkler shall have a stainless steel nozzle retention screw. The angle of trajectory shall be 25º from horizontal. The sprinkler shall have a strong stainless steel retract spring for positive

pop-down. The sprinkler shall have a standard check valve device capable of holding up to 10 feet (3,1 m) of head. Pop-up height as measured from the top of the covert to the centerline of the nozzle orifice shall beat least 5 inches (12, 7 cm). The sprinkler's overall height shall be 101⁄8 inches (25, 7 cm) and the exposed diameter shall be 17⁄8 inches (4,8 cm).

The pop-up sprinklers, shall be installed as per the manufacturers guidelines. Swing joints shall be used to connect the sprinklers to the lateral lines. The top of the sprinkler shall always be flush with the finished ground level such as to ensure that the sprinkler top is not damaged during lawn mowing.

The positioning of sprinklers and the arc setting shall be done as per site condition to ensure maximum coverage of the area to be wetted and to avoid water falling in dry areas.

As a standard rule, 100% overlap from sprinkler to sprinkler shall be maintained, i.e., the throw radius of the sprinkler shall be the spacing to be maintained between sprinkler to sprinkler. However, in high windy areas where the wind velocity is very high and in undulating terrains, the sprinkler-to-sprinkler spacing shall be reduced to prevent any dry patches occurring, to ensure effective coverage.

Sprinkler details are as follows

Radius : 8 - 12 mtr Flow- 0.20 - 0.25 lps

DATA SHEET FOR Horizontal Centrifugal Pump Set			
Sr. No.	**Description**	**Particulars**	**Particulars by Bidders**
1.	Make of Pump Set	**As per Vendor list**	
2.	Model	To be furnished by bidders	
3.	No of Pumps	As per price bid	
4.	Design Capacity	As per price bid	
5.	Total Head	As per price bid	
6.	Shut off Head	To be furnished by bidders	

DATA SHEET FOR Horizontal Centrifugal Pump Set				
Sr. No.	**Description**	**Particulars**		**Particulars by Bidders**
7.	Rated speed & Supply Frequency	To be furnished by bidders		
8.	Type of Casing	robust construction		
9.	Pump Efficiency @ duty point (min.)	To be furnished by the bidder		
10.	BkW at Duty Point	To be furnished by the bidder		
11.	Rated Motor Efficiency	Bidder to furnish		
12.	Overall Pump Ste Efficiency	Bidder to furnish		
13.	Motor Input @ Duty Point	Bidder to furnish		
14.	Motor Rating	To be furnished by the bidder		
15.	Class of Insulation of Motor	F		
16.	Fill of Motor	Air		
17.	Type of Bearing and its rated L_{10} life	Heavy duty Ball or Roller bearings with a minimum L10 life of 75,000 hours as per BS 5512		
18.	Type of Lubrication	**Greased**		
19.	Cable size & MOC	Power cables	___mm² x ___Core x___ Runs ___mm² x ___Core x___ Runs	
		Control Cables	___mm² x	

DATA SHEET FOR Horizontal Centrifugal Pump Set				
Sr. No.	**Description**	**Particulars**		**Particulars by Bidders**
			___Core x___ Runs	
		MOC Of Conductor	Al/ Cu	
20.	Pumps suction and Delivary nozzle Size	Bidder to furnish		
21.	MOC of Motor Rotor's Squirrel Cage	Aluminium Die Cast or Dual Cage Copper Bar		
22.	MOC of Motor Pump Shaft	Stainless Steel (SS 410 or SS 430 or 1.4021 or 1.4460		
23.	MOC of Impeller	Cast Austenitic Stainless Steel (SS 316 or CF 8M or 1.4406)		
24.	MOC of Impeller's Wearing Ring	Cast Austenitic Stainless Steel (SS 316 or CF 8M or 1.4406)		
25.	MOC of Casing's Wearing Ring	Cast Austenitic Stainless Steel (SS 316 or CF 8M or 1.4406)		
26.	Weight of Pump Sets (Kg)	To be furnished by the bidder		

DATASHEET FOR BUTTERFLY VALVES			
	Description	**Particulars**	**Particulars by bidder**
1	**General**		
1.1	Make	As per Vendor List	
1.2	Type	Threaded	
1.3	Applicable standard	IS 13095-1991/BS 5155	
2	**Size ,Location & quantity**	As per Price BOQ	
2.1	Pressure Rating	PN 1.0	
3	**Material of Construction**		
3.1	Body	CI IS 210 FG260	
3.2	Bush	PTFE	
3.3	Disc	SS ASTM A 536	
3.4	Liner	EPDM	
3.5	Lock plate	CS	
3.6	Internal & External hardware	SS 304	
3.7	Lever & Lever lock screw	CS	
3.8	Upper & lower stem	SS	
3.9	Dowel pin	CS	
	Hydrotest Pressure		

3.10	Body	2.4MPa	
3.11	Seat	1.6MPa	
SWING CHECK VALVES			
	Description	**Particulars**	**Particulars by Bidders**
1	**General**		
1.1	Make	As per Vendor list	
1.2	Type	Swing Check Valve	
1.3	Applicable standard	API 594 & 598	
2	**Size ,Location & quantity**	As per Price BOQ	
2.1	Pressure Rating	PN 1.0	
3	**Material of Construction**		
3.1	Body, disc, bonnet	Leaded tin Bronze LTB 2 (IS 318)	
3.2	'O' ring	Nitrile rubber (IS 5192 - 1)	
3.3	Nuts	CSL, IS-1363(P-3),CL 4.0	
3.4	Bolts	CSL, IS-1363(P-3),CL 4.6	
	Hydro Test Pressure		
	Body	1.5MPa	
	Seat	1.0 MPa	

DATASHEET FOR BALL VALVES			
	Description	**Particulars**	**Particulars by bidder**
1	**General**		
1.1	Make	As per Vendor List	
1.2	Type	Threaded	
2	**Material of Construction**		
2.1	Body & body connector	ASTM A 216 GR WCB	
2.2	Ball	ASTM A 351 Gr. CF8M	
2.3	Seat	PTFE	
2.4	Stem	AISI 316	
2.5	Body Seal	PTFE	
2.6	Stem seal	35% Carbon-filled PTFE	
3	**Design parameters**	CS	
3.1	Size (mm)	As per priced BOQ	
3.2	Rating (bar)	150#	
4	**Testing**		
4.1	Shell	31.5 kg/cm2	
4.2	Seat	5.6 kg/cm2	

17 FOUNTAIN & WATER FEATURES

The bidder shall to design ,built, install and maintain the state of art water feature cum fountain . This also include areas which have mist kind of effects. The detail drawings shall be submit to client/ PMC with sign and stamp of Landscape architect. Following are the specification which supposed to followed by bidder but not limit to this .

17.1 Mist Water Feature

The Mist System at site will consist of Mist Spray Nozzles spraying to a height of 3 meters approximately via Pumping system with LED illumination for night time operations. The mist system consists of Mist nozzles spraying upwards mounted on pipe just .The pumping system consists of one working pump and one standby which will be mounted on pump room. The pump room will also house the electrical control panel. The mist fountain will be illuminated at night by RGB underwater LED lamps.

17.2 Ring Jet Fountain Water Feature

The Ring Jet Fountain System at site will consist of Smooth bore jet Nozzles spraying at an angle creating a parabolic jet height of 5 meters along a dia of 3.5 mtr approximately via Pumping system with LED illumination for night time operations. The Ring Jet Fountain water feature consists 12 nozzles on pipe in a circle along the edge of the water body and in centre one big nozzle will be mounted to through water up to 8 mtr height. The pumping system consists of 1working pump .

17.3 Pump System

Closed Coupled End suction back pull out pump

Pumps shall be manufacturer’s standard catalogued product and modified to provide compliance with the Drawings, Specifications and the service conditions specified and indicated.

The following submittals are required:

- Completed pump datasheet
- Certified setting plans, with tolerances.
- Certified results of hydrostatic testing.
- Certified results of dynamic balancing.
- List of recommended spare parts.
- Shop and field inspection reports.

• Bearing Life: Certified by the pump manufacturer Details to Include design data.

• Shop and field testing procedures and equipment to be used.

• Special tools.

• Results of field vibration test data including a vibration signature for each pump and drive assembly.

• Provide vibration testing procedure for review.

• Schematic control and power wiring diagrams.

17.4 Pump Specifications

Mist Fountain: NB80-160/147-127 A-F-A –BQQV 3

Pump Housing: Cast Iron – EN-GJL-250-ASTM A48-40 B

Impeller: Cast Iron –EN-GJL-200-ASTM A48-30 B

Motor Type: SIEMENS – IE Efficiency Class –IE2

Parabolic Jets Golden Arch Water Feature For North West Side-NB125-250/269 A-F-A-BAQE

Pump Housing: Cast Iron – EN-GJL-250 – ASTM A48-40 B

Impeller: Cast Iron – EN-GJL-200-ASTM A48-30 B

Motor Type: MMG200L

Parabolic Jets - Golden Arch Water Feature For South West Side- NB125-250/269-A-F-2-AE-BAQE

Pump Housing: Cast Iron –EN-GJL-250-ASTM A48-40B

Impeller: Cast Iron – EN-GJL-200-ASTM A48-30 B

Motor Type: MMG200L

17.5 Pipe and Fittings

Steel pipes and fittings shall comply with IS 2062 and IS 3589:

- IS: 5822 : Code for practice for laying of welded steel pipes
- IS 554 : Dimensions of Pipe Threads
- IS 1239 (Part I and II) : Specification for Mild Steel tubes and fittings

- IS 1363 : Hexagonal Bolts, Screws and nuts - Grade C
- IS 1364 : Hexagonal Bolts, Screws and nuts - Grade A and B
- IS 1978 : Line Pipe
- IS 2062 : Steel for general structural purposes
- IS 3114 : Code of Practice for laying pipes
- IS 6392 : Steel Pipe Flanges
- IS 10221 : Code of Practice for coating and wrapping of underground MS pipelines
- IS 13257 : Ring type joint gasket and grooves for flanges
- ISO 7005 Part 1 Steel Flanges
- ISO 10474 Steel and Steel Products – Inspection Documents.
- ISO 8501-1 Preparation of steel substrates before application of paints and related products – surface roughness.

Welded pipes shall be made from not more than two plates with two longitudinal welds; no circumferential welds will be permitted except for built-up bends and flanges. All Steel Coated pipes and fittings shall be rated to 6 bar. All material shall have manufacturers test certificates. The Welding of Steel pipe work shall be in accordance with the appropriate standards as follows:

- BS 2633 Class I Arc Welding of Ferritic Steel Pipe Work for carrying Fluids
- IS 814 Class II Arc Welding of Carbon Steel Pipe Work for carrying Fluids
- BS 4677 Arc Welding of Austenitic Stainless Steel Pipe Work for carrying Fluids

When welded up, each pipe barrel shall be truly cylindrical and circular in cross section and shall comply with the tolerance laid down in the BS & IS quoted above.

Steel pipes shall be internally and externally protected by the application of 3 coats of approved high build acid resistant epoxy paint to a minimum thickness of 1000 microns.

Couplings and flange adaptors shall be mechanical couplings comprising centre sleeve, end flanges, wedge-shaped rubber sealing rings, and nuts and bolts.

Couplings shall be nylon-coated and nuts, bolts and washers shall be stainless steel, Grade 316 L. Installed couplings and flange adaptors shall be protected

Unless specified elsewhere, rubber joint rings for water mains and drainage purposes shall be types W and D respectively complying with the relevant provisions of BS 2494 and BS EN 681-1 and shall generally be obtained from the pipe manufacturers.

All pipes, fittings sealing rings, joints and joint lubricants shall conform to all local regulation requirements.

All material shall have manufacturers and mill test certificates. All procedure approval tests shall be witnesses by Employer or Employer Engineer

The cost of carrying out any pre-qualifying trial shall be borne by the Contractor.

Internal surface of the pipe and fittings shall be blast cleaned to SA 2.5 in accordance with ISO 8501-01/SIS 05 59 00 standards.

External surface of the pipes and fittings shall be blast cleaned to SA 2.5 in accordance with ISO 8501-01/SIS 05 59 00 standards and epoxy coated / painted to a total minimum dry film thickness of 275 microns,

Contractor shall provide inspection test certificate for all pipes, fittings and flanges in accordance with applicable API, ASME, STM, ANSI, ISO, BS, IS specification. All material test certificates shall indicate conformity to the requirements

Contractor shall submit a detailed inspection and test plan for approval showing manufacturer inspection and testing activities it is acceptance criteria prior commencement of manufacturing. Radiography test and hydro test shall be witnessed by Employer or Employer representative.

Polyamide (Thermoplastic) flexible pipe and Nickeled brass fittings:

- External diameter: 9.6mm and 12.7mm
- Operating pressure: 100bar @ 23 ºC
- Burst Pressure: 260bar @ 23 ºC
- Operating temperature range: -20 ºC / + 80 ºC

Hand pressure is enough to join the pipe to the fitting without any other tool.

The metal vices inside the fitting prevent the pipe unthreading.

17.6 Anti-Vibration Mounts

Anti-vibrations mounts are designed for vibration isolation of pumps. The leveling and insulating elements should be fitted with respective insulating plate for designed Vibration isolation.

Load Kg /pc 120.

17.7 Mist Nozzles

Nozzles will be cleanable type two piece nozzle with removable cap design producing a uniform spray of fine mist.

Material of construction Stainless steel type 304.

The Nozzle end connection shall be BSPP standard threads

Contractor shall provide inspection test certificate, material test certificated and performance test certificate for the mist nozzles.

Adjustable Smooth Bore Jet Nozzle

Nozzle to produce a high straight stream of water with minimum distortion within designated height. The nozzle must be mounted on an adjustable base capable of universal adjustment 15º from the vertical in any direction.

M.O.C: Brass & Gunmetal

End Connection: 2” BSP Female threaded connection

Fasteners: Stainless Steel 304

Distance of Throw: 5 Meters in a Parabolic Arch

17.8 Pipe Work

Generally all feature pipe work shall be in MS heavy duty (Conforming to BS 5534 /IS Standard 3589) D/E(plant room) For large bore pipe work, bolted flange connection may be used. For Water Screen. All pipe work shall be SS 304 confirming to ASTM A 312 schedule 40. For pump, pipe work shall be sized to give the following maximum flow velocity.

- Suction pipe work maximum flow velocity 1.5meter/second.
- Discharge pipe work flow velocity 1.8meter/second.

Consideration should be given to the pipe work maintenance and drain point should be include Fall to allow full drain down by gravity return where possible. It expected that

coordination with other services will be required and it is imperative that pipe run comply with straight line, level (Or slightly falling on return pipe work) route is maintained. Areas where air lock can develop must be avoided or accounted for by automatic vent valves. Pipe rough tang position should account for the possibility that key fitting may need to be Replace. Therefore unions / or sufficient pipe clearance should be provided to allow this.

17.9 Pipe Supports

The pipe work manufactures installation instruction should be followed and preferably their own Pipe work support system used. If not, closed checking should be made to the pipe gripe size to Ensure compatibility. Pipe work weight should be considered as completely fill with water and adequate support used to Ensure correct support integrity. The design should assume that no other trades will use the same anchors to supports their services.

Note : The bidder shall have to maintain the waterbody ,fountain & irrigation system for five years and replace the fixture which are not working during maintenance period

18 SPECIFICATIONS FOR OTHER MISCELLENOUS WORKS

18.1 Play Equipment & Open Air Gym

The bidder shall to design ,built, install and maintain the play equipment for children and open air gym for adult . The detail drawings shall be submit to client/ PMC with sign and stamp of Landscape architect.

The equipment make shall be Koochie play, Arihant or equivalent and approved by PMC before installation.

18.2 Garden furniture & Dustbins.

The bidder shall to submit the garden furniture and dustbins layout and design as per approved make by PMC.

18.3 Sculpture

The bidder shall to design ,built, install and maintain the stone sculpture. The bidder shall submit the design & layout concept of Sculptures which to be made with a height of 5' and width of 2' in Sandstone . The sculpture should reflect the concept of Guwahati smart city. Bidder to submit the detail and drawings of sculpture and take the approvals from client/PMC before execution of work.

18.4 Public utilities /Toilets/ Guard Rooms etc.

The bidder shall to design ,built, install and maintain Public utilities /Toilets/ Guard Rooms etc. The bidder shall to provide adequate facilities of Public utilities /Toilets/ Guard Rooms etc. in all sense with good industrial practice . The bidder shall to submit the detail drawings of all the component which includes , sanitation, plumbing , electrical civil HVAC etc. The bidder shall also provide the adequate water storage for toilets and drinking water cooler, power back up for emergency light, etc. The bidder shall have to maintain the Public utilities /Toilets/ Guard Rooms etc. areas and fixture for five years and replace the fixture which are not working during maintenance period .

18.5 Gazebo and Pergola

The bidder shall to design ,built, install and maintain Gazebo and Pergola in wood . The bidder submit the design & layout concept of wooden Gazebo and Pergola. The wooden Gazebo and Pergola shall be design for shade and sitting public space. Bidder to submit the detail and drawings of sculpture and take the approvals from client/PMC before execution of work.

19 DRAWINGS TO BE PREPARED BY CONTRACTOR

19.1 Softscape Works

Sr. No.	Drawing title
1	Site Grading with levels Plan
2	Landscape Master Plan
3	Plantation Plan for Trees
4	Plantation Plan for Shrubs, Groundcovers and Lawn
5	Blow-up Plans
6	Site sections
7	Typical Details

19.2 Hardscape Works

Sr. No.	Drawing title
1	Layout and details of seven gates & Ghat
2	Details of Deck ,Bridges, walkway etc.
3	Over all Material Plan
4	Flooring details (cover all the areas and material)
5	Mock- up drawings
6	Drainage Plan & details
7	Plan ,Elevation Section of Toilet block ,Guard room and any other building
8	Sculpture detail and layout
9	Details of Gazebo and Pergola
10	Play Equipment & Open Air Gym
11	Entry gate , Ticket window, kiosk etc.
12	Layout and Details of Garden furniture & Dustbins.
13	Boundary wall and railing detail
14	Details of water feature/ fountain and mist fountain
15	Site sections and blow up details
16	Lighting plans and concept .
17	Typical Details

19.3 For irrigation and fountain

Contractor has to submit the following drawings for approval prior to design the irrigation system.

Sr. No.	Drawing title
1	Construction Layout / Plan
2	Irrigation Layout / Plan
3	Piping layout / Plan
4	Drainage Layout / Plan
5	General Arrangement Drawings for Water Fountains
6	General Arrangement Drawings for Pumping Machineries
7	General Arrangement Drawings for Deep Mist Spray System

Note: These are the tentative drawings list but not limited to these. The bidder shall have to furnish all the working drawings covering each and every elements of landscape works.

20 LIST OF APPROVED MAKES/BRANDS OF MATERIALS

Sr.No.	Details of Materials / Equipment	Manufacturer's Name
1.	Erosion control mats (for slope retention)	Octan Exports Sri Venkateshwara Fibre Udyog Surajbhan Commodities Private Limited Or Approved Equivalent
2.	**Plant material**	Reputed Nursery or nurseries (Shall be approved by Landscape architect & PMC)
3. Tiles		Kajaria, somany, pavit or equivalent as approved by the PMC
1.	Ordinary Portland Cement	L & T, Grasim, Vikram,ACC, Ultratech
2.	White Cement	Birla, J.K.
3.	Coarse Sand	As Per IS 383(Latest Edition) From Approved Quality
4.	Fine Sand	As Per IS 383(Latest Edition) From Approved Quality
5. Stone Aggregate		As Per IS 383(Latest Edition) From Approved Quality
6. Water Proofing		M/S Roofers Combine (3262413), Sika (6426009), Bostik
7. Reinforcement Steel-T.M.T.		TATA steel ,Tisco, Sail,Rathi
8. Structural Steel		TATA steel ,Sail Or Approved Equivalent
9. Stainless Steel Sections		Salem Steel, Jindal Steel
10. Anchor Fasteners/ Couplers		Hilti, Canon
11. Block Board, Ply Wood		Century (3626045), Duro,V.I.Ply, Jyoti Ply
12. Epoxy		Fosroc Or Approved Equivalent
13. Epoxy Grout		BAL(6407272) Or Approved Equivalent
14. Penetrating Sealer(Aquamix)		Pristine(6405480) Or Approved Equivalent
15. Polish Protector(Aquamix)		Pristine(6405480) Or Approved Equivalent
16. Putty		Shalimar Or Approved Equivalent
17. Fire Sealent		Navair (6491167) Or Approved Equivalent

18. Paints/Polish	ICI, Berger, Asian
19. Textured Paint	Spectrum (6836587), Heritage, Asian, Nerolac.
20. Pigment	Sudershan Chemicals, TATA Pigments
21. Mirror	Modiguard, Goldplus
22 Integral Water Proofing	Pidilite, Polydee, Roff, Or Approved Equivalent

20.1 List of Approved Makes for irrigation and Fountain work

1.	G.I. Pipes Class "C"	TATA / Zenith / Jindal / Equivalent
2.	G.I. Fittings	Unik/ NVR/ Equivalent
3.	Gate Valve / Non Return Valve	Sant / Zoloto/ Leader / Equivalent
4.	PVC Pipe & Fittings	Astral / Supreme / Prince / Dutron / Equivalent
5.	Centrifugal Pump sets	Beacon Weir / Jyoti / Kirloskar / KSB / Mather & Platt (Wilo) / Worthington / Equivalent
6.	Submersible Centrifugal Vertical / Non-clog Pumps	Aqua / Kirloskar / Kishor / KSB / ABS / ITT-Flyght / Grundfoss / Xylem / Mather & Platt / Equivalent
7.	Ball Valves	Audco / BDK-Weir / Intervalve / Kirloskar / Saunders / Saturn / Hi-Tech / Virgo / Hawa Engineers / Equivalent

Note: The contractor shall produce all samples including natural stones, before procurement of the materials, for approval of the Architects/Project Manager.

Where more than one manufacturer is listed, the names are given in the order of preference. The contractor shall quote the rates for the various items of work based on the materials of first preference after ascertaining the availability, delivery schedule of the same. Unless the contractor stipulates in this tender, it shall be presumed that the rates quoted are for material of first preference only.

In the event, the contractor is permitted to use the material of lower preference because of valid reasons, then the contract rates for the relevant items of work shall be suitably adjusted on the basis of variation in prices of the materials of first preference and those actually used. If the

prices of the materials used are higher than the material of the first preference, the owner shall not be liable to make any enhanced payment for the affected items of work on this account.

In respect of materials for which approved makes are not specified above, those shall be decided by the Architects/Project Managers as per samples approved.

Request for Proposal

For

DEVELOPMENT OF BORSOLA BEEL

Design, Build and Operate Basis

Volume II B Part-3: Technical Specifications for Geo-Technical Works

Client:

GUWAHATI SMART CITY LIMITED

GSCL,
Guwahati, Assam

DOCUMENT NO: 10477A-CV-3000-3102

1. SPECIFICATION FOR GEOTECHNICAL INVESTIGATION

1.1. Contractor shall carry out detailed soil investigations at sufficient number of locations as per IS code and as directed by the engineer to cover the entire area of construction. The geotechnical investigation shall conform to the specifications and latest IS codes. Any additional tests which are required for fulfilling the design requirement and not covered in this specification shall be carried out as directed by ENGINEER in charge.

1.2. Codes And Standards

All work shall be carried out strictly in accordance with the Technical Specifications, unless otherwise approved by the ENGINEER in writing. Where not specified, the latest edition of the applicable code of practice or procedure as laid down by the Bureau of Indian Standards (BIS) shall be followed. The Earth Manual of the United States Bureau of Reclamation shall also be referred to in the absence of relevant information, procedures and guidelines by BIS. Only the SI system shall be observed.

Some of the relevant standards issued by BIS are listed below. In case of any discrepancy between these specifications and BIS, most stringent shall govern.

IS: 383	-	*Specification for Coarse and Fine Aggregates From Natural Sources*
IS : 456-2000 2005	-	*Plain and Reinforced Concrete- Code of Practice*
IS : 1080-19*85 Reaffirmed -2002*	-	Code of Practice for Design and Construction *of Shallow Foundations in Soils (Other than Raft, Ring & Shell)*
IS : 1498-1970 *Reaffirmed -2002*	-	Classification and Identification of Soil for General Engineering Purpose
IS : 1888-1982 *Reaffirmed -2002*	-	Method of Load Tests on Soils
IS : 1892-1979 *Reaffirmed -2002*	-	Code of Practice for Subsurface Investigations for Foundations
IS : 1904-1986 Reaffirmed -200*5*	-	Code of Practice for Design and Construction of Foundations in Soils – General Requirement
IS : 2131-1981 *Reaffirmed -2002*	-	Method of Standard Penetration Test for Soils *(First Revision)*
IS: 2386 (Part IV)	-	*Methods Of Test For Aggregates For Concrete - Mechanical Properties*
IS : 2720-	-	(Part I to Part *XLI)* - Methods of Test for Soils
IS : 2809-1972 *Reaffirmed -2001*	-	Glossary of Terms and Symbols Relating to Soil Engineering
IS : 2911	-	*(Part I to Part IV and all Sections) - Code of Practice for Design and Construction of Pile Foundations*

IS : 2950-1981 *Reaffirmed -2003*	-	Code of Practice for Design and Construction of Raft Foundations
IS : 3025-1964 Reaffirmed -2005	-	*Method of Sampling and Test (Physical and Chemical) for Water in Industry (Superceding IS: 1631)*
IS : 3043-1992	-	*Code of Practice for Earthing*
IS: 3764	-	*Safety Code for Excavation work*
IS : 4078-1980 *Reaffirmed -2004*	-	Code of Practice for Indexing and Storage of Drill Cores
IS : 4091-1979 *Reaffirmed -2000*	-	Codes of Practice for Design and Construction of Foundations for Transmission Line Towers and Poles *(First Revision)*
IS : 4332	-	(Part I to Part X) - Methods of Test for Stabilized Soils
IS : 4434 -1978 *Reaffirmed -2002*	-	Code of Practice for In-Situ Vane Shear Test for Soils
IS : 4453-1980 Reaffirmed -2002	-	*Code of Practice for Subsurface Exploration by Pits, Trenches, Drifts and Shafts. (First Revision)*
IS : 4464-1985 *Reaffirmed -2004*	-	Code of Practice for Presentation of Drilling information and Core Description in Foundation Investigation
IS : 5313-1980 Reaffirmed -2004	-	*Guide for Core Drilling Observations*
IS : 5529-	-	(Part I and Part II) - Code of Practice for In-situ Permeability.
IS : 6403-1981 *Reaffirmed -2002*	-	Code of Practice for Determination of Bearing Capacity of Shallow Foundations
IS : 6935-1973 Reaffirmed -2012		*Method for determination of water level in a borehole*
IS : 7317-1993 *Reaffirmed -2005*	-	Code of Practice for Uniaxial Jacking Test for Deformation Modulus of Rock.
IS : 8009	-	(Part I *&* Part II) - Code of Practice for Calculation of Settlements of Foundations
IS : 8764-1998 Reaffirmed -2003	-	*Method of Determination of Point Load Strength Index of Rocks (First Revision)*
IS : 9143-1979 Reaffirmed -2006	-	*Method for Determination of Unconfined Compression Strength Test of Rock Materials*
IS : 9214-1979 *Reaffirmed -2002*	-	Method of Determination of Modulus of Sub-grade Reaction (K value) of Soils in the Field
IS : 9221-1979 *Reaffirmed -2003*	-	Method for Determination of Modulus of Elasticity and Poisson's Ratio of Rocks Materials in Uniaxial Compression
IS : 10042-1981	-	Code of Practice for Site Investigations for

Reaffirmed -2002		Foundation in Gravel-Boulder Deposit
IS : 10082-1981 Reaffirmed -2006	-	*Method of Test for Determination of Tensile Strength by Indirect Tests on Rock Specimens*
IS : 10108-1982 *Reaffirmed -2005*	-	Code of Practice for Sampling of Soils by Thin Wall Sampler with Stationary Piston
IS : 11315	-	*(Part 1 to Part 12) Method for Quantitative Description of Discontinuities in Rock Mass*
IS : 11550-1985 *Reaffirmed -2002*	-	Code of Practice for Field Instrumentation of Swelling Pressure in Expansive Soil
IS : 12070-1987 Reaffirmed -2005	-	*Code of Practice for Design and Construction of Shallow Foundations on Rocks.*
IS :13094-1992 Reaffirmed 2002		*Selection of ground improvement techniques for foundations in weak soils –Guidelines*
IS:13063-1991 Reaffirmed 2001		*Structural Safety of Buildings on shallow foundations on rocks*
IS : 13365-1998	-	*(Part I to Part III) Quantitative Classification Systems of Rock Mass – Guidelines*
IS:14593-1998 Reaffirmed 2003		*Design and construction of Bored Cast-in-situ Piles founded on rocks*
IS:15284 (Part 1& II) 2003		*Design and construction for ground improvement - Guidelines* *Part I : Stone Columns* *Part II-Pre-consolidation using vertical drains*
IS:-15681-2006	-	*Geological exploration by Geophysical methods (Seismic Refraction)*
FHWA- RD- 83-026		*Design and construction of stone column – Volume – 1*
FHWA- RD- 83-027.		*Design and construction of stone column – Volume –II*

1.3. **Scope of work**

The purpose, in brief, of the proposed Geotechnical Investigations is:

i. to determine type of substrata and their characteristics upto the required depths.

ii. to assess the general suitability of the site for the proposed works.

iii. to enable an adequate and economic design to be prepared, including the design of temporary works.

iv. to plan the best method of construction; to foresee and provide against difficulties and delays that may arise during construction due to ground and other local conditions.

v. to determine the changes that may arise in the ground and environmental conditions, either naturally or as a result of the proposed works, and the effect of such changes on adjacent works and on the environment in general.

vi. where alternative sites exist or are studied to advise on the relative suitability of different sites, or different parts of the same site.

vii. to explore sources of indigenous materials for use in construction.

viii. All the tests that are considered necessary for this purpose, as per BIS code and best engineering practise shall be conducted.

1.4. **Field Work**

1.4.1. Boring

i. Contactor shall take necessary work permit from the concern department prior to commencement of boring work.

ii. Constructor shall check for the presence of underground utilities in at the proposed locations through hand dug pits up to at least 2m below ground level. Drilling activities shall commence after confirmation that area is free from presence of underground utilities.

1.4.2. Boring in Soil

1.4.2.1. Method of Boring

Boring in soil strata shall be carried out by rotary drilling machine or by method approved by the ENGINEER. In any case the method for boring used shall be such as to bring to the notice of the field operator, any change in stratum, within the accuracy of 100mm. Also rigs shall be capable of boring to required depth. Casing and/or bentonite/ mud slurry may be used to avoid caving. However, for those boreholes where water samples are to be collected for chemical analysis or field permeability tests are to be conducted, bentonite/ mud slurry shall not be used or shall be restricted as directed by the ENGINEER.

In boring particularly through cohesionless and dry soft to medium stiff clay strata, the CONTRACTOR shall take every precaution to avoid unnecessary disturbance to the soil including ensuring that:

i. the net hydraulic head at the bottom of borehole is zero or slightly on positive side within the borehole;

ii. Close-fitting tools such as bailer shall be withdrawn slowly to avoid suction pressure.

1.4.2.2. Diameter of Boreholes

The diameter of the boreholes shall be such as to permit collection of undisturbed samples of 90 to 100mm diameter. However, the diameter shall not exceed 150mm unless approved by the ENGINEER during the award of the work.

1.4.2.3. Casing in Boreholes

Where a borehole is being cased, the bottom of the casing shall always be maintained within 150mm of the bottom of the borehole, till a stratum is reached

where a casing is not required. However, the casing shall never be in advance of the bottom of the borehole during undisturbed sampling, standard penetration tests, and other in-situ test.

1.4.2.4. Obstructions While Boring

If any obstruction to normal boring is encountered in any borehole, this obstruction shall be overcome by drilling and/or by chiselling. Chiselling will normally be paid at the contract rate for boring in soil at appropriate depths, unless a separate rate has been provided for in the Contract.

1.4.3. Drilling in Rock

In rock strata, boring shall be done by using a rotary cutting tool tipped with diamonds and equipped to recover cores. The use of Tungsten Carbide (TC) bits shall be permitted by ENGINEER discretion. Drillhole size shall generally be NX. However in some cases other size holes may be specified.

Core barrels shall normally be double-tube ball-bearing, swivel type, with the core lifter located in the lower end of the inner barrel.

Drilling shall be carried out in such a manner that maximum core is recovered. This requires close surveillance of wash water, drilling pressures, lengths of runs etc. The drill bit shall be withdrawn and the core removed as often as may be necessary to secure the maximum possible amount of core. The CONTRACTOR shall ensure that drilling is carried out with necessary skill and expertise.

Coring runs shall be limited to a maximum length of 3.0m. When less than 50% of the core is recovered from a run or when a geological features is to be accurately determined, the length of the run shall be reduced to 0.5m unless directed otherwise by the ENGINEER.

The core shall be removed from the drill hole immediately if blocking of the bit or grinding of the core is apparent, regardless of the length of run which has been made.

The CONTRACTOR shall not use drilling mud or any lubricant in the drill hole other than water.

The ease or difficulty of drilling at different depths shall be carefully noted and recorded during drilling. The returning drill water shall be kept constantly under observation and its character, such as, its clarity or its turbidity, its colour, etc. shall be recorded.

For each run, Core Recovery and Rock Quality Designation (RQD) shall be noted carefully, immediately after cores are taken out of the barrel.

Each and every core piece shall be serially and sequentially numbered from top downwards as soon as the core pieces are removed from the core barrel. The serial number shall be painted with good quality enamel paint.

All core pieces shall be placed in core boxes in serial order in correct sequence from top downwards. Core boxes shall be made according specifications laid down in IS:4078.

Colour photographs of the cores after placing in core boxes shall be taken and shall be included as a part of report. Cost of photo shall be included in drilling rate.

The cores, arranged in core boxes as noted earlier, shall be submitted to the OWNER/ ENGINEER on submission of the report. The following information will be printed by using good quality paint on the top of core boxes - Project title ,client name ,consultant name, location of drilling, bore hole number, depth of cores

stocked, number of box and total number of core boxes. The cost of this including the cost of core boxes will be presumed to be included in drilling rate.

If core recovery is less than 20 per cent, the payment for drilling shall be same as that for boring in soil at appropriate depths.

1.4.4. Borehole Depth

All boreholes shall be sunk to depths as per the BIS Codes and best engineering practise.

1.4.5. Sampling

The CONTRACTOR shall collect samples and cores as directed by the ENGINEER. This operation shall include the provision of all necessary equipment, tubes and containers and materials.

1.4.5.1. Undisturbed Soil Sampling in Boreholes

1.4.5.1.1. Frequency

Generally, undisturbed soil samples (UDS) shall be obtained at every 3.0m interval and at every identifiable change of soil formation.

1.4.5.1.2. Sample Size

Unless agreed upon otherwise the samples shall be minimum 90mm diameter and generally 450mm long.

1.4.5.2. Types of Samplers

1.4.5.2.1. Thin walled open drive sampler

Generally open drive sampler shall be permitted for sampling in cohesive strata. These samplers shall be made of seamless steel or aluminium tube. Area ratio of sampler shall not exceed 25 percent for 100mm diameter sampler, and 15 percent for 75mm diameter sampler. The cutting edge of the cutting shoe (or edge) of the sampler shall be tapered at an angle not exceeding 20 degrees and inside clearance ratio shall generally be limited to 0.5 to 1.5 percent. Samplers with low clearance ratio shall be used in soft strata and those with high clearance ratio shall be used in stiff strata.

The sample tube and cutting shoe (or edge) shall be free from rust, pitting, burring or any other defect. The use of oil inside the sampler shall be limited to the minimum practicable.

One end of sample tube shall be marked "Top" and this end shall be kept uppermost during sampling.

The adapter head to be used with sample tube shall be fitted with a ball valve to permit the exit of air or water during driving or jacking.

1.4.5.2.2. Stationary piston sampler

In fine grained strata with no or little cohesion such as in silty soils piston sampler shall be used. Requirements of the piston sampler are same as those of open drive sampler.

1.4.5.2.3. Sand sampler

If undisturbed samples are specified to be recovered from sandy strata particularly below ground water table, special sand samplers shall be used. A compressed air sampler (Bishop 1948) or similar sampler would be acceptable.

1.4.5.2.4. Samplers for continuous sampling

When specified continuous sampling shall be obtained to depths specified. For this purpose, the Delft continuous sampler or similar sampler may be used.

1.4.5.3. Procedure for Sampling

Before sampling operation, the CONTRACTOR shall clean the bottom of borehole very carefully and every care shall be taken to avoid disturbance of material to be sampled. For sampling, the sampler shall be lowered to the bottom of borehole without impact, and pressed into the soil in a single continuous movement at a sufficiently slow rate to permit the check valve to pass the water in the tube without creating excess back-pressure. The open drive sampler may also be driven into the soil. The sampler shall never be pushed or driven to its full length. After penetration to the required depth, the sampler shall be freed from the soil by being rotated by one full turn. The sampler shall then be withdrawn smoothly so as to cause the minimum disturbance to the sample. The total length of the sample shall be measured and recorded and, if any of the soil has fallen out of the bottom of the tube, this fact shall also be recorded.

All the samples shall be stored in shade/ cool place to avoid the change in moisture content and shall be transported to laboratory without much delay. Medium to hard consistency clays /cohesive /semi-cohesive located either above or below the water table shall be sampled in an undisturbed condition as per USBR Earth Manual/IS Standards

1.4.5.4. Undisturbed Soil Samples from Test Pits and Other Sources

The CONTRACTOR may be required to collect undisturbed soil samples from trial pits, excavations etc.

Samples to be collected may be core samples or block samples and may be obtained with a special orientation as indicated by the ENGINEER. Block undisturbed samples shall be collected as per recommendations of "United States Bureau of Reclamation" Earth Manual.

Core samples shall generally be obtained by jacking a thin-walled open drive sampler of around 100mm diameter into the stratum. Sample tube may also be driven if approved by the ENGINEER. Sample tubes shall be held steady during jacking/ driving and a suitable frame shall be used for guiding inclined samplers.

1.4.5.5. Disturbed Soil Samples

In all boreholes, unless continuous undisturbed soil sampling is in operation, disturbed soil samples shall be taken at every 1.5m interval and at significant change of stratum. Materials from cutting shoe of undisturbed samplers and from split spoon sampler used for standard penetration tests shall be taken as disturbed samples. These samples shall be placed without delay in air-tight glass jars of not less than 0.4kg nominal size or adequately sealed polythene bags and each sample shall fill the jar or bag as possible. Payment for disturbed samples collected from the cutting edges of undisturbed samplers and from split spoon sampler is presumed to be included in the rate of collecting undisturbed samples and conducting standard penetration test.

In certain cases bulk disturbed samples may be required to be collected from boreholes and trial pits. Bulk disturbed samples from boreholes are to be collected if the material in the ground includes gravel or cobble sized particles.

Such samples shall be representative. Unless specified, the large sample should be minimum 3kg when collected from boreholes, and of 15kg when collected from trial pits. All large samples shall be sealed into heavy duty polythene bags immediately after they are collected with accurate logging .

Trial pits greater than 1.50m in depth shall have proper sloping / be shored. Linear Dimensions of trial pit shall be so as to permit visual logging of all four faces for soil stratification. Excavated material shall be store sufficiently away from the edges. The excavated area shall be barricaded with safety ribbons.

1.4.5.6. Water Samples

Water samples shall be collected from boreholes as specified. Water samples shall be collected before the addition of water to the hole unless this is not possible. If this is not possible, then, prior to collection of water sample, water level in the borehole shall be lowered by about 0.5m and the water level in the borehole then allowed to rise by water seeping through the walls of the borehole. The water sample shall then be collected. Care shall be taken to see that water sample is not contaminated by surface water or rain water.

In some cases water samples may be required to be collected from different depths. In such cases it is advisable to collect the samples on the completion of the relevant borehole unless a suitable sampler to collect water sample from different depths below free water surface is used. To collect the water sample, in absence of a suitable sampler the borehole shall be dewatered to about 0.5m below the depth specified for collecting the sample. The sample shall be collected when the water rises to required depth.

If specified, groundwater sample shall also be collected from trial pits.

If there are any wells within the area investigated, one water sample from each well shall also be collected. If specified, water samples shall also be collected from well(s) located nearby the area being investigated.

The water sample shall be collected in an air tight, scrupulously clean glass or inert plastic bottle or jerry can. The bottle/ can shall be rinsed three times with water being sampled, before filling. The quantity of each water sample collected shall be about 1 litre.

Water samples shall be tested as soon as possible after sampling, for sulphate (SO_3) and chloride contents and its pH, and for other cations and anions.

1.4.5.7. Sealing and Labelling of Samples

Immediately after taking an undisturbed sample in a tube, the cutting shoe and the adapter head shall be removed along with the disturbed material which they contain. The visible ends of the sample shall each be trimmed off any wet disturbed soil. The ends shall then be coated alternately with four layers of just molten microcrystalline wax or other similar material approved by the ENGINEER. More molten wax shall then be added to give a total thickness of not less than 25mm. Any space remaining at the ends of the sample tube shall be solidly filled with damp saw dust or other material approved by the ENGINEER, and ends of the sample tube shall be covered with tight fitting caps preferably screw caps.

Block samples shall also be coated with a succession of layers of microcrystalline wax and it may be advisable to reinforce these with layers of porous fabric (e.g. muslin). These samples should be packed in a suitable material and placed in a strong case. Large samples shall be provided with a tight fitting formwork or packed in a rigid cement or resin so as to prevent fissures opening up under the self weight of the sample.

The CONTRACTOR shall assign a reference number to each soil and water sample taken from the borehole. This number shall be unique for that borehole and shall be in order of depth below the ground level.

All samples shall be clearly labelled indicating job number, borehole number, sample number, date of sampling, brief description of sample, type of sample, elevation of sample etc. and in case of undisturbed samples, the top/ bottom of samples shall also be clearly labelled. Each such label shall be pasted on the container and another shall also be within the container.

1.4.5.8. Transporting and Storing of Samples

The CONTRACTOR shall properly store all the samples at site till they are transported to his laboratory for testing. Sampling tubes containing undisturbed soil samples shall not be exposed to direct sun and shall be kept in a shade covered with wet gunny bags. These tubes shall be transported in specially fabricated wooden boxes with hinged covers. To minimise disturbance during shipment, saw-dust or similar other resilient material shall be used while packing into the wooden boxes.

The rock cores obtained by drilling shall be carefully removed from the core barrel and placed in a properly constructed wooden core boxes with hinged wooden covers as specified above. The cores shall be placed in the boxes in the correct sequence and with each run segregated accurately by labelled wooden blocks 25mm thick. No box shall contain more than 6m of core. Depths of all runs shall be marked on the portions with paint.

The CONTRACTOR shall transport all samples to his testing laboratory as quickly as possible and test the samples. Samples shall be transported by air, if the stipulated completion period so warrants. All unused and excess samples after testing shall be retained and properly stored by the CONTRACTOR for three months after the end of submission of the report.

The CONTRACTOR shall transport all samples to his testing laboratory as quickly as possible and test the samples. Samples shall be transported by air, if the stipulated completion period so warrants. All unused and excess samples after testing shall be retained and properly stored by the CONTRACTOR for three months after the end of submission of the report.

The unit rates quoted by the CONTRACTOR for sampling are deemed to account for sealing, labelling, transporting, storing etc. as specified.

The CONTRACTOR may be directed by the ENGINEER to deliver some of the samples to a laboratory other than his own, and in such cases, the CONTRACTOR shall be paid only for the extra cost of shipment, if any, incurred by him.

1.4.5.9. Specific Observations During Boring

Observations to be made by the CONTRACTOR during boring shall include but not be limited to the following:

1.4.5.10. Sequence and Thickness of Different Strata

Visual description and thickness of each stratum shall be observed. The description shall include but not necessarily be limited to soil type, consistency, colour etc.

1.4.5.11. Groundwater Table

The depth at which groundwater is struck during boring shall be carefully noted and the depth of water table shall be ascertained subsequently in the completed borehole by daily observing the depth for the next six to seven days. Depth of groundwater shall also be observed in wells, if wells exist in the vicinity.

1.4.5.12. "Loss" or "Make" of Drilling Fluid

The “Loss” or “Make” of drilling fluid if observed during the boring shall be noted and brought to the attention of the ENGINEER. Attempts shall be made to detect joints, fissures, artesian conditions, etc.

1.4.5.13. Presence of Lime, Mica etc.

Soil and rock samples shall be examined for presence of lime, mica etc, and shall be recorded, if observed.

The CONTRACTOR's rate for boring shall be deemed to include these and all other relevant observations.

1.4.5.14. Test in a Borehole

1.4.5.14.1. Standard Penetration Test (SPT)

Unless directed otherwise by the ENGINEER, the CONTRACTOR shall carry out Standard Penetration Test in a borehole generally at *1.50m* intervals and at every noticeable change of strata and as per the procedure in IS:2131 or equivalent code of practice or as directed by the ENGINEER. The first test shall generally begin at 1.0 to 1.5m depth, unless UDS is collected at that depth. Generally SPT and UDS shall be conducted alternatively at 1.5m intervals, unless some other test is specified by the ENGINEER at that location. If UDS cannot be collected, this shall be replaced by the SPT.

For conducting the test, the bottom of borehole shall be cleaned properly and the spoon shall be properly and centrally seated in position in the borehole. It is necessary to ensure that drive hammer is of specified weight and has a specified free fall. It shall be ensured that energy of the falling weight is not reduced by friction between the drive weight and guides or between rope and winch drum. Only BIS recommended standard connecting rods shall be used for the test.

In case the blow count of SPT in soil (including the number of blows for seating) exceeds 120, the corresponding penetration shall be recorded and this particular test at that depth stopped. If the total penetration is more than the seating penetration of 15cm, then the break-up of blow count for 15cm seating penetration and for remaining portion of penetration shall also be given.

Standard Penetration Tests shall also be conducted in weathered/ soft rock with Rock Quality Designation (RQD) less than 25%. In such a case, test shall be conducted at every 1.5m interval, unless specified otherwise, with the first test at a depth of 0.5m below the elevation at which weathered/ soft rock is encountered. The procedure for the test shall be same as that in soil except that penetration corresponding to 20 and 120 blows shall be noted. Also, if the total penetration is more than the seating penetration of 15cm, then the break up of blow count for 15cm seating penetration and for remaining portion of penetration shall also be given.

The samples from the split spoon sampler shall be maintained as disturbed shall be conducted at every 3.0m interval, unless specified otherwise, with the first test at a depth of about 0.5m below the elevation at which this rock is encountered. The procedure for the test shall be the same as that in soil except that penetration corresponding to 20 and 100 blows shall be noted. In case the total penetration exceeds 15cm, then the break up of blow count for 15cm seating penetration and for the remaining portion of penetration shall also be given samples as noted earlier.

1.4.5.14.2. Vane Shear Test (VST)

The CONTRACTOR shall carry out field Vane Shear Test in boreholes in very soft to firm cohesive strata as per procedure in IS:4434.

Unless specified otherwise, these tests shall replace about one-third of standard penetration tests and one-third of collection of undisturbed soil samples. In very soft cohesive soils where it may be difficult to obtain proper undisturbed samples, Vane Shear Tests shall be conducted unless specified otherwise.

At each location, Vane Shear Test shall be conducted in two stages. In the first stage, the test shall be done in undisturbed soil and in the second stage, the test shall be conducted on the remoulded soil as per standard practice. For payment purpose both these stages of the test shall be considered as a single test. Hence, if the CONTRACTOR fails to conduct any one stage of the test, he shall not be paid for this test.

1.4.5.14.3. Static Cone Penetration Test

This test shall be conducted as per IS:4968 Part III at locations and to depths as per BIS or best engineering practise or as instructed by the ENGINEER. The cone shall have an apex angle of 60 degrees with base area of 10sq.mm. The cone assembly and method of testing shall be such as to permit measurement of end resistance and frictional resistance. Wherever possible, an electric cone with load cell measuring device within the cone assembly to eliminate effect of rod friction and to provide automatic continuous recording of end resistance shall be used.

1.4.5.14.4. California Bearing Ratio (CBR) Test

The California Bearing Ratio Test shall be carried out as per IS: 2720 Part (XXXI) or as approved by the ENGINEER. The load may be applied through a screw jack using the weight of a vehicle as jacking resistance and deflections may be measured by dial gauges carried on a bridge with independent foundations resting on the ground, well clear off the test point. Depth of test shall be either the ground surface or as directed by ENGINEER.

A circular area of about 300mm shall be trimmed flat to required elevation, special care being taken for the central area on which the plunger will bear. A thin layer of fine sand may be used to seat the plate on which the surcharge weights rest, but the use of sand to seat the plunger itself shall be totally avoided. If it is impossible to trim the soil sufficiently to obtain good seating of the plunger, a thin layer of Plaster of Paris shall be used, care being taken to remove any plasters extending beyond the area of the plunger. Initially a seating load of 50N shall be applied and maintained on the plunger. Thereafter, clean fine sand shall be laid and spread over the surface to be covered by the surcharge annular weight.

Immediately after conducting the CBR test, a field density test shall be conducted from the level at which the CBR test was conducted by either "sand replacement" or "core cutter" method. The test shall be conducted about 200mm away from the

CBR test location and it shall be ensured that moisture conditions are similar. Field dry density and field moisture content values shall be reported along with the CBR curves and test result.

1.4.5.14.5. Trial Pit

If specified the CONTRACTOR shall excavate trial pits. Relevant tests specified in these excavations shall also be carried out. Whether specified or not, in every trial pit, including those excavated for loading tests, tests by pocket penetrometer shall be generously carried out at different depths in different strata in cohesive soils only.

All four walls of the trial pit shall be logged. Each wall shall be identified with respect to compass direction as viewed from the centre of the pit. Measurement of depths from ground surface to the boundaries of various strata shall be measured at the four corners of the pit.

1.4.5.14.6. Density Test

When the method of determination is not specified, in-situ determination of density shall be done by Sand Replacement Method or Core Cutter Method. Furthermore, the former method shall be adopted in non-cohesive soil and even in cohesive soil where driving of core cutter into the soil would affect the density values. The core cutter method shall be restricted to fine grained soils which are sufficiently cohesive for the sample not to fall out and not hard enough so as to prevent easy driving of core cutter.

The soil samples for determining moisture content shall be immediately placed in moisture content cans, filling the cans to the extent possible. These cans shall be immediately sealed and labelled. Moisture content shall be determined immediately in the laboratory, preferably set up at the site for the purpose.

Whenever field density test is specified, the CONTRACTOR shall furnish in-situ dry and wet densities along with natural moisture content.

1.4.5.14.7. Backfilling of Boreholes and Pits

Unless specified/ directed otherwise, the CONTRACTOR shall backfill the boreholes and pits.

Borehole shall be backfilled by bentonite-cement grout. The cement and bentonite for the grout shall be in the ratio 1 to 1 by weight, and shall be made into a slurry with no more water than is necessary for placing the slurry in the borehole. If there is standing water in the borehole, the borehole shall be dewatered first before placing the mix. The pits shall be backfilled with proper ramming using the excavated material.

1.4.5.14.8. Electrical Resistivity test (ERT)

This test shall be conducted to determine the electrical resistivity of soil required for designing safe grounding system for the project. The specifications for the equipment and other accessories required for performing this test, the test procedure and reporting system shall conform to IS: 3043. In case the soil is found uniform, conventional methods are applicable for the computation of earth resistivity. When the soil is found non-uniform, either a gradual variation or a two-layer model may be adopted for the computation of earth resistivity.

a)Testing of Soil Uniformity:

The vertical variations may be detected by repeating the tests at a given location in a chosen direction with a number of different electrode spacing, in EIGHT directions as per requirement unless mentioned otherwise. If the resistivity variations are within 20 to 30 percent, the soil in the vicinity of the test location may be considered uniform. Otherwise a curve of resistivity versus electrode spacing shall be plotted and this curve further analyzed to deduce stratification of soil into two or more layers of appropriate thickness or a soil of gradual resistivity variation. The horizontal variations are studied by taking measurements in various directions from the centre of the edges.

b)Procedure of measuring electrical resistivity in Uniform soils:

When the earth resistivity reading for different electrode spacing in a direction is within 20 to 30 percent, the soil is considered to be uniform. The resistivity for this spacing is noted and taken as the resistivity for that direction. In a similar manner, resistivities for at least eight equally spaced directions from the centre of the site are measured. These resistivities are plotted on a graph sheet in the appropriate directions choosing a scale. A closed curve is plotted on the graph sheets jointing all the resistivity points plotted to get the polar resistivity curve.

The area inside the polar resistivity curve is measured and equivalent circle of the same area is found out. The radius of this equivalent circle is the average Resistivity of the site under consideration. The average Resistivity thus obtained may be used for the design of the earthing grid and other computations and the results will be reasonably accurate when the soil is homogeneous.

1.5. LABORATORY TESTS

1.5.1. General

All laboratory tests shall be performed by qualified and experienced personnel, familiar with and having access to equipment and facilities for the accurate determination of data necessary, for requirements under this specification.

1.5.2. Independent Laboratory

The ENGINEER reserves the right to have the samples tested in an independent laboratory. If the CONTRACTOR is directed to get the samples tested in an independent laboratory, he shall be paid only the actual cost of such tests plus 20% extra towards overhead and profit.

1.5.3. Programme for Testing

The ENGINEER will direct the CONTRACTOR on samples to be tested and on type of tests to be conducted. The ENGINEER will not furnish this information at the beginning of the investigation itself but he will instruct the CONTRACTOR at appropriate times during the course of the investigation. The laboratory tests shall begin as soon as testing schedule/ instructions are received from the ENGINEER.

1.5.4. Standards and Procedures for Testing

Laboratory tests shall be carried out as directed by the ENGINEER and in accordance with the procedures described in the relevant BIS codes of practised and guidelines and/or other specific requirements indicated.

1.5.5. Access to the Laboratory

The ENGINEER shall have the right of access to the CONTRACTOR's laboratory or any other laboratory where tests have been arranged to be carried out, during the progress of this investigation.

1.5.6. Submission of Test Data and Results

The CONTRACTOR shall submit when demanded by the ENGINEER, a preliminary copy of the data and the computed results of tests he has already conducted. However, the final report shall contain all the experimental data and the results as stated below.

1.6. **REPORT**

1.6.1. General

The report shall be in SI units only. Metric units may be used only if approved by the ENGINEER in writing. The report shall generally contain geological history of the site, all detailed boreholes, summarised test data, observations, conclusions and recommendations. Actual field and laboratory observations, calculations of test results, supporting calculations for their recommendations made, etc. shall also be presented as appendices to the report. Initially the CONTRACTOR shall submit three sets to the ENGINEER in a draft form. After getting the draft approved, *5* copies of the report shall be submitted in the final report form. The report shall include, but not be limited to Clauses 8.2 to 8.6. *Soft copy of the same shall also be submitted either in Word/Excel or PDF format.*

1.6.2. Plot Plan

A Plot Plan, showing locations of all tests viz. boreholes, trial pits, bearing tests, static cone penetration tests, etc; properly drawn and dimensioned with reference to the established grid lines, shall be presented in the report.

1.6.3. Boreholes

True cross sections of boreholes or trial pits shall be presented. These cross-sections shall include all the relevant details such as reduced levels of the ground/ bed surface, location co-ordinates of the borehole/ trial pit, and thickness and full classification of each of the strata encountered. The various tests conducted and samples recovered from every soil and rock stratum shall be clearly shown against that stratum. Observations of water table and any peculiar conditions such as artesian conditions, sand blow, etc. shall also be noted in the "Remarks" column.

A record of all incomplete trial pits and boreholes shall be reported in the same manner as the completed pits or boreholes, to be depth of investigation, along with an appropriate explanation for abandoning further investigation.

Generalised subsoil/ rock profiles along various sections, which may or may not be coinciding with grid lines, shall be drawn to obtain realistic idea about the stratigraphy and consistency. Values obtained from SPT and other sounding tests shall also be indicated on these profiles.

1.6.4. Groundwater

All available data on groundwater conditions shall be presented separately and shall be identified by borehole number and observations and sampling dates and timings at each borehole.

1.6.5. Test Results

Results of all the tests, field as well as the laboratory, shall be summarised separately test-wise. All relevant graphs, charts diagrams shall be submitted with the report. In case of boreholes and trial pits, the test results shall also be summarised in a typical manner.

1.6.6. Recommendations

The recommendations shall be based on observations and test results and shall encompass theoretical as well as practical considerations for foundations for type of structures envisaged and other relevant systems as indicated by the ENGINEER, in the area under investigation. The CONTRACTOR shall be acquainted with, with the help of the ENGINEER, about type of structures proposed and their functions.

a) Geological description of the site including that of faults, folds, etc. if any, based on published literature and investigation carried out.

b) Seismic history of site including brief description of previous earthquakes, if any, giving time, period, duration, magnitude, epicentre location, damage done, maximum ground acceleration produced etc. and relevant details about design earthquake.

c) Special considerations, if any, adopted in design of previous structures of the region because of seismicity, faults, folds etc.

d) Recommendations regarding type of foundation to be adopted for the proposed structures based on anticipated loads giving due consideration to tolerable settlements, ground water table and minimum depth of foundation.

e) Allowable or safe bearing capacities in different strata for shallow foundations indicating relevant design criteria adopted, methods of analysis adopted and weightage assigned to different methods.

f) For pile foundations, type of piles recommended with reasons for the same; length, diameter, allowable capacity (both lateral and vertical) of individual and groups of piles.

g) Recommendations for values for modulus of sub-grade reaction for foundation design by elastic method as well as field tests

h) Estimate of magnitude and rate of settlement of the proposed foundations.

i) Behaviour of proposed foundations under seismic conditions including analysis for possibility of liquefaction and expected settlement under earthquake.

j) Negative skin friction, if any; magnitude of estimated negative skin friction. Methods to minimise or eliminate negative skin friction.

k) Corrosivity Classification based on Electrical resistivity tests as per Indian/International standards

l) Comments on chemical nature of subsoil and groundwater with due regards to potential deleterious effects on concrete, steel and other substructure materials and recommended measures to overcome deleterious effects, sulphate attack, acidic conditions etc. Type of cement to be used for concrete sub-structures based on the results of chemical analysis.

m) Recommendations for subsoil treatment such as prefabricated vertical drains (PVD) or stone columns, if any needed, giving reasons for such treatment, available and recommended method(s) of treatment. Mention shall be made of studies/ trials to be carried out, if any, prior to selection of a method/ methods of treatment.

n) Recommendations in regard to use of subsurface material for various construction activities and methods for quarrying the same. Recommendations regarding usage of available top soil for plinth filling

o) Recommendation regarding design and construction of roads and other paved area.

p) Recommendation regarding CNS Layer and its thickness based on swelling pressure tests conducted in worst condition. Report shall provide typical specifications for CNS materials

q) Recommendation regarding site drainage.

r) Recommendations regarding any special construction procedure/ precaution to be adopted/ taken, method of dewatering, if any required, etc.

s) Recommended side slopes for cutting and embankment, if any.

t) Recommendations on lateral earth pressures as relevant.

u) Past observations and historical data, if available, for structures resting in the area under consideration or for other areas with similar profiles.

v) Recommendation regarding reuse of excavated soil

w) Precautions to be taken such that relevant construction activities do not cause damage in any way to adjoining structures, in relation to subsurface characteristics.

x) Recommendation of static spring constant.

y) Recommendations for additional investigation, beyond the scope of the present work, if the CONTRACTOR considers such investigation is necessary.

z) Suitability of usage of available soils/rock for various construction activities such as footing backfill, site grading, and pavement/floor slabs.

2. SPECIFICATION FOR GROUND IMPROVEMNT WORKS

2.1. Based on the detailed geotechnical investigation carried out by the CONTRACTOR, suitable ground improvement technique as per IS 13094 shall be identified. All the specifications relevant to ground improvement using Vibro Stone columns (VSC) shall be as per IS 15284 part 1.

2.2. The selected type of ground improvement shall be submitted to ENGINEER and obtained approval.

2.3. Design methodology shall conform to the international standard FHWA-RD-083-026 & 027. Prior approval of the design methodology from Engineer-In-Charge shall be obtained. The design shall fulfil the mitigation of liquefaction potential of substrata.

2.4. The work shall include Design (approved by consultant), Supply and installation of vibrated stone columns preparation of working platform, laying of drainage blanket with approved material in accordance with the requirements of specifications and approved drawings or as directed by the Engineer-in-Charge.

2.5. The work shall also include evaluating the performance of the improved ground by performing load tests or other suitable tests as per IS 15284 part 1. The proposed number of field load tests to be performed before commencement of work and on the improved ground shall be submitted to the Engineer-in-Charge to obtain approval along with the test locations layout

2.6. The performance load tests results should be satisfactory and shall fulfil the design requirement.

2.7. All works shall be according to all latest relevant codes or specified elsewhere in this tender document.

3. SPECIFICATION FOR BORED CAST INSITU PILING

3.1. Scope of work

Scope of this Specification covers bored cast-in-situ piles whose bores are formed by any of the following techniques:

(a) Using percussion type of boring technique and bentonite slurry to stabilise the hole, with temporary guide casing through unstable strata only upto a maximum of 5 m below working ground level.

(b) Using Direct Mud Circulation or Reverse Mud Circulation Method with bentonite slurry as drilling mud and appropriate equipment, and with temporary guide casing through unstable strata only upto a maximum of 5 m below working ground level.

(c) Using permanent rigid liners of steel or any other material approved by the ENGINEER.

(d) Using Rotary Drilling Method.

Temporary casings of length exceeding 5 m below working ground level shall not be used for forming the pile bores. Concrete piles formed shall be free of any necking and excessive bulging.

For the present works, Piling Works shall be executed using Rotary Drilling Method only.

3.1.1. It shall be clearly understood that the specifications given here are brief and do not cover minute details. However, all works shall have to be carried out in accordance with the relevant standards and codes of practice or in their absence, in accordance with the best accepted current engineering practices or as directed by the ENGINEER from time to time. Items for which separate specifications have not been included shall be carried out in consultation with and as directed/ approved by the ENGINEER. The decision of the ENGINEER as regards the specification to be adopted and their interpretation and the mode of execution of work shall be final and binding on the CONTRACTOR and no claim whatsoever will be entertained on this account. Notwithstanding what is contained in this document, the CONTRACTOR shall execute all the work in a professional manner, exhibiting workmanship of the best quality. Prior to mobilisation, the CONTRACTOR shall submit to the OWNER/ ENGINEER for approval, his programme for Quality Assurance and Quality Control that he will adopt for the work, along with three copies of documentation format for enabling enforcement of his QA-QC programme.

3.1.2. Prior to submitting his proposal, the CONTRACTOR shall acquaint himself fully in regard to the scope of the work in accordance with the intent and meaning of the subsurface data as indicated by the geotechnical investigation report and other data given by the OWNER, and the drawings and specifications. He is deemed to have examined the site and premises sufficiently to compare them with the drawings and specifications and satisfy himself in regard to the condition of the site, obstructions, accessibilities, etc. required in connection with the work. Failure to comply with this requirement shall in no way relieve the CONTRACTOR of his responsibility to perform the work complete in accordance with the specification. The information given in the geotechnical investigation report has been made available to the

CONTRACTOR in good faith. The OWNER will not be held responsible for any inaccuracies or discrepancies therein and no claim whatsoever from the CONTRACTOR on this account will be entertained by the OWNER.

3.1.3. Nothing contained in the Contract documents will relieve the CONTRACTOR from the responsibility of obtaining approval from the ENGINEER for all the installation criteria.

3.1.4. Access to the work areas shall be kept unobstructed and clear at all times so as not to hamper the work of other trades. Temporary access roads, if required, suitable for plying heavy vehicles like concrete mixers, dumpers, etc. shall be constructed by the CONTRACTOR.

3.1.5. All arrangements necessary for concreting of the piles/ pile groups by pumping shall be deemed to be included in the rates quoted by the CONTRACTOR.

3.1.6. The CONTRACTOR shall ensure that the site is kept clean, tidy and dry during the execution of the work. Dewatering of accumulated water at all locations on job site from whatever source or cause is deemed to be included in the rates quoted by the CONTRACTOR.

3.2. APPLICABLE CODES AND SPECIFICATIONS

All applicable documents, including standards, codes, rules, laws, regulations of regulatory bodies referred to herein shall be of latest issue or edition and shall be considered part of this specification, except as may otherwise be stated herein.

the design, materials and workmanship shall conform to the latest revisions of following standards:

IS 2911	:	Code of Practice for Design and Construction of Pile Foundations
(a) Part-1, Sec.2	:	Concrete Piles, Section 2 - Bored Cast-in-situ Piles
(b) Part -4	:	Load Test on Piles
IS 2131	:	Method of Standard Penetration Test for Soils
IS 456	:	Code of Practice for Plain and Reinforced Concrete
IS 269	:	Specification for Ordinary, Rapid Hardening and Low Heat Portland Cement
IS 1489	:	Portland Pozzolana Cement
IS 8112	:	High Strength Ordinary Portland Cement
IS 6909	:	Supersulphated Cement
IS 383	:	Specifications for Coarse and Fine Aggregates from Natural Sources for Concrete
IS 2386	:	Methods of Test for Aggregates for Concrete
IS 432	:	Specification for Mild Steel and Medium

		Tensile Steel Bars and Hand Drawn Steel Wire for Concrete Reinforcement
IS 1786	:	Specification for Cold Twisted Steel Bars for Concrete Reinforcement
IS 3764	:	Safety Code for Excavation Work
IS 1200	:	Method of Measurement of Building Works - Part XXIII

The temporary casing or permanent liner and the pile bore shall be of diameter adequate enough to give the necessary nominal finished diameter of the concrete piles. The inner diameter of the upper guide casing shall not be less than the specified nominal diameter of the pile. In case a permanent liner is used, the inner diameter of the permanent liner shall correspond to the specified nominal diameter of the pile.

The bored hole shall exclude any subsoil or detrimental material before reinforcement and concrete is placed inside the casing/ borehole. The CONTRACTOR shall, in his Bid, fully outline the methods that he proposes to adopt to accomplish this.

3.3. TRIAL BOREHOLES FOR LOCATING FOUNDING STRATUM

3.3.1. To ascertain the subsurface strata and their characteristics, the CONTRACTOR may be permitted to conduct trial boreholes only with the permission of the OWNER/ ENGINEER.

3.3.2. The locations of trial boreholes shall be subject to approval by the ENGINEER/ OWNER.

3.3.3. On completion of the investigations, all trial boreholes shall be backfield upto 1 m below cut off level of the piles in that area by sand and subsequent filling shall be done by excavated clay or cement bentonite grout unless directed otherwise by the ENGINEER. The ENGINEER's approval shall be obtained prior to commencement of backfilling of the trial boreholes.

3.3.4. Cost of all such trial bore holes including all necessary backfilling shall be to the CONTRACTOR's account. No concessions in time schedule will be granted on this account.

3.4. SETTING OUT

3.4.1. The CONTRACTOR will be furnished with one reference benchmark and with two mutually perpendicular reference axes. Based on these, the CONTRACTOR shall establish minimum four (4) “Mother Pillars” for marking the co-ordinates and levels for the entire works. Adequate protection and care shall be taken to ensure that these pillars are protected during the period of construction. Should they be disturbed, for any reasons, during execution of the works, the CONTRACTOR shall re-establish the pillars, at no additional cost to the OWNER. Additional reference pillars may be erected as per requirements of work or as directed by the ENGINEER at no additional cost. The CONTRACTOR shall accurately mark the pile locations using Total Station.

3.4.2. The CONTRACTOR shall locate accurately the position of piles and install stakes as directed or as required by drawings, with reference to the reference bench mark and axes furnished. The CONTRACTOR shall make good to the satisfaction of the ENGINEER, defective or infructuous work arising out of any error in the field layout, notwithstanding that such layout and staking may have been checked and approved by the ENGINEER.

3.4.3. The CONTRACTOR shall check the co-ordinates of initial guide casing or permanent liner position for each pile during and immediately after placing the casing on the ground prior to its driving and confirm the same with the co-ordinates of that pile on the drawing prepared by the CONTRACTOR and approved by the ENGINEER.

3.5. CONTINUITY OF CONSTRUCTION

3.5.1. Any pile that is taken up for execution from boring to final concreting shall be executed at a continuous stretch without interruption. Stoppage of work in between shifts will be permitted only during boring stage of the pile execution if further boring is pending. Thereafter right from boring or chiselling of the final portion of the length of the pile, through subsequent activities of flushing, lowering of reinforcement cage, lowering of tremie, pre-concrete flushing and upto concreting, no halt whatsoever in the execution of the pile will be permitted.

3.5.2. In case there is a halt of work during any of these activities except concreting, the CONTRACTOR shall take steps to bore an extended length of further 300 mm or as decided by the ENGINEER, or adopt any other measure as decided by the ENGINEER.

3.5.3. If there is any stoppage of work during concreting, this pile shall be abandoned altogether.

3.5.4. Costs of remedial measures and their consequences shall be borne by the CONTRACTOR if the stoppage is due to the CONTRACTOR's act of commission or omission.

3.6. **MATERIALS**

3.6.1. CONCRETE

3.6.1.1. General

All concrete work shall conform to enclosed civil Specification unless otherwise stated herein. All aspects of concrete work including material specifications, preliminary mix designs, workability, inspection, testing, etc. shall be as specified in civil Specification

3.6.1.2. Aggregates

The CONTRACTOR shall get the source of supply of all aggregates approved by the ENGINEER prior to commencement of work. Samples of both fine and coarse aggregates shall be tested for soundness as per IS: 2386 in a laboratory approved by the ENGINEER for each quarry location or source. Aggregates shall be particularly tested for any evidence of expansive reaction between the aggregates and the cement to be used. The costs of supplying samples of aggregates and the costs of all tests thereon shall be borne by the CONTRACTOR.

Coarse and fine aggregates shall be totally free of chlorides and other deleterious salts and materials. All aggregates shall be washed to the satisfaction of the ENGINEER. Marine and creek sources of aggregates shall be avoided to the extent possible and shall be used only through written permission of the ENGINEER. Extra care shall be exercised in this regard if sulphate resisting cement is used.

All aggregates brought to site shall be free of, and kept free from deleterious matter. Aggregates from different sources, of different type and of different sizes shall be stored separately in different stockpiles or different hoppers. Where stored on the ground, care shall be exercised during retrieval for use that the batch is not contaminated by soil or organic matter.

Sieve analysis of aggregates shall be conducted at regular intervals to ensure that the grading conforms to that in the design mix. If a change in grading or angularity of coarse aggregates is unavoidable, the mix shall be redesigned. Only 20 mm downgraded aggregates shall be used.

3.6.1.3. Water

Only water permitted by the ENGINEER shall be used for making concrete. All testing of water shall be got done by the CONTRACTOR at no extra cost to the OWNER.

3.6.1.4. Cement

Cement used shall be Ordinary Portland Cement conforming to IS: 269 due to deleterious effect of sulphates and chlorides in ground water. The C_3A content in cement shall range between 5% and 7% unless approved otherwise by the ENGINEER. Where Portland Pozzolana Cement is specified to be used, only cement which does not contain fly ash as Pozzolana shall be used.

All concrete for both piles and pile caps shall be produced only by weigh-batching the ingredients as specified in civil specification

Concrete shall be of minimum grade designation M25. It shall conform to IS: 456 unless otherwise more rigidly specified by civil Specification.

The cement content shall not be less than 400 kg/m3. The water : cement ratio shall not exceed 0.50, if necessitated by adverse subsurface environment.

The slump as measured at the pile head itself shall range between 150 mm to 180 mm. To achieve the slump within this required range with the water : cement ratio within the limit specified, special plasticiser admixtures shall be used. The plasticiser to be used shall be got approved from the ENGINEER. Any admixture containing chlorides or nitrates shall not be used. The plasticiser shall be added as per manufacturer's instructions or as directed by the ENGINEER.

Cube tests of preliminary mix design as well as works cubes shall be done in a laboratory approved by the ENGINEER. All such tests including supplying and transporting the cubes to this laboratory and all other related works shall be at the CONTRACTOR's cost.

At least one series of tests for cube strength of concrete shall be conducted for every 20 piles constructed, or 50 cubic metres of concrete, whichever is least, and not less than one set of tests shall be conducted for any one shift's concreting operations. Each set of tests shall consist of nine work test cubes, field cured. Three cubes shall be tested at 7 days and three at 28 days. The balance three cubes shall be kept for testing at 14 days in case the 7 days test results are not

satisfactory. Records of all cube test results shall be communicated to the ENGINEER, identifying the pile being concreted while making the cubes. The ENGINEER reserves the right to reject piles of deficient concrete strengths. Such rejected piles shall be replaced by the CONTRACTOR by additional piles along with necessary extended pile cap and the cost of this additional and extended work shall be wholly borne by the CONTRACTOR.

The CONTRACTOR shall provide at his own cost all labour, materials and equipment necessary for routine site tests on all aggregates, water, slump tests on concrete, cube tests and all other tests as specified in IS and shall carry out the same as required by the ENGINEER.

3.6.1.5. REINFORCEMENT

All reinforcement shall be as per the drawings. The reinforcement shall be assembled and tied together and made up into cages sufficiently rigid to withstand handling without damage and distortion. the reinforcement bars shall be coated with anti-corrosion fluid as specified. The method of application of coating shall be such that there are no holidays. After fabrication of the cage all surfaces, which become exposed due to scrapping, welding, etc. shall be recoated. All tie wires, stiffener bars, spreader forks, lacings, etc. used to fabricate the cage shall also be coated similarly.

Where the number and diameters of reinforcement bars change as per the drawing, laps of reinforcement bars shall be as indicated on the drawing. Joints in longitudinal bars, if unavoidable, shall be made by lapping. Laps shall be tack-welded as approved by the ENGINEER to prevent distortion of the reinforcing cage. The number of joints in longitudinal steel bars shall be kept to a minimum and staggered. Joints in reinforcement shall be such that the full strength of each bar is effective across the joint and shall be made such that there is no detrimental displacement of the reinforcement during the construction of the pile. Mechanical splices if and as approved by the ENGINEER may be used for jointing reinforcement bars of same diameters. Hooks, required for anchoring the reinforcement cage to the guide casing/ temporary liner, are deemed to be included in the CONTRACTOR’s rates.

The projecting lengths of the longitudinal bars beyond the pile cut-off level shall be equal to a minimum of 24 times bar diameter or such other length as shown on the drawings.

The lateral links or helical reinforcement shall fit closely around the main longitudinal bars and be fixed to them by soft annealed 16 gauge black iron wire, the free ends of which shall be turned towards the centre.

Concrete cover over all reinforcement including lateral links or helicals shall be 50 mm unless shown otherwise on the drawing. Suitable and adequate cover blocks shall be provided. The cover blocks shall be circular with a concentric hole of adequate size to allow lateral reinforcement to pass through and allow free rotation. The cover blocks shall be manufactured of concrete of grade higher than that of concrete designated for the pile, using the same grade and type of cement. Alternately, the cover block shall be of more durable material approved by the ENGINEER, which will not lead to corrosion of the reinforcement or spalling of the concrete cover. The cover blocks shall be placed all along the length of the reinforcement cage with adequate number in the upper portion over the length of the temporary casing. The cover blocks shall be aligned for smooth lowering of the cage into the pile bore and for lifting of the temporary casing without displacing the reinforcement cage from its seated position.

Stiffener bars, spreader forks and lacings within the reinforcement cage shall be provided to prevent twisting or any type of distortion of the reinforcement cage during its lifting, handling and lowering into the pile bore. These shall be placed in a manner and pattern such that the inside dimension of the reinforcement cage is adequate for concentric placement of the tremie pipe and its operation without disturbing the cage during concreting.

3.6.1.6. TEMPORARY STEEL GUIDE CASINGS

Temporary steel guide casings for bored cast-in-situ concrete piles shall have an internal diameter equal to the nominal diameter of the pile. The thickness shall be adequate for strength to withstand driving without damage. Length of each casing component shall be maximum possible. Joints shall be welded, lockseamed or screwed.

Guide casings shall be free from any distortion and buckling and of uniform cross-section throughout. The inside of the guide casings shall be free from projections and encrusted concrete.

3.6.1.7. PERMANENT LINERS

Permanent liners shall be used for bored cast-in-situ concrete piles where specified. The scope of this specification excludes geo-fabrics as permanent liners and includes only liners of approved rigid material.

The inner diameter of permanent liners shall correspond to the specified nominal diameter of the pile. The liners shall be of mild steel or of material approved by the ENGINEER in writing. Thickness of the liner shall be at least as specified, or more if required to withstand handling, driving, etc. without any damage, denting, distortion or buckling. If the CONTRACTOR is of the opinion that a thicker liner than that specified is required, he shall get the approval for use of thicker gauge from the ENGINEER in writing. Liners which are damaged, distorted, dented or buckled in any manner shall not be used.

The inside surface of the liners shall be clean and free of any loose scales, rust, soil, debris, encrusted concrete or any projections.

Liner joints shall be welded. It shall be ensured that the vertical axes of the liners being welded coincide and the liners are not welded together with eccentricity.

Where specified, the outer surface of the permanent liner shall be coated or treated accordingly.

3.6.1.8. BENTONITE DRILLING MUD

Bentonite powder and bentonite suspension fluid shall conform to requirements specified in IS: 2911 (Part I/ Sec.2). The CONTRACTOR is advised to obtain Manufacturer's test certificate for each consignment delivered to the site to ensure the conformity of the material delivered. However, each batch of bentonite powder delivered and the suspension fluid made therefrom shall be tested by the CONTRACTOR and results presented to the ENGINEER. Any batch not conforming to required specifications shall be rejected.

The bentonite powder shall be mixed thoroughly with clean, potable water to make a suspension of density as specified. The temperature of the water used and that of the bentonite fluid supplied to the pile bore shall not be lower than 5^0 C. Where saline or chemically contaminated ground water occurs, special precautions shall be taken as approved by the ENGINEER to modify the bentonite suspension or

prehydrate the bentonite with fresh, potable water so as to render the fluid suitable for construction of piles. The pH of the fluid shall range from 9.5 to 12. The bentonite suspension fluid shall be continuously circulated and agitated using circulating pumps to prevent deposition of suspension and coagulation.

The suspension fluid shall be regularly tested to ensure its suitability for use as drilling mud. The frequency of testing the fluid and the method of sampling shall be proposed by the CONTRACTOR for approval prior to the commencement of the work. The frequency may subsequently be varied as deemed necessary by the ENGINEER. These tests shall ensure consistency of the fluid properties, after the mixing process, blending of freshly mixed bentonite suspension and previously used bentonite suspension and any process, which may be adopted to remove impurities from previously used bentonite suspension.

The CONTRACTOR shall construct an adequately sized tank using brick masonry. The top of the tank shall be covered for safety. Proper approach shall be provided to the tank. The CONTRACTOR shall ensure that the tank is cleaned periodically of all the sedimented mud and bentonite. The CONTRACTOR shall ensure that this muck is taken away and disposed of appropriately. No space/ area shall be provided by the OWNER for disposal of the bentonite slurry/ muck and it shall be the CONTRACTOR's responsibility to dispose this to the satisfaction of the OWNER and in accordance with local Municipal guidelines. This work shall be deemed to be included in the rates quoted by the CONTRACTOR and no extra payment shall be made on this account.

3.7. PILE BORING

3.7.1. FORMATION OF PILE BORES

Pile bores for bored cast-in-situ concrete piles shall be executed upto a minimum depth specified on the Drawings or as modified by the ENGINEER in writing during progress of boring. The pile shall achieve its required capacity to take downward and upward force and horizontal forces in combination as specified.

Pile bores shall be executed by any of the following methods:

(a) Using the Direct Mud Circulation or Reverse Mud Circulation Methods with bentonite slurry as drilling mud and appropriate equipment.

(b) Using percussion type of drilling and bentonite slurry to stabilise the hole.

(c) Using permanent rigid liners of steel or any other material approved by the ENGINEER and boring through the liners.

(d) Using Rotary Drilling Method.

The BIDDER shall indicate along with his Bid which of the above methods he proposes to adopt for this work. However the decision of the ENGINEER regarding the method to be adopted for executing the bores shall be binding on the CONTRACTOR.

Use of temporary guide casings through unstable strata is permitted only upto a maximum of 5 m below ground level.

The CONTRACTOR shall ensure that bores formed are true to a cylindrical shape to the extent possible and overcutting is minimised. The CONTRACTOR shall also

ensure that water cavities behind temporary casings are altogether avoided so as to ensure quality concrete for the pile shaft.

Sequence of piling shall be such that there is no damage caused to the concrete recently laid in the adjacent pile. Boring shall not be carried out within a distance of five times the diameter of the pile from a pile, which has been freshly concreted within the past forty-eight hours. On award of work the CONTRACTOR shall submit a rig movement plan to satisfy this condition. The CONTRACTOR may have to undertake excessive rig movement to adhere to this condition. However, on no account shall this qualify either for additional compensation or consideration for additional time.

Further, the sequence of installation may be dictated by the priority of construction of various buildings.

3.7.2. STANDARD PENETRATION TESTS

The CONTRACTOR shall conduct Standard Penetration Tests (SPT) within the pile bore at pile locations and at depths as indicated on the drawing or as directed by the ENGINEER. The procedures for conducting these SPTs in soil shall be as per IS: 2131.

SPTs shall be conducted as the boring for the pile bore progresses and at the founding level of the pile (pile tip). The CONTRACTOR shall provide a mechanised arrangement for ensuring the fall of the dolly over prescribed heights. Manual dropping of dolly shall not be permitted.

3.7.3. BORE LOGS AND EXTRACTED MATERIAL SAMPLES

A complete log of the subsurface profile shall be maintained during execution of boring for each and every pile shaft. A copy of such log shall be submitted to the OWNER for his scrutiny prior to commencement of reinforcement cage lowering.

All through the boring operations, the subsurface material (soil or rock cuttings) as extracted through the flap valve bailers or wash of circulating mud shall be preserved in polythene bags at regular 0.5 m to 1 m intervals of depth. The samples shall be labelled, indicating the unique pile number and depth. The labelled sample will be placed in another polythene bag. All these samples shall be handed over to the ENGINEER.

3.7.4. DIRECT MUD CIRCULATION METHOD

The initial boring of about 1.5 m shall be done by bailer and the guide casing shall then be lowered into the bore hole. The bore shall be filled with bentonite slurry fed from bentonite installation.

The centre line of the guide casing shall be checked with respect to the reference points before proceeding with further boring. Further boring shall proceed with the use of direct mud circulation chisel upto the founding strata.

The chisel used to bore the hole, shall be of diameter appropriate for the specified nominal diameter of the hole to be bored. The chisel shall be connected to API rods of adequate diameter and thickness through which bentonite slurry shall be pumped.

Any filling, dressing up or excavation required for easy movement of the piling rigs and all precautions necessary for the safety of the works, tools and adjoining structures shall have to be undertaken by the CONTRACTOR at his own cost. The

cost incurred for shifting of rigs, machinery, etc. from one location to another is deemed to be included in the rates quoted by the CONTRACTOR.

Bentonite slurry shall be pumped through the chisel rods by means of high pressure pumps. The chisel shall have suitable ports for the bentonite slurry to flow out at high pressure. The bentonite slurry and the cuttings, which are carried to the surface by the rising flow of slurry shall pass through a settling tank of adequate size to remove the cuttings and spoils from the slurry before the slurry is recirculated to the pile bore. A suitable bentonite slurry mixing and recirculation plant shall be designed and installed.

3.7.5. REVERSE MUD CIRCULATION METHOD

The CONTRACTOR shall adopt Reverse Mud Circulation Method only where strata encountered are such that there is no danger of loosening of the subsoil during the boring operations and the subsoil gradually becomes denser and more compact with progressive depth, or where bedrock is being penetrated at shallow depths. This method shall be adopted only if approved by the ENGINEER.

The method is essentially the same as the Direct Mud Circulation Method except that the bentonite slurry shall be sucked through the chisel instead of being pumped through it. Except for this, the specifications for Direct Mud Circulation Method apply here also.

3.7.6. BAILER BORING USING BENTONITE SLURRY

This process is essentially the same as the Mud Circulation Method except that all boring shall be done by flap valve bailer or flap valve bailer and chisel upto the founding stratum, using bentonite slurry. Bentonite slurry shall be allowed to flow into the guide casing through pipes or channels, so that the guide casing is always kept filled with bentonite. The material extracted by the bailer shall be left alongside the boring if so directed by the ENGINEER. Fresh bentonite slurry shall be allowed to flow into the casing so that the top level of the bentonite is kept the same at all times.

Except as modified hereinabove, the specification for Direct Mud Circulation Method shall apply to Bailer Boring also.

3.7.7. BORING FOR PILES WITH PERMANENT LINERS

Where specified, permanent liners shall be used for bored cast in situ piles. The permanent liners shall be installed simultaneously as the boring for the pile progresses.

Pile boring shall be done from within the permanent liner by flap-valve bailer boring or by any percussive method or rotary method as approved by the ENGINEER. To the extent possible, the bottom of the permanent liner shall be driven ahead of the boring except where SPTs are to be conducted. Where SPTs are specified to be conducted, the permanent liner bottom shall be maintained at least 300 mm above the bottom of the bore.

3.7.8. LOSS OF DRILLING MUD WHILE BORING

In the event of a rapid loss of drilling mud in a pile bore, the CONTRACTOR shall immediately draw the attention of the ENGINEER and take necessary action as approved by the ENGINEER.

3.7.9. FINAL POST-BORE FLUSHING AND CLEANING

On completion of the total length of the pile bore, the bore shall be thoroughly cleaned and flushed.

If the pile bore has been executed by either of the mud circulation methods, fresh bentonite slurry shall be pumped through the chisel resting at the base of the bore to completely remove all cuttings and other loose material from the base. During the flushing, the speed of the bentonite circulation pump shall be raised to maintain high pressure. Such flushing shall be continued for at least 20 minutes while occasionally agitating the chisel. Flushing shall be continued beyond 20 minutes if the return slurry indicates presence of cuttings still within the bore.

In case the pile bore has been executed by Bailer Boring with Bentonite Slurry, the bore shall be initially cleaned of loose material by light tamping of the flap-valve bailer. Thereafter the bailer shall be withdrawn and a string of API rods shall be lowered upto the base of the bore and bentonite slurry shall be pumped through under high pressure as in the case of the Mud Circulation Method. Agitation shall be effected by circular movement of the string of rods around the pile bore. Flushing shall be thus continued for at least 20 minutes. Flushing shall continue beyond 20 minutes till the return wash indicates that the bore is clean to the satisfaction of the ENGINEER.

Where permanent liners have been used, the bore shall be filled with water that has been certified for concreting and a flap valve bailer shall be used to remove the loose material by light tamping. The bailer shall then be withdrawn and a string of API rods shall be lowered down to the base of the bore. The certified water shall then be pumped through the string of rods at high speed for at least 20 minutes. Agitation shall simultaneously be effected by a gentle vertical movement and vigorous circular movement to the rods. Flushing shall continue thus beyond 20 minutes till the return wash indicates that the bore is clean to the satisfaction of the ENGINEER. The water from within may be pumped out with approval of the ENGINEER. However no pumping out shall be done if the ground water table is above the bottom of the pile bore and/ or if the subsoil around the bottom of the pile bore is likely to be disturbed by pumping out the water.

3.8. PLACEMENT OF REINFORCEMENT CAGE

3.8.1. Immediately after successful completion of final post-bore flushing and cleaning, the reinforcement cage shall be lowered into the pile bore. All care shall be taken during transporting, lifting and lowering of the cage that the cage does not twist or distort out of alignment.

3.8.2. The cage shall be lowered into the pile bore by gravity and shall not be forced into the bore. Care shall be exercised that no collapse of any portion of the unlined bore occurs while lowering. In case the total length of the pile is such that handling of the entire length of the cage becomes unwieldy, the cage shall be fabricated in two lengths. The location of such jointing shall however be got approved by the ENGINEER in writing. After the first section of the cage is lowered and held with the top of the bars adequately outside the bore, the upper cage section shall be lifted, held vertical and gradually lowered over the lower cage section so that the main longitudinal reinforcement bars of the two cage sections are aligned bar for bar. Jointing of the respective bars of the two cages shall be effected as indicated. The integral cage shall then be lowered into the pile bore and into final position and held in place by slings or suitable devices approved by the ENGINEER.

3.8.3. Longitudinal reinforcement above the ground level shall not be arbitrarily bent for seating the concrete tremie hopper. If the reinforcement cage has been fabricated longer than that required on the drawing (in view of a shorter pile bore than that

envisaged earlier), the excess lengths shall be cut. Outward flaying of the main reinforcement bars of the cage shall not exceed 5 degrees with the vertical to avoid breaking of the bars while rebending the reinforcement back into position after the concreting. In any case, the internal radius of the bend shall not be less than five times the bar diameter. While flaying the reinforcement cage outwards, it shall be ensured that the cover to reinforcement within the pile bore to be concreted is maintained.

3.9. FINAL PRE-CONCRETING FLUSHING

3.9.1. Immediately after the reinforcement cage is positioned, the concrete tremie pipe shall be lowered into the pile bore concentrically within the reinforcement cage, with the bottom of the tremie pipe just above the bottom of the bore. The top of the tremie pipe shall be connected to a high speed bentonite pump and flushing with bentonite slurry shall be resumed. If concreting of the pile bore is to be done by concrete pump, flushing shall be done through a string of API rods lowered into the pile bore concentrically within the reinforcement cage with the bottom of the string of rods just above the bottom of the pile bore.

3.9.2. The procedure for flushing shall be the same as that indicated in Clause 9.9 above. At the end of such flushing the CONTRACTOR shall ensure that heavy contaminated bentonite suspension, which could impair free flow of the concrete from the tremie pipe or concrete pump trunk has not accumulated in the bottom of the pile bore. The suspension shall be sampled from the pile bore bottom by a suitable device approved by the ENGINEER and the density of the suspension checked by a calibrated hydrometer. The density of the sampled suspension shall not exceed 1.2 gm/cc. In case this value is exceeded, flushing shall be resumed as per Clause 9.9 till the suspension is within the desired density range.

3.10. PILE CONCRETING

3.10.1. GENERAL

Concreting of pile bores shall be executed only through a tremie system or concrete pump over the entire length of the pile. Tipping in of concrete from ground level or above into the pile bore is prohibited even if the pile bore is dry (as may perhaps be the case for pile bores with permanent liners).

Only freshly mixed concrete shall be used. Placement of the concrete shall be a continuous operation. The CONTRACTOR shall ensure that concrete mixers of adequate capacity are provided at the site with standby. If concrete pump is to be used for concreting a standby pump shall be provided. The pile shall be abandoned if concreting operations are suspended due to any reason by more than 20 minutes. It shall also be ensured that there are no air pockets created within the concrete shaft.

3.10.2. TREMIE CONCRETING SYSTEM

Tremie pipe concreting shall be done as per IS: 456 and IS: 2911 (Part I/ Sec.2). The minimum diameter of the tremie pipe shall be 200 mm. The steel hopper at the top of the tremie pipe shall have a volume in excess of the total volume of the tremie pipe below. The neck of the hopper shall be fitted with a steel plate covering the entire opening. Suitable arrangements shall be made to remove the steel plate and uncover the hopper neck aperture when the hopper is full of concrete. The hopper and the entire length of the tremie pipe shall be thoroughly clean and free of any encrusted concrete or internal protrusions such as sleeves, collars, etc. or any soil or debris. The entire tremie pipe-hopper system shall be water tight.

After the final pre-concreting flushing has been successfully executed, the tremie pipe shall not be extracted but shall continue to remain upto the bottom of the pile bore. Suitable ramps or staging shall be provided to facilitate easy and smooth feeding of the hopper with concrete either manually or by mechanised means. The ramps or staging shall be flexible enough to allow concrete feeding if the hopper is raised during concreting.

A sliding plug of polystyrene (or similar material lighter than water and approved by the ENGINEER) shall be placed in the tremie pipe to prevent direct contact between the first charge of concrete in the tremie and the bentonite slurry. At the commencement of concreting, the steel plate shall first cover the hopper neck while the hopper is completely filled with concrete. The steel plate shall then be removed and the concrete in the hopper allowed to flow into the tremie pipe. Subsequent charges of concrete shall be maintained as continuous as possible until the pile bore is concreted as specified in Clause 12.5 below. The tremie pipe shall at all times penetrate the concrete by minimum two metres after placing of the concrete has commenced, and shall not be withdrawn from within the concrete until completion of concreting. Particular care shall be exercised when vertical movement is imparted on the tremie pipe to force the concrete down the tremie pipe. Such movements shall be limited. The CONTRACTOR shall note that the pile shall be abandoned if in the opinion of the ENGINEER, the tremie pipe bottom has been raised above the concrete level within the pile bore. While raising the tremie pipe, care shall be exercised that the reinforcement cage is not disturbed from its position.

3.10.3. CONCRETE PUMP

If the concrete pump is used to feed the hopper of a tremie concreting system, Clause 12.2 shall apply.

If the concrete pump is used for placing concrete directly into the pile bore, the trunk of the pump shall be placed upto the bottom of the pile bore immediately after the string of API rods used for final pre-concreting flushing have been removed after successful flushing. The trunk shall at all times penetrate the concrete after commencement of concreting by at least two metres and shall not be withdrawn from within the concrete until the completion of concreting. The CONTRACTOR shall note that the pile shall be abandoned if in the opinion of the ENGINEER, the trunck has been raised above the concrete level within the pile bore. While raising the trunk, care shall be exercised that the reinforcement cage is not disturbed from its position.

3.10.4. LIFTING OF TEMPORARY CASING

The temporary casing shall be carefully withdrawn only after the concrete surface in the pile bore has risen to not less than three metres above the bottom of the casing or not less than one metre above the level of ground water whichever is higher. The casing shall be lifted only to the extent that there is minimum one metre of concrete above the casing bottom. The level of concrete shall be checked vis a vis the casing bottom and ground water level by suitable methods as approved by the ENGINEER.

While withdrawing the temporary casing, care shall be exercised that the reinforcement cage is not pulled out along with the casing. It shall also be ensured that no voids or ground water pockets are formed around the pile shaft during withdrawal. Adequate precautions shall be exercised to ensure that the concrete is not lifted up along with the casing and that no necking or waisting occurs in the pile shaft. Special care shall be exercised when the ground water level is high. During

withdrawal, the movement of the temporary casing shall be maintained in an axial direction relative to the pile.

3.10.5. COMPLETION OF CONCRETING

Irrespective of the specified pile cut-off level, concrete shall be poured into the pile bore until all the contaminated concrete at the top of the bore overflows the top of the pile bore and neat concrete appears continuously as overflow. Concreting shall then be terminated after permission of the ENGINEER.

3.11. PILE CUT-OFF AND EXTENSION

Excavation for pile cut-offs shall be done by the CONTRACTOR. The extent of excavation shall not exceed the minimum necessary for the required pile cut-off. The CONTRACTOR shall provide adequate side slopes/ shoring at no extra cost to the OWNER, in order to provide safe working space for pile cut-off. Excavated material shall not be stacked near the edge of any excavation, but at locations designated by the OWNER within the plant limits at no extra cost to the OWNER.

Pile cut-offs to specified levels shown on the drawing shall be done by the CONTRACTOR for all piles at no extra cost. The CONTRACTOR shall station at site an adequate work force for the same.

Manual breaking of piles shall not be permitted. All pile cut-offs to specified levels shall be done using percussion tools or specified devised methods..

When cutting off and trimming piles to the specified cut-off level, the CONTRACTOR shall take care to avoid shattering or otherwise damaging the rest of the pile. Any cracked or defective concrete shall be cut away and the pile repaired in an approved manner to provide a full and sound section at the cut-off level.

Minimum chipping of the pile shall be 600 mm or till sound concrete is met with or specified cut off level, whichever is greater. While chipping the concrete, care shall be taken to ensure that the reinforcement is not damaged in any way. If the reinforcement is damaged while chipping or bending back, the CONTRACTOR shall rectify the same as directed by the ENGINEER at no extra cost to the OWNER. If the specified cut-off level is less than 600 mm below the ground level (which is the concrete overflow level after all temporary casings are withdrawn) or if the cut-off level is above the ground level, the concrete shaft shall be chipped by minimum 600 mm or till sound concrete is met with, whichever is greater. Thereafter, if found necessary, additional reinforcement shall be jointed as specified earlier in Clauses above. The pile shall then be built up to the specified cut-off level using suitable circular formwork and concrete of grade specified for the pile shaft.

If due to any defective concreting, honeycombing, exposure of reinforcement, snapping of reinforcement bars, etc., stripping of pile concrete is required to be done to a level lower than the specified cut-off level to obtain dense and sound concrete, the pile shall be built up with the good concrete of specified grade for the pile shaft upto the specified cut off level by the CONTRACTOR at no extra cost to the OWNER. Such building up including excavation, concreting, formwork and compacted backfiring shall be at the CONTRACTOR's cost.

On completing pile cut-off for any pile, all exposed reinforcement surface shall be coated with cement wash at no extra cost to the OWNER.

The CONTRACTOR shall backfill all excavation done by him for pile cut-off to levels specified by the ENGINEER or as shown on the drawing. These levels shall be lower than or at least equal to the original working level.

Any over excavation and backfiring of the same with consolidation shall be at no extra cost the OWNER.

3.12. TOLERANCES

3.12.1. POSITIONAL

For a pile cut-off at or above ground level, the maximum permitted deviation of the pile centre from the centre point shown on the drawing shall be 75 mm in any direction. An additional tolerance for the pile head cut-off below ground level will be permitted in accordance with the Clauses 14.2 and 14.3 below.

3.12.2. VERTICAL

Tolerance of verticality shall be within 1 in 75 for the completed pile shaft.

3.12.3. RAKE

The equipment governing alignment of the inclined permanent casing and boring tool shall be set to give the correct alignment of the pile to within a tolerance of 1 in 50.

The maximum deviation of the finished pile from the specified rake shall be 1 in 25 for piles raking upto 1:6 and 1 in 15 for piles raking more than 1:6.

3.12.4. CORRECTIVE MEASURES

No forcible corrections to piles to overcome errors of position or alignment shall be attempted.

If after excavation for pile cut off, any pile or piles are found to exceed the specified positional and/ or alignment tolerances, these shall be replaced or supplemented by the CONTRACTOR by additional pile(s) as directed by the ENGINEER at no extra cost to the OWNER. Also if as a result of pile(s) exceeding the specified permissible positional deviations, and/ or the consequent addition of any replacement pile(s), any pile cap is required to be enlarged, the extra cost of such pile cap enlargement shall be to the CONTRACTOR's account.

3.13. ABANDONED PILE BORES AND REJECTED PILES

Abandoned pile bores shall be filled with sand, which constitutes fine aggregate used for making concrete. If a permanent liner has already been driven, the same shall be withdrawn progressively as the sand is poured in. However no attempts shall be made to extract the liner if, in the opinion of the ENGINEER, this can damage or set out of alignment any other pile in the vicinity.

No attempt shall be made to forcibly extract a rejected pile shaft. Rejected piles shall be cut off as directed by the ENGINEER. The CONTRACTOR shall install replacement pile or piles in lieu of rejected piles as directed by the ENGINEER.

The CONTRACTOR shall not be paid any additional amount for filling up abandoned pile bores or cutting off rejected piles, provision of extra piles, enlargement of pile cap, etc. necessitated due to faulty work of the CONTRACTOR.

3.14. PILE CAPACITIES

Safe structural capacity of the pile shall be taken as the load calculated on the basis of permissible concrete stresses and permissible steel stresses as per IS: 456.

The negative skin friction shall be determined using results of the pull-out test of short piles. Skin friction component of total load carrying capacity shall be determined by conducting initial cyclic pile load tests on piles installed to full length. Also the capacity of piles to resist uplift forces shall be determined by conducting pull-out tests on piles installed to full length.

Pile load tests on both initial piles as well as working piles shall be carried out to establish and prove the design safe vertical, lateral pile capacities.

3.15. PILE LOAD TESTS

3.15.1. GENERAL

Any number of test piles and working piles as specified in the schedule of items or at the discretion of the ENGINEER shall be subjected to load tests. The CONTRACTOR shall provide everything necessary including equipment, measuring devices, jacks, structural framework, kentledges, etc. This includes installation of test piles also and concreting of pile cap either temporary or permanent over single or group of piles for testing the piles. The pile cap concreting will not be paid for separately.

Load tests shall in general be carried out as per IS: 2911 (Part IV) except as modified herein or directed otherwise by the ENGINEER.

Piles to be load tested shall either be so designated on the drawings or specified/ selected by ENGINEER in the field.

Test load shall be applied to the piles by any suitable means preferably by a properly calibrated hydraulic jack with a remote control pump. Test load applied to the piles shall be such that a constant load is maintained under increasing settlement.

The required reaction may be derived from either a loaded platform or anchor piles. Anchor piles shall not be closer than 6 times the pile diameter on either side. Working piles shall not be used as anchor piles. Anchor piles, if provided, shall be at CONTRACTOR's cost.

Load tests shall in general be carried out not earlier than 28 days from the time of casting the pile and may be performed concurrently with the pile installation operations if permitted by the ENGINEER.

The design and arrangement of application of loading, etc. for all types of load tests, shall be submitted by the CONTRACTOR to the ENGINEER for his approval.

All load tests shall be conducted under the supervision of the ENGINEER. All responsibilities for conducting the tests safely and properly shall rest with the CONTRACTOR.

NOTE:

(a) Kentledge load shall be at least 25% higher than the maximum test loads. Concrete blocks shall be used for loading.

(b) The CONTRACTOR shall make arrangements to record the readings of the dial gauges remotely through webcams without necessitating getting below the kentledge.

3.15.2. CALIBRATION OF EQUIPMENT

The CONTRACTOR shall ensure, that all the equipment/ instruments are properly calibrated, at the start of the tests, to reflect the correct values. If so demanded by the ENGINEER, the CONTRACTOR shall have all or such specific instruments tested at an approved testing laboratory at the CONTRACTOR's cost and the test report shall be submitted to the ENGINEER. If the ENGINEER desires to witness/ inspect such tests, the CONTRACTOR shall arrange for this and also provide such access and facilities for inspection as are required.

3.15.3. INITIAL LOAD TESTS

Immediately on mobilisation to site, the CONTRACTOR shall prepare to install piles for conducting initial vertical load (downward and pull-out) and lateral pile load tests.

In case the cut-off is below ground level, a suitable excavation shall be made to provide access to the level after breaking off the unsound concrete.

For the compression type of test, the pile head shall be cut off level and capped by a RC cap to provide a horizontal plane bearing surface upon which a steel plate shall be placed. Earth from under the pile cap shall be scooped out so that pile cap has no soil support. Thereafter, the kentledge and all other accessories outside the pit pertaining to and necessary for conducting the test shall be set up. An easy access to the pile test head shall be provided.

If the pile test head is below the ground water level, the CONTRACTOR shall provide suitable sumps and dewater the pit so as to render the pit dry enough to enable conducting the test. Any dewatering will be considered as part of the test and the CONTRACTOR shall not be separately paid for the same.

The test load shall be so applied that it reaches the pile in a static manner. The loading may be applied directly by kentledge or jacking against a reaction system provided by means of kentledge, tension piles or ground anchors. Where kentledge is used it shall be supported on a properly designed frame or gantry such that there is no possibility of the load tilting or collapsing. The foundations of this frame or gantry should be sufficiently far way from the test pile so as not to affect its behaviour to any significant extent. Where tension piles or ground anchors are used, they shall be located a minimum distance of three times the test pile size from the centre of the test pile to the centre of the pile/ anchor.

The displacement of the test pile shall be related to a fixed datum. This may consist of a reference beam (datum bar) supported by two foundations positioned outside the zones of influence of the reaction support area. The deflection measuring equipment must be set up in such a way that any tilting of the test pile will not cause errors in the measurements. Dial gauges shall be used for measuring deflection. The least count of the dial gauges shall be at least 0.02 mm. At least two but preferably four dial gauges shall be used and shall be placed at diagonally opposite corners.

The reference bars for the strain gauges shall be adequately rigid and on firm supports. The supports for the reference bars shall be so located that they are beyond the zone of influence of the loaded test pile (equal to three times the pile size from pile edge) and the zone of influence of kentledge supports. The bars shall be adequately stiffened and placed on supports in a manner such that any effect due to ambient temperature variations and vibrations due to traffic, etc. are minimised. The reference bars and strain gauges shall not be exposed to direct sun and the pit shall be protected by tarpaulin sheets while the test is in progress.

The total test load shall be three (3) times the estimated safe load carrying capacity of the pile or failure, whichever is earlier, and shall be applied in equal increments of 20 percent of the estimated safe load. Unloading may however be in higher decrements with total number not less than five. At each load increment, pile deflection shall be observed accurate to 0.02 mm at an interval of 1, 5, 10, 15, 25, 35, 50 and 60 minutes and thereafter at half hourly intervals, upto a time when the rate of deflection of the pile top reduces to 0.1 mm in half hour or 0.2 mm in one hour. The load increment in any case shall be maintained for 1 hour at least. The design load as well as the final load shall be maintained for 24 hours at least. At these load increments, after the first hour, deflection readings shall be taken at every one hour interval.

During the release stage, each load decrement shall be maintained at least for 30 minutes and readings of deflection noted. When the load is fully released to zero, measurements of rebound shall be continued till the deflection of the pile top is not more than 0.1 mm per half hour.

Initial cyclic tests shall be carried out to determine skin friction and point resistance of piles. This shall be carried out as per IS: 2911 (Part-IV). However, each cycle of loading and unloading shall be repeated allowing a time interval of 10 minutes between the end of one cycle and the beginning of the next.

For the initial lateral pile load test pairs of piles for lateral load tests shall be driven. Lateral load test shall be conducted as per IS: 2911 (Part-IV) with horizontal loading increment as per BIS, stagewise till failure occurs. Load shall be applied at cut-off level.

Piles specified for pull out test shall be subjected to pull-out force in equal increments of not more than 2.5 tonne till the rise exceeds 12 mm or specified ultimate pull-out force is reached whichever is earlier. A graph of pull out force and the corresponding rise of pile top shall be plotted immediately.

If the initial test pile(s) which is (are) load tested fails (fail) to attain the specified safe structural capacity of piles and if this can be attributed to defective workmanship and/ or negligence on the part of the CONTRACTOR, the OWNER reserves the right to terminate the contract and to award the contract to other parties. In such an event, all costs of mobilisation, installation and testing of test pile(s) and any other work in connection with the test piles, shall be borne entirely by the CONTRACTOR.

While executing the pile bore for all test piles, a record of bore log and Standard Penetration Tests shall be maintained over the continuous length of boring in an approved format. Subsoil samples and rock cuttings shall be collected and systematically preserved.

3.15.4. LOAD TESTS ON WORKING PILES

These tests shall be carried out on piles selected by the ENGINEER after they have been cast. Tests to be carried out on working piles shall essentially be ordinary compression type. The test will be similar to that conducted on initial test piles, except that the capacity of the pile shall be limited to 1.5 times the safe pile capacity, the maximum settlement during test loading not exceeding 12 mm.

The working pile shall be considered to have stood the test satisfactorily if total settlement under final test load is not more than 12 mm and net (residual) settlement after removal of test load not more than 6 mm.

If the pile does not satisfy these requirements and if this can be attributed to defective workmanship or negligence on the part of the CONTRACTOR, all costs of the load test, the cost of providing and installing additional piles, cost of additional or enlarged pile caps and other work necessitated because of the defective pile, shall be at the cost of the CONTRACTOR.

3.15.5. RECORDS OF LOAD TEST RESULTS

Within 48 hours of completion of each test, the CONTRACTOR shall furnish a copy of all recorded test data to the ENGINEER. Upon completion of pile load tests, the CONTRACTOR shall furnish the ENGINEER at no extra cost with a pile test report in triplicate and this shall include the following information where applicable.

(a) Identification of working pile/ test pile as per drawing.

(b) Co-ordinate axes of pile, elevation of bottom of pile, cut off level of pile, type of pile, pile size.

(c) Pile Borelog Records.

(d) SPT results.

(e) Deviation from designated location/ alignment.

(f) Jack gauge calibration curves from approved Test House.

(g) Tabulation of loads and settlement readings during the loading and unloading of the pile.

(h) Graphic representations of the test results in the form of time-load-settlement curves.

(i) Graphic analysis of Initial Cyclic test results to separate skin friction and end bearing as set out in IS: 2911 (Part-IV).

(j) Remarks concerning any unusual occurrences during installation or test loading of the working piles/ test piles.

3.15.6. INDIRECT INTEGRITY TESTS FOR PILES

The ENGINEER may desire to get bored cast in situ piles subject to integrity tests by indirect methods through another agency. The CONTRACTOR shall give all co-operation in getting such tests conducted. The ENGINEER reserves the right to give due weightage and consideration to results of these tests, which will affect the integrity of the installed piles.

3.15.7. INSTALLATION RECORDS

The CONTRACTOR shall submit each working day, detailed pile installation records in duplicate for each pile installed in the enclosed formats. The ENGINEER's piling plans will show all piles serially numbered as per the piling layout plans. The cost of all labour, materials and services called for herein shall be included in the CONTRACTOR's unit rates.

The details of the record shall include but not be limited to the list below:

3.15.8. PILE INSTALLATION RECORD

A. BASIC DATA

1. Piling Layout Drawing No.

2. Pile Number.

3. Location Co-ordinates.
4. System/ Structure.
5. Pile Location vis-a-vis Pile Group (Draw dimensioned sketch with reference axes and shade the pile).
6. Pile Type: Vertical/ Raker, 1:__.
7. Pile Nominal Diameter.
8. Pile Tip Elevation.
9. Pile Cut-off Elevation.
10. Ground Level at Pile Location.
11. Grade of Concrete Specified.
12. Reinforcement Details (Draw sketch if complex).
13. Safe Capacity of Pile Specified.

B. PILE BORE DATA

1. Date and Time of Start.
2. Date and Time of Completion.
3. Method of Boring.
4. Inner Nominal Diameter of Temporary Casing/ Permanent Liner.
5. Length of Temporary Casing/ Permanent Liner.
6. Material of Permanent Liner.
7. Method of Jointing Temporary Casing/ Permanent Liner.
8. Treatment to Permanent Liner.
9. Length Bored in Soil.
10. Length Bored in Rock Notes to Schedule of Quantities for purpose of measurement).
11. Bore Log (Draw sketch or refer to separate sheet).
12. Details of Standard Penetration Tests.
13. Number of Subsoil Samples/ Rock Cuttings collected.
14. Ground Water Elevation.
15. Any Artesian Conditions.
16. Any Bore Collapse and Details.
17. Any Loss of Drilling Mud and Details.
18. Any Other Details or Phenomena Observed.

C. FLUSHING RECORD

1. Date and Time of Start of Final Post-bore Flushing.
2. Date and Time of Completion of Final Post-bore Flushing.
3. Remarks on inspection of Wash of Post-bore Flushing.
4. Date and Time of Start of Final Pre-concreting Flushing.
5. Date and Time of Completion of Final Pre-concreting Flushing.
6. Remarks on Inspection of Wash of Pre-concreting Flushing.

D. CONCRETING RECORD

1. Date and Time of Start of Concreting.
2. Date and Time of Completion of Concreting.
3. Grade of Cement and Name of Manufacturer.

4. Date of Manufacture of Cement.
5. Grade of Concrete as Mixed.
6. Grade of Concrete Specified.
7. Slump of Mixed Concrete at Pile Head.
8. Cube Test Results.
9. Method of Concrete Placement in Pile Bore.
10. Theoretical Volume of Concrete: (Pile Tip to Top of Pile as Cast).
11. Actual Volume of Concrete: (Pile Tip to Top of Pile as Cast).
12. Ratio of Actual Volume to Theoretical Volume of Concrete: (Express as Percentage).
13. Any Delays during Concreting and Reasons.
14. Overflow Quantity.
15. Any Other Details.

3.15.9. CLEAN-UP

All throughout the work, the CONTRACTOR shall take all steps to prevent spillage of bentonite slurry on the site in areas outside the immediate vicinity of boring. The slurry shall not be allowed to flow into any water courses, nallas, site drains or any public drains.

Any discarded and/ or used bentonite shall be removed from the site without any undue delay.

Upon completion of piling work, all casings, equipment, construction tools, protective coverings and any debris resulting from the work shall be removed from the premises.

All debris, empty containers, scrap timber, etc. shall be removed as directed by the ENGINEER/ OWNER.

Exposed and finished concrete and dowel surfaces shall be left in a clean condition satisfactory to the ENGINEER.

4. SPECIFICATION FOR EARTHWORK

4.1. APPLICABLE CODES

IS 1498	:	Classification and identification of soils for General Engineering Purposes.
IS 3764	:	Safety Code for Excavation Work
IS 1200	:	Method of Measurement of Building Works and civil engineering works Part 1: Earth work Part 27: earthwork done by mechanical appliances.

4.2. EXCAVATION

4.2.1. All excavation work shall be carried out by mechanical equipment unless, in the opinion of the ENGINEER, the work involved and time schedule permit manual work.

4.2.2. Excavation for permanent work shall be taken out to such widths, lengths, depths and profiles as are shown on the drawings or such other lines and grades as may be specified by the ENGINEER. Rough excavation shall be carried out to a depth 150 mm above the final level. The balance shall be excavated with special care. Soft pockets shall be removed even below the final level and extra excavation filled up as directed by the ENGINEER. The final excavation if so instructed by the ENGINEER, should be carried out just prior to laying the mud-mat.

4.2.3. The CONTRACTOR may, for facility of work or similar other reasons excavate, and also backfill later, if so approved by the ENGINEER, at his own cost outside the lines shown on the drawings or directed by the ENGINEER. Should any excavation be taken below the specified elevations, the CONTRACTOR shall fill it up, with concrete of the same class as in the foundation resting thereon, upto the required elevation. No extra shall be claimed by the CONTRACTOR on this account.

4.2.4. All excavation shall be done to the minimum dimensions as required for safety and working facility. Prior approval of the ENGINEER shall be obtained by the CONTRACTOR in each individual case, for the method he proposes to adopt for the excavation, including dimensions, side slopes, dewatering, disposal, etc. This approval, however, shall not in any way relieve the CONTRACTOR of his responsibility for any consequent loss or damage. The excavation must be carried out in the most expeditious and efficient manner. Side slopes shall be as steep as will stand safely for the actual soil conditions encountered. Every precaution shall be taken to prevent slips. Should slips occur, the slipped material shall be removed and the slope dressed to a modified stable slope. Removal of the slipped earth will not be paid for if the slips are due to the negligence of the CONTRACTOR.

4.2.5. Excavation shall be carried out with such tools, tackles and equipment as described herein before. Blasting or other methods may be resorted to in the case of hard rock only with the specific permission of the ENGINEER.

4.3. STRIPPING LOOSE ROCK

4.3.1. All loose boulders, semi-detached rocks (along with earthy stuff, which might move therewith) not directly in the excavation but so close to the area to be excavated as

to be liable, in the opinion of the ENGINEER, to fall or otherwise endanger the workmen, equipment, or the work, etc., shall be stripped off and removed away from the area of the excavation. The method used shall be such as not to shatter or render unstable or unsafe the portion, which was originally sound and safe.

4.3.2. Any material not requiring removal as contemplated in the work, but which, in the opinion of the ENGINEER, is likely to become loose or unstable later, shall also be promptly and satisfactorily removed as directed by the ENGINEER. The cost of such stripping will be paid for at the unit rates accepted for the class of materials in question.

4.4. EARTHWORK IN EXCAVATION FOR MAJOR EXCAVATION (BASEMENTS/ RETAINING WALLS)

4.4.1. Excavation shall be undertaken to the width of the Basement/ Retaining Wall Raft/ Footing including necessary margins for construction operation as per drawing or as directed by the ENGINEER. Where the nature of soil or the depth of the trench and season of the year do not permit vertical sides, the CONTRACTOR shall, at his own expense, put up the necessary shoring, strutting and planking or cut slopes with or without steps, to a safer angle or both with due regard to the safety of personnel and works and to the satisfaction of the ENGINEER. The scheme proposed by the CONTRACTOR shall take into consideration the presence of existing buildings/ structures in the vicinity, if any.

4.4.2. All the major excavation shall be carried out by mechanical excavator. No extra payment shall be made for that.

4.4.3. The CONTRACTOR shall make, at his own cost, all necessary arrangements for maintaining water level, in the area where works are under execution low enough so as not to cause any harm to the work. These shall be considered as inclusive of pumping out or bailing out water, if required, for which no extra payment shall be made. This will include water coming from any source such as rains, accumulated rain water, floods, leakages from sewer and water mains, water ingress from nearby nallah, subsoil water table being high or due to any other cause whatsoever. The CONTRACTOR shall make necessary provision of pumping, dredging, bailing out water coming from all above sources and excavation and other works shall be kept free of water by providing a suitable system approved by the ENGINEER.

4.4.4. In order to avoid possibility of basement raft of building getting uplifted/ damaged due to water pressure, the CONTRACTOR shall lower the ground water table below the proposed foundation level by boring tube wells all around the proposed building using well point sinking method or any suitable method as approved by the ENGINEER. Sub soil water table shall be maintained at least 50 cm below the layer of blinding concrete (Plain Cement Concrete (PCC) level during laying of PCC, water proofing treatment, laying of basement raft and beams including filling of earth/ sand under the basement floor. The water table shall not be allowed to rise above base of raft level until completion of outer retaining walls including water proofing of vertical surface of walls and back filling along the walls upto ground level and until the structure attains such height to counter balance the uplift pressure.

4.4.5. The CONTRACTOR should inspect the site and make his own assessment about sub-soil water level likely to be encountered at the time of execution and quote his rates accordingly. Rate of all items are inclusive of pumping out or bailing out water, if required. Nothing extra on this account whatsoever shall be paid to him. The CONTRACTOR shall obtain the ENGINEER’s approval on the sequence of construction.

4.4.6. The CONTRACTOR shall take all necessary measures for the safety of traffic during construction and provide, erect and maintain such barricades including signs, markings, flags, lights and flagman, as necessary at either end of the excavation/ embankment and at such intermediate points as directed by the ENGINEER for the proper identification of construction area. He shall be responsible for all damages and accidents caused due to negligence on his part.

4.5. SITE FILLING

4.5.1. FILL MATERIAL

General All fill material whether such material is brought from outside borrow areas or from excavation from within the site, will be subject to the ENGINEER's written approval. Notwithstanding any approval given to the fill material of borrow areas from which fill material is proposed to be brought, the ENGINEER/ OWNER reserves the right to reject such material, which in his opinion either does not meet the specification requirements or is unsuitable for the purpose for which it is intended.

4.5.2. Borrow Areas

It shall be CONTRACTOR's responsibility to locate suitable borrow areas for borrowing fill material. Such area will be inspected by the ENGINEER and approved before the CONTRACTOR makes arrangements to borrow the fill material. The top soil which may contain vegetation, rubbish, slush, etc. shall not be used. If demanded by the ENGINEER, the CONTRACTOR shall arrange to have trial pits of specified dimensions and numbers dug at locations specified, for the ENGINEER to examine the nature and type of material likely to be obtained from the borrow area.

4.5.3. Lead, Lift and Transportation

Unless separately provided for, all lead, lift and transportation required for bringing in the fill material from borrow areas or from excavation from within the site shall be included in the CONTRACTOR's quoted unit rates.

4.5.4. Quality

The borrowed soil shall be generally granular, and non-cohesive. It shall consist of sand, silty sand, murrum, ordinary soil, gravel and shingle. Dredged material shall also be free from sulphates, salts, organic, foreign and other harmful or objectionable materials. Any material rejected by the ENGINEER shall be removed from the site immediately.

4.5.5. ACCESS ROADS

Roads, whether of temporary or other nature, required to be constructed for access and for movement of men, materials, equipment, transport vehicles, vehicles carrying fill material, etc. to or over borrow areas and/ or to or over areas on which fill has to be deposited shall be constructed by the CONTRACTOR at his cost. Such costs shall be deemed to have been included in the unit rates quoted by the CONTRACTOR. Such access roads shall be maintained in good condition during all seasons to ensure completion of work according to time schedule.

4.5.6. CLEARING

The area to be excavated/ filled shall be cleared of fences, trees, plants, logs, stumps, bush, vegetation, rubbish, slush, etc. and other objectionable matter. If any roots or stumps of trees are met during excavation, they shall also be removed. The

material so removed shall be burnt or disposed off as directed by the ENGINEER. Where earth fill is intended, the area shall be stripped of all loose/ soft patches, top soil containing objectionable matter/ materials before fill commences.

4.5.7. Soil Fill

a) Approved soil fill consisting of ordinary soil, murrum, soil containing gravel, shingle, etc. shall be deposited in layers not exceeding 200 mm. CONTRACTOR should ensure that all clods of earth are broken down to a size not larger than 100 mm.

b) Filling with excavated earth shall be done in regular horizontal layers each not exceeding 30 cm in depth. All lumps and clods exceeding 8 cm in any direction shall be broken. Each layer shall be watered and consolidated with power roller of minimum 10 tonnes, unless otherwise directed by ENGINEER. The CONTRACTOR shall make good all subsidence and shrinkage in earth fillings, embankments, traverses, etc. during execution and till the completion of work unless otherwise specified.

c) Where specified, the required density of fill shall be obtained by proper compaction.

4.5.8. FILL DENSITY

The compaction, only where so called for, in the Schedule of Quantities/ Items shall comply with the specified (Standard Proctor/ Modified Proctor) density at moisture content differing not more than 4 percent from the optimum moisture content. The CONTRACTOR shall demonstrate adequately at his cost, by field and laboratory tests that the specified density has been obtained.

4.5.9. PROPERTIES OF FILLING MATERIAL

The soil selected for filling purpose shall comply with the following requirements:

a) Soil shall be free from swelling properties. Preferably, soil having free swelling index less than 50 shall be used. However, soil having free swelling index up to 100 may be used after carrying out necessary soil improvement and approval by ENGINEER. Liquid Limit and Plasticity Index shall be as per Table 8 of IS: 1498 for low degree of expansion.

b) It shall be possible to compact the soil upto 97% of Proctor Density or Modified Proctor Density as per the project requirement. Broad guidelines for selection of various types of soil groups and their requirements for compaction are indicated in Table 8 of IS: 1498.

c) Soil shall be free from chemical contamination. It shall have pH value, sulphate and chloride content within the permissible values specified in IS: 456.

4.5.10. LEAD

Lead for deposition/ disposal of excavated material, shall be as specified in the respective item of work. For the purpose of measurement of lead, the area to be excavated or filled or area on which excavated material is to be deposited/ disposed off shall be divided into suitable blocks and for each of the blocks, the distance between centre lines shall be taken as the lead, which shall be measured by the shortest straight line route on the plan and not the actual route taken by the CONTRACTOR. No extra compensation shall be admissible on the grounds that the lead including that for borrowed material had to be transported over marshy or 'katcha' land/ route.

4.5.11. MEASUREMENT AND PAYMENT

Backfilling, plinth filling, etc. with borrowed earth will be paid for at rates quoted. The quoted rate shall include all operations such as clearing, excavation, lead and transport, fill, compaction, etc. as specified. Actual quantity of consolidated filling or actual quantity or excavation in the borrow pits (less such top soil, which has been excavated and not used for filling) whichever is less shall be measured and paid for in cubic metres. The lead, lift, etc. shall be as indicated in the Schedule of Quantities.

Actual quantity of consolidated sand filling shall be measured and paid in cubic metres.

4.6. DEWATERING

4.6.1. All excavations shall be kept free of water. Grading in the vicinity of excavation shall be properly closed to prevent surface water from draining into excavated areas. CONTRACTOR shall remove by pumping or other means approved by ENGINEER any water inclusive of rain water and subsoil water accumulated in excavation and keep all excavations dewatered until the foundation work is completed and backfilled. Sumps made for dewatering must be kept clear of the excavations/ trenches required for further work. Method of pumping shall be approved by ENGINEER; 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. Pumping arrangements shall be adequate to ensure no delays in construction.

4.6.2. The CONTRACTOR shall take adequate measures for bailing and/ or pumping out water from excavations and construct diversion channels, bunds, sumps, coffer dams, etc. as may be required. Pumping shall be done directly from the foundation trenches or from a sump outside the excavation in such a manner as to preclude the possibility of movement of water through any fresh concrete or masonry and washing away parts of concrete or mortar. During laying of concrete or masonry and for a period of at least 24 hours thereafter, pumping shall be done to ensure that the surface below the concrete remains dry.

4.6.3. Capacity and number of pumps, location at which the pumps are to be installed, pumping hours, etc. shall be reviewed by the CONTRACTOR from time to time. The ENGINEER may direct the CONTRACTOR to make changes in his scheme if the adopted scheme fails to achieve the desired results.

4.6.4. Pumping shall be done in such a way as not to cause damage to the work or adjoining property by subsidence, etc. Disposal of water shall not cause inconvenience or nuisance in the area or cause damage to the property and structures nearby. When there is a continuous inflow of water and quantum of water to be handled is considered in the opinion of ENGINEER as large, well point system

- Single stage or multi stage, shall be adopted. CONTRACTOR shall submit to ENGINEER his scheme of well point system including the stages, the spacing, number and diameter of well points, headers, etc. and the numbers, capacity and location of pumps of approvals. Unless separately provided for in the Schedule of Prices, the cost of dewatering shall be included in the item rate for excavation.

4.6.5. MEASUREMENT

Unless separately provided for in the Schedule of Quantities, dewatering is deemed to have been included in the unit rates quoted for excavation.

Request for Proposal

For

DEVELOPMENT OF BORSOLA BEEL

Design, Build and Operate Basis

Volume II C Part-1: Technical Specification for Mechanical Works

Client:

GUWAHATI SMART CITY LIMITED

GSCL,
Guwahati, Assam

DOCUMENT NO: 10477A-CV-3000-3102

1.1	**INTRODUCTION**
	This part of Owner's requirements sets out the general standards for mechanical equipment to be used by the contractor for the works. Any item not mentioned herein but required for completion of work shall have to be taken into account by the contractor. Reference to any specific items does not necessarily imply that it is to be included in the works All equipment used for the works shall, unless otherwise specified, comply with the provisions of this chapter. Successful Bidder has to submit the list and schedule of all design / drawings /calculation / QAP/ etc., within 1 month of issue of LOI.
1.2	**GENERAL**
1.2.1	**Material**
	All materials incorporated in the works shall be the most suitable for the duty concerned and shall be new & from reputed/approved make or approved quality and of first class commercial quality, free from imperfection and selected for long life and minimum maintenance. Destructive/Non-destructive tests, if called for, shall be carried out. All the moving parts of the plant, or shaft and spindles or faces etc. In contact with then shall be of corrosion resistance materials. All parts directly in contacts with various chemicals, shall be completely resistant to corrosion, or abrasion by these chemicals, and shall maintain their properties without aging due to the passages of time, exposure to light or any other causes. All material shall confirm to the material as per BIS or any equivalent standard. All stainless steel materials used shall be of SS 316 unless otherwise specified.
1.2.2	**Workmanship**
	Workmanship and general finish shall be of first class quality and in accordance with best workshop practice. All welds shall be as per BIS or any equivalent standards. All tolerances and clearance shall be as per good and sound engineering practice. Should the owner’s representative not consider any material acceptable, it shall be replaced.
1.2.3	**Design Features**

As far as practicable, all proposed designs shall be as per latest proven concepts and practices. The equipments shall be new, of robust design for long reliable operating life. These shall be capable of 24 hours operation in a day for 365 days in a year for continues operation for prolong period in the climatic and working conditions prevailing at the site and with a minimum of maintenance. Particular attentions shall be given to extra temperature and the rating of electrical and mechanical equipments, cooling systems and choice of the lubricating system.

The equipments shall be designed to provide easy access to and replacement of the component/parts which are subjected to wear without the need to replace whole units. All parts in contact with water/sewage/chemicals shall have a life from new to replacement for 15 year minimum and new to repair of not less than five years. Design features shall include the protection of equipments against damages caused by vermin, dirt, dust and dampness and to reduce the risk of fire. Equipment shall operate without undue vibration.

The noise level produces by any equipment like pump sets, compressor sets, blowers etc.., shall not exceed 85 dB(A) measured at a distance of 1.86 m from outer surface of source. At the time of operation, the mechanical vibration shall not exceed the limit given in the **Table 2-1**, at recommended points of the measurement as per ISO 10816:1995.

During the commissioning of the plant/equipments if noise level/vibrations found beyond the permissible limit, contractor to rectify/replace the particular equipment at no extra cost with in mutually agreed time limit. During the O&M period (O&M is done by contractor) if noise/vibration of equipment found beyond the permissible limit, rectify/replace of the particular equipment shall be responsibility of contractor.

Table 2-1 : Permissible Equipment Velocity of vibration (in mm/sec)

Sr. No.	Equipment	Permissible Velocity of Vibration (in mm/sec)
1	All rotating equipment without reciprocating parts of motor rating ≤ 15 kW	1.12
2	All rotating equipment without reciprocating parts of motor rating > 15 kW & ≤ 75 kW	1.8
3	All rotating equipment without reciprocating parts of motor rating >75 kW	2.8

Parts shall be design to withstand the maximum stresses under the most sever conditions of normal service. All rotating elements shall be dynamically and statically balanced.

1.2.4 Lubrications

	The equipment shall be lubricated by long life lubricants such that working life is not less than 3000 operation hours or as per recommendation of the equipment manufacturer. A complete schedule of recommended oils and other lubricants shall be furnished by the bidder. The number of different types of lubricants should be kept to minimum. The schedule and the name of the supplier of the lubricant shall be submitted to the owner's representative for approval. Lubricants shall be oil and grease. The contractor shall indicate indigenously available equivalent lubricants with complete specifications. Where the lubricant is grease, preference shall be given to a pressure system which does not require frequent adjustment or recharging. Preferably, life lubricated grease packed bearings shall be used. Grease gun for each type of grease used shall be supplied.
1.2.5	**Name Plates**
	Each equipments of the plant shall have permanently attached to it a nameplate and rating plate in a conspicuous position, upon these shall be engraved or stamped, the manufacturer's name, type and serial number of the equipment, details of the loading and duty at which the equipment has been designed to operate, and such diagrams as may be required by the owner's representative. All indicating and operating devices shall securely attached to them or marked upon them designations as to their function and proper manner of use.
1.2.6	**Painting**
1.2.6.1	**At Manufacturer's Work**
	The contractor shall be responsible for the cleaning, preparation for painting and priming or otherwise protecting, as specified, all parts of the plant/equipment at the place of manufacture prior to packing. Parts may be cleaned but surface defects should not be filled in before testing at manufacture's work. Parts subjected to hydraulic test shall be tested before any surface treatment. After testing, all surfaces shall be thoroughly cleaned and dried out, if necessary by washing with as approved dewatering fluid prior to surface treatment. Except where the specification provides to the contrary, all painting materials shall be applied in strict accordance with the paint manufacturer's instructions.

	Steel and cast iron parts shall be sand blasted to near white cleaning before painting. Edges, sharp corners etc. Shall be grounded to a curve before sand blasting. A primer coat of a zinc rich epoxy resin based coating with at least 75 microns dry film thickness is to be provided. In addition, the parts for wet duty are to be provided with an adequate number of coats of coal tar epoxy polyamine coating to a dry film thickness of 175 microns excluding primer coating.
1.2.6.2	**At Site**
	Immediately on arrival at the site, all items of the plant shall be examined for damage to the paint coat applied at the manufacturer's work. Any damaged portions shall be cleaned down to the bare metal, all rust removed, and the paint coat made good with similar paint. After erection, such equipment/items which are not finish painted shall be done so. Items that have been finished painted at the manufacturer's work shall be touched up for any damaged paint work. Damaged paint during erection shall be made good with similar paint. For finish painting, two coats of synthetic enamel confirming to IS: 2932 shall be applied. Dry film thickness of each coat shall be at least 25 microns. The dry paint film thickness shall be measured by Elcometer or other instruments approved by the owner's representative. In order to obtain the dry film thickness specified, the contractor shall ensure that the coverage rate given by the paint manufacturer will enable this thickness to be obtained. Strength of adhesion shall be measured with an adhesion tester and this value shall not be less than 10 kg/cm^2. Painted fabricated steel work which is to be stored prior to erection shall be kept clear of the ground and shall be laid out or stacked in an orderly manner that will ensure that no water or dirt can accumulate on the surface. Suitable packing shall be laid between the stacked materials. Where cover is provided, it shall be ventilated.
1.2.7	**Galvanizing**
	Wherever galvanizing has been specified the hot dip process shall be used and electro galvanized parts, equipments shall not be permitted. The galvanized coating shall be of uniform thickness. Weight of zinc coatings for various applications shall not be less than those indicated below: a) Fabricated Steel : 460 gm/m^2 b) Fasteners : 300 gm/m^2 Galvanizing shall be carried out, after all drilling, punching, cutting, bending and welding operations have been carried out. Burrs shall be removed before galvanizing. Any site modification of galvanized parts should be covered well by zinc rich primer and aluminium paint.

1.2.8	**Wet Well**
	i). In order to prevent surcharging of sewers, the maximum level of sewage in the suction/wet well of the TSPS/ISPS shall be limited to 300 mm below the invert of the lowest incoming sewer. ii). For the TSPS/ISPS, in order to prevent sewage from turning septic, maximum retention of sewage in the wet / suction well shall not exceed 30 minutes for the average flow. iii). The depth of sump shall be such that it provides at least 15 % margin over the minimum required pump submergence calculated at duty point on the basis of the Hydraulic Institute Standard. iv). The wet well effective operating volume (volume between low level where all pumps are shut off and high level where all pumps except standby are operating) shall be such that the hydraulic retention time in this volume at peak flow is not less than 5 minutes and the number of starts per hour does not exceed 6 for any single pump under any circumstances. v). Appropriate baffles shall be provided in the wet/suction well to prevent the excessive turbulence and air entrainment when free fall of material to be pumped occurs. vi). Benching shall be provided at the bottom of the wet well towards the suction bell mouth to ensure that the pumps can be used to completely drain the wet well. The wet well design shall incorporate corner fillets and ogees as appropriate to eliminate dead spots, prevent accumulation of solids or debris, and to ensure that the wet well is fully self-cleaning – automatically cleaned by the hydraulics of the flow. vii). Priming of pumps shall be ensured by providing positive suction head. viii). Operation of sewage pumps shall be automatic based on the sewage levels in the wet well. ix). Standby unit of each type and size of pump employed shall be provided as specified in particular mechanical requirement and these shall be minimum requirement. x). The clearance between pumps outer periphery (or pump foundations) shall be not less than 1000 mm. xi). Sequence of operation of raw sewage pumps shall be changed every 8 hours to avoid accumulation of solids in the wet/suction well.

	xii). + 5% margin on the pump capacity shall be provided for all the pumps. xiii). The total head of the pump shall be selected considering peak flow and maximum design level in the wet well for normal conditions of operation, and checked for satisfactory operation under extreme conditions of operation; the selected head to be revised if required. xiv). The minimum permissible velocity in the pumping mains shall be 0.6 m/sec. The maximum velocity in the pumping main shall not exceed 2.5 m/sec. xv). All dry well pumping stations shall be provided with a pit and drain pumps (1 working + 1 standby) to automatically empty the stuffing box drain. xvi). Ventilation shall be provided for the pumping station based on 10-12 air changes per hour. xvii). For TSPS/ISPS, mechanical rake coarse bar screen shall be provided upstream of the pumping station wet well. Provisions shall be made to allow lifting of screenings by belt conveyor. Appropriate lifting devices shall be provided for safe and easy retrieval and/or removal of the pumps from wet well or dry well for maintenance or any other purpose at all pumping stations.
1.3	**Process Equipments**
1.3.1	**Mechanically Raked Bar Screen**
1.3.1.1	**Purpose** i). Mechanical screens should be suitable for installation in Sewage treatment plant for removal of floating wastes coming along with sewage. These screens should be capable to screen out most of the medium and large floating material such as plastic bags, floating debris, weeds, paper wastes, clothes and rags etc. Which are generally clogging the impellers of the pumps installed downstream of the screens. ii). The operation of the screen shall be automatic. An ultrasonic type differential level controller shall be provided to sense the head loss through the bar and give the signal to the travelling raking mechanism to start its operation. The sensor will signal the raking mechanism to operate continuously till the head loss is reduced to a preset level. iii). A complete electrical control system shall be supplied with each screen and shall be mounted independently near to the screen installation. The system shall provide for

	total automatic operation of the screen with the feedback from the level controller.
1.3.1.2	**General**
	The screen shall be of the front raking type with aperture size of 20 mm. All the materials and sub-assemblies used shall be suitable for outdoor application. They shall be constructed so that maintenance is kept to a minimum. There shall not be any moving part, sprocket, bearing, etc. continuously immersed in sewage. All lubricating points shall be conveniently accessible from the deck level. The screen shall be suitable for discharging 75% of the screened material lifted from the screen in to chute. The screen shall be designed such that in case of heavy accumulation of solids, the same is to be removed gradually without overloading or damaging the screen bars or mechanism.
1.3.1.3	**Scope:**
	i). Contractor shall furnish and install mechanically cleaned bar screens with multiple rake blades. Each screen shall be manufactured from SS 316 stainless steel shapes. Fabrication and assembly shall be in conformance with this specification. ii). Each screen shall be furnished complete with bar rack, dead plate, discharge chute, side frames, covers, rake blades, drive chains, sprockets and bearings , scraper assembly, drive motor, gear reducer, anchor bolts, controls and all accessories and appurtenances specified or otherwise required for complete and proper operating installation.
	iii). Contractor shall coordinate all details of the equipment with other related parts of the work. He shall verify that all structures, piping, wiring, and equipment components are compatible. Contractor shall be responsible for all structural and other alternations required to accommodate equipment differing in dimensions or other characteristics from these specifications and drawings. iv). Contractor shall install the equipment according to instructions and recommendations of the equipment manufacturer. v). Power supply is 400Volts, 50Hz, 3-phase.
1.3.1.4	**Material** i). Screen shall be manufactured from AISI 316 stainless steel shapes (rods, angles, and channels), pipes and sheets. In particular, side frames and guides, bar rack, rake assembly, scraper assembly, shafting, discharge chute, fasteners and anchor bolts shall be made of this material. ii). Screen shall be manufactured in a stainless steel factory only to prevent contamination of the stainless steel with rusty dust.

	iii). Screen shall be manufactured in a stainless steel factory only to prevent contamination of the stainless steel with rusty dust. iv). All stainless steel components and structures shall be submersed in a chemical bath of nitric acid and hydrofluoric acid (pickling bath) to remove any residues that may be present on the material as a result of forming, manufacture, or handling. After removal from the pickling bath, the equipment must be washed with a high-pressure wash of cold water to remove any remaining surface debris and promote the formation of an oxidized passive layer which is critical to the long life of the stainless steel. v). Chains and sprockets shall be made of SS 316. vi). Lower sprocket bearing shall have a stainless steel casing including a shaft made of white cast iron and a ceramic (calcium carbide) friction bushing. Upper sprocket bearings shall have a paint coated cast iron casing and include ball bearings that are greased for life and shall be double-sealed with Nilos rings.
1.3.1.5	**Performance & Design Requirements**
	i). Separation of floating, settling and suspended material from wastewater by means of an inclined bar rack installed within the channel. ii). Both ends of the cleaning elements are connected to drive chains. iii). Each chain is driven by a sprocket on a common shaft and a flange mounted gear motor. iv). Furthermore, defined meshing of the cleaning rakes with bar rack ensures a high operating reliability. v). The cleaning elements, attached to the chain system, should be adjustable.
	vi). The cleaning elements, consisting of the rake and comb plate, are screwed and thus independently replaceable. vii). If the screen operation is blocked, the electromechanical torque control reliably protects the screen against damage caused by overload.
1.3.1.6	**Frame work** The frame work of the screen should be such that it should mount on the top of the channel wall Screen construction should be such that, it should mount only on top of the channel wall. The frame will rest on the special supports installed on the wall along the depth of channel. In case of maintenance, screen should be able to be lifted out from the top with crane. No personnel should go inside the screen chamber for any type of maintenance or repair work.

1.3.1.7	**Screens Construction**
	i). The bar Screen shall remove floating materials from the incoming wastewater by means of a positively cleaned bar rack that is installed in a concrete channel. The screen shall retain floating materials at the bar rack. ii). A multitude of rake blades shall remove and lift the floating materials to a discharge mechanism. iii). The bar rack shall be cleaned by a series rakes engaging the bar rack from the upstream side at the bottom of the channel and then moving up along the bar rack. iv). The floating materials shall be lifted above the channel and dropped on a discharge chute at the downstream side of the screen. v). Screens with single rakes shall not be approved. vi). The bar rack shall consist of equally spaced, straight bars that are inclined from the horizontal. vii). The lower ends of the bars shall be provided with a minimum 4 mm thick curved base plate such that the rakes positively remove all screenings from the bottom of the bar rack. Bars shall have Tear Drop profile with a cross section of 12 mm(front width/Tear Dia) X 10 mm(back Width) X 50 mm (Depth). ix). The bar rack shall be securely fastened to the frame of screen and be readily removable. x). The bar screen shall be provided with a dead plate extending from the bar rack to the discharge chute. xi). The dead plate shall be made of a minimum or 4 mm thick stainless steel plate and shall be stiffened by structural members so that it is flat without undulation so that the tips of the rake's teeth ride at a distance between 1 to 2 mm over the dead plate. xii). The dead plate shall be securely fastened to the side frames. xiii). A Discharge chute shall be provided that fully encloses the discharge section of the screen. An access hatch with hinges and a handle shall be provided in the chute permitting easy access. The discharge chute shall be mounted to direct screenings into the appropriate receiving container or conveyor.
	xiv). The chute shall have a slope of minimum 45 degrees. The discharge chute shall be made of a minimum 4 mm thick stainless steel plate. xv). A frame shall be provided supporting all required loads. Side frames shall be made of 4 mm thick 316 stainless steel plates with a minimum of four axial edges. The side frames shall be connected with each other through channels having a minimum thickness of 4 mm and a minimum cross section of 108 X 49 mm. The side frames shall be connected to support frames. The support frames shall be securely anchored onto the operating floor. xvi). The screen shall be provided with easily removable, sufficiently, stiffened covers made of 1.5 mm thick stainless steel plates with edges on all sided. The covers shall be provided with turn locks and handles. xvii). Each side frame shall include separate roller tracks to guide the rakes. The roller tracks shall be bolted to the frame so that they can easily be replaced. The roller tracks

	shall be made of 4 mm thick L-profiles xviii). Drive chains for the rakes shall be roller type chains and be made of hardened steel and shall be zinc and chrome electroplated. xix). Each chain shall have strength of 125 kN. Drive chains, chain guides, sprockets and their bearings shall be replaceable without removing the screen from the channel. xx). Chains rollers shall be made of polyamide and shall have a diameter of 70 mm and shall be a minimum of 32 mm wide. xxi). The sprockets shall be made of minimum 29 mm thick hardened steel plates and shall be Zinc galvanized and chrome plated. Rakes shall include rake bars made of 6 mm thick channel profile having a cross section of 105 x 60 mm. xxii). The rake blades shall have teeth matching and engaging the bars of the bar rack. The rake blades shall each consist of several pieces with teeth such that only one piece needs to be replaced in case that a tooth should be damaged. xxiii). A pivoting scraper mechanism shall be positioned at the point of discharge and shall be attached to the side frames. The scraper shall clean the rake on each pass and return to its rest position with minimal shock. The scraper shall be designed such that screenings do not wrap around the rake or scraper. The scraper shall be provided with a scraper bar made 4 mm thick channel profile with a minimum cross section 39 x 68 mm and an adjustable 10 mm thick wiper made of polyethylene. The scraper shall be connected with the frame through a pair of minimum 500 mm long scraper arms that shall be made of 4 mm thick channel profile with a minimum cross section 68 x 59 mm. xxiv). A pair of shock absorber elements made of neoprene shall be provided. xxv). The drive shaft shall have a diameter of minimum 80 mm and a wall thickness of minimum 5 mm. xxvi). The drive shaft includes an integral rocker arm assembly on the drive end that flexes if the screen rakes get jammed. xxvii). The rocker arm assembly shall consist of a drive unit mounted to a stainless steel arm. The stainless steel arm will be held in place by a flanged roller bearing connected to the drive shaft and two heavy duty tension springs. The flange bearing shall be connected to the rocker arm by four bolts. The rocker arm shall be maintained in the standard operating position by the two tension springs. If the screen rakes experience a jam, the force will cause the rocker arm to rotate around the drive shaft, compressing one of the tension springs. This motion shall be limited by a rocker guide. When the rocker arm rotates out of the normal operating position a proximity sensor will send a signal to the PLC causing the motor to enter a self cleaning mode. If the self clearing mode should prove unsuccessful then the system shall initiate an alarm signal. xxviii). All stainless steel parts must be completely passivated and submerged fully in Pickling Bath. xxix). Rake screen must be full flexible to make the cleaning frequency to the requirements on site. To do so, the quantity of rakes installed on the screens. The quantity of rakes can be increased to meet the necessary screenings conveying capacity. xxx). Motor can be equipped to run on frequency converters; therefore can adjust the speed of the rakes to meet the necessary screenings conveying capacity. xxxi). A pair of shock absorber elements made of neoprene shall be provided. xxxii). The drive shaft shall have a diameter of minimum 80 mm and a wall thickness of minimum 5 mm. xxxiii). The drive shaft includes an integral rocker arm assembly on the drive end that flexes if

	the screen rakes get jammed. xxiv). The rocker arm assembly shall consist of a drive unit mounted to a stainless steel arm. The stainless steel arm will be held in place by a flanged roller bearing connected to the drive shaft and two heavy duty tension springs. The flange bearing shall be connected to the rocker arm by four bolts. The rocker arm shall be maintained in the standard operating position by the two tension springs. If the screen rakes experience a jam, the force will cause the rocker arm to rotate around the drive shaft, compressing one of the tension springs. This motion shall be limited by a rocker guide. When the rocker arm rotates out of the normal operating position a proximity sensor will send a signal to the PLC causing the motor to enter a self cleaning mode. If the self clearing mode should prove unsuccessful then the system shall initiate an alarm signal. xxxv). All stainless steel parts must be completely passivated and submerged fully in Pickling Bath. xxxvi). Rake screen must be full flexible to make the cleaning frequency to the requirements on site. To do so, the quantity of rakes installed on the screens can be increased to meet the necessary screenings conveying capacity. xxvii). Motor can be equipped to run on frequency converters; therefore can adjust the speed of the rakes to meet the necessary screenings conveying capacity. xxviii). Rake screen must be using stainless steel covers as a standard. xxix). Rake screen bar rack is put together with segments. A segment has a higher stiffness instead a single bar. In case of damage, only the damaged segment has to be changed, not the whole bars rack. Rake screen should be with front rake system with no of rakes should be minimum 8 considering channel depth.
1.3.1.8	**Screen Drive**
	i). Bauer or equivalent make of TEFC motor with protection grade IP 65. ii). Explosion protection in accordance with II2GEExeIIT3
1.3.1.9	**Control & Instrumentation**
	The screen shall be pre-wired so that the tenderer is only required to make electrical connections to the control panel and from the control panel to a junction box at the screen. **Local control on Screen:** i). One proximity switch for monitoring of the rocker arm position. ii). One local control station.
1.3.1.10	**Water Level Sensors**

	Tenderer shall provide one transducer and electronics package for continuously monitoring of the upstream water levels for control of screen operation. The transducer shall be rated for hazardous locations and shall be intrinsically safe without the use of additional barriers, complete with built-in temperature compensation and submerged shield. The transmitter shall be mounted in the control panel. Tenderer shall install the transducers and provide wiring to the control panel.
1.3.1.11	**Control Panel**
	i). A single main control panel shall be furnished with a lockable corrosion- resistant stainless steel enclosure together with 8 local push button stations rated for a hazardous environment. ii). Control panel shall contain all power and control devices necessary for the proper function of the screen.
1.3.1.12	**Shop Testing**
	i). The screen shall be factory assembled and subjected to following tests at manufacture's premises. ii). Dimensional check: The overall dimension of the screen shall be confirming to the approved drawings. iii). Operational Test: The Complete screen including its carriage, rake, drive system and brake motor shall be mechanically operated and tested to verify interference free movement and satisfactory operation.
1.3.1.13	**Inspections & Tests** i). The Purchaser & its representative shall have the right to inspect and / or to test the Goods (major equipments as specified in scope of work) to confirm their conformity to the Contract. The special conditions of contract and / or the Technical Specification shall specify what inspections and tests the Purchaser requires and where they are to be conducted. ii). The Purchaser shall notify the Supplier in writing of the identifying of any representatives retained for these purposes. All the expenses related to inspection at manufacturer's works & at site viz. Lodging & boarding, transportation, all facilities including third party inspection (TPI) fees and other related commercial expanses as and where required shall be borne by the successful bidder. iii). Offered items for testing at manufacturer's premises & at site shall be done by third party inspection and owner's (client's) representative deputed by purchasers. iv). Also major equipments as specified in Scope of Work shall be tested at manufacturer's works. The inspections and tests may be conducted on the premises

	of the Supplier or its subcontractor(s), at point of delivery and / or at the Good's final destination. v). Should any inspected or tested Goods fail to conform to the Specifications, the Purchaser may reject them and the Supplier shall either replace the rejected Goods or make all alterations necessary to meet specification requirements free of cost to the Purchaser. vi). The bidder shall be responsible for communication & co-ordination between all supplier for the compatibility of the various electrical & mechanical equipments. The Purchaser's right to inspect, test and, where necessary, reject the Goods after the Good's arrival in India shall in no way be limited or waived by reason of the Goods having previously been inspected, tested and passed by the Purchaser or its representative prior to the Goods' shipment from the country of origin. Approval of Documents:- It will be in the scope and responsibility of the Contractor to get the documents(drawing and data sheet) approved by the client prior to manufacture.
1.3.1.14	**Conveyor System** For the disposal of screenings, a motor driven endless belt conveyor shall be provided. The conveyor shall be designed in accordance with IS 11592 or equivalent. The conveyor and chutes shall be suitable for handling occasional heavy objects, which may cause shock loads. The capacity of the conveyor shall be in accordance with the peak flow. The construction of the frame and support shall be robust and torque resistant. Belt conveyor shall be of maximum 20 deg.Trough type complete with drive assembly structures, idlers, pulleys and belt cleaners/Scrapers. Idlers and pulleys shall be provided with anti-friction bearings. The belt material shall be three-ply nylon or equivalent with minimum 3 mm neoprene covering on carrying side. Splicing shall be employed to make the belt endless. The belt shall operate over three roll twenty degree, troughing idlers. The idlers shall rotate on precision type, deep groove, single row ball bearing with built-in close fitting triple labyrinth grease seal. The ends of the outer shell shall be counter bored and a full length centre tube journalled concentricity. The outer shell, centre tube and precision die formed steel ends shall be brazed into an integral unit to provide concentricity. The ends of the centre tube shall be bored concentrically with each other after roll assembly to provide correct bearing alignment and to provide pre-stressing of boring. The centre tube shall be grease fit after assembly. Troughing idlers shall have means of adjustment of ensuring belt tracking. On the return run the belt shall operate over flat roll idlers having bearing, shaft and lubrication arrangements as above for carrying idlers. Spacing of idlers shall be of 1200 mm on carrying side and 2400 mm on return run. The width of the belt shall be minimum of 600 mm and speed of the belt shall be between 18-20 metre per minutes.

	The head and tail pulleys shall be manufactured from welded steel/ alloy steel and shall be provided with rubber lagging. Lagging for drive pulleys shall have herringbone grooving. Pulleys shall be equipped with taper lock bushings. Shafting for pulleys shall be of heat-treated carbon steel. They shall be forged, ground and polished to obtain close diameter tolerances. The head shaft shall be provided anti friction bearings. The belt conveyor shall be driven by a squirrel cage, TEFC motor coupled to the reduction gears. The gears shall have service factor of 2. A V-belt drive arrangement shall be provided between the motor and a helical speed reducer, the latter shall be mounted on the end of the head shaft. The driving pulley shaft shall have backstops to prevent backward movement of the belt. The conveyor shall be supported on 150 mm channel section with 14 gauge steel deck plate between the two runs of the belt and the necessary supports to the floor. The floor supports shall be made out of steel plates having minimum 6 mm thickness. The conveyor shall be protected from weather by a 'dog box' type canopy. An adjustable belt scraper shall be provided on the hopper end of the conveyor belt. The scraper and attachments shall be of fibreglass/ fibre reinforced plastic/ PVC. The conveyor shall be fitted with an emergency stop operated by wire rope at foot level. Two Nos. Belt sway switches shall be provided on conveyor. Screening discharge chutes (Galvanized MS made) shall be provided to transfer screening from the screen to the conveyor and from conveyor to Portable screening container. The discharge chute of conveyor shall extend beneath the belt scraper and shall allow access for maintenance of the belt scraper. Chute shall be design to minimize the accumulation of rags and stringy materials.
1.3.1.15	**Portable Screening container**
	Portable screenings containers made of galvanized steel shall be provided to store the screenings until time of pick up/The container shall have capacity of approximate 2.0 cu.m and shall be of a convenient height to permit the discharge of screenings directly into the container without having to transfer the screenings manually. The container shall have hinged covers and its design shall permit their being lifted by an overhead hoist or packer truck. The container shall be trolley type attachable to tractor. The sides shall be constructed of 12-gauge steel. The bottom of container shall be made of 5 mm steel plate. The containers shall be reinforced with 50 mm x 50 mm x 5mm angle.

1.3.2 Manual Coarse Screen

Screens shall have opening not more than 20mm, to prevent coarse debris from entering the inlets and protect the plant against mechanical damage. They shall be inclined at an angle of not less than 90 degrees from vertical to facilitate raking.

The design shall avoid the formation of areas of stagnation in the flow. Sealing shall be provided between the frame and the inlet channel walls.

Screens shall be designed to withstand the maximum possible pressure differential across the screen when fully blinded, without incurring any damage or overload. The working head loss across the screen at maximum flow shall not exceed 50 mm following screen cleaning. Unless otherwise specified the velocity of the flow through the screen shall not exceed 1.2 m/s.

The equipment shall be capable of operation under all duty flow variations and debris loadings, and shall be capable of withstanding the impact of large floating material and heavy objects in the flow without damage to the screen.

Screen bars shall be accurately set and secured to give the designed clearance between the bars. The bars shall extend from the sole plate, to which they shall be individually welded, to a point above maximum possible top water level, at which point they shall be individually welded to the screen top plate. Intermediate stiffening supports shall be welded to the screen bars as necessary for screens to accommodate hydraulic pressure due to depth and high flow rates through the inlet channels. The screen bars shall be individually welded to each stiffening support. Stiffening supports shall be fitted so they cannot impede raking. Sole plate shall be profiled to induce screenings and debris to be directed onto the screen bars and not to accumulate at the foot of the screen. The leading edge of the sole plate shall be level with the inlet channel invert.

The top edge of the screen shall be profiled to enable easy raking-off of screenings material.

When specified, for applications where large or heavy oversize debris may accumulate against the screen, hoisting equipment shall be provided. The screen shall then be fitted with hoist-guide pulleys, and operator access shall be provided to enable manual removal of oversize objects from the flow.

Screens shall be constructed from SS 316.

Raking shall be manual and screenings shall be transferred manually to a rakings container. The scope of supply shall include manual rakes and manually moved containers, with all accessories needed to remove the collected debris.

Rake tines shall be designed to fit the screen apertures, and tines shall be of material which cannot damage the screens. Rakings containers shall be sized so that, when fully loaded with the typical tropical organic material expected, the gross weight shall not exceed 50kg. They shall be fitted with handles to facilitate manual or mechanical handling.

1.3.3 Mechanical Fine Band (Escalator)/Perforated Plate Screen

1.3.3.1 General

i). The fine band (Escalator)/Perforated Plate screen shall consist of continuously moving perforated stainless steel panels.
ii). The machine shall be arranged to pivot out the channel.
iii). The aperture size shall be 6 mm.

1.3.3.2 Construction

i). Self-supporting stainless steel construction with attached screenings chamber for reception of the brush roller, including maintenance-free flange bearing
ii). The screening elements are perforated plate filter baskets, partly equipped with rake bars.
iii). Each end of the perforated plates is connected with a drive chain that is driven by chain wheels. Each chain is driven by a sprocket on a common shaft and a flange mounted gear motor.
iv). At their upper turning point the perforated plates are continuously cleaned by a fast counter rotating brush which increases the cleaning energy and thus significantly improves the cleaning efficiency.
v). Cleanising is supported by an integrated spray bar.
vi). The sturdy perforated plate screen is able to reliably cope with even high amounts of gravel and grit.
vii). The two-dimensional screening elements prevent especially long fibres from passing through the screen and achieve thus the maximum separation efficiency.
viii). Formation of screenings rolls is prevented by rake bars extending over the full width of the screen in combination with the screen's installation angle. Even cans and bottles are lifted by these rakes.
ix). Counter rotating brush roller for removal of screenings from the trough edge so that no additional scraper roller is required for trough edge cleaning.
x). Wear-resistant plastic elements ensure proper sealing between the travelling screening elements and the frame whilst the perforated plates are moving.
xi). The connection between the plastic and screening elements is designed to allow quick and easy replacement.
    a. Internal spray nozzle bar
    b. Wash water connection: Storz C coupling,
    c. Required washing pressure: 4-5 bar;
    d. Washing medium: service water (particle size < 200 µm)
xii). Activation via the solenoid valve of the customer's wash water supply unit.
xiii). Bushed conveyor chains each deflected by two upper and lower chain wheels and gui in lateral profiles.
xiv). Guiding tracks with required connecting profiles for reception of the jack-to-jack chains
    a. Chain wheel bearings:
    b. Regreasable upper flange bearings
    c. Wear-resistant, maintenance free lower ceramic bearings

xv). Upper chain tensioning unit, easy to access from outside
xvi). Completely odour-encased screen with easy to remove covers
xvii). The machine should be suitable to be used in zone 1 hazardous areas.

Screen Panels: Minimum 3 mm thick panels of SS 316 construction shall incorporate 6 mm diameter perforations. These panels shall be carried on the chains. The Panels shall be speci formed to give a very rigid construction and shall create steps to enable larger screenings to b removed.

Seals: Polypropylene sealing brushes shall be incorporated at each side and across the botto of the screen to prevent screenings from by-passing the screen panels.

1.3.3.3 Screenings Discharge

i). Screenings shall be discharged on the downstream side of the unit and shall be removed from the screen panels by a heavy duty rotating brush. The brush material shall be polypropylene.
ii). Screenings are delivered down an enclosed chute.
iii). Two nos. Screening collection containers (wheeled) of suitable capacity shall be supplied with the screens.

1.3.3.4 Enclosure

The entire assembly shall be enclosed in reinforced fibre glass housing. A hinged front cover shall be provided to give access to the rotating brush assembly and screen discharge area. A Sliding inspection hatch shall also be incorporated.

1.3.3.5 Drive Unit

i). The drive to the main shaft shall be TEFC weatherproof IP 55 motor fitted with an anti-condensation heater and shall be suitable for operation on 415 V + 10% and frequency of 50 Hz + 5%. The motor shall be flanged to a shaft mounted gear unit giving the final output speed. This shall produce a linear speed for screen panels of about 3 m/min.
ii). The drive shall be protected from mechanical overload by an electrical current sensing device in the screen control panel.
iii). Differential pressure switches shall be provided to annunciate screen jamming.

iv). Suitable conveyor arrangement shall be provided to transfer the screening to the nearest container/trailer.

v). A spry system shall be provided to backwash the screen panels and to help in cleaning the screenings. Water/treated sewage shall be used for the back wash purpose.

1.3.3.6 Control Panel

The control panel shall have IP 55 protection, painted with Epoxy paint and shall be comprising of

i). Mushroom Headed Emergency stop
ii). Overload relays for motor protection
iii). MCB's, HRC fuses and Glass Fuses
iv). Circuitry to operate the screen with level sensor
v). Selector Switch to operate the screen on JOG mode.

1.3.4 Automatic Drum Screen

i). General

The automatic drum screen shall be composed of screen, screw conveyor, washing unit, dewatering unit and drive unit, etc. The automatic drum screen shall have 6 mm opening and shall be used to block, scrape, wash, and dewater the suspended solid or scum in the influent or sludge.

ii). Design Condition

a) This equipment shall be designed with sufficient safety factor in strength.
b) This equipment shall be of integrated type and shall be constructed such that it can be installed easily.
c) The difference of water level, the characteristics of suspended solid, and flow rate shall be considered in design.

iii). Fabrication

a) Drive unit

- Cycloidal reduction gear or worm reduction gear shall be used as drive unit. Drive unit shall transmit the power by means of gear transmission or direct connection with coupling.

- Gear box shall be provided in case of gear transmission.

b) Screen

- The screen shall be made of cylindrical stainless steel. The screen shall have a

smooth finish in order to prevent the attachment of screenings and shall be arranged with equal spacing.

- An electrical pole shall be installed in front of the screen in order to detect the overflow and control operation.

c) Rake

- The rake shall be connected with the screw conveyor along the same axis and shall rotate with it. The raked screenings shall be scraped down into the screw conveyor by the scraper.

- The rake shall be constructed such that the screenings never remain on the screen after raking.

d) Screw conveyor

- The impeller and shaft of the screw shall be a welded structure of stainless steel and shall endure the incurred stress.

- A dewatering device shall be provided at the upper portion of the screw conveyor. The dewatering device shall be sealed and shall have sufficient strength to endure the pressure of screenings and scum. The inspection hole and washing water pipe shall be provided for the dewatering device. The inspection hole shall permit easy inspection and the washing water pipe shall be used to wash the casing for filtrated liquid.

e) Shaft and bearing

- The shaft of screw shall be made of stainless steel and shall have sufficient strength to endure the incurred stress.

- The submerged bearing shall be an oil-less enclosed pneumatic type. For a bearing installed above the water level, an automatic oiling device shall be provided.

f) Washing unit

Washing nozzles shall be provided at the inlet of the screw conveyor in order to wash down the screening or scum with pressurized water.

g) Chute

A stainless steel chute shall be provided at the discharge part of the screw conveyor. The chute shall be constructed such that the screenings are blocked from being discharged.

iv). Materials for automatic drum screen

(a) Screen : Stainless Steel AISI316

(b) Rake : Stainless Steel AISI316

(c) Screw conveyor : Stainless Steel AISI316

(d) Chute : Stainless Steel AISI316

v). Protection Equipment

a) Mechanical protection

For cyclodial reduction gear, a built-in torque limiter shall be provided.

b) Electrical protection

An over-current detector with instantaneous converter shall be provided in case the mechanical protection is not provided.

vi). Accessories (per Unit)

Anchor bolts and nuts - 1 set

1.3.5 Manual Fine screen

The manual bar screen will be of opening not more than 10 mm. Hand rake shall be providing with manual screen for cleaning of screen. The screen shall be rectangular in shape. The screen shall be fabricated out of stainless steel SS 316 of not less than 6 mm thick and 50 mm wide in section. The screen shall be rigidly fixed to the frame and provided with 2 sets of cleaning rakes.

1.3.6 Grit Removing Equipment

For STP initially the sewage shall be subjected to pre-treatment which includes removal of floating material through screen and grits with the help of grit removal mechanism. From the inlet chamber, the sewage will overflow to screen chambers, each screen channel comprising of mechanical fine perforated plate screen suitable for design peak flow shall be provided. Perforated plate screens shall be provided for removal of floating materials, etc. Shall be provided in each screen channel. After screening, the sewage shall overflow to grit chambers for removal and washing of grits from the sewage. Each grit chamber shall have grit separating system and grit washing system. The grit will be collected and transferred to the collector via screw conveyor

Grit chamber

The flow from the screen channel shall be allowed into the grit chamber for the removal of grit/inorganic matter by means of RCC tank designed as per relevant is code of practice.

There shall be 2 no. Mechanical vortex type grit chamber. Grit chambers shall be designed for peak + other flow.

Mechanical grit chamber shall be capable of removing grit of particle size of 100 micron and

above and sp. Gravity of 2.65.

The surface loading rate, settling velocity and other design parameters shall be as stated earlier. The grit chamber shall be of RCC M30 grade construction with suitable RCC foundation with necessary water tightness test.

The inside surface of the grit chamber shall be provided with 20 mm thick water proof plaster in cement mortar 1:3. The bottom of the chamber shall be provided with 40 mm thick ips screeding. The outside surface shall be provided with 20 mm thick double coat sand faced plaster in cement mortar 1:3 with exterior emulsion as per civil specification.

Chamber should be curved the vortex in shape.the mechanical grit chamber shall be of curved vortex type so the screened wastewater enters at the bottom of the grit chamber will rotate tangentially.

The grit chamber shall be equipped with constantly rotating stirrer which helps the wastewater circulation within the grit chamber ensuring a constant velocity of rotation within the complete grit trap system even under dry weather conditions.

Due to the constant radial rotation the solids are very quickly collected within the centre of the grit chamber from where they then pass into the bottom of the grit collection tank.

The grit-free wastewater then exits and flows onto the next treatment step.

Centrifugal or airlift pumps can then deliver the collected solids from the grit collection tank into a grit classifier or grit washer where the solids can then be subsequently separated and dewatered and organic particles removed.

Mechanism

Turning drive shaft, driven by the bull gear, material 1.4307 (316) or better.

4 pcs. Stainless steel paddles with hard cast iron welding, fixed on the drive shaft. The paddles should be adjustable in all directions, interlocked with counter screws.

Central tubing prearranged for air lift pump with funnel in the grit discharge area.

The central shaft is ending with a flange. Removable floor plate over grit storage chamber with minimum opening 75 mm to storage chamber, design plate assembly in two sections with lifting lugs, plate thickness minimum 10 mm.

Totally enclosed squirrel cage motor with at least ip55 protection in accordance to vdi/iso standards.

Gear reducer to include anti-friction bearings with high overhung load properties, and double lip oil seals. Drive unit and motor bearings have a minimum bearing life of 100.000 hours.

Turnable bearings supporting the paddles assembly have a minimum bearing life of 20 years. Grit from grit washing unit should be guided with the help of screw conveyor to the

grit collector.

DEGRITING TANK MECHANISM, CLASSIFIER AND WASHING OF GRIT

Removing different type of grit, clay, sand, metal etc. From tank mechanism, classifier and washing of grit etc.

It shall incorporate following.

i). Removing different type of grit, clay, sand, metal etc. From tank mechanism:
ii). The different type of grit, clay, sand, metal etc. Settled in a tank shall be scrapped a collection point by a scrapper mechanism.
iii). It shall be designed for continuous operation. The mechanism will be coupled to a suitable motor-gear- box assembly.
iv). The collected grit shall be elevated to the top of tank by the help of a classifier. While the grit is being elevated from the tank bottom, suitable arrangement for grit washing by plain tap water shall be made.
v). All moving parts shall be abrasion resistant.

GRIT WASHER

The grit mechanism will be suitable for installation in a round tank and will comprise of the following:

Grit collection mechanism.

Organic return pump.

Classifier cum washing mechanism.

The grit contained in waste water is usually removed in grit traps by gravity or centrifuge force to protect downstream equipment.

FUNCTION

No additional screening must take place upstream of the grit washer. The plant must be able to handle mineral grain sizes up to 30 mm.

The grit/water mix must centrally flow into the grit washer.

Grit classification and washing must take place in one tank, i.e. preceding longitudinal grit traps are not permitted.

i). Surface overflow rate (incl. Wash water) must be < 25 m/h.
ii). The grit washer must be equipped with an circumferential overfall weir on the outside.
iii). Overflow weir load must be < 15 m²/h.
iv). The combined addition of water and air or fixed bed plants are not permitted.
v). The grit washer must have a separate organics discharge ≥ Dn 100.
vi). The grit washer must have a clogging-free perforated membrane sandwich-plate at

the lowest point of the wash cylinder for best water distribution in order to achieve best wash results.

vii). Grit level measurement must be carried out by means of a hydrostatic pressure probe.

viii). The grit washer must remain in full function (wash and discharge grit) even during feeding from the grit trap.

ix). The grit removal screw must be a stainless steel screw supported on both ends.

x). Shaftless spirals or screws made of “special steel” are not permitted.

xi). The grit removal screw trough must not have guide bars or plastic shells.

xii). The grit washer must be acid treated in a pickling bath and passivated

xiii). The complete grit washer must be made of at least 1.4307 stainless steel material.

xiv). The stirrer must be made of at least 1.4307 full stainless steel material ≥ 30.

Grit washer

i). The grit washing machine should achieve high grit separation efficiency through optimum utilization of the tank volume due to the defined and calculable flow path based on the coanda effect in the inlet combined with the preceding vortex chamber.

ii). After solids separation the organic particles are washed out in the bottom part of the tank by means of a grit fluidized bed.

iii). The wash water is added across the entire wash zone cross section. To achieve constant washing results, the system should work with an uniform, constant upflow velocity in the wash zone.

iv). Washout is supported by a slowly running stirrer. As a result, the lighter organic particles are separated from the dense mineral particles.

v). Organic material should be additionally removed via a separate automatically actuated organics discharge located above the grit fluidized bed.

vi). The washed grit should be removed and at the same time dewatered by a sturdy grit transport screw supported on both ends in a trough. There should be special arrangement of the screw flights for plug-free operation. The screw should be impulse-pause operated in dependence of the fed amount of grit, which is measured by a pressure probe.

vii). Organic loss should be less than 3%

1.3.6.1 Classifier Mechanism

The classifier mechanism shall comprise of a screw driven by a suitable motor. The material of construction of the mechanism shall be SS 316 and the diameter shall be minimum 400 mm. The length of screw shall be such that the grit can be elevated up to the discharge end. SS puddle pipe shall be provided in the concrete trough at the discharge point of wet grit.

Classifier Mechanism: The mechanism shall consist of the following:

i). Chain and sprocket with guard.

ii). Reciprocating rake with hangers of screw mechanism.

iii). A.C. Motor.

iv). Local push button shall be provided.

1.3.6.2 Organic return Pump

Vertical Propeller pump with suitable motor, starter, etc. Shall be provided. The design of the pump and the piping on the inlet and outlet side has to be such that there are minimum numbers of bends as they are liable to be choked with organic matter.

One set of push button shall be provided near the pump set and one starter in the terminal sewage pumping station. The suspended organic matter washed in the de-gritting system will be returned to the distribution chamber. Impeller shall be of SS CF8M and shaft shall be of SS 316.

In the event of tripping of working grit removing equipment (motor), the sizing of this equipment (including motor) shall be done in such a way that it shall take the overhead to remove the excess grit collected after starting of the tripped grit removal equipment.

1.3.7 Primary & Secondary Clarifiers

Circular (radial), fixed bridge with scum collector, central turns table type or peripheral drive type, collecting effectively with proper circumferential speed, clarifiers shall be provided. The clarifier shall be rugged and robust in design and shall be provided with high capacity drive head and induction motor having high torque rating, centrally or peripherally located, with positive sludge raking by means of one or more raking arms. Both the raking arms should have scraper blades fitted at the bottom, so that the sludge from scraper blades is pushed to the sump on every rotation.

(a) The drive head mechanism arrangements shall consist of a turn table base casing mounted on top of the centre pier and shall have an angular ball bearing mounted internal gear that supports the underwater mechanism. The pinion meshing with the internal gear should be driven through a worm gear reduction unit mounted on top of the turn table drive unit. The balls should ride on hardened steel strips set into grooves in the base and gear casing so that they can be readily replaced whenever required.

(b) The unit will have mechanical overload arrangement with a torque indicating arrangement along with necessary contacts for tripping the motor in the event of overloading. This condition shall be enunciated. The unit shall have push button station near the motor and starter with push button shall be provided in the control room, i.e. the return activated sludge pump house along with necessary switches. The clarifier unit should also be provided with necessary M.S. scum trough, scum baffles, skimmer assembly, M.S. rake blades, arms and brass squeezes. The V-notch weirs shall be 6mm thick of reinforced fiber glass with clamps etc. For making the necessary adjustments.

(c) The bridge connecting the periphery of the tank to centre pier shall have walkway covered with chequered plates and provided with hand railing on both sides.

(d) Corrosion allowance of 2mm shall be taken in the structural sections of scraper arm, bridge etc.

Structural design calculations shall be submitted for all structures including scraper arm, bridge etc.

1.3.8 Decanter Assembly

(a) Decanter Assembly

Mechanical floating decanter and related equipment accessories as described herein for each basin. Each decanter shall consist of an integral flotation unit, a stainless steel movable weir assembly, and an electric motor-driven actuator to open and close the weir.

(b) Performance

Each decanter shall be capable of withdrawing decant fluid beneath the liquid surface, regardless of liquid depth, down to the minimum allowable water level. The decant liquid shall be drawn through an adjustable weir. The weir shall be circular in shape and permit liquid to enter the decanter from the entire 360 degrees without obstruction or equivalent.

(c) Weir Actuator

Weir actuator shall include a reversible electric motor operated linear actuator. The actuator shall be capable of operating with a closing force and shall operate from a 415 volt, single phase, 50 hertz source. Adjustable limit switches shall be included to permit adjustment of the weir opening. A spring shall be included to provide for travel after the weir has closed and provide desired closure pressure. A corrosion resistant removable cover shall be included to provide protection to the actuator and motor during normal operation. The power section is painted steel. Power cable shall be provided from the NEMA 4X junction box of the unit to the basin wall. Supply of junction box/disconnect at the basin wall shall be the responsibility of the installing contractor.

(d) Weir

The weir shall be constructed of 316 stainless steel, be circular or rectangular in shape, and shall include vortex control baffles permanently affixed to the weir. The weir shall be attached to the actuator through a removable single shaft or linkage which shall also function as the torque restraint.

(e) Floatation

Each unit shall be equipped with a modular float constructed of fiber reinforced polyester filled with closed cell polyurethane foam having a minimum 2.0 lbs./ft3 density. Float shall be completely sealed to prevent the foam from being in contact with the external environment. Float shall have appropriate eight reserve buoyancy to ensure stability and to provide support flotation required during decanter servicing. A urethane type or equivalent seal shall be molded into the bottom of the float assembly to receive the decanter weir.

(f) Decanter Discharge Pipe

Each decanter shall include a 316 stainless steel elbow flange and 316 stainless steel flanged flexible joints and others. The installing contractor shall provide a valve with hose bib connection on the decant line between the decanter and the decant valve.

All piping, supports, gaskets, and hardware beyond the terminating flange of the decant pipe

flexible joint shall be supplied by the installing contractor.

(g) Decanter Restrained Mooring System

Each decanter shall include a stainless steel mooring frame attached to the float. Stainless steel mooring post assembly with base plate shall be provided to assure consistent location of the decanter in the basin. Mooring post shall be filled with concrete by the installing contractor.

Stainless steel dewatering support posts consisting of vertical pylons with base plates and pipe dewatering support post with pipe saddle and base plate shall be provided. Each support with base plate shall be affixed to the basin floor with 316 stainless steel adhesive anchors. Top and bottom mooring post supports constructed of stainless steel shall be provided for attachment to the basin wall by the installing contractor.

(a) Decant Flow Control Valve

Furnish one electrically operated butterfly valve for each basin to control the decant rate.

Valves shall be electrically operated butterfly valves with ANSI Class 125# flanged end ASTM A-536 ductile iron body, ductile iron disk with a 316 stainless steel edge, fully lined EPDM seat vulcanized in the body, 316 stainless steel shaft assembled and tested with 415 volt, three phase, 50 cycle open/close service electric actuator. Valve actuator shall include a compartment heater. Each valve shall include a manual override with limit switch feedback to the microprocessor in both the open and closed positions. Field wiring and junction/box disconnect shall be provided by the installing contractor.

The bidders are encouraged to propose alternative type and design of Decanters with proven technology and successful operation for last 5 years and minimum 15 number of installations.

1.3.9 Diffused Air Aeration system

This section of the specification sets out the minimum requirements of the design and selection of diffused air aeration system equipment.

i). The pipe works, instrumentation and the diffusers shall be correctly sized to deliver the required quantity of air at the available pressure to meet all operating conditions. The pipe work to the tank shall be sized for 125% of the required oxygen transfer capacity to cater for the higher loadings.

The aeration header shall be design for removal/replacement from/to the reactor without taking the reactor off-line or dewatering the reactor. The operator shall be required to demonstrate removal and replacement of the headers with the reactor on-line.

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The Blowers shall be provided for providing adequate oxygen into the reactor tank for aeration. The blowers shall be capable of developing the required total pressure at the process unit rated capacity for continuous operation. The blowers shall be Twin Lobe type preferably.

1.3.9.1 Air Blowers

Compressor blowers shall be of the Centrifugal Type Turbo Blower, each provided with inlet filter and silencer, automatic load-unload valves, pressure gauges, pressure relief valve, drain, air flow indicator and acoustic bend of silencer in the delivery branch. Bearings and gear boxes shall be separated from the blower housing by air spaces. The units shall be complete with a self contained oil cooling system for the bearings. The blowers shall be housed in a separate sound proof room to reduce the noise level or inside acoustic enclosure. The noise level shall not exceed 85 dBA at 1.86 m from blower. The Air Blower Arrangement shall be capable of handling Total Water Level and Bottom Water Level operation conditions controlled by process sensors such as DO, Temperature and Level.

- Each set of Air Blowers shall have dedicated standby. Each blower shall operate through Variable Frequency Drive.
- Air Blowers shall be Single Stage, Direct Drive, CE/UL certified, Centrifugal type Turbo Blower consisting of Air Bearings, Impeller, high-speed Motor, Inverter, Controller and Cooling System. It shall be capable of operating within a range of 20,000 – 30,000 RPM with normal operating speed being 25,000 RPM. It shall be able to operate under varying Pressure and Flow conditions as per process requirement. Minimum turndown ratio should be 50%. The maximum idle time between OFF and ON shall not exceed 30 seconds.
- Blower capacity shall be calculated to maintain DO levels for biological treatment basins with detention time of 24 hours at average flow.

- It shall be composed of Casing, Suction Filter, Reducer, Acoustic Hood, Blow-Off Valve, Inverter, Electrical Panel and Controller etc. Noise level should be less than 85 dBA at 1.00 m from Blower whereas Vibration level should be less than 1 mm/sec.
- Casing shall be of high-quality Aluminium Alloy and able to resist thermal expansion, vibration and air leakage.
- Air Bearings shall be non-contact type, bump type foil air bearings with oil free lubrication, low noise and no vibration. The wearing surfaces shall be made of Inconel. Air Bearings should be able to withstand minimum of 20,000 On/Off in its life time.
- Impeller shall be of high strength Aluminium Alloy (A7075). It shall have high compression efficiency, high surge stability and wide flow range. It shall be capable to keep dynamic balance in high speed revolution and shall be suitable for transmission of power and safety factor at critical speed. It shall be directly connected with the motor shaft without any coupling. The inlet to the Impeller Compartment shall be open without any restrictions like fins etc.
- Inverter shall be high-speed Inverter equipped with Electrical Filter, AC Reactor and LC Filter.
- Motor shall be high-speed Permanent Magnet Synchronous Motor (PMSM). The Shaft of the Motor shall be of Titanium and shall be directly connected to the Impeller.
- Control panel for blower shall be placed in air conditioned room.
- Motor, being high-speed, shall be provided with the best suited Cooling System to ensure consistent motor output and longevity. Motors up to 150 HP shall have Air Cooling and above 150 HP shall have Integrated Water Cooling. In Air Cooled System, cooling shall be achieved by connecting a fan to the motor shaft to push air through the cooling fan and into the motor and by discharging the heated air out of the Blower Enclosure through the Impeller or Blow-Off Air Discharge Hole. In Water Cooled System, cooling shall be achieved by suction air through the Radiator.
- Blow-Off Valve shall be located within the Blower Enclosure and shall be equipped with a Silencer.
- Controller shall have 16-bit color touch screen with convenient user interface to support various operation modes such as Auto Flow Mode, Auto power mode, Auto RPM Mode, Auto Pressure Mode, Proportional Mode, DO-Link Mode and

Failure, Check and Reset Option. Following measurements and operating data are shown on the Controller Screen:

(a) Operating state of the turbo blower
- Run
- Stop
- Error

(b) Measurement and display data
- Suction Filter Differential Pressure
- Suction Temperature
- Discharge Temperature
- Discharge Pressure
- Suction Flow Rate
- Revolution
- Power

(c) Warning and Error message
- Filter differential Pressure Over
- Motor overheating
- Inverter Error

- Material of construction of various parts of Blowers shall be as follows:

Bearing	:	Nickel alloy or stainless steel
Casing	:	Aluminium Alloy
Impeller	:	Aluminium Alloy (A7075)
Shaft	:	Titanium Alloy

- Head for blowers shall be decided on the basis of S.O.R. of diffusers and maximum liquid depth in Basin duly considering the losses governing point of delivery (diffusers) and the blowers
- The operation of Aeration System shall include PLC based control. The operation and speed of Air Blowers shall be automatically adjusted using parameters like Oxygen Uptake Rate, Dissolved Oxygen and Temperature and Liquid Level in the Basin such that the DO is supplied as per demand and power utilisation for operation of Air Blowers is optimised.
- The main Air Header/Ring Main shall be in MS as per relevant IS Code, painted with corrosion resistant paint as per Manufacture's recommendations. The Air Header/Ring Main shall be supported on saddles at suitable intervals or shall be protected against external corrosion in case laid below ground. The Sub-header

shall have Auto Valves to facilitate switch over of Aeration Cycle from one Basin to other by PLC. The Sub-header shall supply air to fixed type Diffuser Grid through vertical Air Supply Pipes. These Air Supply Pipes above water level shall be in MS, painted with corrosion resistant paint and below water shall be in SS 304. All under water Lateral Pipes shall be of UPVC. Junctions between horizontal Sub-header and vertical Air Supply Pipes shall be suitably protected against corrosion due to dissimilar materials.

- The Air Blower House shall have Rolling Shutter, Windows, Exhaust Fans, Safety Equipment with sufficient Ventilation, Lighting and Working Space. It shall be equipped with Forklift of suitable capacity to facilitate lifting / removal / transportation of Air Blower for repair and maintenance, if required.
- All other accessories, whether specified or not, but required for completeness shall form part of Contractors scope.

i). The Bearing shall be generously designed to give long operational life. Bearing at the drive end may be oil or grease lubricated. The gears and bearings at the non-drive end shall be oil lubricated. Bearings shall be provided with oil throwers to prevent leakage of oil. The delivery velocity not exceeding 25 m/s and each blower shall be provided with following components but not limited to:

a. Common base frame for blower & Motor
b. Inlet silencer and filter
c. Discharge silencer & non-return valve in delivery branch
d. Butterfly valve in delivery branches
e. Pressure relief valve or excess pressure safety device
f. Bellows type couplings on inlet and delivery branches
g. Acoustic Enclosure
h. Motor-Blower Direct Coupling
i. Isolating valves, Automatic load-unload valve

ii). The interconnecting pipe work shall be flanged to BS EN 1092-1. A drain cock shall be provided at the lowest point in the each delivery pipe work along with reflux valve. Individual stop valves and safety valves shall be provided for each unit.

iii). Blower shall be driven by squirrel cage motor through a direct coupling. Blowers shall not run above 750 rpm.

iv). Each delivery branch shall include a drain at the lowest part and a reflux valve.

v). The blower equipment specified herein is standard equipment for blowers handling ambient air for use in aeration tank diffusers.

1.3.9.1.1 General Design Requirements

i). The air blowers shall be such design as to achieve energy efficient operation continuously over the range of design airflow rates at the discharge pressure that shall remain practically constant.
ii). Each blower shall be fitted with a variable speed motor and be capable of operating between 80 % and 110% of its nominal peak airflow demand.
iii). The discharge pressure shall be calculated by the operator dependent on the final design layout of the aeration system and of the delivery manifold.
iv). The blower shall be capable of supplying the design “mass flow” rate at maximum ambient inlet temperature of 50 deg C.
v). Each of the blowers shall be capable of operating without surge in parallel with the other duty blower at the maximum mass flow against design maximum gauge pressure at the outlet pipe. The operator shall demonstrate this during testing and commissioning.
vi). Performance curves for the blower system shall be submitted. Standard certified factory test sheets showing the results of each test shall be supplied to the Engineer prior to Delivery of the blowers. The blower unit shall be capable to operate at maximum duty for continuous operation.

1.3.9.1.2 Blower General Arrangement

The blower arrangement shall have the following features:

i). The blowers shall be roots type units
ii). Each blower shall be fitted with an acoustic enclosure
iii). The arrangement shall be such that all blowers are accessible for operation and maintenance and the installation of additional blowers in the future is possible.
iv). The inlet air to the blower house shall be filtered to suit the blowers and aeration diffusers selected.

1.3.9.1.3 Ancillary Equipment for Blowers

The blowers shall be provided with the usual ancillary equipment for aeration duty, including:

i). Acoustic enclosure with fan cooling
ii). Discharge pressure switch
iii). Discharge pressure relief valve
iv). Discharge automatic loading-unloading valve
v). Discharge check valve
vi). Discharge isolation valve
vii). Discharge silencer, designed to minimise noise propagation along the pile work
viii). Vacuum switch, pressure switch, oil level indicator and any other monitoring devise shall be mounted outside the acoustic enclosure
ix). Inlet and outlet pressure gauge shall be mounted outside the acoustic enclosure
x). Vibration absorbing mounting pads

1.3.9.1.4 Blower Noise Limits

The blowers supplied under this contract shall be quiet in operation. The operator shall guarantee that the total sound power noise emission for the aeration system shall be broad band and free from any total or intermittent components. Under any loading condition from no load to full rated, the blower supplied shall comply with the noise requirements.

1.3.9.1.5 Materials of Constructions & Tests

The material of construction for the blowers shall be at least equal in quality to the following:

Casing	CI Conforming to IS : 210 Gr FG 260
Rotor	Alloy Steel
Shaft	Carbon Steel C40/EN 24/19
Timing gear	Cast Alloy steel
Pulley and gear side Plates and covers	CI conforming to IS 210 Gr FG 260
Impeller	As per Manufacturer’s std.
Base Plate	Steel, Galvanized
Nuts and Bolts	SS

Following testing shall be carried out

Sr. No.	Test	Specification
1	Hydrostatic Test	Twice the maximum working pressure
2	Performance test	As per BS: 1571
3	Strip test	Clearances with tolerance limit
4	Mechanical Balancing	ISO 1940 Gr. 6.3 or better
5	Visual Inspection	Before Painting

1.3.9.1.6 Filters and Silencers

i). The filters shall be used to remove dust, etc. Contained in the suction air. For this purpose, a filter shall be mounted directly on the suction silencer of each blower. The filter element shall be non-textile cloth or equivalent, and the element passage speed shall be 2 m/s max. The operator shall be indicate the useful life period for the diffuser.

ii). The blower shall receive filtered air individual replaceable filter elements suitable for the intended duty.

iii). The filter element shall be housed in an airtight housing which shall allow easy replacement of the filter elements. Replacement of elements shall be possible without use of tools.

iv). If the filters/silencer element supplied are located out of doors, a weatherproof cover shall be provided for protection from rain.

v). The filter unit shall be fitted with suitable vacuum gauges to indicate the suction pressure into each blower. The gauge shall be industrial Bourdon of Schaffer type gauge with a nominal diameter of 150 mm. The scale shall be suitably selected and shall include a red line to indicate the point at which the filter elements require renewal.

vi). Each blower intake shall be fitted with a differential pressure switch, which shall indicate an alarm signal in the event of excessive pressure drop in the blower intake.

1.3.9.1.7 Flexible Connections

i). The blower discharge shall be fitted with an approved flexible sleeve with fixing clamps and a flanged outlet spigot for connection to site pipe work. If the blower inlet is via a common plenum the inlet pipe shall be also fitted with a flexible connection.
ii). Flanges shall be drilled to Table D and shall comply with the required standard. Sleeves shall be manufactures from an approved non-metallic material suitable for the duty and location in which the blower are to be installed.

1.3.9.1.8 Pressure Relief Valve

i). The pressure relief valve shall be sized and adjusted to allow the full flow of the blower to be discharged in the event of a blockage of valve closure in the downstream pipeline and without overloading the drive motor.
ii). Each blower shall be fitted with a suitable pressure switch, which shall shut down the blower in the event of excessive discharge pressure. The pressure setting shall be lower than the set pressure of the pressure relief valves.
iii). The pressure relief valve shall be installed at a height above 2m from floor and away from blower suction point. The pressure relief valve shall be fitted with a silencer.

1.3.9.1.9 Non-Return Valves

A non-return valve shall be installed on the discharge pipe work of each blower, upstream of the blower isolation valve.

1.3.9.1.10 Isolation Valves

Isolating valves shall be installed on the delivery pipe work of the blowers: such that each blower and all associated pipe work and valves upstream of the common distribution manifold can be dismantled without disruption to the normal operation of the plant.

1.3.9.1.11 Temperature Measurement

Temperature sensor complete with gauge of an approved type shall be supplied for each main distribution pipe work and for the blower room.

1.3.9.1.12 Piping Vibration

If the blower type selected produces a discharge flow with a pulsating characteristic, flow pulsation dampers shall be installed on the blower intake and discharge, as required, to eliminate excessive noise or vibration from this source.

1.3.9.1.13 Air Compressors

However, if a compressor system is required for some reason, it shall comprise compressors, after-coolers and air dryers, duty/standby air receivers together with control equipments, oil eliminating filters, flow regulators and oil mist lubricator as required.

Electrically driven air compressor sets shall operate up to minimum 10 bar working pressure.

Compressor sets with at least 1 standby shall be provided complete with the following:

i). Common base frame for compressor & Motor
ii). Single stage air cooler unit
iii). Isolating valves
iv). Air filter and silencer
v). Pressure relief valve of excess pressure safety device
vi). Pressure reducing valves
vii). Pressure gauges
viii). Off loading Piston
ix). Automatic changeover (failure of duty unit)
x). Drain pipes
xi). V-Belt drive arrangement with belt Guard
xii). Stoppers
xiii). Air receivers
xiv). Other necessary appurtenances

Compressors shall be arranged for automatic changeover on failure of the duty unit. Failure of the duty unit shall initiate an alarm. Control equipment shall include automatic unloading valves, pressure switches for duty standby and alarm, and lockable changeover switches.

One duty & One standby after cooler shall be provided. Water cooler of air blast types will be considered. Air receivers shall be design and fabricated in accordance with relevant approved standards. They shall be mounted vertically on steel feet so that sufficient space is allowed for each access to the whole outside surface. Receivers shall be provided with drain cocks piped to drain pressure gauges, relief & check valves.

Supply of all necessary electrical components, devices, equipment, control panels, etc. Together with cabling, earthing provisions, etc. Shall be the responsibility of the operator.

Interconnecting pipe work shall be arranged with drain cocks piped to waste.

1.3.9.2 Aeration Diffusers

i). Air diffuser system consist of tube type porous membrane of Acid resistant Silicon/EPDM/PU based rubber with diameter ranging from 65 mm to 121 mm size, single piece injection moulded PP support tube, SS clams.

ii). Entire diffuser has to be manufactured, assembled, tested in factory premises & no site work is permitted.

iii). Flat surface facing upwards as membrane shall not be accepted.

iv). The aeration tank is used to remove oxygen consuming organic matter from the effluent by biological treatment. Diffused aeration is used for air supply. The bubbles produced from the diffuser are of extremely small size between 0.5-0.8 mm, thus the total surface area that interacts is large and the contact time of bubble is large due to slow rise of bubbles. The system is thus extremely power efficient in terms of oxygen transfer efficiency. The flow of fine bubble of 0.8 mm in size provides a gentle mixing, which prevents flock shear.

v). Fine Bubble diffuser consists of a porous membrane made of acid resistant silicon based rubber. Each diffuser is fully supported over the length and circumference on the single piece injection molded polypropylene (PP) tube with a RIDGE on the top to hold the membrane in position against the velocity generated in the wastewater.

vi). No drilled holes on the supports tubes are permitted and only channel type of arrangement for entry of air into membrane is desired. Air opening on the membrane should be 0.8-1 mm with staggered perforation.

vii). The diffuser will be retained in place by two clamps. It is fitted to the pipe lateral by CLIPIN arrangement. The Laterals are connected to a pipe header. The wetted parts of the system shall be made of Non-corrosive material specifically SS 316. During power shutdown at the STP the membrane will contract and lose around the PP support pipe and means shall be provided to prevent any back flow.

viii). Each diffuser shall consist of the following: outer diameter (OD) ≥ 65 mm to ≤ 90 mm PP injection moulded support pipe.

a. Porous membrane made of silicon based rubber lateral.
b. RCC support block with SS 316 clamping.
c. Flexible hose pipe (Drop pipe for each diffuser assembly)
d. PP ropes for lifting and guide position.
e. Hose clamp
f. pipe connector
g. GI barrel nipple with connector for connection with pipe

ix). Complete diffuser shall be assembled at original factory level and site fabrication of diffuser is not acceptable.

x). All hardware accessories including clamps, fasteners, fan-hooks, eye bolts, should be of SS 316 material only.

1.3.9.3 Air supply Pipe Work

General design Criteria

Many factors need to be incorporated in the design of the air distribution pipe work to minimize the potential of noise problems occurring. Factors to be considered in the design of the air pipe work to be minimize noise level shall includes:

i). The diameter of the pipe work, to keep velocity low.
ii). The connection of the blower discharge pipes to the manifold should be “wye”, not at right angles.
iii). No blind flange at the end of the manifold.
iv). The manifold shall be design to ensure air travels in one direction.
v). The air pipe work shall be designed to minimize changes of direction and use large radius bends.
vi). Flexible connections shall be provided between the diffuser assembly nits and the main air supply pipe work to allow for any differential movements.
vii). Expansion and contraction shall be fully allowed for in the design and installation of the air distribution pipe work.
viii). Rain taps shall be provided on the air pipe work to allow draining of moisture.
ix). The pipe work and the support brackets shall be galvanized steel.
x). Pipe work shall have inbuilt flexibility such as packer flanges for reasonable construction tolerances on the structures to which it is attached.

Pipe shall be designed to ensure the efficient operation of the aeration system and compliance with the noise limitations. All valves in the air delivery system shall be correctly selected for the duty. Calculations of Cv (Head loss co-efficient) values for the range of flows and pressure losses across each valve should be prepared to ensure that each valve has adequate range of controllability for the duty.

However the air piping submerged in sewage has to be in SS316 confirming to IS specification. Two spare drop pipes with diffuser elements shall be supplied by the Operator one for each compartment. This will be used to replace the choked diffusers drop pipe or on preventive basis on rotation. The choked one will be attended to and used as spare drop pipe.

1.3.9.3.1 Air supply Headers

The air supply headers run from the main air distribution pipe work to the down comers. Pipe work shall have inbuilt flexibility such as packer flanges for future modifications and to allow for reasonable construction tolerances on the structures to which it is attached. An isolation valve for each main air supply pipe shall be installed at the point of connection to the main distribution pipe work. The design of the main air supply header shall incorporate all components necessary to enable the easy connection of the main distribution pipe work to the main air supply header.

1.3.9.3.2 Blower Discharge Pipe Work

The Discharge pipe work from each blower shall be connected to a common manifold. Flexible connections shall be provided between the blower assembly units and the discharge pipe work to allow for any differential movements. The design of the manifold pipe work shall incorporate all components necessary to enable the easy connection to the main distribution pipe work.

1.3.9.3.3 Air Flow Measurement

The amount of air being supplied to each air supply header shall be measured by the installation of flow measuring devices. The flow measuring devices shall be suitable for the intended application. The sensor assembly shall be supplied with suitable fittings which shall enable easy removal during maintenance. The accuracy of the flow meter shall be within 5% of the minimum design flow rate. The installation shall provide adequate length of straight pipe upstream and downstream of the flow meter to ensure the accuracy of the meter is attained.

Pressure and temperature sensors, shall be provided to measure the pressure and temperature of the air in the pipe, upstream of the flow measurement device.

Pressure and temperature compensation measurements shall be provided for volumetric correction if the control air is based on airflow rate.

1.3.9.3.4 Pressure Gauges

Pressure gauges of an approved type shall be installed on each main distribution pipe work and main header.

1.3.9.3.5 Leak & Pattern testing Diffuser System

The diffuser system shall be visually tested by filling the tanks with clean water to level 1 m above the top of the diffuser assembly units. Air shall then be passed through the diffusers and a visual assessment of the diffuse operation shall be made.

The visual assessment shall include the following minimum inspection:

i). Checking all diffusers for installation level within the required tolerances.
ii). Checking that all joints along the diffuser headers have been made airtight
iii). Checking the required air distribution of diffused air is achieved across the entire tank floor.

1.3.10 ASPIRATING AERATOR

1.3.10.1 General

The Supplied equipment must be in operating condition in India for minimum of three years in any Government plant with minimum three successful installations and documentary proof of performance certificates of the same shall be produced to approving authority. The client reserves the right to inspect any one of the successful installation at the referred site; in case found not satisfactory, vendor shall be disqualified.

1.3.10.2 General Description

Aspirator aeration shall consist of motor driven aspirator Draft tube/Air Suction Inlet/blower. The Device shall draw air through a hollow tube and inject it underwater where both high velocity and propeller action create turbulence and diffuse the air bubbles.

The assembly shall consist of electric motor connected to a hollow shaft with a protective housing positioned at a suitable angle downward into the water. The hollow shaft shall drive a mixing propeller and diffuser beneath the water surface to effect fine bubble diffused aeration.

1.3.10.2.1 AERATOR/MIXER COMPONENTS:

A. AERATOR DRIVE MOTOR

Motor shall be suitable to operate at 3phase, 415 volts, 50Hz supply. Motor shall conform to IS325.

2) Motor shall be provided with suitable starter and starter panel as per tender specifications.
3) Motor enclosure configuration shall be totally enclosed, fan cooled TEFC and meet IP65 specifications.
4) Motor shall be suitable for S1 duty, shall have class F insulation and temperature rise to class B.
5) Motor shall be of energy efficiency class EFF-1 as per IS-12615.
6) Winding, bearing, temperature detector shall be provided for motors above 200kW. Space heater shall be provided for motor above 30kW.
7) Motor frame shall be made-up of cast iron end brackets and cast iron body. Fan material shall be 42 turbulence or propylene with metal hub. Fan cover shall be carbon steel.
8) Total motor shall be epoxy painted – Final Total Dry film thickness of minimum 180 microns.
9) The noise level of the motor shall be within acceptable limit (<85dB) in accordance with IEC specifications.

B. BLOWER/DRAFT TUBE/AIR SUCTION INLET

1) The equipment shall include a high efficiency regenerative blower/Draft Tube/Air Suction Inlet sized to provide sufficient airflow to yield the rated oxygen transfer capacity. Such Device shall include the following features:

a) Maintenance free and CE compliant – Declaration of Conformity on file
b) Aluminum alloy construction
c) Inlet and outlet sound attenuating silencers/acoustic hood to minimize noise, if applicable.
d) Inlet filters with epoxy-coated wire mesh media rated for 150 microns or better, if applicable.

The blowers shall be tropicalized for corrosion resistance and motors should be suitable for 415V, 50Hz cycle, 3 phase service and with IP65 rating.

C. BEARING

1) The aerator shall be supplied with a field replaceable water lubricated lower support bearing /Grease Lubricated Bearing. The bearing shall be constructed of an appropriate material for the application inside a fiber backing. The bearing shall be press-fitted into the housing to allow ease of replacement.

D. SLEEVE :

1) The sleeve shall be solid, homogeneous and replaceable hardened non-metallic sleeve.

E. PROPELLERS:

1) The stainless steel mixing propeller shall be specifically designed to maximize oxygen transfer and mixing characteristics. Propellers shall be self-tightening such that the propeller threads tighten on the shaft threads during normal operation. The entire flow of air shall pass through the propeller via the hollow drive shaft along the axis of the propeller hub.

2) The propeller design shall be tested in clean water and shown to draw a minimum of 85% of the recommended full motor amperage load at nameplate voltage and power factor. The propeller shall be designed to allow easy removal and replacement in the field.

F. FLOTATION:

1) The aerator flotation assembly shall consist of suitable number of pontoons/Suitable Floating arrangement. Galvanized or stainless steel structural members to be used to prevent corrosion. To allow for servicing by not removing the aerator from the flotation, the flotation assembly shall be designed so the aerator may be rotated completely out of the water and taking care of water level fluctuations.

Note- The Floating Arrangement may not be applicable in Fixed type Installation for Aerator.

G. BRIDGEMOUNT:

1) The fixed bridge mount shall be made of Galvanized steel. The recommendation of the Float and Fixed mount shall be as per recommendation of the client according to the site conditions.

H. ELECTRICAL SERVICE CABLE:

1) Cable shall be IEC/IS/CSA/UL approved for severe environments, suitable for underwater service and one continuous length based on the site condition. The cable shall be jacketed, flexible stranded cable with individually wrapped conductors.

Approved Makes: Aire-O2, Hitachi, ITT or any other make approved by KMC.

1.3.10.2.2

Particular Specification :-

1.3.10.3

1. Contractor shall explain the technology by suitable simulation software to explain the bubble formation and zone of aeration to ensure total aeration basin shall get uniform oxygen zone is created.
2. Float and Fixed mount both are acceptable and shall be provided with 100% installed/ shelf standby for the total system.
3. Stad Pro model along with structural calculation shall be provided for Float or/and Fixed mounting.
4. The bidder shall provide support documents/certificates to testify the claimed oxygen transfer efficiency achieved by the aerator for minimum 5m depth in line with tender specifications, for example- inspection report by competent third party or/and certified lab reports.

1.3.11 CLARIFLOCCULATION WORKS

i). WORKS TO BE INCLUDED:

The works which are to be included by the contractor this section of the treatment process shall comprise at least the following:

a) The design and necessary arrangement for the “Clariflocculator” to flocculate settle and decant the coagulated water from the inlet works.
b) The design and necessary arrangement for the control removal by gravity of the settled sludge from the clariflocculator and the waste product
c) The design and necessary arrangement to drain down the clarifiers and provide a facility to scour the sludge withdrawal, under higher head.
d) The design and necessary arrangement for the uniform collection of settled water from the clariflocculator and its delivery to the filter battery for filtration.
e) The supply and installation of clariflocculator.

ii). BRIEF DESCRIPTION OF THE WORKS:

The clariflocculator shall be designed entirely in reinforced concrete. The tank shall be arranged to suit the works flow path, convenience of operation and effective maintenance of structure and equipment. The task shall be disposed minimise hydraulic losses and to achieve optimization of performance. Separate zones for flocculation and sedimentation shall be provided.

iii). GENERAL DESIGN CRITERIA AND PERFORMANCE GUARANTEE:

The clarification works shall be designed to:-

a) Continually clarify the water for filtration and meet the performance standards with a unit flow rate of design flow as per data sheet during monsoon period and during commissioning period fair weather trials, clarify higher rates of flow.
b) Efficient removal of waste products from the process with minimum water loss.
c) The contractor shall guarantee that following chemical coagulation for the monsoon quality raw water, the water leaving the sedimentation tank shall comply with the following on 95% of occasions.
   - Turbidity: Not greater than 10 NTU
   - Suspended solids: Not greater than 10 Mg/l. Solids.
   - Total Aluminium: Not greater than 0.5 mg/l on the laboratory treatment tests.

The test results indicating non-achievement of water quality shall make modifications in mechanical or electrical or chemical works in order to achieve the specified quality to the entire satisfaction of the Engineer.

iv). CLARIFlocculATION PROCESS:

The clarification process designed, offered and supplied by the contractor shall achieve flocculation, sedimentation and decantation in the self-contained circular tank. The process shall not include a sludge blanket, solids recirculation facility or any other process to enhance the performance of the self contained unit.
The clariflocculator shall be provided with the following:

- An inlet feed pipe to the clarifier centre.
- A central, mechanically agitated flocculation zone.
- Around the flocculator an upward flow annular sedimentation zone where in the sludge shall get settled to the floor of the annular zone floor for scraped clearance.
- Decantation of settled water uniformly from the surface of the sedimentation zone by launders to the filter battery.

v). PERMITTED VARIATION IN THE CLARIFlocculATION STAGE :

Tendering contractors are informed that the clarification arrangement specified herein has been well proven in India. And many similar clarification works are operating successfully and maintained satisfactorily even in rural areas.
The tendering contractors may offer their own design of the clarifier type outlined in this section meeting the general requirements and specifications given for the works, its commencements, performance and standards, wherever possible.

vi). ALTERNATIVE CLARIFlocculATION PROCESSES:

If the contractor wishes he may submit an additional offer, his own alternative design for the clarification works, if necessary, the contractor shall also include full details of his amended design of the inlet works to 45urbul the requirements of his alternative design for the same.

vii). CLARIFLOCCULATOR DESIGN:

The clariflocculator shall be design to the following criteria:

Flocculation zone	30 minutes detention period at a flow rate of design flow as per data sheet
Depth of tank	3.5 m
Velocity of floc	0.2 to 0.4 m./sec
Flocculation	Flocculator supplied with paddle
Agitation	Agitators of substantial construction and designed to achieve an internal maximum “G” = 10 to 75 Sec. -1
Flocculator	Total area of paddles shall be 10 to 25% of cross sectional area of tank. Design of paddle shall be given as per the latest CPHEEO volume. To be adjusted suitably as per scope of work and design
Zone separation	Distinct isolation by a circular concrete wall of the flocculation and sedimentation zones.
Outlet velocity of settling tank	5 to 0.25 m/sec
Sedimentation	The ports for the entry of flocculated water shall be sized and arranged to give steady and uniformly distributed flows

	in the sedimentation zone, to avoid the break down of flocs
Surface loading	Shall not be more than 30 m3/m2/day based on the net open surface area of sedimentation zone. The area occupied by decanting weirs shall not be included in the net effective open surface area
Detention period-Sedimentation Zone	2 hours & 30 minutes
Zone dimensions	Floor slope not greater than 1:10 for scrapped sludge transit to centre
Decanting weirs loading	Maximum loading of 300 m3/m/day
Sludge collection	By single arm scraper hung from an overhead rotating bridge and driven by an outer perimeter motor driven steel wheel traction unit on a peripheral circular steel rail (Rubber typed machine are not preferred).
Sludge withdrawal	By telescopic draw of valve. The sludge draw off pipes shall be at least 250 mm. Diameter 25% extra above the designed depth for sludge collection

viii). FLOCCULATION ZONE

Flocculation zone shall be circular in plan, with a volumetric capacity of 30 minutes detention and be substantially separate from the sedimentation zone.
The zone separation wall shall be in reinforced concrete, supported from the tank base in columns or a supporting wall

ix). ZONE ENTRY

The flows in the flocculation zone shall be dispersed and there shall not be any short circulating in the retention to ensure an even distribution of flows. The inlet pipe will feed the central vertical reinforced concrete diffuser column outlet ports

x). SCRAPED SLUDGE REMOVAL:

Adequate means of continuous sludge removal from flocculator floor is envisaged.
Double arm type center torque driven machines are illustrated in the conceptual arrangement shown on the drawings.

xi). AGITATION:

A continual treatment process agitation shall be provided in the flocculation zone to ensure satisfactory floc formation and preservation for subsequent sedimentation.
The Gt values shall be in a suitable (104 to 105) to suit the raw water characteristics, 46 turbulence flow rates at all times.
The design shall achieve the agitation by internal hydraulic sheet induced either between rotors and stators or between opposing rotational elements. If individual paddle assembles are provided, they shall be static mounted from a concrete platform and there shall be at least four such units in each flocculator. If individual rotating paddles mounted from a bridge are offered, they shall be of a very study design.
The contractor shall include full details of his proposed flocculation machinery with his tender along with detailed drawings, energy calculations, also the range of rotational and tip speeds proposed.
The peripheral speed of paddle shall be between 0.3 to 0.40 m/sec.

xii). SLUDGE REMOVAL:

In consideration to the design and raw water conditions, the arrangements for continual removal of settled solids from the flocculator base may be provided, if necessary.

xiii). SEDIMENTATION ZONE ENTRY:

The sedimentation zone entry arrangements shall be specifically designed to preserve the size and settling characteristics of previously formed flocs. Entry ports shall not creates turbulence and keep the entering water free from hydraulic currents induced by the flocculating machinery. Flows through the entry ports shall be radial and well distributed in the entire sedimentation zone. Hydraulic flows in the sedimentation zone shall be at low level with velocities between 0.15 to 0.25 m/sec. Contractor shall specifically state these requirements with their calculations in their submissions.

xiv). SEDIMENTATION ZONE:

Sedimentation zone shall be circular in plan with upward flow arrangements and have a total net surface area in order to limit the design surface loading to 30 m3/m2/day. The settling sludge shall fall to the floor for scraped collection and clarified settled water decanted into collecting launders.

xv). FLOOR SLOPE:

The sedimentation zone floor shall radially fall to the center at a slope not more than 1:10.

xvi). SIDE WALL DEPTH:

The minimum outer side wall depth shall not be less than 3.5 m. From working top water level to the point of intersection of vertical internal surface of the outer tank wall with that of the finished tank floor.

xvii). LAUNDERS:

Launders shall be constructed in reinforced concrete, either attached to the perimeter wall or suspended within tank. The Launder arrangement shall minimise the rising flock for uniform decantation of settle water. The launder channel shall be provided either with square openings of size with a maximum weir loading of 300 m3/day/m length of weir in the form of notches provided in steel plate of minimum thickness of 10 mm. Launder collection channels shall be designed to remove the water efficiently from the decanting orifices and shall continue to be a free down stream discharge at throughout rates of design flow as per data sheet considering 20% overload.

xviii). SLUDGE SCRAPPER:

The sedimentation zone floor shall be scraped by a rotating scraper to progressively clear the sludge to the tank centre for collection the bridge shall rotate along perimeter, running on a circular steel rail by means of a perimeter drive unit. The rubber tyre types shall not be offered. The minimum driving horse power at the rack shall be 3 HP. (Minimum). Bidders should note that high standard of machine and structural rigidity is required. The design life shall be at least 20 years.

xix). VARIATION IN TENDERED SCRAPPER DESIGN:

Tendering contractors may, if appropriate to their own particular clarifier design, offer a scraper mechanism designed to jointly clear both the sedimentation zone and the area below the flocculation zone.

xx). FLOOR FINISH TO TANK:

The final finish to the tank floor shall be specified by the contractor with his tender. He shall submit the civil works procedure for applying a cement screed incl. Water proofing compound of a suitable thickness to the structural concrete base slab in order that the surface finish may be laid to profile matching the surface finish may be laid to profile matching the scrapper blades.

xxi). SETTLED WATER OUTLET TO FILTERS:

Settled water from the clariflocculator shall be fed to the filters by extending the decanting launders till the common filter influent channel/chamber. A free fall is envisaged between the extended launder and common filter influent channel. The velocity of water in outlet conduit should not be more than 0.4 M/Sec.

xxii). SLUDGE REMOVAL:

Sludge shall be continuously removed from the clarifier by telescopic draw off valve during normal operation. The telescopic valve shall be operated from head stock at the peripheral walk-way level. It shall be constructed with cast iron body fitted with bronze guides. A telescopic valve stand pipes shall be fitted with best key level by pass drainage valves. The contractor shall state in his tender the anticipated average sludge draw off rate, the peak rate achievable and capacity of his proposed telescopic draw off units.

xxiii). TANK DRAINAGE:

For maintenance purposes the contractor shall provide the necessary arrangements for draining the clarifier by gravity.

xxiv). PERIMETER WALKWAY:

The contractor shall arrange a perimeter walkway to enable works operational staff to inspect the decanting orifices. These walkways may be founded on finished ground level or be cantilevered outwards from the tank wall, the walkways shall be continuous and level with the top of the sludge draw off chamber facilitating access to the draw off head stock, and shall be provided with hand rails on outer side.

xxv). EMERGENCY STOP OF MACHINERY :

The contractor shall provide appropriately located emergency stop buttons on the clarifier which when pressed shall immediately cut off all electrical power to the flocculator, scrapper and rotating bridges. Reset shall only be from the clarifier machinery control disc. At least two stop buttons one at the centre of the access bridge and the other on the access way to the clarifier at the outer tank wall shall be provided.

xxvi). CLARIFIER TANK MACHINERY AND CONTROL:

The scrapers, flocculator, blades and the rotating bridges supplied by the contractor shall generally be manufactured in steel, painted and protected. All steel members of

the bridge shall be painted and hand rails, scraper elements galvanized.

xxvii). ROTATING BRIDGE STRUCTURE :

The rotating bridge structure shall incorporate a walkway having a minimum affective width of 1.0 m, which shall be surfaced with M.S.chequered plate, painted black. The bridge shall be designed to take its own dead weight together with uniformly distributed super loading of 500 kg/m over the half span and width of the walkway bridge. Maximum deflection of the bridge under the specified loading shall not exceed 1/360 of the span. The bridge shall be so braced as to a limit lateral deflection to less than 8 mm, measured at mid span under full load conditions. A drawing to support the contractor proposal in this regard shall be submitted to the Engineer for approval.

xxviii). CONCRETE SUPPORT AND END CARRIAGE:

The bridge structure shall be supported at the centre of the tank by means of a substantial cast iron bearing assembly of the slowing ring type and incorporating trunion type mounting to accommodate vertical undulation of the traction wheels at the peripheral wall of the tank. The central bearing assembly shall be extended to a battery mounted at the convenient point above the walkway. Oil-fill and drain points, where applicable shall be extended to provide a convenient access for filling and drawing the system. Catch drains shall be provided under all oil and grease points to prevent spillage from reaching the water surface. The wheel carriage assembly shall be suitably proportioned to provide adequate stability to the rotating bridge structure while providing the substantial base for the motors, gear box, driving and idling wheels, shafts and bearings.

The wheel assemblies shall be so arranged as to provide the necessary adjustment of the radial and the cone angle. The wheel shall be designed to run on a circular steel rail without scuffing and shall be given long service or a continuous running basis.

The size and design of wheels and carriage shall be calculated to transit optimum tractive effort relative to the proportions of the scraper without producing wheel spin when the wheel path is subject to the climatic conditions which reduce the adhesion. Contractor's calculations for these shall be submitted with those specified before.

xxix). SCRAPER DRIVE:

The scraper drive shall comprise a direct coupled electric motor with reduction gear units.

The assembly shall be rigidly mounted and shall be completely weather-proof whole of it shall be adequately rated for continuous service in a water treatment works environment. All lubrication points and all necessary provisions shall be made for routine maintenance and for a prevention of oil and grease spillages. A deflector shall be provided and fitted to the leading edge of the driving carriage. It shall be angled at 45^0 and arranged to be adjustable to within 3 mm of the perimeter rail such that materials liable to foul the free passage of the wheel shall be deflected out of its way.

xxx). HAND RAILS:

The bridge shall have hand railing to both sides forming an enclosure at the centre in between. The finished height of the hand railing shall be 1 m above the walkway. The guards shall be provided and secured around the bridge walkway which shall be not less than 100 mm. High and 5 mm. Thick.

xxxi). BLADES AND FIXINGS:

Scrapers shall be arranged to give continuous and progressive scraping of the entire floor of the tank and the swept area of the successive blades shall overlap. The configuration of blades shall be designed to convey sludge and deposited suspended solids from the periphery of the tank and deposit it efficiently in the withdrawal hopper/sludge pocket. The No. And length of individual blades shall be at the discretion of the contractor. But the depth shall not be less than 300 mm. And the thickness not less than 6 mm.

The top portion of blades shall be folded forwards in the direction and overall proportions shall be such that individual blades shall maintain rigidity at all times. Renewable fabric reinforced rubber wearing strips of cross section not less than 12 mm. X 100 mm. Shall be fitted to each blades to provide a continuous contact surface which is adjustable for water. The materials chosen shall have share hardness not greater than 40 and be manufactured from well proven compound details of which shall be submitted with the tender.

Backing strips shall be fitted to give support to the fixing of the rubber wearing strips and the assembly shall be secured by means of stainless steel bolts, S.S. 316 of not less than 10 mm dia. Appropriate washers shall be fitted beneath all bolt heads and nuts. The backing strips shall not project beyond the lip of the scraper blade and the rubber wearing strips shall not project by more than 3 times their thickness. Drilling of scraper blades and packing strips shall be uniform about the centre to facilitate and to end reversal and complete replacement of rubbers to compensate for wear.

The upper most edge of the blades is mounted in such a way that they will at all times, be inclined slightly forwards in the direction of rotation.

Depending arm scraper plates shall be connected to the rotating bridge structure by an extension frame attached to the bridge structure or by means of tubular depending arms (or in equally robust alternative) of adequate proportions, which shall be capped or otherwise sealed at the ends.

Robust cast iron brackets with knuckle joints shall be used to connect the depending arms to the bridge structure and to the blades.

The top connections shall permit the blades to follow slight undulations in the tank floor. The bottom connection shall allow the blades to maintain contract with the floor throughout its length, while accommodating slight variations in the radial plane of the tank floor.

xxxii). FLOCCULATION ZONE ARMS AND SCRAPERS:

The flocculation zone arm and scrapers shall be arranged to suit the contractor's own specific requirements and shall be designed and constructed to similar standards as specified above (for outer scraper), and provide with similar features and fittings.

Central driven flocculators and scrapers shall be passed via a spun gear and ball slowing ring, running in a fully enclosed oil bath. The lower pivot around the central riser shall be constructed with atleast three bronze slipper bearings on a steel guide ring.

xxxiii). SLIP RING ASSEMBLY:

The electrical supply to scraper or flocculator driving motor shall be taken through a multi ring and slip ring collector unit mounted in a fully water proof enclosure. The unit shall be fitted at the centre of rotation of each scraper and shall be complete with necessary support brackets, Antirotation device. A suitable means of lubrication shall be provided and the covers shall have a suitable worded warning lable that the source of supply is to be switched off before removing the cover. The slip ring

assembly shall be mounted above the top level of the tank walls. Sufficient rings shall be included to cover the mortar supply and any ancillary circuits.

xxxiv). MOTORS:

Scraper motors shall be of squirrel cage type, protected to IP 55 and shall be rated 25% above design maximum.

xxxv). STARTERS:

Unless otherwise specified the starters shall be accommodated within a fibre based kiosk in the building on the clarifier bridge.

xxxvi). METHOD OF CONTROL:

The flocculator and scrapers shall each be arranged for individual manual control. Where the tanks are elevated and access to the bridge is limited to one point of the periphery, the contractor shall provide a limit switch positioned on the peripheral wall which in conjunction with “Striller Mechanism” positioned in the bridge stop shall be driving mechanism in the “Park” selector switch shall be provided in the control panel which shall be located in a fibre glass kiosk on the approach walkway.

(xxvii). METAL PROTECTION:

All ferrous and Non-ferrous metals except stainless steel shall be suitably treated to prevent corrosion and weathering.

1.3.12 FILTRATION WORKS

i). WORKS TO BE INCLUDED:

The works to be included by the contractor in this section of the treatment process shall comprise of at least the following:

a) Design and necessary arrangements for variable decline rate filtration of the works flows in a filter battery comprising of two identical filter units.
b) Design and necessary arrangements to distribute the flow (from either the flash mixers or the clarifiers proposed) between the filters, cleans, the filters, removing the back wash water and collect the filtrate flow for final disinfection.
c) Design and necessary arrangement to construct the filtration works.
d) Design and layouts for administrative purposes for the filter house and machinery shall be attached with the filter battery.
e) Supply of filters with filtering media and the necessary machinery and equipment required for the filters.

ii). BRIEF DESCRIPTION OF THE WORKS:

The filter battery shall be constructed in reinforced concrete, boxes, shall be covered rectangular in plan arranged in a single row with common influent channel and a common filtered water channel and pipe gallery on one side of the filter controls. The filter to back wash waste water channel, shall be arranged below filter influent channel, and suitable piping for eventual disposal. The filters shall be arranged for convenience of operation and maintenance, minimization of hydraulic losses and the optimization of performance in terms of quantity and quality of treated water.

iii). GENERAL DESIGN CRITERIA AND FILTER TYPE:

a) The filtration works shall be designed to receive the works flows from the inlet works during the fair season and achieve the specified treated water quality with works throughout rate of design flow as per data sheet.
b) To receive the settled water from the clarification works either existing or proposed and achieve the specified water quality with a works throughout rate of design flow as per data sheet.
c) The average filtration rate shall be 4.8 m^3/ m^2/ hr. The filtration rate shall be calculated by dividing the unit flow per filter (m^3/hr.) by the net unit media plan area (in m^2). Based on the above, the conceptual design adopts. Tendering contractors should note that they are at liberty to reduce the filtration rate during fair season up to what they deem fit.
d) Each filter unit shall contain a single sized silica sand bed, (Effective size in the region of 0.60 mm,. Uniformity coefficient 1.5 and depth not less than 0.75 m.) carried on a gravel media of about 0.40 m. Layer thickness for piped under drain system or on a suspended floor fitted with along stemmed plastic nozzles. They shall be designed for cleaning with the reverse flow of air followed for by a water wash at a sufficient rate to fluidize and expand the bed, detach and remove the filter burden without assistance of surface wash. Declining rate filters shall be adopted with split flow arrangement from a common settled water influent channels, and outlet arrangements by a weir in the inspection chamber with its crest at 0.10 m. Above the top of sand bed, and then the spillage point and conveyed to the pure water sump through req. Length MS pipe of a pipe of adequate diameter.
e) The rapid sand declined rate filter shall be designed for an average filtration rate 4.8 m^3/ m^2/ hr, with a flow range of 9.6 m^3/ m^2/ hr. At the beginning of filter run to 2.4 m^3/ m^2/ hr, before washing the filters. The abnormally high filtration rates immediately after the back wash shall be avoided by manual operation of pure water outlet valves in the filter gallery. The filtration works shall be designed for a water column of minimum 2.0 m. (without free board) above the top of sand bed, with a provision for increase in water column to a height of 2.25 m. Above the top of sand bed. A suitably designed orifice with an arrangement to measure the different head across it and hence the rate of flow on each of the outlets shall be provided. Filter shall be cleaned on time basis. The back wash rates for air and water shall be as per hydraulic design or CPHEEO, W.S. Manual, 1991.
f) An air wash causing a loosening of filter media, shall be followed by a water wash.
g) The quantity of wash water used should not exceed 2% of the total of the water filtered. No continuous filter run shall be less than 23.5 hours and 95% of all continuous filter-runs shall achieve 36 hours, when the clarifiers are in operation.
h) Filter outlets weirs shall be located in the inspection chamber with their crests at 0.10 m. Above the top of filter media and they shall discharge into a common reinforced concrete filtered water collection channel.
i) The filters shall be divided into the two identical balanced sections with a central filter feed/back wash collecting gullet, which it turn shall receive back wash waste water from a pair of waste water troughs constructed for each section and separate cleaning ports. Filter control valves shall be manuals operated from head stocks.

iv). PERMITTED VARIATION IN THE FILTRATION WORKS:

The specified filter type has been selected for its simplicity of operation, ease of maintenance (over and under floors), its reliability and its inherent resistance to operation upset.
Bidders may offer their own particular or “Nearest” version of the filter type envisaged. No tender will be considered which does not include a filtration process

bases on the specified number of units of atleast the specified size and the filter type with either suspended floors or piped under drain system, single sized filtering media and separate air and water wash facilities. However, the Bidders shall note that a variable head declining rate filtration type shall be offered by them as a part of the basic tender.

v). ALTERNATIVE FILTER ARRANGEMENT :

Bidders may submit another filter design and arrangement as a second ALTERNATIVE OFFER. However, preference shall be given to separate air and water wash systems ease of maintenance, single sized media filter bed and a variable head declining rate type filter.
Alternative systems which may include:

a) An excessive No. Of filter units or more than one filter stream.
b) Multi media units (Anthracite, pumice, crushed coconut shell)
c) Complete control system.
d) Regarding rate of flow controllers and rate setters, slow devices etc
e) Cleaning or flushing with jets or spray systems.
f) Automatic self cleaning systems

Alternative which may be offered shall include:

a) Slight variation in the number of filter units.
b) Piped (And at least partially accessible)
c) Variation in media size with corresponding adjustment of sand depth

vi). EXTENT OF WORKS:

Under this contract, the contractor shall supply required filter units and shall all the machinery. Equipment required for all the filter units.
Contractors design and installation shall be such as to enable the filter battery to filter water at a rate of design floe as per data sheet. In the event of conversion into dual media, filters at a later date, for this the shell design all the transmission system pertaining to filtration works, that is settled water channel, pure water channel, pure water gravity drain, all of the under drain system for throughout put rate of i.e. double the rate of design flow rate. Contractor's designs shall also be such as to enable the filter battery to be linearly extended at a later date with the minimum of interference to the works.

vii). FILTER FEED:

Inlet flows to the filters shall be distributed along the length of the filter battery externally arranged in a reinforced concrete settled water common influent channel with a suitable arrangements of the enable the incoming flows to be divided equally between the two filters say an adjustable weir plate. Channels and associated chamber floors shall be given slope towards the drains and drainage valves. They if necessary, shall be fitted with to stop or step irons for internal access.

viii). FILTER MEDIA:

Filtration shall be by gravity through a bed of hard gained silica (Quartz) sand of minimum thickness 70 cm. Filter sand shall be of effective size 0.60 mm and uniformity coefficient of 1.50.
The sand depth shall be checked with the help of following formula

Qd^3/h =	B x 29323
Where,	
Q =	Filteration Rate in $m^3/ m^2/ hr$
d =	sand size in mm
h =	Terminal loss of head in m
L =	Depth of bed in m
B =	Break through index (Between 4 x 10-4 to 6 x 10-3) Assume 4 x 10-4

ix). FILTER SUPPORT:

Filter sand shall rest on a gravel bed of not less than 0.40 m. Thickness in the event of piped under drain system, or any directly on the suspended floor in case of nozzled under drain system to suit a particular design.

x). FILTER SAND:

Filter sand shall be of hard and resistant quarts or quartzite and free of clay, mica, shale, dirt, loam organic impurities, later soluble iron and manganese. Effective size shall be 0.45 to 0.70 mm. Uniformity coefficient shall not be more than 108 not less than 1.3. The weight loss or contact with N hydrochloric acid shall not exceed than 5% weight after 24 hours. Ignition loss should not exceed 0.7 percent by weight. The friability weight loss after mixing for 15 minutes (750 strokes) shall be less than 10% and for 30 minutes (1500 strokes) shall be less than 20%.
The specific gravity of the sand shall in the range of 2.55 to 2.65 silica content should not be less than 90% wiring loss should not exceed 3% IS 8419 (Part-I) 1947: Filtration media. Sand and gravel may be referred for other details.

xi). FILTER MEDIA AND CHARGING:

The contractor shall supply the filter media for the works and shall submit with his tender details of the source from which the proposed to draw his supplies of filter sand and verify that sufficient quantities of satisfactory filter sand can be obtained, packed stored on site and the filter shells charged in accordance with his work programme.
Within the two months of the date of acceptance of tender, the contractor shall submit to the Engineer to 20 Kg. Representative samples of the filter sand and also a sample of supporting media for testing. When the sand is found to be confirming to the requirements, the contractor will then be given permission to place an order for his supplies.
Prior to packing, all filter sand, shall be washed, heat dried and sieved to conform the specified grading and tested. Separate test certificates (In triplicate) shall be provided to the Engineer for each 20 cubic meters of media so supplied.
Packing shall be in suitable approved double or triple bags to protect the media from spillage or contamination.
Any sand or media delivered losses or found to be split or open bags shall be rejected on site. Storage on site shall be only in an approved. Pre designed area, well drained and free of mud and silt. Following installation and satisfactory testing of all the filter floors, the contractor will be given written permission to commence filling the filters. The contractor will set out and indicate and the methods of filling the media in his tender submission and specification. Filter media shall be carefully

placed and not charged by dropping, dumping, machine handling or any other method which in the opinion of the Engineer will be determined to the floor media, nozzles/drains to or sealants.
In each filter, two adjacent valves shall be charged simultaneously.
Following the initial charging the filter shall be washed by the contractor. Filter beds, designed for expansion during, cleaning shall be skimmed prior to disinfections and commissioning of the works.

xii). FILTER FLOOR:

In the conceptual design, piped under drain system has been adopted. In the event of adopting similar system, the contractor shall provide reinforced concrete flooring with slots in each section of filter, to accommodate manifold or he may provide concrete channel in each section, to collect and convey pure water back wash water and air from/ to under drain laterals. If the tendering contractor wishes to adopt nozzles and suspended floor arrangement the filter media shall be supported by a suspended floor, fitted with long stemmed plastic floor nozzled and designed to pass the air and water required for the reserve flow cleaning and to exclude the media from the filter base and outlet systems.
The filter shall be manufactured in precast concrete segments with accurately screwed thread plastic nozzles fixing sleeves.
Nozzles shall be evenly spread over the full floor area with a concentration of at least 50/ m. During installation of any floor all nozzle socket shall be plugged until nozzle fitting commences.
The contractor shall at the time of tendering provide the following:
a) For suspended floors:

- A detailed specification of the calculations for his proposed filter floor, its nozzles, the floor seals between slabs and around the perimeter.
- The tolerances required for the support beams and walls, and tolerance for the slabs and the finished floor.

b) For piped under drains.

Complete hydraulic calculations for laterals, orifices, and manifolds, and the tolerance ratios of their area with filter area

The inter-relations of the areas of all the components of under-drain system

The Contractor shall clearly indicate at the tender stage the arrangements he proposes to connect the laterals with the manifold and back wash water and air arrangements.

xiii). FILTER BASE:

In case of suspended floors, the filter base shall be designed for access below the filter floor and the central trough. It shall be arranged to ensure free passage of the filtrate to the outlet pipe work, equal division of air and wash water between the filter half and designed to achieve a level air scour fusion and uniform distribution or air along the length and breadth of the filter, regardless of the size and position of the floor supports.

xiv). FILTER CLEANING:

Filter cleaning shall be (Uwards (reverse) flows of air and water, systems employing separate air and water washing are envisaged.
The air supply shall be taken from one of the two lobe type/ roots type air blowers and the water supply from the wash water tank to be constructed on top of the chemical house under the scope of this tender.

The free air flow rate shall be 45 m/hr. To 50 m/hr. For duration of 5 minutes. The wash water flow rate shall be 36 m/hr. (600 LPM/m²) for duration of 10 minutes.

xv). CLEANING AND SEQUENCE:

The contractor shall fully justify in his tender submission, the filter cleaning system for the contractor's particular version of the conceptual design.
The contractor shall include consideration of water loss, design sequence and timings, rise rates, the water temperatures, surface, travel distance for wash water, ease or operation, timings and durations of the wash period etc.
Following criteria shall be adopted in the designing under drain system.

Area of orifices	= 0.3% of filter bed area
Area of laterals	= 2 x area of orifices
Area of Central manifold	= 1.5 x area of laterals

The perforations may vary from 5 to 12 mm in diameter and should be staged at a straight angle to the vertical axes of pipe.

xvi). WASTE WATER TRAVEL DISTANCE :

The Contractor shall, as far as possible to suit his own design, limit the horizontal distance of travel of wash water across the bed surface to the wash water cross troughs.

xvii). WASTAGE OF THE FIRST FILTRATE :

Systems employing the wastage of the first filtrate shall not be offered.

xviii). FILTERING TO WASTE :

The contractor shall provide the facility for the entire works output to be filtered to waste during the testing, commissioning or subsequent operation of the works.

xix). OUTLET CHAMBER:

Each compartment of every filter adjacent to filtrate outlet chamber constructed in reinforced concrete with a weir 0.10 m. Above the sand bed top into an inspection chamber connected to the common filter water collection channel. The minimum chamber capacity shall be 30 m3. The chamber shall be covered with sheet glasses fixed in a removal wooden frame.
The flooring for inspection chamber shall be in white glazed tiles. The walls of the inspection chamber shall be covered with white glazed tiles for full height.

xx). HEAD LOSS/ BACK PRESSURE GAUGES:

Each filter be provided with two head loss/back pressure gauges, one mounted in the filter house at upper gallery level, and the other (a manometer) in the pipe gallery. Both shall indicate the water pressure across the filter during normal operation.

xxi). GAUGE:

The Kirloskar mounted gauge shall be of the float operated type with a 150 mm. Diameter indicator, a geared drive to a cable drum, 100 mm. Dia meter copper flat, 1 mm. Diameter stainless steel wire woven cable and counter weight. The float tube shall be connected to the filtered water outlet port casting by a 12.5 mm. Dia meter valve and copper tube. It shall terminate at its lower end in a blank flange to enable the float to be removed if necessary and shall be fitted with a 25 mm. Dia drain

valve.
The gauge dial shall have two scales in opposite directions :
Alternative arrangement to the above may be offered provided they are of simple reliable construction Ed could readily be attained.

xxii). MANOMETER:

Filter manometers to serve as stand by head loss gauges shall be well mounted in the lower filter pipe gallery.

xxiii). FILTER CONTROLS:

In an attempt to minimize mechanization, the conceptual design adopts manually operated filters. All filters inlet and outlet flows shall preferably be manually controlled by head stock operated sluice valves or penstocks. Head stocks at upper filter gallery or walkway wheel valve shall be provided at each filter for the following controls:

- Filter inlet.
- Filtered water outlet 2 Nos.
- Air inlet
- Wash water inlet
- Wash water outlet.

Knocked or angled spindle extensions shall be avoided.

xxiv). FILTER PORTS:

To limit the head loss arising from friction, turbulence and velocity heads, the following upper limits of velocity shall preferably apply:

Filter Inlet	:	1.0 m/Sec.
Filtrate outlet	:	1.3 m/Sec.
Wash water inlet	:	2.5 m/Sec.
Wash water outlet	:	2.0 m/Sec.
Air inlet	:	25.0 m/sec.

xxv). FILTER GALLERY AND FILTER MACHINERY HALL PIPE WORKS:

Filter gallery water carrying pipe work shall be in either steel or cast iron with flanged connections, with a provision of detachable flanged couplings to facilitate maintenance of valves and fittings. The filter gallery and machinery shall pipe work shall be arranged for easy operation, access for maintenance and to minimize undesirable head losses in the works.

xxvi). AIR MAINS:

The Contractor shall feed air to the filter through a steel header, at a high level within the pipe gallery. Individual filter section suppliers from the air header shall be in flanged steel pipe work but the filter entry pot shall be a cast iron flanged piece, with integral puddle which shall incorporate a siphon and valving to exclude reverse water flows to the blowers.

xxvii). WASH WATER MAIN:

Wash water supply pipe work shall be from elevated service reservoir as specified. Velocity in the header shall be designed to account for head losses arising in the future development & preferably shall not exceed 2.0 m/sec. The req. Valves and its chamber shall be also provided by the contractor at his own cost.

xxviii). WASTE WATER COLLECTION & DISPOSAL:

The filter back wash waste from each filter shall be collected in a common waste water channel connected in drainage system which is a part 7 parcel of filtration works. Care should be taken while designing the outflows about uniform collection sludge / muddy water as otherwise sludge pockets are likely to remain which will eventually clot the pipeline.

The final disposal leads to the natural drain passing near bye and all required piping, channel is to be designed ad provided and constructed by the agency at his on cost up to 500 m length.

xxix). lateral length:

The length of lateral on each side of manifold shall not be more than 16 times the diameter of laterals.

xxx). WASH WATER SUMP:

Wash water recirculation sump should be provided for all the Filter Plants irrespective of its capacity. The capacity of recirculation sump should accommodate back wash water of one Twin (Twin compartment) or two single beds + 10,000 litres.

Necessary pumping 58 turbulence including all accessories for recirculation back wash water pumping shall be provided by the agency.

1.3.13 Chlorination

Chlorine solution diffusers shall be supplied and installed at the dosing point.

Treated sewage shall be dosed with chlorine gas at concentrations not more than 10 mg/l. Effluent from the chlorine contact tank shall not have more than 1 mg/l of residual chlorine.

1.3.13.1 Chlorinators

i). Vacuum type chlorinators shall be supplied with one duty and one standby unit.
ii). Chlorinators shall be free-standing, floor-mounted, and shall have a turn down ratio of 10: 1 over the full range of works operation.
iii). The dosing rate shall be manually set and each chlorinator shall be equipped with a 0 to 10 mg/l scale and a manual dose setter over the complete range.

1.3.13.2 A: Motive water pumps and Injector

i). Motive water pumps (1 working + 1 standby) shall be installed.

ii). The pumps shall draw their supply from bore well/plant water supply.

iii). The pumps shall be installed outside the chlorination room and shall be made from material resistant to corrosion by chlorine.

Two injectors shall be provided, each serving a duty / standby pair of chlorinators. The injectors shall be located near point of dosing i.e upstream of Chlorine contact tank.

1.3.13.3 B: Inline Vaccum/ventury type chlorine injectors

i). In line Ventury type which shall mix Cl gas metered from Chlorinator into motive water from Booster Pump

ii). All wetted materials shall be constructed of Grade 2 Titanium (unalloyed). The motor shall be chemical duty type.

1.3.13.4 Chlorine

Chlorine shall be supplied as liquid from nominal 1 tonne chlorine tonner.

1.3.13.5 Tonner Room

i). Storage shall be provided for chlorine tonners sufficient for at least one month's usage at normal rates of application.

ii). The system shall be designed to prevent freezing of the liquid chlorine at the maximum rate of withdrawal.

iii). Tonners on line, tonners on standby and full and empty tonners, shall be stored separately in the tonner room.

iv). Four sets of tonner rollers shall be provided. Tonners not in use shall be stored on concrete cradles. Tonner shall be provided with suitable capacity chain pulley block (Min. 2 Tonne)

v). The container lifting beam shall be specifically designed for handling chlorine containers and equipped with necessary shackles and hooks.

vi). Operation of crane system shall be from the floor level using independent push button pendant controls operating at a 230 volt 50 Hz AC supply.

vii). Two lifting beams shall be provided (a duty and a spare) and a one tonner weigher to be suspended from the crane hoist.

viii). When the pressure in the duty chlorine tonner falls to less than 1 kg/cm^2 the automatic changeover device shall operate to isolate the empty tonner and to bring the full standby tonner on line.

ix). A pit and alkali absorption system shall be provided to contain and neutralise

chlorine in the event of a leak. The system shall comprise a pit located in the tonner storage room and accessible by the overhead crane system. The pit shall be surrounded with removable guard railing. The pit shall be kept full with a neutralising solution of lime. The pit shall be capable of holding side by side two chlorine tonners. A provision shall be made to drain the pit. Tonner shall be provided with suitable capacity chain pulley block (Min. 2 Tonne) also Neutralization Pit for the suitable capacity to handle the leakage of Chlorine Tonner to be constructed in the vicinity of the tonner in Chlorine room.

x). Special consideration shall be given to any floor drainage system in the tonner building; adequate traps shall be provided to ensure that chlorine gas cannot escape. All leader tubes carrying cables or pipes out of the building shall be sealed at either end to prevent any chlorine gas leaking out.

1.3.13.6 Chlorination Room

i). The chlorination room shall be constructed adjacent to the tonner room but with no interconnecting door or other form of access.

ii). Gas lines from the tonner room into the chlorination room shall run in ducts to be sealed after installation and prior to commissioning.

1.3.13.7 Chlorine Leak Detectors

(a) One Chlorine Gas Detector shall be provided with Single Detection Cell located in Chlorine Tonner room

(b) Statutory warning notices relating to the storage and handling of chlorine shall be provided. The signs shall be pictorial and provided in Telgu, Hindi and English.

1.3.13.8 Ventilation System

i). Each area where chlorine is stored or used as gas or liquid shall be provided with a forced ventilation system. Air intakes shall be sized to allow uniform ventilation and positioned to prevent possible recirculation. Exhaust air shall be ducted from low level and discharged at high level.

ii). An air change rate of four per hour under normal condition and a minimum of twenty changes of air per hour under shall be used in the event that a chlorine leak is detected.

iii). Exhaust fans shall be heavy duty industrial pattern manufactured from chlorine resistant materials.

iv). Ductwork shall be manufactured from U-PVC extruded sheets or circular sections.

v). Ducts shall be designed in accordance with relevant Indian standard specifications.

1.3.13.9 Safety Equipment

i). Materials and equipment necessary to ensure the safety of personnel operating the chlorination plant and others shall be provided.

ii). The equipment shall include:

(1) Two sets of approved self-contained breathing apparatus, each comprising an air set, carrying harness, face mask and valves and ancillary equipment. Each set shall be provided with three 1200 litre capacity, 140 mm diameter, air tonners.

(2) Two No of Canister type Gas Mask

(3) Two sets of approved positive airline breathing apparatus, each comprising body harness, face masks and valves and 30 m of airline with Suitable Air Tonners along with airline hose.

(4) Emergency Repair Kit suitable to handle Gas leakage from Chlorine Tonner

(5) Two `instant action' resuscitators.

(6) Four sets of safety clothing in various sizes, each comprising PVC overalls, wellington boots with steel toe caps, goggles, gloves and safety helmets.

Note- All the Safety Equipment should be as per the applicable IS standard for Chlorination as per the CPHEEO and in addition to above list as per the requirement.

iii). Each set of safety equipment shall be mounted in a glass-fronted, non-locking PVC coated steel cabinet in approved locations on the outside of the building.

iv). Two emergency showers shall be provided and shall be installed outside on either side of the tonner room.

v). Each shower shall be operated automatically by a quick acting hand or foot valve.

vi). Four eyebaths shall be supplied. Two eyebaths shall be adjacent to each of the showers.

vii). Water for the showers, etc, shall be drawn from the service water supply.

viii). A telephone will be provided close by outside the building for emergencies.

1.3.13.10 Chlorination Power & Control

A combined MCC and control panel shall be provided and located in a suitable location protected from the weather and the effects of the process. The control panel shall provide facilities for :

(1) Display status and values associated with the chlorination systems;

(2) Duty pump selection;

(3) Annunciate alarms associated with the chlorination systems;

1.3.14 Sludge Handling

As sludge generated from different process units depending upon the process adopted, it is advised to provide sludge handling units and equipments like sludge thickeners, Digesters, centrifuge or vacuum filter press or screw press or bag filter, combo-machine and other ancillary units which is suitable for the process and which is sustainable from Operation & Maintenance point of view. The units and equipments shall be selected accordingly which occupies less power, space, chemicals and maintenance.

1.3.14.1 Gravity Thickeners

Circular (radial), fixed bridge, central turn table type or peripheral drive type picket fence, collecting effectively with proper circumferential speed, a clarifier shall be provided. The clarifier shall be rugged and robust in design and shall be provided with high capacity drive head and induction motor having high torque rating, centrally or peripherally located, with positive sludge raking by means of one or more raking arms. Both the raking arms should have scraper blades fitted at the bottom, so that the sludge from scraper blades is pushed to the sump on every rotation.

(a) The circular reinforced concrete thickeners tapering at bottom shall be provided for thickening process. The sludge laden suspension from Waste water balancing Tank shall be fed to thickeners.

(b) Design shall be such that the sludge can become compacted and can be extracted from the bottom. Interstitial liquid flows through peripheral weir at top. Tanks shall be deep enough to allow the sludge to settle. At least 50 cm freeboard shall be provided.. Provision shall be made to remove the sludge from top if there is a serious risk.

(c) Provision shall be made for collection of thickened sludge and pumping it to Centrifuge.

A full diameter bridge with central drive shall be provided with: central platform for the installation of the scrapers and their drives and for the local control panel; a radial scraper system with bottom scraper blades, suspended on the bridge.

(a) The thickeners shall have a full diameter fixed bridge complete with 1200mm walkway for personnel access to the centre, access stairs to ground level and hand railing, a motor driven sludge scraper complete with all necessary controls, delivery pipe work, a stilling well and overflow steel weir plates. Hand railing, walkways, access steps etc shall be galvanized. Handrails shall be of tubular construction and made of 32Nbpipes.

(c) The scraping gear shall be supported from the tank base and from a fixed bridge carrying the central electrical drive for the rotating gear. The equipment including driving motor, gears, shafting and scrapers shall be designed for continuous operation and sized for the most arduous operating condition including starting from rest with an accumulation of sludge in the thickeners.

(d) The electric motor, gearbox etc., shall be provided with a sunshade.

(e) The fixed bridge, hand railing, access steps and the feed well shall be galvanized steel. The main drive shall be cast Iron construction and shall be enclosed in a dustproof enclosure with oil bath lubrication. All underwater hardware shall be of SS316.

(f) Suitable overload protection for the drive shall be provided to ensure that the sludge shall not overload the equipment and emergency stop pushbutton shall be provided.

(g) The scrapers shall be fitted with rotation monitors and over torque protection to alarm in the event of a failure.

(1) Corrosion allowance of 2 mm shall be taken in the structural sections of scraper arm, bridge etc.

(2) Structural design calculations shall be submitted for all structures including scraper arm, bridge etc. And also the calculation for drive head selection including the Torque Rating.

(h) V-notch weir in Reinforced fibreglass construction of size minimum 5mm thick and 200 mm wide shall be provided along the launders for uniform draw-off of the overflow. The weir plate shall be fixed to the launder by means SS316 grade clamping plates and fasteners.

(i) The hydraulic equipment will consists of the DI inlet pipe(runs along the bridge) to the central feed well of the thickener; sludge draw-off pipe with an manual & Motorized Knife Gate valve (in SS CF8M material of construction) for intermittent operation according to an adjustable timer; a drain pipe with manually operated gate valve for the complete emptying of the unit; a discharge pipe/channel from the peripheral collecting channel to the main channel leading to the Supernatant sump. The sludge thickener mechanism shall be generally in MS galvanized construction,

suitable for installation in a circular RCC tank and shall include the following:

a. Mechanism support beam spanning the diameter of the tank.

b. Walkway and handrail from the edge to the centre of the tank.

c. Drive mechanism with internal gear type.

d. Reduction gear box.

e. Chain and sprocket with guard.

f. Central shaft with scrapper arm and picket fence.

g. Skimmer Scum Baffle and Scum trough.

h. Overflow weir:

i. Vertical pickets.

j. Torque Indicating Device.

k. Overload Alarm protection.

1.3.14.2 Dewatering Centrifuges

i). The Dewatering Machine and its peripheral equipment shall include but not necessarily be limited to the following;

1. Powder or liquid Coagulant storage tanks.
2. Mixers and solution tanks.
3. Coagulant service tanks.
4. Supply line & flush line.
5. Chemical feeding pumps.
6. Water supply pumps.
7. Sludge feeding pumps.
8. Dewatering Centrifuge
9. Belt conveyor.
10. Cake hopper.
11. Flow meters for feeding Sludge, and for feeding chemical solution.
12. Control valves on sludge feeding line, and on Chemical feeding line.
13. Drain system

ii). Dewatered cake shall be conveyed by a belt conveyor to cake hopper for carrying out for reuse.

iii). To select the type of dewatering machine, Contractor shall provide technical information to show client that performance to obtain his approval in advance.

Decanter Centrifuge

The centrifuge shall comprise a conical cylindrical bowl and scroll feed horizontally mounted in bearings on a frame. The centrifuge bowl and scroll support frame shall be mounted on a fabricated steel sub-frame.

The bowl and scroll shall be made from stainless steel AISI 316 material. The leading faces of the scroll shall be protected against abrasive wear by the application of a suitable hard-coated material.

The whole rotating assembly shall be enclosed by a Stainless steel (AISI316)fabricated casing incorporating a Centrate discharge hopper and outlet pipe, and a rectangular solids hopper which shall discharge the dewatered sludge into the disposal system.

The rotor shall consist of a solid bowl which is conical-cylindrical in shape and which rotates about a central shaft. An inner scroll shall be provided to convey separated sludge from the periphery of the cylindrical bowl to the beach at the conical end of the rotor.

The main scroll bearings shall be arranged for lubrication by an external lubrication system. Wherever practicable greasing nipples shall be arranged together as a battery. The complete rotating assembly shall be dynamically balanced and test certificates provided.

Sludge shall be fed into one end of the rotor through a centrally positioned feed tube and dispersed to the bowl through an inlet chamber.

The bowl shall be provided with an adjustable 360^{o} peripheral weir at its cylindrical end to control the depth of the Centrate in the rotor.

The fixed outlet castings of the rotor shall be designed to collect the Centrate and dewatered sludge from the rotor. Baffles within the casing shall direct the separate phases to the relevant discharge points and prevent cross-contamination.

The centrifuge shall be mounted on heavy-duty vibration isolators, located between the machine and the supporting steelwork or foundations, to damp vibrations and prevent vibration transmission. Two axis vibration monitors shall be provided to stop the centrifuge automatically when excessive vibration is detected.

Flexible connections shall be provided on the sludge fed system and the Centrate system at the centrifuge. The dewatered sludge discharge system shall incorporate flexible chutes.

iv). Variable Speed Drive

A variable speed drive shall be provided to accelerate the rotor to operational speed and

maintain that speed during the centrifuge's duty period. The bowl drive shall be electric or hydraulic and shall be coupled to the drive shaft by a multiple 'V' notch belt drive.

v). Differential Scroll Drive

The scroll drive shall be provided with a separate drive mechanism to control its rotation in the same direction but at a different speed to the outer bowl. The differential speed shall be adjustable.

The drive shall be linked to the main bowl drive by an epicyclic gearbox. The differential speed of the scroll shall be automatically and manually adjustable so that the moisture content of the dewatered sludge can be controlled as required.

For safe operation, contractor shall provide control panel showing proper Sequence of operation with interlocking.

Chutes and interconnecting piping shall be provided with flexible joint (minimum 10 mm flexible in all direction) to avoid vibration.

1.3.14.3 Screw Press

The screw press should be with a conical screw shaft and cylindrical sieve consisting of three treatment zones: inlet and drive zone, three-part thickening and dewatering zone, and press zone with pneumatic counter-pressure cone.

The screw press must be fed with flocculated sludge of sufficient stability. The first part of the screw press should be provided with large free screen surface so that the free supernatant liquor is quickly removed from the sludge.

The pressure probe should be provided in the inlet to protect the plant against excessive primary pressure and consequently excessive pollution of the filtrate liquor and excessive residual moisture in the sludge outlet.

The second part of the screen is to be designed in such a way that the volume of material between the screw flights is reduced by the conical screw and the sludge is pressed against the inner screen surface so that the sludge is dewatered, with a continuous reduction of the filter cake thickness. The screen apertures should be much smaller in this screen section.

In the third part of the screen the residual water will be pressed out of the sludge, at a minimum filter cake thickness, by the pneumatic counter pressure cone at the press discharge. Depending on the type and consistency of the sludge flocks the pressure applied on the sludge is to be varied infinitely.

The conveying screw should push the dewatered sludge past the pressure cone into the discharge chamber.

The sludge residence time in the screw press and thus the filtration time should be adjustable to individual requirements by adjusting the rotational speed of the screw shaft.

Brushes should be fitted on the flights to ensure permanent automatic sieve cleaning from inside.

Intermittent cleaning of the sieves from outside is to be accomplished by a spray bar. The spray bar should be stationary mounted whereas the screen basket is a rotating element.

For the purpose of cleaning, the feed into the screw press is to be temporarily stopped and the screw shaft should rotate in reverse. The flexibly supported screen drum should perform one complete rotation passing by the spray nozzle bar to clean the complete screen surface.

In pressing mode, sludge feeding should start again and the screw shaft should rotate forward. The screen basket should rotate until arrested by ratchets anchored in the casing. Thus the pressing process should continue.

Electrical appliances on the machine:

Drive motor of screw

Solenoid valve in the wash water connection

Pressure sensor on the sludge inlet housing

Pressure switch for compressed air supply (optional)

Material of construction : Screw Press should be made of stainless steel material AISI 316 (or similar) and pickled in an acid bath

Accessories for Screw Press :

Polymer injection and mixing device

For continuous mixing of coagulants and sludge, comprising of polymer injection ring with integrated distribution channel and 4 injection nozzles. Double sealed cover provides easy access to distribution channel and nozzles.

One-piece blockage-free design, self adjusting mixing energy via lever and adjustable weight. Weight loaded mixing valve with inspection opening.

Nominal width	DN 65, DIN 2501
Fitting length	280 mm
Total length	660 mm incl. Lever and weight
Polymer connection	DN 25 socket
Housing	Cast iron, RAL 5015
Movable parts	AISI 420

Supercharge reactor

For optimal flocc formation downstream the polymer injection and mixing unit. Horizontal reactor shaped to provide defined turbulence and pressurized feeding of the screw press.

Reactor length	4000 mm
Diameter	250 mm
Height adjustment range	180 – 200 mm
Volume	approx. 160 l
Inlet flange	DN 65
Outlet flange	DN125

Material of Construction:

Reactor completely made AIS 316, including height adjustable support legs.

Pressure adjusting system

To regulate the pneumatic pressure cone. The system allows a fine adjusting of the compressed air. Lack of air is electronically detected and the cone can be moved backwards by hand lever valve.

Supply should include pressure sensor and a hand lever valve wired ready for connection on a galvanised plate.

L x H: 334 x 355 mm
Air inlet (6-8 bar): 1 x 10 mm push-in fitting
Air outlet: 2 x 10 mm push-in fitting
Electronic pressure switch with 2,5 m connector cable for voltage supply (24 V) and PNP switch output.

Electrical control panel for Screw Press
Control panel suitable for wall mounting in compliance with UVV and VDE standards. Complete with all components required for fully automatic plant operation, switch on/off of individual drives via function keys on control unit, motor protection relay, overload protection, fuses, relays, lockable mains isolator, socket-power unit 24 V DC. Display on control unit of operating hours, operating and fault signals, run times.

Control panel:
Painted steel RAL 7035
Protection grade: IP55
To control the following units:
1 Screw Press incl. Power element (frequency converter:)
1 flocculation reactor stirrer incl. Power element (frequency converter:)
1 filling level probe in flocculation reactor to prevent reactor overflow
1 washing system control
1 release/fault thin sludge pump
1 release/fault coagulant agent pump

Frequency convertor

Designed in compliance with CE safety and EMV standards
Convertor for integration in main control panel of the electrical switchboard comprising:

three-phase alternating voltage 3 x 380 / 460 V AC
typical shaft power PM,N = 3.0 kW
frequency f = 50 Hz
protection IP 20

integral class A EMI filter
control display

Compressed-air plant

Miniature compressor for compressed-air production and pneumatic regulation.

Type Piston compressor
Effective delivery: Q = 200 l/min
Max. Pressure: p = 10 bar
Reservoir volume: V = 24 l
Performance with 400 V AC:P = 1.1 kW
Protection grade: IP 54
incl. Maintenance unit and pressure regulating valve

1.3.15 Sluice Gate

1.3.15.1 Design requirement and construction features

The construction of the sluice gate shall be in accordance with the specification and generally as per AWWA C 560-00 / IS: 13349-1992 or other applicable standard. All sluice gates shall be of the rising spindle type. The sluice gates shall be capable of performing the duties set in this specification without undue wear or deterioration. They shall be constructed so that maintenance is kept to a minimum. All parts of sluice gate, including lifting mechanism components shall be designed for the heads required with a minimum safety factor of five.

1.3.15.2 Frame

Guide shall be bolted to the frame of cast integrally with it and shall be machined on all bearing and contact faces.

The length of guide shall be such that it should support the gate upon the horizontal line of stem nut pocket.

Arrangement shall be made to prevent lateral movement of bolted on guides. they shall be capable of taking the entire thrust produced by water pressure and wedging action. wedges or wedge facings shall be attached securely to the guides at points where, in the closed position, they will make full contact with the wedging surface on the slides.

Seating Faces

Seating faces shall be made of full width, solid section; dove-tail strips of stainless steel. They shall be secured firmly by means of counter sunk fixing in finished dove-tail grooves in the frame and slide faces in such a way as to ensure that they will remain permanently in

the faces shall be of ample section and finished smooth.

1.3.15.3 Wedging Devices

Sluice gates shall be equipped with adjustable side, top and bottom wedging devices as required providing contact between the slide and frame facing when the gate is in closed position. All faces shall be machined accurately to give maximum contact and wedging action. wedges shall be fully adjustable screws and locknuts and so designed that they will remain in the fixed position after adjustment.

1.3.15.4 Lifting Mechanism

Sluice gate shall be operated through suitable lifting mechanism which shall incorporate suitable gearing if required.

Lifting mechanism shall be suitable for operation by one man under all conditions. lifting mechanism shall incorporate a strong locking device suitable for use with a padlock or padlock and chain.

The manual operation shall be of the hand wheel crank operated type and shall have a lift nut threaded to fit the operating stem. Crank shall be removable. Ball or roller thrust bearing shall be provided above and below the flange on the lift nut to take the load developed in opening and closing the gate with torque of 14 kg-m on the crank. Fitting shall be provided to lubricate gears and bearing.

The design of the lifting mechanism of the hand operated gates shall be such that the slide can be operated with a torque of not more than 7 kg-m on the operator after the slide is unseated from wedges based on the operating head. the maximum crank radius shall be 380 mm.

All gear and bearings shall be enclosed in cast iron housing with labyrinth seals. The lifting mechanism shall be with a cast iron pedestal, machined and drilled to receive the gear housing and suitable for bolting to the operating floor. The gates shall close with clockwise rotation of the crank. The direction of rotation to close the gate shall be indicated on the lift mechanism.

A suitable means shall be provided for lubricating the stem threads directly adjacent to the lift nut. An inspection cover shall be provided to access the lift nut and gearing.

Stem shall be provided with a GI pipe cover shall be fixed to the headstock.

Lift mechanism shall be provided with a suitable position indicator to show the position of the gate at all times.

1.3.15.5 Wall Thimbles

Wall thimbles shall be made of CI and shall be supplied along with the gate. The wall thimbles shall provide a rigid mounting, designed to prevent warping of the gate frame during installation.

The cross section of the thimble shall have the shape of the letter 'F'. The front, or mounting flange, shall be machined and shall be drilled and tapped to the same template used for its particular gate frame. the frame shall be attached to the thimble with bolts of studs. The depth of the wall thimbles shall not be less than 300 mm.

To permit entrapped air to escape as the thimble is being encased in concrete, holes not lesser than 35 mm diameter at not more than 600 mm span, shall be cast or drilled in each entrapment zone formed by the reinforcing ribs or the flange and water stop.

1.3.15.6 Lifting Lugs

Lifting lugs shall be provided for all gates.

1.3.15.7 Flush Bottom Seal

When sluice gate are provided with flush bottom seals, the wedging device and facing along the bottom edge of the slide and frame shall be omitted.

A solid square cornered, resilient rubber seal shall be provided on the bottom facing of slide.

The seal shall be securely fastened to the bottom face of the slide by a retainer bar and corrosion resistant metal fasteners. The top surface of the bottom facing of frame shall be flush with invert of the gate opening. Bottom facing of the slide shall be accurately machined to make contact with the seal when the slide is closed.

Suitable arrangement shall be made for on all the sluice gates or actuators such that the portable electrical actuator is capable of operating all sizes of sluice gates.

One No. of portable type electrical actuator for closing and opening of sluice gates shall be provided at each STP, so that the closing and opening operation time shall be maximum of 10 min.

Suitable arrangement shall be made on all the sluice gates or actuators such that the actuator is capable of operating all sizes of sluice gate, under this contract.

Pipe hood shall be provided on the top of headstock to protect the spindle from damage dirt, dust, water etc. The hood shall be made of transparent fracture resistant polycarbonate material. The hood shall have vent holes to prevent condensation.

The material of construction of sluice gate shall be as follows:

Component	**Material**
Wall thimble	CI: IS 210 Gr. FG 260
Frame & Slide	CI: IS 210 Gr. FG 260
Seating Faces	SS : ASTM Countersunk Fixing A276 type 316
Wedge	CI: IS 210 Gr. FG 260
Stem	SS: ASTM extension A276 type 316
Stem guide bracket	CI: IS 210 Gr. FG 260
Stem nut	SS : ASTM A743 CF8M
Stem Coupling	SS: ASTM A276 type 316
Fasteners, Anchor	SS: ASTM A276 type 316
Lifting Mechanism, pedestal gear house cover and stem guide	CI: IS 210 Gr. FG 260
Lift nut	Bronze : ASTM B 148 (CA 952, CA 954 or CA958)
Headstock Body	CI: IS 210 Gr. FG 260

1.3.16 Open channel Gates

The manufacture of open gate channel shall be in accordance with manufacturer's standard.

All open channel gate shall be of the rising spindle type and manually operated.

Open channel gates shall be tested as per manufacturer's standard.

The open channel gates for pumping station shall be CI sluice gates. All other gates shall be of marine grade aluminium alloy gates.

The material of construction shall be as follows.

Components	**Material**	**Specification**	**Grade**
Gate frame, Shutter, headstock, Flush bottom seal support bar, stop nut	Cast Iron	IS 210-1993	FG:260
Sealing Faces / Seat Facings	SS	ASTM A276	AISI: 316
Resilient rubber seal	Natural Rubber EPDM Rubber Neoprene Rubber		
Seal retainer bar	SS	ASTM A276	AISI: 316
Stem/Spindle	SS	ASTM A276	AISI: 316
Operating Nut/Stem nut	Leaded Tin Bronze	IS:318-1981	LTB 1, LTB 2
Fasteners	SS	ASTM A276	AISI: 316
Anchor Bolts	SS	ASTM A276	AISI: 316
Yoke	MS	IS: 2062-1992	Grade A

1.3.17 Submersible Mixers

i). The submersible mixer shall be installed in the Anaerobic and anoxic zones, and they shall be capable of providing a velocity gradient in the range of 500 to 1000 mm/sec.
ii). The mixer shall have a self-cleaning propeller optimised for effective mixing and vibration-free running, and required power shall be at least 10Watt/m3 of tank volume.
iii). The mixer shall be driven by a high efficiency 3 phase motors IP68 Class F. Motor shaft and rotor shall be dynamically balanced.
iv). Bearings shall be lubricated-for-life with a calculated life of more than 100,000 operating hours.
v). The mixers shall have the flexibility to be located at different depths and thereby avoiding dead zones.
vi). The mixer shall be provided with the following :
(1) Lifting frame with a winch which can be dismantled, fee standing with adjustable boom length.
(2) Mounting socket for free standing hoist suitable for wall mounting.
(3) Guide for floor fixing components and support brackets for wall mounting.
(4) Stainless steel rope for raising and lowering the mixer.
(5) Rope block for holding the stainless steel rope where the lighting frame is used in different locations.
(6) Support rope for reliable support and guidance of power supply cable.
(7) Support clamps and hooks to support the power supply cable in such a manner that it is not under strain.
vii). The propeller, propeller shaft and motor housing shall all be of SS 316.

1.3.18 Mechanical Floating Mixer

(a) General

Mechanical floating mixer and related equipment accessories shall consist of a motor, direct-drive impeller driven at a constant speed, an integral flotation unit, and impeller volute.

(b) Performance

Each mixer shall have a zone of complete mix and a direct pumping with a recirculation. Complete mix shall be defined as maintaining biological suspension of all mixed liquor suspended solids with design MLSS or less without the introduction of air.

(c) Mixer Drive Motor

The motor shall be rated for 415 volt, 50 hertz, three-phase service. The motor shall be standard efficiency, vertical P base design, totally enclosed fan cooled TEFC, and generally rated for severe duty. The motor shall in all cases equal or exceed standard NEMA specifications. A minimum service factor of 1.15 shall be furnished.

The motor winding shall be non-hygroscopic, and insulation shall equal or exceed NEMA Class "F". A labyrinth seal shall be provided below the bottom bearing to prevent moisture from penetrating around the motor shaft. A condensate drain shall be located at the lowest point in the lower-end bell housing. Unit shall have a one-piece motor shaft continuous from the top motor bearing, through the lower bearing and down to and through the propeller. The shaft shall be manufactured from high quality stainless steel. Motor bearings shall be regreasable. Sealed bearings are not acceptable.

(d) Motor Mounting Base

The motor shall be securely mounted onto a solid 316 stainless steel base which is integral with the motor base extension. All submersed wetted motor mounting base components shall be constructed of 316 stainless steel.

(e) Floatation

Each unit shall be equipped with a modular float constructed of fiber reinforced polyester skin FRP or equivalent with a central float passage of a size to allow installation and removal of the pump impeller. The float shall be foamed full of polyurethane foam of the closed cell type, and shall be totally sealed to prevent the foam from being in contact with the external environment.

(f) Impeller

The impeller shall be designed to pump the liquid from near the surface and direct it down toward the vessel/basin bottom. The impeller shall be a two-blade marine type precision casting of 316 stainless steel and shall be specifically designed for the application intended. It shall be dynamically and hydraulically balanced. The propeller must be attached to the motor shaft with a hardened stainless steel pin and set screw. Impeller shall be capable of being reversed to cause back flow liquid movement without causing damage to the mixer chassis and without causing upflow liquid damage to the motor bearing and windings. No liquid spray or other liquid leakage upward onto the surface of the motor support surface or flotation chassis will be allowed.

(g) Intake Volute Assembly

The impeller shall operate in a volute made of 316 stainless steel plate

(h) Vibration

The entire rotating assembly including the motor rotor, shaft, shaft accessories, and impeller shall be dynamically balanced within 2.0 mils peak-to-peak horizontal displacement measured at the upper and lower motor bearing. Measurements shall be taken at a frequency equivalent to the motor RPM. Measurements shall be taken with the motor in a

vertical, shaft down position with the entire power section mounted on resilient pads.

(i) Cable Mooring System

Each unit shall be provided with a maintenance cable mooring system complete with mooring cable, clips, thimbles, quick disconnects, anchors, and extension springs as shown on the drawings. Mooring cable, anchors, and hardware shall be 316 stainless steel. Field attachment of mooring points to the tank shall be the responsibility of the installing contractor.

(j) Cable Mooring Electrical Service Cable

Each unit shall include conductor power cable wired into the motor conduit box and terminating at the basin wall. Electrical cable shall be supplied with kellems grips at the motor and basin wall terminations. Electrical cable floats for flotation of electrical service cable shall be provided. Attachment of cable and supply of junction box/disconnect at the basin wall shall be the responsibility of the installing contractor. 316 stainless steel adhesive anchors for attachment of mooring system components to the basin wall shall be provided.

1.4 Pumps

1.4.1 Dry Pit Pumps

1.4.1.1 General

The total head capacity curve shall be continuously rising towards shut off with the highest at shut off.

i). Pumps shall be suitable for single as well as parallel efficient operation at any point in between the maximum and minimum system resistances.
ii). Pumps shall run smoothly without undue noise & vibration. Noise level shall be limited to 85 dB(A) at 1.86 M at sites. Vibration shall be limited to class II C of BS 4675/ zones A & B of ISO 10816-1The pump set shall be suitable for starting with discharge valve open or closed.
iii). The pump set shall be capable of withstanding accidental rotation in reverse direction.

1.4.1.2 Features of Construction

i). Pump shall be centrifugal, back pullout, single stage type.
ii). Pump casing shall be of robust construction. Liquid passages shall be finished smooth and designed so as to allow free passage of solids. The volute tongue shall be straight across and filed to a smooth rounded edge. Casing shall be provided with wearing ring.

iii). Hand hole shall be provided in the casing to allow easy access to the impeller as well as to the casing throat. Casing drain connection with stainless steel collared plug shall be provided.

iv). Impeller shall be non clog type with smooth blunt edges and large water ways so as to allow free passage of the 50 mm size solids. It shall be free from sharp corners and projections likely to catch and hold rags and stringy material.

v). The critical speed of the rotor shall be at least 30% above the operating speed. Complete rotor shall be balanced dynamically as per ISO 9906

vi). Replaceable shaft sleeves shall be provided and shall be securely locked or keyed to the shaft to prevent loosening. The surface hardness of the shaft sleeve shall be minimum 400 BHN.

vii). Bearings shall be easily accessible for inspection and maintenance. The bearings shall have a minimum working life of 40000 hours of working. Bearings shall be grease lubricated or non grease type.

viii). Stuffing boxes shall be of such design that they can be repacked without removing any part other than gland and lantern ring. Stuffing box drain with pipe connection shall be provided at the lowest point so that no leakage accumulates in it.

ix). Lantern ring shall be sandwiched between packings and shall be easily removable. Lantern ring shall be of axially split type. Grease shall be used for stuffing box sealing. Water will not be available for this purpose.

x). The pump and motor shall be coupled through a flexible coupling. The motor shall be mounted directly on pump casing.

xi). It should be possible to lift the complete pump vertically through the opening provided in the motor floor level in the pumping station.

xii). Tapings shall be provided at suction and discharge nozzles for pressure gauge connection. Water flushing arrangement shall be provided for cleaning of sludge pipe line at its delivery side.

xiii). Impeller wear ring hardness shall be min 50 BHN higher than that of Casing wear ring.

xiv). The material of construction for Centrifugal Dry Pit Pump shall be as follows :

Sr. No.	**Component**	**Material**	
		Non-clog type	**For clean water (for service water etc)**
(i)	Impeller *	Stainless Steel : ASTM A 743 CF8M	Cast Iron to BS EN : 1561 Gr EN-GJL-200 with 1.5 to 2% Nickel, or better
(ii)	Casing *	Cast Iron to BS EN : 1561 Gr EN-GJL-200 with 1.5 to 2% Nickel	Cast Iron to BS EN : 1561 Gr EN-GJL-200 with 1.5 to 2% Nickel
(iii)	Shaft*	Stainless Steel : BS:970 Gr 431 S29	Carbon steel or better
(iv)	Shaft sleeve	Stainless Steel : ASTM A 743 CA 15 Hardness 400 BHN	Stainless Steel : ASTM A 743 CA 15 Hardness 400 BHN
(v)	Casing ring	Stainless Steel : ASTM A 743 CA 15	Stainless Steel: ASTM A 743 CA 15

(Vi)	Impeller ring	Stainless Steel : ASTM A 743 CA 15	Stainless Steel: ASTM A 743 CA 15

* Material test certificates shall be furnished by the Contractor

1.4.2 Submersible Pumps - General

Submersible pumps shall be of the single entry design supplied complete with boltless self-aligning duck-foot assemblies giving automatic connection to the discharge pipe work.

The total head capacity curve shall be continuously rising towards the shutoff with the highest at shutoff.

Pumps shall be suitable for single as well as parallel efficient operation at any point in between the maximum and minimum system resistances.

The pumps shall be designed to handle solid sizes of up to 80 mm.

Pumps shall run smooth without undue noise and vibration.

The pump set shall be suitable for starting with discharge valve open and/or closed.

The pump set shall be capable of withstanding the accidental rotation in reverse direction.

Construction Features

i). Pump shall be centrifugal, vertical spindle, non-clog, wear resisting, single stage type.

ii). Pump casing shall be of robust construction. Liquid passages shall be finished smooth and designed as to allow free passage of solids. The volute tongue shall be filed to a smooth rounded edge.

iii). Double mechanical seal shall be provided to protect the motor from ingress of liquid along the shaft. The preliminary and secondary seals shall be oil-lubricated with tungsten carbide or silicon carbide faces and they shall be equipped with an electrical monitoring system for seal failure detection. Sensors are to be provided to detect if leakage of liquid into oil housing is above 30% concentration.

iv). Double mechanical seals shall be provided to protect the motor from ingress of sewage along the shaft. the preliminary and secondary seals shall be oil-lubricated with tungsten carbide or silicon carbide faces and they shall be equipped with an electrical monitoring system for seal failure detection.

v). Impeller shall be non-clog open/semi open type for raw sewage and sludge application and enclosed type for clear water/treated sewage / filter rate pumping application with smooth blunt edges and large water ways so as to allow free passage of the large size solids. It shall be free from sharp corners and projections likely to catch and hold rags and stringy materials. The number of impeller vanes for pumps up to 1000 m3/hr shall be limited to two and shall be limited to three for the

pumps higher than 1000 m3/hr.

vi). The critical speed of the rotor shall be at least 30% above the operating speed.

vii). Pump sets shall have double bearings. the bearing life shall be minimum 40,000 hrs of operation.

viii). Each pump shall be complete with a CI delivery connection arrangement for fixing to the concrete floor of the suction well. All necessary SS fixtures required for guiding the pumps during lifting/lowering shall be provided. The installation shall facilitate automatic installation and removal of pump without a person entering the wet well. Each pump shall be provided with a SS-316 lifting chain with suitable provision for engaging the hook of the crane at 1 m interval.

ix). Each pump shall be provided with an automatic coupling device for attaching the crane hook to the pump at low level, even whilst the pump is submerged, without the need for personnel to enter the wet well. This automatic coupling devise shall easily and automatically couple and uncouple the hoist hook and be complete with necessary accessories. All links and cables shall be multi-stranded SS.

x). The submersible pumps shall be suitable for operation with or without submergence.

xi). The pump shall start and stop automatically based on the level in the wet well.

xii). The synchronous speed shall not exceed 1500 rpm at 50 Hz supply.

xiii). The material of construction for submersible pumps shall be as follows:

Sr. No.	**Component**	**Material**
1	Impeller	SS : ASTM A 743 CF8M
2	Casing	CI, IS: 210 Gr FG 260 with 1.5 to 2 % Nickel
3	Shaft	SS : BS:970 AISI Gr 316
4	Bush	Bronze IS 318 Gr LT B2
5	Guide Rail Pipe	SS : BS 970 AISI Gr 316
6	Fasteners and Foundation Bolts	Ss : BS:970 AISI Gr 316

Material test certificates shall be furnished by the Operator and shall have the approval of Engineer.

The submerged cable shall be a multi-core flexible cord, Vulcanized rubber insulated with tough rubber sheath and outer PCP sheath to BS 6500.

Where both thermal protection and moisture-sensitive devices are incorporated within the pump, both devices shall be brought out via separate conductor within the motor cable, although one such conductor may be common.

1.4.3 Centrifugal Pumps

i). Centrifugal pumps shall have head/quantity characteristics which fall continuously from the maximum pressure at closed valve conditions and which are steep in order that variation in head shall have a minimal effect on the quantity discharged.

ii). The design speed of any pump with a duty flow greater than 20 l/s shall not exceed 1500 rpm. Pump motor rating shall exceed the maximum pump power consumption over the operational range of the pump by at least 10%.

iii). Waterway through the pump shall be smooth in finish and free from recesses and obstructions. Impeller passageways shall be as large as possible. The leading edges of the impeller vanes shall be rounded and smooth.

iv). Water velocities in the pump suction side shall not exceed 1.5 m/s and on delivery branches of a pump the velocity shall not exceed 2.0 m/s when the pump is operating within its specified duty range and within this working range there shall be no discernible noise due to hydraulic turbulence or cavitations within either the pump or its associated pipe work and valves.

v). The NPSH requirements of the pumps, based on the 3% output drop criterion shall be at least 2 m less than the NPSH available at every working condition.

vi). The velocity of vibration shall be within 4.5 mm/sec. Combined noise level of pump motor system shall be limited to 85 dB(A) at a distance of 1.85 m from the equipment, at manufacturer's works / free field condition at site after erection.

vii). The pump shaft shall be of SS BS:970 Gr 410S21 compatible with the impeller which shall be of stainless steel ASTM A743 CF8M and the impellers and shaft sleeves shall be secured to the shaft by means of a key/s. The impeller retaining nut shall be fitted with a locking device. The pump casing shall be of cast iron to IS 210 Gr. FG 260, wearing rings shall be of bronze to IS: 318 Gr. LT B2 and shaft sleeve shall be of SS ASTM A 743 CA 15.

viii). All parts exposed to wear shall be adequately protected by means of renewable sleeves, bushes, wear rings etc. which shall be arranged for easy inspection, adjustment, or replacement without removal of the pump casings, pipe work etc, or the need to disturb the drive shaft alignment.

ix). The pump thrust shall be taken by a combined thrust and radial type bearing assembly capable of taking the weight of the moving parts and the hydraulic load under all conditions of the operation with minimum life of 100 000 hours.

x). Bearing cooling arrangement if used shall be designed on the closed-circuit principle; open discharge of cooling water into the pumping station drainage system is not permissible.

xi). The pump casing and other parts of the pump subjected to pressure shall be hydraulically tested by the manufacturer to at least one and half times the maximum working pressure.

xii). Integral inlet & discharge flanges shall be provided and integral lifting lugs shall be incorporated.

xiii). Facilities shall be provided for the removal of air during priming and for draining.

xiv). Glands may be fitted with mechanical seals or conventional soft packing. The gland arrangement shall be designed for easy adjustment and removal of the seal.

xv). When soft packed gland are used suitable means shall be provided for collecting and preventing splashing of the gland leakage water.

xvi). Drainage and gland leakage water shall be piped into the building drainage system.

xvii). The shaft of the pumps fitted with conventional packed glands shall be fitted with removable gland sleeves.

xviii). The rotating element of the pump and the motor shall be readily removable from the pump casing without the need to disconnect the adjoining pipe work.

xix). Rotating assemblies of the pumps of 100 mm dia. inlet and over shall be statically and dynamically balanced and shall be designed so that the first critical speed is at least 50% greater than the maximum operating speed.

xx). Lubrication arrangements shall be so designed that there is no contamination of the pumped fluid.

xxi). On pumps of 75 mm inlet and over, tapping shall be provided at both the suction and discharge flanges of suitable size for pressure gauges.

1.4.4 End Suction Pumps

i). End suction pumps shall be horizontally mounted complete with drive motor on a common base plate. The pump/Drive coupling shall be of the spacer type to facilitate removal of the pump rotating element and bearing housing without dismantling the pump casing, adjoining pipe work or drive motor. These types of pumps shall be used for filter backwash, Chlorination motive water and service water pumping applications etc.

ii). The dimensions of the pump shall be metric confirming to BS 5257 or its equivalent standard. Flanges shall conform to BS EN 1092-2/BS 4504/ IS 1538.

iii). The bedplate shall be of substantial fabricated steel construction with floor fixing bolt holes ready drilled. All holding down bolts etc. shall be supplied with the units.

iv). The velocity at the entrance to the pump impeller shall not exceed 3.5 m/s.

v). Impellers shall be provided with means to prevent abrasive matter reaching the glands and with fully shrouded impellers, to prevent the trapping of matter between the impeller vanes and the casing.

vi). The speed of any pump shall not exceed 1500 rpm.

vii). Glands may be fitted with suitable mechanical seals or conventional soft packing. The gland arrangement shall be designed for easy of adjustment or removal of the seal or packing material. Shafts shall be sleeved around the area of the gland when soft pack gland are used.

viii). Flushing facilities shall be provided for mechanical seals or packed glands where pump fluid may be contaminated with abrasive material. Where soft packed gland are used, means shall be provided for collection of the gland leakage water, which shall be piped into the drainage system through adequately sized ports.

ix). Lubrication arrangements shall be so designed that there is no contamination of the pumped fluid.

x). The pumps and associated pipe work shall be wherever possible, arranged so that air can be completely expelled during priming. Where this is not possible, facilities shall be provided for the removal of the trapped air. Adequate facilities shall be provided for drainage of the pumps for inspection purposes.

xi). Tapping shall be provided at both the suction and discharge flanges for pressure gauge equipment.

1.4.5 Pump performance Guarantees

i). The pump performance guarantee shall relate to the flow rate, the total head and the efficiency of the pump when tested at the manufacturer's work and shall obtain approval of engineer.

ii). The pump shall operate at its design point within acceptance tolerances for flow rate and total head laid down in BS EN ISO 9906:2000.

iii). Each pump shall be tested at the manufacturer's work in accordance with BS EN ISO 9906:2000 or other relevant standards in conjunction with one of the contract motors.

iv). This test shall be carried out on at least one pump set using the flexible coupling and contract drive shaft arrangement to establish that the drive arrangement with supports and couplings operates satisfactorily under all operating conditions.

v). Where similar drive shaft arrangement have been installed by the operator and have been proven satisfactory in service this requirement may be withdrawn subject to the approval of the engineer.

vi). A test shall be carried out of the performance from closed valve to the maximum quantity that can be delivered under abnormally low discharge heads.

vii). Sufficient reading shall be taken at each test to produce accurate curves of the heads, flow, pump speed and power required at pump coupling throughout the operating range of the pump.

viii). Vibration and noise dB(A) levels shall be measured and shown to be acceptable and shall have Engineer's approval. The operator shall have engineer approval and provide acceptable test certificates, showing the NPSH requirement for the pump is at least 2m less than the NPSH available under all working conditions.

ix). in the absence of the approved test certificates the supplier shall carry out a test on one pump of each type to verify the NPSH requirement based upon the 3% output drop criterion and shall taken approval of Engineer.

x). The certificates shall be submitted to the Engineer immediately following each of the test mentioned above. Performance curves shall also be incorporated in the operation and maintenance manual.

Single Pump Operation

i). Head / Quantity Curve

ii). Motor kW input/Quantity curve

iii). Overall efficiency/quantity curve

iv). NPSH required/quantity curve

v). Vibration and Noise dB(A) levels.

Parallel Pump Operation

i). Head / Quantity Curve
ii). Motor kW input/Quantity curve
iii). Overall efficiency/quantity curve
iv). NPSH required/quantity curve
v). Vibration and Noise dB(A) levels.

1.4.6 Progressive Cavity Pumps

i). These pumps shall be used for handling thickened sludge transfer/feed applications.
ii). Pumps shall be of the type in which a pumping action is generated by a helical rotating eccentrically within a resilient stator in the form of a double internal helix. The eccentric motion of the rotor shall maintain a constant seal across the stator as it travels through the pumps to give a uniform positive displacement.
iii). Pumps shall be arranged generally with a single shaft seal at the suction end. Mechanical seals shall be used. If a flexible shaft is used to accommodate the eccentric motion, a corrosion resistant shroud shall be fitted to prevent fibre build-up on the shaft. Enlarges inspection access holes shall be fitted to the suction chambers of all pumps for periodic removal of accumulated debris.
iv). The shaft bearing shall be positively isolated from the fluid being pumped.
v). The rotor material shall be selected and abrasion resistance for the fluid being pumped, and for prolonged service life. Hard chrome of other approved coating shall be not less than 250 micron thickness and shall be diffused in to the base material. The rotor shall generally be single stage and shall incorporate not less than 3600 of twist, but for high-end applications, it may be necessary to use more than a single stage. the stator shall be of a resilient material selected for chemical and abrasion resistance for the fluid being pumped.
vi). Pump speed shall suit the application, where variable delivery output is needed; the pump shall be provided with a variable speed drive. The size and speed range of the pump shall ensure that the highest expected duty point shall lie within the available speed range.
vii). Pumps shall normally be driven by a fixed-speed electric motor through reduction gearing and the combined drive shall be continuously rated. Pump and motor shall preferably be mounted in-line on a common base plate. Alternatively, the drive motor may be top mounted above the pump to minimize floor area, and shall be connected by external V-belts and pulleys. V-belt drive shall have full guards of the type that allow the belts observed without removal of the guard. Facilities shall be provided for ready adjustment of belt tension.
viii). Coupling guards shall be provided, which shall be rigid, securely fixed, and designed so that removal is not necessary during normal operation, routine maintenance and routine inspections. All motor enclosures shall be provided with ingress protection to IP55. Motor anti-condensation heaters shall be provided and shall be suitable for use on a 220V single phase, 50Hz supply.

ix). All bearing shall have a B10 design life not less than 40,000 running hours and shall be designed for loading 20% in excess of calculated maximum loading, pumps shall be fitted with individual dry-running protection to initiate pump trip. Dry-running protection by 'under-current' monitoring of 'pipeline-intrusive' device shall not be used.

Material of Construction.

Component	**Material**
Pump housing	CI IS 210 Gr. FG 260
Rotor	SS AISI 316 (hard chrome Plated)
Shaft	SS AISI 410 (hard chrome Plated)
Stator	Nitrite Black
Type of drive	V belt & pulleys
Base plate	MS Fabricated
Seal Type	Gland Packing (Asbestos free)

1.4.7 Chemical dosing Pumps

i). Chemical dosing pumps shall be piston diaphragm or mechanical diaphragm type as specified. Pump may be simplex or duplex arrangements to suit the capacity or process requirements. The pump design shall incorporate positive stroke return. The maximum stroking speed shall not exceed 100 strokes per minute. Pump, motor and driving arrangement shall be mounted on a robust combined base plate.

ii). Pump liquid ends shall be selected for compatibility with the pumped liquid. Suction and discharge valves shall be the single ball type allowing a free flow self cleaning action. Ball and seat materials shall be resistant to abrasion.

iii). Pumps shall incorporate a variable stroke mechanism to allow the output to be varied while the pump is running. Stroke adjustment shall be manual or where specified by electrical or pneumatically controlled stroke positioner. A stroke length indicator and digital stroke counter shall be fitted, Pumps shall be driven by a flange mounted IP 55 motor, via an oil bath reduction gearbox and variable stroke mechanism giving step less adjustment between zero and maximum stroke length. where flow proportional dosing is required the variation of output shall be achieved by varying the speed of the pump motor and not the pump stroke length.

iv). The normal operating range of dosing pump shall be not less than 6:1.

v). Mechanical Diaphragm: Diaphragm rigidly coupled to the drive train. Single suction pumps and discharge valves. Glandless. Accuracy: 3% of stoke.

vi). Piston Diaphragm pumps: Diaphragm hydraulically operated by liquid displaced by a plunger and protected from excess pressure via a relief valve. Accuracy: 2% of the

stroke.

vii). Material shall be selected to suit the chemical being pumped. Liquid end shall be polypropylene, AISI 316 SS, Glass or Hastelloy C. Diaphragm material shall be butyl rubber, PTEE, or Hypalon and glans shall be PTEE or Neoprene.

viii). Each pump shall be provided with inlet and outlet isolating valves and where necessary with pressure relief and non-return valves. dosing pumps shall be provided with back pressure loading valves and pulsation dampeners in the delivery lines depending on the downstream conditions.

ix). A relief valve shall be incorporated in the delivery lines under conditions where the pump discharge pipe may be shut off or where pressure may rise to an excessive point. the relief valve shall be sized to handle the system pressure and to discharge maximum pimp output freely, and shall be located in the discharge line between the pump and the first downstream isolating valve or in the case of dosing pumps the back pressure loading valve. Relief valves when used on the pumps handling non-hazardous chemicals shall discharge the vented liquid to waste. When used on hazardous chemicals the valve outlet shall be piped back to the suction supply tank or bounded area. The open end of the return pipe shall be located where it is visible, so that any relief valve leakage/operation can be detected.

x). Pump transferring/dosing chemicals to system under pressure shall incorporate a pressure gauge on the pump delivery. Air cocks shall be provided for release or air where necessary.

xi). Unless otherwise specified flushing connection shall be provided at each inlet and flushing shall be manual. when flushing, water shall be discharged either locally through a drain valve or to the point of application of the chemical. Facilities shall also be provided for flushing chemical pump suction and delivery manifolds and delivery lines to point of application.

xii). Dosing Pumps and motor shall preferably incorporate an integral reduction gearbox drive which shall be totally enclosed and oil bath lubricated. the Gear box shall incorporate the cams for the diaphragm drive and shall provided with filling and drain connections and visible oil level indication.

1.4.7.1 Chemical Tank and Mixer

i). General

This tank shall be used to dissolve the alum or polymer to a constant concentration and feed the solution to the outlet channel of the aeration tank or the dewatering equipment. It shall be a vertical tank and shall be composed of tank main body, mixer, manhole, electrical level gauges, direct reading level gage, ladder, air exhaust pipe etc.

ii). Fabrication

(a) The tank shall be made of corrosion resistant material.

(b) The tank shall be provided with a removable cover to prevent chemical scattering, and also with a vent pipe.

(c) The tank shall be provided with necessary mounting seats for overflow pipe, etc.

(d) The motor-driven mixer shall be vertical speed reducer, direct-coupled type of 2-stage propeller type, as a rule and shall be constructed to endure continuous operation free from vibration, etc. The mixer shall be at the center or at a position off the center according as the tank being angular or circular.

(e) The mixer shall be protected by electrical prevention of dry operation.

(f) The tank shall be constructed to seal gas and splash from below at the area where the mixer shaft drive portion passes through.

(g) Alum feed cage of stainless steel shall be provided inside the alum solution tank.

iii). Materials

(a) Main Tank body : GRP/HPDE or equivalent
(b) Mixer frame : SS316
(c) Mixer shaft : SS316
(d) Blade : SS316

iv). Accessories (per Unit)

(a) Foundation bolt and nut 1 set
(b) Air vent pipe 1 set
(c) Mixer 1 unit
(d) Direct reading level gauge 1 unit

1.4.7.2 Alum Dispersion Rapid Mixer

i). The alum dispersion rapid mixer shall be in-channel submersible chemical vacuum induction unit and consist of chemical induction unit with mount bracket, guide rail assembly, floor mount base, boom hoist with manual brake winch and SS 316 cable, hose assembly, control panel and submersible power cable.

ii). The unit shall be provided instantaneous diffusion / mixing and the highest level of durability and performance required for chemical feed application.

iii). The hermetically sealed SS 316 motor shall provide the highest level of durability and performance required for chemical feed applications. All wetted materials shall be constructed from Grade 2 Titanium (unalloyed) and shall be designed for use with all common water and wastewater treatment chemicals. The mounting bracket shall be engineered for installing in open-channel applications.

iv). The material of construction of chemical induction shall be as follows:

S. No.	Component	Material
(i)	Vacuum chamber	SS
(ii)	Vacuum port	SS
(iii)	Vacuum enhancer	Non-metallic
(iv)	Propeller	SS
(v)	Propeller bolt	SS
(vi)	Shaft	SS
(vii)	Mechanical seals	Carbon /ceramic
(viii)	Hardware	SS 316

1.5 Pipe work

1.5.1 Pipe work General

All sewage pipes inside the plant premises shall be made of DI internally lined with SRC lining. The treated and chlorinated sewage should be disposed off to the disposal site by closed RCC pipes or DI pipe. In general, the colour code for piping shall be blue for portable water, white for air and red for gas as received colour from manufacturer for all other sewage pipes.

The pipe works for the plant involves procuring, supply, laying and jointing of suitable size electrically welded steel, CI, DI, uPVC, RCC and PSCC pipes along with matching specials etc. as required. All yard piping inside the plant shall be CI or DI. All pipe work and fittings shall be a class rating in excess of the maximum pressure attained in service including any surge pressure. The pipe work installation shall be so arranged to offer ease of dismantling and removal of pumps or major items or equipment. CI/DI piping above ground level shall be only flange jointed and adequately provided with structural/masonry supports.

SS AISI 316 expansion bellow which can take radial and axial misalignment of minimum one percent of the valve nominal size and tie bolts shall be provided. All pipe work shall be adequately supported with purpose-made fittings. When passing through walls, pipe work shall incorporate a puddle flange. flange adapters and union shall be fitted in pipe work runs, where necessary, to permit the simple disconnection of flanges, Valves and equipment.

The operator shall be responsible for ensuring that the internal surfaces of all pipe work are thoroughly cleaned before and during erection and commissioning. Cleaning shall include removal of dirt, rust, scale and welding slag due to site welding. Before dispatch from manufacturer's works, the ends of the pipe, branch pipes etc., shall be suitable removed until immediately prior to connections adjacent pipes, valves or pumps.

All mall bore pipes shall be blown through with compressed air before connection is made to instruments and other equipment. No point of passage of pipes through floors or walls shall be used as a point of support, except with the approval of owner's representative. All underground-buried mild steel piping unless found otherwise necessary, shall be protected by the application of hot coal tar enamel and fibreglass wrapping. The coating shall consist of one coal tar primer one coat, wrapping of fiber glass one more coat of enamel and the final wrap of enamel impregnated fiber glass.

All water supply plumbing pipeline shall be of uPVC class 4 thick-walled inside the premises in concealed piping. they shall be GI class B in external locations and either anchored externally with SS AISI fasteners or appropriately buried below the ground with a sand cushion of 20 cm all round. All sanitary piping shall be of uPVC class 4 suitably buried below the ground with a sand cushion of 20 cm all round. changes in direction on the ground shall be achieved with inspection chambers of 45 cm X 45 cm and heavy-duty CI/steel reinforced fiber glass chamber covers.

1.5.2 GI Pipes

The procurement, supplying, laying, jointing and testing at works and site of galvanized iron pipes and fittings shall be in accordance with IS 1239 (part I and II) and its latest revisions. The general requirements relating to the supply of mild steel tubes shall confirm to IS 138. The sulphur and phosphorus requirements in steel shall not exceed 0.05 % each. The galvanizing of the pipes shall be as per IS 4736. the zinc coating shall be uniform adherent, reasonably smooth and free from imperfections.

The pipes shall be galvanized before screwing. all screwed pipes and sockets shall have pipe threads confirming to the requirements of IS 554. Gauging in accordance with IS 8999 shall be considered as an adequate test conformity of threads of IS 554. Screwed tubes shall have taper threads while the sockets shall have parallel threads.

The specifications for G.I. pipes shall be generally in accordance with Standard specifications. the tolerances on the length shall follow IS 1239 -part I. The fitting for G.I. pipes shall be of mild steel tubular or wrought steel fitting conforming to IS 1239 Part II. The

laying of GI pipes and fitting shall follow the relevant Is codes. These pipes shall be used for drinking water supply for the office and laboratory buildings. The pipes shall be painted with two coats of anticorrosive bit mastic pint.

1.5.2.1 Testing of G.I. Pipes

Hydrostatic test shall be carried out at works at a pressure of 5 Mpa, maintained for at least 3 sec. and shall not show any leakage in the pipe. The tensile strength of length of strip cut from selected tubes, when tested in accordance with IS 1894 shall be at least 320 N/mm2. The elongation percentage shall be as per IS 1239 Part I. The bend test shall also be carried out as per IS 1239. The G.I. Pipes and fittings shall be tested at site after they are laid and jointed as per standard specifications.

1.5.3 Unplasticized Poly Vinyl Chloride (uPVC) Pipes

The latest versions of IS shall be adhered to for the design, manufacturing, inspection, factory tasting, packing, handling and transportation, laying and jointing of the uPVC pipes. The rubbers shall be vulcanized from Ethylene Propylene (EPDM) confirming to IS 5382. The uPVC shall be of minimum 4 kg/cm2 and as per IS 4985 and the pipes for plumbing work in office buildings shall be SWR (type B0 as per IS 13592, with electrometric sealing rubber ring joints. The method of sampling of rubber rings should be as per IS 5382.

The material from which the pipes are made shall consist substantially of unplasticized PVC as per IS 10151, to which only those additives shall be added that are absolutely needed to facilitate the manufacture of the polymer and the production of sound, durable pipes of good surface finish, mechanical strength and opacity. The total quantity of additives like plasticizer, stabilizer, lubricants and fillers shall not exceed more than 7 %. The bulk density of uPVC pipes shall be 1.39 to 1.44 gm/cm3. The PVC resin suspension grade K-66/K-67 shall be used for extrusion of uPVC pipe. The uPVC fittings shall be fabricated from Class 4 uPVC as per IS 4985.

1.5.3.1 Tests on Material:

Following in house tests shall be carried out on the raw material:

- Grade (K-value)
- Particle size Distribution
- Bulk density of resin
- Bulk density of compound

1.5.3.2 Acceptance Test on Pipes:

The acceptance test shall be conducted in accordance with IS 4985 and presence of the

Engineer's representative.

- Visual and dimensional Check
- Reversion test
- Vicat softening test
- Ash content
- Bulk density
- Resistance to external blows
- Internal Hydrostatic pressure test for pipes and joints
- Opacity

1.5.3.3 Marking on Pipes

Each pipe shall be clearly marked as indicated below:

- Manufacturer's name and trade mark
- outside dia in mm
- Class of the pipe and pressure rating
- Month and year of manufacturing
- Length of pipe
- Marking of insert depth of spigot

1.5.3.4 Marking on Rubber ring

Each sealing ring shall be permanently marked with:

- Manufacturer's name and trade mark
- Month and year of manufacturing
- Dia of pipe for which the ring is suitable
- type of rubber material

1.5.3.5 Tests on Rubber Ring

Following tests shall be conducted on rubber rings conformity:

- Hardness
- Tensile strength
- Elongation at break
- Compression test
- Accelerated ageing
- Water absorption
- Stress relaxation

1.5.4 Ductile Iron (DI) Pipes

The Di pipes shall be centrifugally cast (spun) for water and sewage application and confirming to IS 8329-2000. The pipes used shall be both gasket joints and flanged joints. The minimum class of pipe to be used shall be class K-9 as per IS 8329. In general, pipes inside the buildings and below structures shall be jointed as double flanged pipes and those outside the building can either EPDM gasket as per IS 5382 and manufactured by the pipe manufacturer only.

The pipes shall be supplied in standard length of 5.5 m and 6.00 m length with suitably rounded chamfered ends. Any change in the stipulated length should be approved by the engineer's representative. The flanged joint shall be as per IS 8329. The pipe supply will also include one rubber gasket for each flange.

1.5.4.1 Inspection and testing

The pipes shall be subjected to following tests for acceptance:

- Visual and dimensional check as per IS 8329
- Mechanical tests as per IS 8329
- Hydrostatic tests as per IS 8329
- The test reports for the rubber gaskets shall be as per acceptance test of the IS 5382.
- Sampling shall be done as per IS 8329

1.5.4.2 Marking

All pipes shall be marked as per IS 8329 and as show in below:

- Manufacturer's name /stamp
- Nominal diameter
- Class reference
- A white ring line showing length of insertion at spigot end.

1.5.4.3 Packing and Transport

The pipes should be preferably transported by road from factory and stored as per the manufacturer's specifications to protect them from damage.

1.5.4.4 Specials for DI pipes

The DI specials shall be manufactured and tested as per IS 9523 or BS 4772. the mechanical test and hydrostatic test shall be as per IS 9523. The tolerances on the dimensions shall be as per Is 9523. The manufacturer of the pipes shall supply the fittings.

1.5.4.5 Supply

All the DI fittings shall be supplied with rubber rings for each socket. The rubber ring shall be as per IS 12820 and IS 5328. flanged fittings shall be supplied with one rubber gasket per flange and the required numbers of nuts and bolts.

1.5.5 Reinforced Cement Concrete (RCC) Pipes

1.5.5.1 Design

Design of RCC pipes including reinforcement details and the ends of pipes shall be in accordance with the relevant clauses of IS: 458.

1.5.5.2 Manufacturing

The method of manufacture shall be such that the form and the dimensions of the finished pipes are accurate within the limits specified in relevant clause of IS: 458. The surfaces and edges of the pipes shall be well defined and true, and their ends shall be square with the longitudinal axis. The ends of the pipes shall be further reinforced by an extra ring of reinforcement to avoid breakage during transportation.

The RCC pipes and collars/rubber rings shall be systematically checked for any manufacturing defects by experienced supervisors so as to maintain a high standard of quality.

The Engineer shall at all reasonable times have free access to the place where the pipes and collars/rubber rings are manufactured for the purpose of examining and testing the pipes and collars/ rubber rings and of witnessing the test and manufacturing.

All tests specified either in this Employer’s Requirements or in the relevant Indian standards shall be performed by the supplier/contractor at his own cost and in presence of the Engineer if desired. For this, sufficient notice before testing of the pipes and fittings shall be

given to the Engineer.

If the test is found unsatisfactory, the Engineer may reject any or all pipes of that lot. The decision of the Engineer in this matter shall be final and binding on Contractor and not subject to any arbitration or appeal.

1.5.5.3 Manufacturing

For all materials Factory's test result, and written guarantee document with necessary analysis data shall be submitted to obtain the approval of the Engineer before carrying to sites.

1.5.5.3.1 Cement

Cement used for the manufacture of RCC pipes and collars shall conform to relevant IS codes. The use of pozzolana as an admixture to Portland cement shall not be permitted.

1.5.5.3.2 Aggregates

Aggregates used for the manufacture of RCC pipes and collars shall conform to IS: 383. The maximum size of aggregate should not exceed one third the thickness of the pipe or 20mm, whichever is smaller.

1.5.5.3.3 Mixing and Curing Water

Water shall be clean, colour less and free from objectionable quantities of organic matter, alkali, acid, salts, or other impurities that might reduce the strength, durability or other desirable qualities of concrete and mortar. Contractor shall submit water quality report before using it.

1.5.5.4 Reinforcement

Reinforcement used for the manufacture of the RCC pipes and collars shall be mild steel Grade I or medium tensile steel bars conforming to IS:432 (Part-1) or hard-drawn steel wire conforming to IS: 432 (part-2). Reinforcement cages for pipes and collars shall be as per relevant requirement of IS:458.

1.5.5.4.1 Concrete

Concrete used for the manufacture of RCC pipes and collars shall conform to IS: 456. The minimum cement content and minimum compressive strength of concrete shall be as per relevant requirements of IS: 458. Compressive strength tests shall be conducted on 15 cm cubes in accordance with the relevant requirements of IS: 456 and IS: 516.

1.5.5.4.2 Curing

Pipes manufactured in compliance with IS: 458 shall be either water cured or steam cured in accordance with the relevant requirements of IS: 458.

1.5.5.4.3 Dimensions

The internal diameter, wall thickness and length of barrel and collar of pipes, reinforcement (longitudinal and spiral), type of ends and minimum clear cover to reinforcement and strength test requirements shall be as per the relevant clauses / tables of IS:458 for different classes of pipes.

The tolerances regarding overall length, internal diameter of pipes or sockets and barrel wall thickness shall be as per relevant clause of IS: 458.

1.5.5.4.4 Workmanship and Finish

Pipes shall be straight and free from cracks. The ends of the pipes shall be square with their longitudinal axis so that when placed in a straight line in the trench no opening between ends in contact shall exceed 3 mm in pipes upto 600mm diameter (inclusive), and 6 mm in pipes larger than 600 mm diameter.

The outside and inside surfaces of the pipes shall be smooth, dense and hard, and shall not be coated with cement wash or other preparation unless otherwise agreed to between the Engineer and the manufacturer or supplier.

The pipes shall be free from defects resulting from imperfect grading of the aggregate, mixing or moulding.

The pipes shall be free from local dents or bulges greater than 3 mm in depth and extending over a length in any direction greater than twice the thickness of barrel.

The deviation from straight in any pipe throughout its effective length, tested by means of rigid straight edge parallel to the longitudinal axis of the pipe shall not exceed, for all diameters 3 mm for every meter run.

1.5.5.5 Testing

All pipes for testing purposes shall be selected at random from the stock of the manufacturer and shall be such as would not otherwise be rejected under the criteria of tolerances as mentioned in IS: 458.Engineer reserve the right to attend all testing.

During manufacture, tests on concrete shall be carried out as per IS: 456. The manufacturer shall supply, when required to do so by the Engineer the results of compressive tests of concrete cubes and split tensile tests of concrete cylinders made from the concrete used for the pipes. The manufacturer shall supply cylinders or cubes for test purposes required by the Engineer and such cylinders or cubes shall withstand the tests prescribed as per IS:458. Every pressure pipe shall be tested by the manufacturer for the hydrostatic test pressure. For non-pressure pipes, 2 percent of the pipes shall be tested for hydrostatic test pressure.

The specimen of pipes for the following tests shall be selected in accordance with relevant clause of IS: 458 and tests in accordance with the methods described in IS: 3597.

i) Hydrostatic test

ii) Three edge bearing test

iii) Absorption test

iv) Visual Examination

1.5.5.5.1 Sampling

In any consignment, all the pipes of same class and size and manufactured under similar conditions of production shall be grouped together to constitute a lot. The conformity of a lot to the requirements of this Employer's Requirements shall be ascertained on the basis of tests on pipes selected from it.

The number of pipes to be selected from the lot for testing shall be in accordance with Table 15 of IS: 458.

Pipes shall be selected at random. In order to ensure randomness, all the pipes in the lot may be arranged in a serial order and starting from any pipe, every pipe be selected till the requisite number is obtained, or being the integral part of N/n where N is the lot size and n is the sample size.

All pipes selected shall be inspected by Engineer for dimensional requirements, finish and deviation from straight. A pipe failing to satisfy one or more of these requirements shall be considered as defective.

The number of pipes to be tested shall be in accordance with column 4 of Table 15 of IS:458. These pipes shall be selected from pipes that have satisfied the requirements mentioned in the above clause.

A lot shall be considered as conforming to the requirements of IS:458 if the following conditions are satisfied.

The number of defective pipes shall not be more than the permissible number given in column 3 of Table 15 of IS: 458.

All the pipes tested for various tests shall satisfy corresponding requirements of the tests.

In case the number of pipes not satisfying requirements of any one or more tests, one or two further samples of same size shall be selected and tested for the test or tests in which the failure has occurred. All these pipes shall satisfy the corresponding requirements of the test.

All result of tested data must be prepared by contractor at site so that the Engineer shall make decision of “fail or pass” at once. All cost for the test shall be borne by the Contractor.

1.5.5.5.2 Marking

The following information shall be clearly marked on each pipe:

a) Internal and External diameter and length of pipe

b) Class of pipe

c) Date of manufacture and

d) Name of manufacturer or his registered trade-mark or both.

1.5.5.6 Joining

1.5.5.6.1 General

Jointing of RCC pipes shall be done as per the requirements of following Employer’s Requirements and as per the relevant IS standard. After jointing, extraneous material, if any, shall be removed from the inside of the pipe and the newly made joints shall be thoroughly cured. In case, rubber sealing rings are used for jointing, these shall conform to IS: 5382. The pipe joint work must be done neatly and keep even slope and level for pipe laying works.

1.5.5.6.2 Spigot and Socket Joint

The spigot of each pipe shall be slipped home well into the socket of the pipe previously laid and adjusted in the correct position. The opening of the joint shall be filled with stiff mixture of cement mortar which shall be rammed with caulking tool. This joint is used for low pressure pipe line.

1.5.5.6.3 Collar Joint

After laying the RCC pipes at proper alignment and gradient their abutting faces shall be coated with hot bitumen in liquid condition by means of a brush. The wedge-shaped groove in the end of the pipe shall then be filled with a tarred gasket in one length for each joint. The collar shall then be slipped over the end of the pipe and the next pipe butted well against the tarred gasket by suitable appliances approved by the Engineer so as to thoroughly compress the tarred gasket into the grooves, care being taken that the concentricity of the pipes and levels are not disturbed during this operation.

The collar shall then be place symmetrically over the end of the two pipes and the space between the inside of the collar and the outside of the pipe filled with a mixture of cement and sand to withstand any stress and prevent any water leakage, tempered with just sufficient water to have a consistency of the semi-dry conditions, well packed and thoroughly rammed with caulking tools. The joints shall be finished off with a fillet sloping at 450 to the side of the pipe. The finished joints shall be protected and cured thoroughly as directed by the Engineer. Any plastic solution or cement mortar that may have been squeezed into the inside of the pipe shall be removed so as to leave the inside of the pipe perfectly clean.

1.5.5.6.4 Flush Joint (Internal)

This joint shall be generally used for culvert pipes of 900 mm diameter and over. The ends of the pipes are specially shaped to form a self-centring joint with an internal jointing space 13 mm wide. The finished joint is flush with both inside and outside with the pipe wall. The jointing space is filled with cement mortar mixed sufficiently dry to remain in position when forced with a trowel or rammer.

1.5.5.6.5 Flush Joint (External)

This joint is suitable for pipes which are too small for jointing from inside. This joint is composed of specially shaped pipe ends. Each end shall be butted against each other and adjusted in correct position. The jointing space shall then be filled with cement mortar sufficiently dry and finished off flush. Great care shall be taken to ensure that the projecting ends are not damaged as no repairs can be readily affected from inside the pipe.

1.5.5.6.6 Spigot and Socket (Semi Flexible)

This joint is composed of specially shaped spigot and socket ends on the RCC pipes. A rubber ring shall be lubricated and then placed on the spigot which is forced into the socket of the pipe previously laid. This compresses the rubber ring as it rolls into the annular space formed between the two surfaces of the spigot and socket, stiff mixture of cement and mortar shall then be filled into the remaining annular space with a caulking tool.

1.5.5.6.7 Collar Joint (Semi-flexible)

This joint is made up of a loose collar which covers two specially shaped pipe ends. Each end shall be fitted with a rubber ring which when compressed between the spigot and collar, seals the joint. Stiff mixture of cement mortar shall then be filled to withstand stress and prevent any water leakage, into the remaining annular space and rammed with a caulking tool.

1.5.5.6.8 Spigot and Socket Joint (Flexible)

The RCC pipe with the rubber ring accurately positioned on the spigot shall be pushed well home into the socket of the previously laid pipe by means of uniformly applied pressure with the aid of a jack or similar appliance. The RCC pipes shall be of spigot and socket type and rubber rings shall be used, and the manufacturer's instructions shall be deemed to form a part of these Employer's Requirements. The rubber rings shall be lubricated before making the joint and the lubricant shall be soft soap water or an approved lubricant supplied by the manufacturer.

1.5.5.6.9 Cleaning of pipes

As soon as a stretch of RCC pipes has been laid complete from manhole to manhole or for a stretch as directed by the Engineer, Contractor shall run through the pipes both backwards and forwards a double disc or solid or closed cylinder 75 mm less in diameter than the internal diameter of pipes. The open end of an incomplete stretch of pipe line shall be securely closed as may be directed by the Engineer to prevent entry of mud or silt etc.

If as a result of the removal of any obstructions the Engineer considers that damages may have been caused to the pipe lines, he shall be entitled to order the stretch to be tested immediately. Should such test prove unsatisfactory, contractor shall amend the work and carry out such further tests as are required by the Engineer.

It shall also be ascertained by contractor that each stretch from manhole to manhole or the stretch as directed by Engineer is absolutely clear and without any obstruction by means of visual examination of the interior of the pipe line suitably enlightened by projected sunlight or otherwise.

1.5.5.7 Testing at work site

After laying and jointing of RCC pipes is completed the pipe line shall be tested at work site as per the following Employer's Requirements and as directed by the Engineer. All equipment for testing at work site shall be supplied and erected by contractor. Water for testing of pipes shall be arranged by him. Damage during testing shall be contractor's responsibility and shall be rectified by him to full satisfaction of the Engineer. Water used for the test shall be removed from pipes and not released to the excavated trenches.

After the joints have thoroughly set and have been checked by the Engineer and before back filling the trenches, the entire section of the sewer or storm water drain shall be proved by the contractor to be water tight by filling in pipes with water to the level of 1.50m above the top of the highest pipe in the stretch and heading the water up for a period of one hour. The apparatus used for the purpose of testing shall be approved by the Engineer. Contractor if required by the Engineer shall dewater the excavated pit and keep it dry during the period of testing. The loss of water over a period of 30 minutes should be measured by adding water from a measuring vessel at regular 10 minutes intervals and noting the quantity required to maintain the original water level. For the approval of this test the average quantity added should not exceed 1 liter/ hour/100 linear metres / 10mm of nominal internal diameter. Any leakage including excessive sweating which causes a drop in the test water level will be visible and the defective part of the work should be removed and made good.

In case of pressure pipeline, the completed stretch of pipeline shall be tested for site test pressure. The site test pressure should not be less than the maximum operating pressure plus the calculated surge pressure, but in no case should it exceed the hydrostatic test pressure as specified in IS: 458.

All of results of test and inspection data must be prepared by contractor at site so that the Engineer shall make decision of "fail or pass" at once. All cost for the inspection shall be borne by the Contractor.

1.6 Valves

1.6.1 Sluice Valves

Sluice valves shall be of rising spindle type. The valve shall be furnished with a bushing arrangement for replacement of packing without leakage. Shoe and channel arrangement shall be limited to valves of 450 mm and above. The gap between the shoe and channel shall be limited to 1.5 mm.

Valves of 450 mm and above shall be provided with thrust bearing arrangement for ease of operation.

Valves of dia 450 mm and above shall be provided with enclosed gear arrangement for

ease of operation. The operation gear of all valves shall be such that they can be opened and closed by one man against as unbalanced head 15% in excess of the maximum specified rating. Valves and any gearing shall be such as to permit manual operation in a reasonable time and not exceed a required rim pull of 400 N.

All valves, spindles and hand wheels shall be positioned to give good access for operational personnel.

All the hand wheel shall be arranged to turn in a clockwise direction to close the valve. the direction of rotation of opening and closing of the valve shall be indicated on the hand wheels.

The material of construction of Valve shall be as follows:

Sr. No.	Component	Material
1	Body and Doors	CI IS 210 Gr. FG 260
2	Spindle	SS BS : 970 Gr 431
3	Seating rings	SS BS: 970 Gr 316
4	Back Seat Bush	Bronze IS:318 Gr LTB2
5	Shoe and channel linings	SS BS: 970 Gr 316

1.6.2 Knife Gate Valves

i). The valve shall meet the requirements of MSS SP 81 / AWWA C520-10.

ii). Outer body shall be provided with inner liner in corrosion resistant SS which shall extend into gland. The body shall be devoid of any wedge/dead pockets to avoid setting of suspended particles and solids in the service fluid. MOC & Design may be offered as per AWWA C 520-10 also.

iii). The gate/plate shall be precision buffed and the edge contoured to a knife edge. The gate shall move along / be guided by the seat ring to ensure that it scrapes any deposit / scale, enabling smooth uninterrupted movements.

iv). Seat shall be so designed that there is no recess / relieved groove to harbour deposition that could build-up and swamp the valve. The design to also incorporate bosses that guide the gate and avoid deflection, ensuring positive shut off.

v). The stem shall have double start threads cut in order to ensure smooth and speedy operation.

vi). Gland packing shall offer minimal frictional resistance and precludes external lubrication. As positive sealing element, the packing shall also include a resilient rubber ring.

vii). The knife edge and seat face in flow path shall be hard faced to a hardness of 400 to 450 BHN to counter erosion. In such cases, provision shall also be made ensure the

fluid contact with the seat ring minimal.

viii). The material of construction of valve shall be as follows:

Sr. No.	Component	Material
1	Body	CI IS:210 Gr FG 260
2	Inner Lining	SS BS:970 Gr 316
3	Knife gate/plate	SS BS:970 Gr 316
4	Stem	SS BS:970 Gr 316
5	Seat ring/Boss	SS BS:970 Gr 316
6	Gland Housing	DI BS:2789 Gr 500
7	Gland Packing	Teflon Impregnated with the asbestos + rubber

1.6.3 Butterfly Valves

i). This valves shall be installed at the pipe-line to seal the water or air and to adjust the flow/

ii). Valves shall be used suitable for throttling operations and for infrequent operation after period of inactivity.

iii). The body of the valve shall be made from cast iron of ductile iron.

iv). Valves shall have fabricated steel, cast iron or ductile iron discs with a resilient rubber sealing ring.

v). Valves stem, shall be if stainless steel designed for both torsion and shearing stresses when the valve is operated with permanently self-lubricated shaft stub bearing, sized to withstand bearing loads.

vi). Butterfly valves shall be provided with hand-wheels and rack and pinion gearing operation. the valves shall be open by turning the hand wheel in an anticlockwise direction. the direction of valve opening and closing shall be marked on the hand wheel casing.

vii). The valve shall be designed to hold the disc in any intermediate position between fully opened to fully closed without creeping or fluttering by manual or electrical operation.

viii). The material of construction of valve shall be as follows:

Sr. No.	Component	Material
1	Body	CI IS 210 Gr. FG 260
2	Disc	CI IS 210 Gr. FG 260
3	Stem	SS 316
4	Seat	Rubber or Equivalent

1.6.4 Non Return Valves

i). The internal parts of the valves shall be easily accessible for inspection through inspection hole.
ii). Hydraulic passages and door shall be designed to avoid cavitations.
iii). Valves shall be of swing type or ball type. Ball valves must house a freely moving ball in such a way that return flow is effectively prevented.
iv). Valves shall be quick closing type with non-slam characteristics. In case of swing type , the nonslam characteristics shall be achieved by providing suitable combination of door and hydraulic passages without any external level/damping arrangement.
v). Valves of 450 mm and above shall be provided with supporting foot
vi). Swing door valves of size 600 mm and above shall be of multi door type.
vii). Direction of the flow shall be clearly embossed on the valve body
viii). Maximum pressure drop across the valve shall be 0.4 mm WC
ix). Maximum allowable leakage rate shall be 7 cc/hr/mm diameter.
x). The material of construction of valve shall be as follows

Sr. No.	Component	Material
1	Body & Door	CI IS 210 Gr. FG 260
2	Body and door Ring	SS ASTM A743 CF8, BS 970 Gr. 316 S11
3	Hinge Pin	SS BS 970 431 S49
4	Bearings	Teflon

1.6.5 Telescopic Valves

i). the telescopic valve shall be a proprietary item of proven design manufactured in CI and adjustable to cater for 1000 mm variation in level.
ii). The bell mouth height shall be controlled by a hand wheel operated from top of the chamber.
iii). The bell-mouth, pipe work, spindle and headstock shall be robustly constructed with adequate brackets of cast iron.
iv). The ball mouth shall be connected by swept tees to a CI sludge outlet pipe of 300 mm diameter.
v). Material of construction shall be as follows.

Sr. No.	Component	Material
1	Bell Mouth	CI IS : 210 Gr. FG 260
2	Piping	CI IS 210 Gr. FG 260
3	Spindle	SS 316
4	Hand Wheel	CI IS 210 Gr. FG 260

1.6.6 Pressure / Vacuum relief Valves

i). Pressure relief valves shall be capable of relieving pressure in the system to prevent the system being pressurized in excess of a present maximum allowable pressure. the valves shall be drops tight under no flow conditions.
ii). Vacuum relief valves shall be capable of preventing the vacuum pressure to be developed in the system by allowing air entry. The valves shall be drops tight under no flow conditions.
iii). The valve operation shall be achieved by the interaction of the inlet pressure and an intermediate pressure produced by a pilot valve or relay system acting on the upper side of the main valve.
iv). The pilot valve or relay system shall be actuated by a diaphragm connected to the inlet pressure on its underside and a constant pressure on its upper side derived either from weights or from a spring.
v). Body ends shall be flanged and drilled to BS 4504.

1.7 Material Handling Equipments

Contractor shall supply, install, test, commission and maintain the material handling equipments which shall be required for normal operation and/or maintenance of the STP. the selection and sizing of the equipments shall be based on the requirements of the equipment to be maintain.

1.7.1 Electrically Operated Hoists

i). Electrical hoists shall be complete with hoisting motor, wire rope drum, wire rope, hook, necessary gearing, sheaves, electromagnetic brake for hoisting motion, weather & dust proof push button station, operator panel, all wiring, limit switches, etc.
ii). Electric hoist shall confirm to IS: 3938 and shall be suitable for outdoor application. All the parts of the hoist shall be designed to withstand surrounding atmospheric conditions without any deterioration.
iii). Rope drums shall be either cast or welded to sustain concentrated loads resulting from rope pull.
iv). Drums shall be machined grooved right and left with grooves of a proper shape for the rope used.
v). Gears shall be cut from solid cast or forged steel blanks or shall be of stress-relieved welded steel construction or built-up from steel billets and welded together to form a one piece gear section.
vi). Hoist ropes shall be extra flexible, improved plough steel rope with a well lubricated hemp core and having six strands of 37 a wires per strand with minimum ultimate tensile strength of 1.6 X 106 kN/m2.
vii). Hooks shall be solid, forged, heat treated alloy or carbon steel of rugged

construction of the single hook type and provided with a standard depress type safety latch.

viii). Hoisting motor shall be equipped with electrically released, spring set, friction shoe type brakes having torque capable of holding 125% of the full rated hook load. breaks shall apply when either the motor controller or the main power switch is in "OFF" position or in the event of power failure.

ix). Drive motors shall be designed for frequent reversal, braking and acceleration and shall be as per IS: 325. Pendant control switch, controllers and resistor, controls, electrical protective devices, cable and conductors, earthing guards etc. shall be as per IS: 3938. limit switches shall be provided for over hoisting and over lowering.

x). The electrical hoist shall be of class II duty.

xi). 25% overload test, speed tests, limit switch tests and brake test shall be conducted for the hoist and trolley at manufacturer's works.

1.7.2 Hand operated Hoist and Trolleys

i). Manual hoist shall be complete with hand chain, trolley, pulley block, hook, hand and load chains, brake and other accessories. They shall comply with the latest applicable standards, regulations and safety codes in the locality where equipment will be installed.

ii). Each hoist shall be operated on a monorail (I-beam). The factor of safety shall not be less than 5. The load chain may be heat-treated to give ductility, toughness and as per IS 3109/BS 1663/BS 3114. The load wheel is to be made heavy duty malleable castings. the hand chain should be as per BS 6405 and hand chain wheel may be made from pressed sheet steel with roller type guarding. Gears shall be cut from solid cast or forged steel blanks or shall be stress - relieved welded steel construction. Pinions shall be of forged carbon steel of heat treated alloy steel. strength, Quality of steel, heat treatment, face, pith of teeth and design shall be as per BS-436, BS-545 and BS 721. Spur and helical gear must comply with BS 436 and worm with BS 721. Bearing must be ball and roller type as per IS 2513 / BS 2525-32. Proper lubricating arrangements are to be provided for bearing and pinion. The brakes for the lifting gear shall be automatic and always in action.

iii). The proof testing of each chain pulley block is to be carried out as per latest applicable standards. the safe working load is to be marked in such a way that is clearly visible from the operating level.

1.7.3 Manually Operated Travelling Crane

i). The crane bridge shall consist of a single bridge girder carrying two wheels at each end of the span. steel used shall be tested quality steel confirming to IS 2062. The girder shall have enough strength to carry the test load without causing undue stress or deflection.

ii). The long travel bridge wheels shall be rim toughened, heat treated carbon steel or low alloy steel or CI. they shall be double flanged type. The wheels shall have

antifriction ball/roller bearings. The Wheels shall be machined on their treads to match the runway rail section. The bridge shall have a geared shaft and pulley connecting to opposite wheels of the span, to achieve the long travel motion of the bridge, by means of a chain. The runway rails of adequate strength and rigidity, rail clamps and other accessories for mounting the rails and suitable end stops for the bridge shall be supplied.

1.7.4 Trolley and chain Pulley Block

i). The chain pulley block shall be operated on the lower flange of the bridge girder.

ii). The load chain shall be made of alloy steel as per IS:3109. It shall be heat treated to give ductility and toughness so that it will stretch before breaking. It shall be of welded construction with a factor of safety not less than 5.

iii). The hand chain for the hoisting and traverse mechanism shall hang well clear of the hook and both the chains shall be on the same side. the hand chin wheel shall be made from pressed sheet and shall be provided with roller type guarding to prevent snagging and fouling of the chain.

iv). All the gearing shall be totally encased. Proper lubricating arrangements shall be provided for bearings and pinions. Gears shall be cut from forged steel blanks. Pinions shall be of heat treated alloy steel. Gears shall be as per BS 436/IS : 4460.

v). The trolley track wheels shall be rim toughened, heat treated carbon steel or low alloy steel or CI and shall be single flanged and shall have antifriction ball bearings. The wheels shall be machined on their treads to match the flanges of the track joints.

vi). The travelling trolley shall be made of rolled steel as per IS : 2062. The side plates of trolley frame shall extend beyond wheel flanges, thus providing bumper protection for the wheels. the two side plates shall be connected by means of an equalizing pin.

vii). Axles and shafts shall be made of carbon steel and shall be accurately machined and properly supported.

viii). The lifting hooks shall be forged, heat treated alloy or carbon steel of rugged construction. they shall be single type provided with a standard depress type safety latch. They shall swivel and operate on antifriction bearings with hardened races. Locks to prevent hooks from swivelling shall be provided. Hook shall be as per BS: 2903/IS:3815.

ix). The break for the lifting gear shall be automatic and always in action. It shall be screw and friction disc type self actuating load pressure brake. Breaks shall offer no resistance during hoisting.

x). Ratchet and pawl mechanism shall be provided to arrest the full load from lowering due to gravity. The ratchet and pawl shall be of steel, hardened and tempered so as to attain required wear resistance and toughness..

1.7.5 Jib Crane

Fixed jig crane shall be provided in for lowering/removal of equipments/parts to/from the rector tanks floor and transferring the same outside reactor area. The crane capacity shall be 1.25 times the maximum weight to be handled or 1.5 tonnes, whichever is more.

The lift and reach of the crane shall be suitable for the equipments/parts to be handled. The

crane shall be capable of being swivelled by 360 deg. All material used in the construction shall be corrosion resistant, MS used shall be galvanized. Rope chains and pulleys shall be of SS construction. Hardware shall be of SS 316. the jib crane shall also be provided for submersible pumps in reactor tank, thickened sludge sump.

1.7.6 EOT Crane

The crane shall be electrically operated, bridge type complete with all accessories including down shop conductor, crane rails and fixtures, and shall confirming to BS 2573, IS : 3177 or relevant internationally approved standards.

The crane bridge shall consist of bridge girders on which a wheeled trolley is to run. The bridge trucks and trolley frames shall be fabricated from structural steel. Access walkway with safe hand railing as required along the full span length of the bridge girder. steel shall be tested quality as per ASTM A36 except that, plates more than 20 mm thick shall confirm to IS 2062, BS 4360 or relevant international standards. The All antifriction bearings for bridge and trolley track wheels, gear boxes and bottom sheaves on hook shall be lubricated manually by hand operated grease pump through respective grease nipples.

Wheel base and structural frame of the wheel mounting of the end carriages shall be designed so as to ensure that the crane remains square and prevent skewness. Bridge and trolley track wheels shall be of forged steel shall be double flanged type. The wheel dia. and rail sizes shall be suitable for the wheel loads. The crane rail shall be manufactured from wear resistant austenitic manganese steel. Mountings of the wheels shall be designed to facilitate easy removal for maintenance. Walkways shall be at least 500mm clear inside width with a 6 mm thick non-skid steel plate surface. Steel rail stops to prevent rails from creeping and trolley from running off the bridge shall be abutted against ends of rails and welded to the girders. Bridge and trolley stops to match the wheel radius shall be provided before the buffer stops.

All exposed couplings, shafts, gear, wheels, pinions and chain drives etc. shall be safety encased and guarded completely to prevent any hazard to persons working around. All bearings and gears shall have a design life of 100 000 operating hours. electro-magnetic or hydraulic thrust breaks shall be provided for the main hoist. One electro-magnetic brake shall be provided for each of the cross travel and long travel motions.

Hook shall be solid forged, heat treated alloy or Carbon Steel suitable for the duty service. They shall have swivels and operate on ball thrust bearings with hardened races. The lifting hooks shall comply with the requirements of IS 8610 or BS: 2903 / BS:3017 or relevant internationally approved standards and shall have a safety latch to prevent rope coming off the hook. Hoist rope shall be extra flexible, improved plough galvanized steel rope with well lubricated hemp core and having six strands of 37 wires per strand with minimum ultimate tensile strength of 1.6 X 106 kN/m2 of right hand Ordinary laid construction. The ropes shall have a 6 safety factor on the specified working load, and shall conform to IS: 2266. Rope drums shall be grooved and shall be either cast iron or cast steel or welded steel as per IS:3177, BS:466.

Gears shall be cut from solid cast or forged steel blanks or shall be stress relieved welded

steel construction. Pinions shall be forged carbon or heat treated alloy steel. Strength quality of steel, heat treatment, face, pitch of the teeth and design shall confirm to BS: 436, IS: 4460 and BS:721.

Name plate showing the capacity, year of manufacturing and rated capacity of the crane, in figure not less than 150 mm height shall be placed on the each side of the crane girder.

The deflection test shall be done as per IS:3177

All accessory and auxiliary electrical equipments including drive motor, electrically operated brakes, controllers, resistors, conductors, insulators, current collectors, pendant, push button station, protective devices, operation devices, cables, conduits, etc, necessary for the safe and satisfactory operation of the crane shall be provided.

Power to the crane shall be provided by down shop conductors manufactured from high conductivity hard drawn copper. Conductors shall be completely shrouded such that they have no exposed current caring surfaces. Pendant type button station shall be sheet steel enclosed and shall comprise the following push buttons and indicating lams:

- "start" and "stop"
- Long travel -'Right' and 'left'
- Cross travel 'To' and 'Fro'
- Hook 'Hoist' and 'Lower'

Red indicating lamp for supply 'ON' indication.

Pendant type push button shall be supported independently of the electrical cable and shall be earthed separately, independent of the suspension. Automatic reset type of limit switches shall be provided to prevent over travel for each of the following:

- for "UP" and "Down" motion of the hook
- Long travel motion

Cross travel motion

Crane structures, motor frame and metal cases of all electrical equipment including metal conduit and cable guards shall be earthed. All motors, brakes, limit switches, panels, drum controllers, resistor sets shall be provided with two studs for earthing.

All motors shall be of the quick reversing type with electrical mechanical brakes suitable for the duties specified. All movements shall be electrically powered suitable for operating with the hook loaded. Facilities shall be provided for the accurate location of the hook by means of inching the cross travel and down shop travel motions.

Sufficient slings, ropes, shackles, lifting beams, etc. shall be supplied to handle all items of plant covered by the crane. they shall be labelled or marked with safe working load and the purpose for which they are intended.

The crane and all slings, ropes and other lifting equipments shall be tested by the

manufacturer at their place. The test shall be carried out at 125% of safe working load and test certificate shall be supplied.

The operator shall include with the cranes all necessary contactors, control cubicles and protection equipment necessary to operate the crane and provide adequate electrical protection against overload, phase and earth fault and fail safe protection in the event of an power failure. All access ladders and platforms necessary to carry out maintenance and repair shall be provided and installed by the operator.

All electrical equipment shall be fully tropicalised

Site tests shall be carried out by the operator who shall supply the necessary materials for the test load. The test load shall be removed from site by the operator after successful tests have been carried out.

1.8 Auxiliary Equipments

1.8.1 Reduction Gear Units

Reduction gear units, wherever provided hall be double reduction units without V-belts and pulley, gear shall be cut from solid cast or forged steel blanks or shall be stress relieved welded steel construction. Pinions shall be of forged carbon or heat treated alloy steel. Strength quality of steel, heat treatment, face, pitch of teeth and design shall be confirm to BS:436 and BS:721. split gears shall not be used. Gears and pinions shall be pressed on and keyed to shafts.

All pinions and gears are to be of the totally enclosed type up to the last stage of reduction in all motions and shall be carried in fabricated steel gear cases which must be dust-proof and firmly sealed to prevent oil leakages and shall be oil bath lubricated. The gear boxes shall have covers split horizontally and arranged so that top half can be removed for inspection. They shall be fitted with bolted type machined inspection covers and with cast steel cartridge housing for carrying roller bearings.

Dip sticks or indicator shall be provided for indicating the oil level. Guards shall be strong enough to retain the whole gear or any part that might otherwise fall. No overhanging gears shall be used. Drain plugs shall be provided on all gear cases. Lifting lugs shall be provided for handling purposing.

1.8.2 Propeller Exhaust Fan

The fan should comply with IS 2312.

The blades shall be of MS and properly balanced so as to avoid noise and vibration. The blade and Blade carriers shall be securely fixed so that they do not loosen in operation. The means provided for securing the fan mounting or fan casing to the wall partition or window

shall be such as to provide a secure fixing damage to the fan or wall.

Suitably designed guards shall be fitted to the inlet and the outlet side to prevent accidental contact. No flammable material shall be used in the construction of fan. moulded parts, if used, shall be such material as to withstand the maximum temperature attained in the adjacent component parts.

The fan shall have protective insulation or be capable of being earthed. A fan with protective insulation may be of all insulated construction or have either double insulation or reinforced insulation. Each fan should be provided with a 10 mm2 mesh bird screen. the sheet used for cowl should be 14 G.

1.8.3 Air Conditioning Equipment

Wall mounted split type air conditioners of appropriate capacity shall be provided for the control room. Outdoor condensing unit shall be located on the roof of the building or grouted on the external side of the wall with suitable brackets.

1.8.4 Domestic Water Pump Sets

The pump shall be Centrifugal type, self priming and mono-block type, suitable for pumping the clear water and treated sewage water. All the necessary piping with union, bends and tees shall be provided. Suction and discharge isolation valves and non return valves on the discharge side shall be forged steel. Piping shall be as per IS:1239 heavy class.

1.8.5 Fire Extinguishers

i). Portable fire extinguishers are to be provided for all units as per the requirement of Tariff Advisory Committee (TAC) or meeting the requirement of local regulations whichever is more stringent.

ii). All the extinguishers shall be of TAC approved.

1.9 Inspection and Testing

i). Inspection of all the equipments shall be carried out by the manufacturer at their facility in the presence of purchaser or his representatives.
ii). Successful bidder has to intimate purchaser / his representative in writing (Inspection call), 7 working days before the scheduled date of inspection.
iii). All internal test reports (as per approved QAP/ contract Document) to be submitted along with the inspection call letter.

2.0 INDUCTION MOTOR

2.1.1.1 SCOPE

The specification covers the design, material, constructional features, manufacture, inspection and testing at the VENDOR's / his SUB-VENDOR'S works, delivery to site and performance testing of Low Voltage induction motors rated up to 1000V.

2.1.1.2 CODES AND STANDARDS

The design, material, construction, manufacture, inspection, testing and performance of induction motors shall comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment will be installed. The equipment shall also conform to the applicable standards specified in data sheet latest revision as on the date of offer. Nothing in this specification shall be construed to relieve the VENDOR of this responsibility. In case of conflict between the standards and this specification, this specification shall govern.

2.1.1.3 DRIVEN EQUIPMENT

a. When this specification forms part of the driven equipment specification, information not given in the Data Sheet will be governed by the driven equipment specification.
b. Motors shall be capable of satisfactory operation for the application and duty as specified in the motor Data Sheet and as specified for the driven equipment.

2.1.1.4 PERFORMANCE AND CHARACTERISTICS

a. Motors shall be capable of giving rated output without reduction in the expected life span when operated continuously under either of the following supply conditions as specified in Data Sheet.
b. Supply Condition
   i. Variation in supply voltage from rated voltage: ±10%
   ii. Variation in supply frequency from rated frequency: +5%
   iii. Combined voltage and Frequency variation: +10%

c. Motors shall be suitable for the method of starting specified in the Data Sheet.

d. The minimum permissible voltage shall be 85% of the rated voltage during motor starting.

   i. Motors shall be capable of starting and accelerating the load with the applicable method of starting, without winding temperatures reaching injurious levels, when the supply voltage is in the range of 85% of the rated motor voltage to maximum permissible voltage specified in Data Sheet.

e. The locked rotor current of the motor shall not exceed 600% of full load current (subject to tolerances as per the applicable standard) unless otherwise specified. The locked rotor current of VFD controlled motor shall be within the limit of IS12615 / IEC.

f. Motors shall be capable of developing the rated full load torque even if the supply voltage drops to 70% of the rated voltage. The pull out torque of the motor shall be at least 205% of full load torque.

g. Motors when started with the driven equipment coupled shall be capable of withstanding at least two successive starts from cold conditions & one start from hot condition without injurious heating of windings. The motors shall also be suitable for three equally spread starts per hour under the above referred supply conditions.

h. Motors shall be of Energy Efficient type. Category of Energy efficiency shall be as mentioned in data sheet.

2.1.1.5 INSULATION

a. The insulation shall be given tropical and fungicidal treatment for successful operation of the motor in hot, humid and tropical climate.

b. Motors which are VFD controlled shall be inverter grade and shall be suitably derated to take care of reduced cooling at lower speeds.

c. Insulation of VFD controlled Motors shall be designed to withstand a dv/dt of 0.1 micro sec rise from 10 % to 90 % of steady voltage and a maximum peak of 1600 volts as per NEMA standard MG1 Part 31.40.4.2 .

d. The insulation shall be of double coat winding wires which having superior electric strength and thermal capability for VFD controlled motors.

e. Winding shall be insulated as VPI (Vacuum Pressure Impregnation) of winding with suitable resin forces which eliminating voids for VFD controlled motors.

2.1.1.6 TEMPERATURE RISE

a. The temperature rises shall not exceed the values given in IS 12802. Under extremes of supply condition (clause 4.1 above), the temperature rise shall not exceed the value indicated in IS by 10˚C.
b. For motors specified for outdoor installation heating due to direct exposure to solar radiation shall be considered.

2.1.1.7 CONSTRUCTIONAL FEATURES

a. All windings shall be of Copper. The winding insulation shall be Non-hygroscopic, oil resistant and, flame resistant.
b. Motors weighing more than 25 kg. shall be provided with eyebolts, lugs or other means to facilitate safe lifting.
c. Noise level and vibration limit should not exceed as specified in relevant IS / IEC.
d. Submersed Motor (wherever applicable) shall have following specific constructional features:
    i. Motor shall be Air Filled yet capable of Water immersion up to 20mwc for S1 duty. Motors with Oil or Water filled windings shall not be allowed. Motor's Rotor shall be of dual caged copper bar brazed type to ensure;
        - Long Corrosion free Service life (in presence of high moisture inevitable in submerged motors, Aluminum corrodes much faster than Copper),
        - Ease of Onsite Repairing &
        - Beneficial Fly Wheel type Inertial effect (as compared to aluminum rotor, copper rotor is heavy) which reduces detrimental effects of water hammer
        - Better Motor Efficiency & Cooler Operating Temperature.
        - Motors rated ≤ 110kW may be supplied with Aluminum Die Cast Rotors but Dual Cage Copper Bar shall be preferred.
        - The Motor Rating should be higher of the two criteria i.e.,10% over Maximum pump shaft input at any point of the curve &/or 20% over pump shaft input @ duty point
    ii. Motor Cooling :
        - To restrict the Dead Water Level (in case of Vertical Installation) in the Sump to 1m, Medium & Large sized pumps (≥55kW) should have a

Cooling Jacket – i.e. motor cooling is accomplished by circulation of pumped water between the motor casing & the jacket shell.

- In case the pumps are to be installed horizontally, the motor can be cooled just by water immersion i.e. no jacketing is required.
- This jacket shell is fed by cold water from the pump casing & discharges its heated water back into the sump (in case of Wet Installation) or Pump casing (in case of Dry Installation) by integrally cast ducts. There should not be any pipes, hoses, etc for this circulation.
- Alternatively Close Circuit cooling technology (using Glycol, etc) may also be offered.

iii. Motor Protection:

- Thermal Overload Protectors (Bi Metallic Over Load Relays) should be embedded in each phase of the stator winding to detect overheating & trip the motor from the control panel in the event of the temperature exceeding the safe operating limit (above B temperature class).
- To detect primary Mechanical Seal's Leakage a Moisture & Winding Sensor shall be provided in intermediately Oil Chamber (& not in the Motor casing or elsewhere) – this shall detect water mixing in oil by mode of increased leakage current from the moisture sensor.

iv. Motors Cables:

- A watertight Cable Junction Box sealed from the motor shall be provided for the motor power and signalling cables.
- The cable shall be brought directly out of the submerged motor without joints, and shall be of sufficient length, minimum 10 m to be terminated in an IP 67 junction box (in the scope of electrical contractor) outside adjacent to the wet well & above the HFL. They shall be sized in accordance with the electricity utility regulations and BS 7671.
- It should have Power as well as Control Cables of Dual Sheathed EPRS / PVC Armoured type with Copper Core of required size. However the Cross Section of the cable be shall ample enough to ensure a Voltage Drop of not more than 2% at actual running conditions.

v. Stuffing Box / Oil Chamber:

- The pressurized entry of water into the motor (from the pump's volute casing) should be prevented by two separate mechanical seals

mounted in a Tandem mode within an oil chamber.

- The Primary (Inboard) seal should be of Silicon Carbide or Tungsten Carbide faces to withstand erosive wear due to any silt particles. The Secondary (Outboard) seal should be of Carbon v/s Cast Chrome Molybdenum Steel or Silicon Carbide or Tungsten Carbide – i.e., Thermally Unstable materials like Alumina/ Aluminum Oxide shall not be allowed.

2.1.1.8 BEARINGS

a. Unless otherwise specified in data sheet, motor bearings shall not be subjected to any external thrust load.
b. Unless otherwise specified, motor bearings shall have an estimated life of at least 70,000 hrs.
c. The bearings shall permit running of the motor in either direction of rotation.
d. When forced oil lubrication or water cooling is required, prior approval from the purchaser shall be obtained.
e. It shall be possible to lubricate the bearings without dismantling any part of the motor.
f. VFD controlled Motors shall have their bearings insulated to prevent motor shaft currents from entering the bearing race.
g. The bearings should be Permanently Greased with Premium Quality, High Temperature, Long Life Grease thereby obviating the need of re-lubrication for up to L10 life of the bearings.

2.1.1.9 TERMINAL BOX

a. Terminal boxes shall have a degree of protection of atleast IP 55 for out door applicable.
b. Unless otherwise approved, the terminal box shall be capable of being turned through 360o in steps of 90o.
c. Terminals shall be of stud type & the terminal box shall be complete with necessary lugs, nuts, washers.
d. When single core cables are to be used the gland plates shall be of non magnetic material.
e. Sizes of terminal boxes and lugs shall be as given in Table-I, unless specified otherwise in data sheet.

TABLE-I

415 V MOTORS - SIZES OF CABLES, STUDS, TERMINAL LUGS & TERMINAL BOXES (TO BE PROVIDED ON MOTORS BY VENDOR)

Sr. No.	Motor Rating (kW)	1100V Al Conductor, armoured PVC/XLPE Cable Core x mm^2
1.	Upto 3	3x4
2.	3.1 - 7.5	3x6
3.	7.6 – 15	3x16
4.	16 – 25	3x35
5.	26 – 40	3x70
6.	41 – 55	3x120
7.	56 – 70	3x185
8.	71 – 85	3x240
9.	86 – 110	3x400
10.	111 – 200	3Rx1Cx500

2.1.1.10 PAINT AND FINISH

a. All motor parts exposed directly to atmosphere shall be finished and painted to produce a neat and durable surface which would prevent rusting and corrosion. The equipment shall be thoroughly degreased, all rust, sharp edges and scale removed and treated with one coat of primer and finished with two coats of grey enamel paint.

2.1.1.11 HEATING DURING IDLE PERIODS

a. Motors rated above 30 kW shall have space heaters suitable for 240V, single phase, 50 Hz, AC supply. Space heaters shall have adequate capacity to maintain motor internal temperature above dew point to prevent moisture condensation during idle period. The space heaters shall be placed in easily accessible positions in the lowest part of the motor frame.

2.1.1.12 ACCESSORIES

a. Two independent earthing points shall be provided on opposite sides of the motor, for bolted connection of the PURCHASER'S earthing conductors as

specified in data sheet. These earthing points shall be in addition to earthing stud provided in the terminal box.

b. Except when otherwise specified, the motors shall be provided with a bare shaft extension having a key slot and a key at the driving end.

2.1.1.13 TESTS

a. Motor shall be subjected to all the routine tests as per applicable standard in the presence of the PURCHASER'S representative. Copies of test certificates of type and routine tests shall be furnished as specified in the distribution schedule, for the PURCHASER'S approval. The VENDOR shall ensure to use calibrated test equipment/instruments having valid calibration test certificates from standard laboratories traceable to national/international standards.

b. If type tests have not been carried out on similar Motors, or if the type test reports submitted are not found in order, then VENDOR shall carry out these tests without any extra cost to the Purchaser.

Request for Proposal

For

DEVELOPMENT OF BORSOLA BEEL

Design, Build and Operate Basis

Volume II C: **Technical specification for Electrical Works**

Client:

GSCL,

Guwahati, Assam

DOCUMENT NO: .10477A-CV-3000-3102

1.0 SCOPE OF WORK

1.1 The scope of work covers the design, detailed engineering, preparation of construction drawing, manufacture, acceptance testing at manufacturer's works or at any accredited agency, supply, packing, forwarding and delivery from manufacturer's works/ place of storage to erection site including transit insurance, unloading, storage at site, moving from place of storage to place of installation, assembly,cleaning/ lubricating, touch up painting, erection, testing, commissioning & performance demonstration and handing over of the following systems/ equipment along with all necessary spares of original ratings & specifications in Design, Build and Operate (DBO) basis for nos. of years as indicated in this document including the Defect Liability and Operation & Maintenance period.

Electrical System for Sewage treatment Plant

(a) Compact Substations with Ring Main Unit, FRTU, transformer and LV panel

(b) Standby Diesel Generator and Auto Mains Failure panel along with LV breaker

(c) LV metal enclosed switchgears including Power control center(PCC),Motor control center(MCC), Power Distribution Boards (PDB), Sub DBs, Lighting DBs, Receptacle DBs and receptacles for utilities

(d) LV Automatic Power Factor Correction (APFC) Panel with APFC relay to improve the power factor.

(e) Cabling system consisting of various HV and LV grade, XLPE/ PVC insulated, multi-stranded Al/ Cu, GI round wire/ flat strip armoured power & control cables; Point Wiring of the luminaries and receptacle; Prefabricated GI ladder/ perforated type cable trays, GI raceways & associated accessories including support structures

(f) Earthing system and lightning protection system for the STP.

(g) Lighting and Receptacle systems for all indoor & outdoor areas

(h) Grid connected Solar PV Panel system with Inverter, Meters and All other accessories as per MNRE.

(i) Continuous Monitoring of Electrical Power & Energy Parameters like Voltage, Current, Power Factor, Frequency, Kilo Watts, Kilowatt-hours etc.

(j) Motor Starters and Drives

(k) Local Start/ Stop push button stations for Motors

(l) Illumination of Buildings and roads of STP.

(m) Foundation for the electrical equipment's

(n) Trench for laying of cable inside the MCC/electrical room.

(o) Chain link fence for CSS and DG

Electrical system for Landscape Area

(a) Compact Substations with Ring Main Unit, FRTU, transformer and LV panel

(b) Standby Diesel Generator and Auto Mains Failure panel along with LV breaker

(c) LV metal enclosed switchgears including Outdoor feeder Pillar (OFP), Sub FPs, Lighting DBs and receptacles

(d) Cabling system consisting of various HV and LV grade, XLPE/ PVC insulated, multi-stranded Al/ Cu, GI round wire/ flat strip armoured power & control cables; Point Wiring of the luminaries and receptacle; Prefabricated GI ladder/ perforated type cable trays, GI raceways & associated accessories including support structures.

(e) Earthing system and lightning protection system for the building/structure.

(f) Lighting and Receptacle systems for all indoor & outdoor areas as per the requirement. which includes

(i) Vehicular roads and Walkway along both sides of the Beel.

(ii) Park and Landscape area.

(iii) Retail Blocks

(iv) Toilet Blocks

(v) Viewing Deck

(vi) Pedestrian Walkway.

(vii) Parking and Miscellaneous areas

(g) Grid connected Solar Tree, inverters,DC Combiner Box and All other necessary accessories.

(h) Foundation for the CSS, DG, Outdoor feeder pillar and Outdoor light mounting pole and structures.

1.2 Obtaining approval including load sanction/ release from APDCL, No Objection Certificates from APDCL, Electrical Inspector (CEIG), relevant government agencies, and statutory authority, as applicable is included in BIDDER scope. All necessary legal fees required for various applications to APDCL, relevant government agencies, statutory authorities shall be paid by the PURCHASER. Net metering equipment & electric supply connection shall be provided by APDCL for which necessary liaison shall be done by BIDDER. Incoming point of supply till tariff meter is in the scope APDCL. Further, the entire distribution is in the scope of contractor only. If the supply arrangement is not provided by the APDCL then the arrangement of supply including transmission line/underground cable, four pole structure(if required),Ring main unit ,installation of the HT breaker in the APDCL substation(if required) shall be in the scope of the contractor.If the fault level at the incoming switchyard is more than 25 kA for 11kV then HT switchgear panel shall be considered instead of RMU.

1.3 With reference to the estimated demand of the development for the entire plot, the voltage level of the incoming power supply from APDCL is considered as 11kV. It is also assumed at this stage that APDCL shall arrange for the incoming supply from the nearest substation till the development plot upto the tariff meter.

1.4 Inland and overseas transit insurance, transport, testing at site shall be in BIDDER's scope.

1.5 Tender BOQ and drawings, if provided, are for reference purposes only which are the minimum requirements; BIDDER shall ensure that design & equipment ratings shall be as per specification requirements.

1.6 The BIDDER shall prepare design calculations based on parameters/ design criteria indicated in the specifications. The BIDDER shall carry out detailed engineering and prepare construction

purpose drawings to make his/ her own estimate of ratings & quantities in accordance technical data sheets, other relevant details provided in the specifications. All documents shall be submitted to PURCHASER for approval before execution.

1.7 BIDDER shall take due care of the site Seismic conditions while designing all equipments/ components used in entire electrical systems covered in this specification. BIDDER shall furnish list of additional design parameters considered in design to fulfil the above requirement.

1.8 Design and detailed engineering of the materials procured by BIDDER is included in scope. BIDDER shall submit each document/ calculations of system which is included in scope to PURCHASER/ CONSULTANT for final review/ approval. All design documents/ calculations prepared by BIDDER shall be duly signed by PURCHASER and stamped. Design documents/ calculations prepared by sub-BIDDERs shall be approved by BIDDER and stamped copy of approval along with no-deviation sheet from sub-BIDDER shall be submitted by the BIDDER to PURCHASER/ PURCHASER's Representative for final review/ approval.

1.9 Manufacturer's supervision for sub-BIDDER supplied material shall be provided by BIDDER and shall be included in offer.

1.10 CONTRACTOR shall be solely responsible for any shortages or damages in transit for his supply scope, handling and/ or in storage of any materials and erection of the equipment, supply of erection tools at site. BIDDER shall ensure that it will not affect any activity or project schedule. Any demurrage, wharfage and other such charges claimed by the transporters, railways etc. shall be to the account of the BIDDER.

1.11 Nothing in this specification shall be construed to relieve the BIDDER of his/ her responsibilities towards following best engineering practices established in the country.

1.12 The BIDDER's scope shall also include measurement of soil resistivity at site by Wenner's four electrode method as per IS: 3043 – 1987 (Reaffirmed in 2006 or its latest version) at minimum sixlocations at site. The earthing system shall be designed for the actual mean soil resistivity value obtained.

1.13 Even if all components of a system included in this specification are not explicitly identified and/ or listed herein, these shall be supplied under this contract to ensure completeness of the system and facilitate proper operation and easy maintenance of the plant. Any and all other works not indicated above but necessary/ required to complete the job in all aspects, are included in the BIDDER's scope.

1.14 The BIDDER shall indicate and include start up spares, essential spares, recommended spares and a set of special tools necessary for operation, routine maintenance of equipment supplied for a period of five years.

1.15 Whether specifically called for or not, all accessories required for normal and satisfactory operation (as deemed by the PURCHASER) of the equipment shall be considered to be a part of the BIDDER's basic scope of supply and/ or work and no claims whatsoever, for extra payment on these grounds, will be accepted.

1.16 BIDDER should visit site and get himself/ herself ascertained regarding the scope of work for the complete Electrical works before submission of quote/ offer.

1.17 BIDDER's scope shall also include all civil works and structural works required for installation of all electrical equipment/ systems such as equipment foundations, indoor & outdoor trenches, equipment support structures and all excavation works including those for lighting, earthing, cabling systems etc.

1.18 It is not the intent to completely specify herein all details of design and construction of the equipment and systems. Nevertheless, the Electrical system shall conform to high standard of engineering, design and workmanship in all respects and shall be capable of performing satisfactorily in continuous commercial operation under the specified environmental conditions.

1.19 The electrical specifications are divided into three parts in this document. The Specification given in any one part shall be applicable to rest of the part unless otherwise specified.

1.20 PURCHASER reserves the right to issue addendum to the technical specification to indicate modification/ changes in the requirements, if so required at a later date.

2.0 DESIGN CONCEPT

2.1 The design concept of electrical system as a whole is based on providing safe, reliable & stable power and efficient performance of electrical system.

2.2 The design standards described herein are generally in compliance with the Central Electricity Authority Regulations 2010, latest Indian Standards, State Electricity board standards and code of practices already established in the country.

2.3 The design ambient temperature for all electrical equipment shall be 45°C.

3.0 PROJECT DETAILS

3.1 Site/ Environmental Conditions:

(a) Ambient temperature : 45ºC (site specific)

(b) Relative Humidity : 5 - 95%

(c) Area Classification : Non Hazardous

(d) Seismic Data : As per IS 1893 (latest Issue)

3.2 Power/ Control Supply Distribution Voltage:

(a) Voltage level for supply need to be confirmed with APDCL by BIDDER before the commencement of design.

(b) HV -11kV, 3 Phase, 3 Wire, 50 Hz, AC depending upon the available source at the site or as per the recommendation of the Local Power Supply Company

(c) LV - 415V, 3 Phase, 4 Wire, 50 Hz, AC

(d) General Lighting & Space Heating - 240V, 1 Ph, 2 Wire, 50Hz, AC

(e) Control & Protection –110/ sqrt(3)V, 1Ph, 50 Hz, AC

(f) Critical Lighting: 240V, 1 Ph, 2 Wire, 50Hz, AC through UPS

(g) Voltage Transformer Secondary: 110 V, 3 Ph, 50 Hz, AC

(h) Voltage Variation: -

For 11kV, As per CEA Guidelines

For 0.415kV, As per CEA Guidelines

(i) Frequency Variation: ± 3%

(j) Combined Voltage & Frequency Variation: ± 10%

3.3 System Earthing:

(a) 11 kV, 3 Ph AC system : Neutral Solidly Earthed

(b) 415 V, 3 ph, AC system : Neutral Solidly Earthed

(c) 240 V, 1 ph, AC system : Neutral Solidly Earthed

4.0 POWER DISTRIBUTION ARRANGEMENT

4.1 The power supply to the BorsolaBeel area shall be provided from the nearest APDCL Substation with two independent feeder of 11kV, through underground buried cable/Overhead conductor, each capable of supplying 100% load(STP + Landscape).

4.2 It is assumed that the two incoming lines from APDCL substations shall be terminated at an outdoor RMU with two incomers with Load Break Switch and three outgoing Vacuum Circuit breakers - Two feeders for the STPand one feeder for the landscape area.

4.3 Separate Net Metersshall beprovidedfor tariff metering of Landscape area and STPat HT level as the grid connected solar PV system shall be connected for the generation of renewable energy. Net metering shall be as per the latest guidelines and specification of the AERC/ APDCL.

4.4 Schematic Single Line Drawing (SLD) - TCE.10477A-EL-4001-AU-40005 - is attached for reference.

4.5 Electrical System for Sewage treatment Plant

(a) CSS shall be provided for stepping down the power from 11kV to 415V for supplingthe STP loadsinSTP area. STPshall be provided with 100% standby unit for reliability and redundancy.. The LV panels of the CSS shall have only one outgoing breaker.

(a) The main PCC,located in the panel room, shall inhouse theincomers from two CSSsand one DG. Thus PCC shall have three bus connected by bus-couplers. Interlocks shall be provided between the incomer breakers and their respective bus-couplers such that each bus is supplied from only one source at any given time.The two CSS shall operate independently and shall not be synchronised at any point in time.

(b) Separate MCCs/ PDBs, as suitable and supplied from the PCC, shall be considered based on the load centres and ease of distribution like Pump house, Processor and Blower building, Sludge Dewatering Building etc.. Separate PDBshall be considered for the Administrative building, maintenance workshop.

(c) A DG Set rated to cater 100% STP and pumping station loads shall be considered. The DG shall be operated in Auto Mains Failure Mode.

(d) The solar PV system shall be installed on the roof of the buildings and on the structure wherever feasible in consultation with the PURCHASER and shall be connected to the nearest distribution panel. All the equipment and system of the PV system shall be as per MNRE approved makes. The generation of the solar power and its integration with the grid shall be as per the AERC Norms.

(e) Schematic Single Line Drawing (SLD) - TCE.10477A-EL-4001-AU-40005 &TCE.10477A-EL-4001-AU-40007 - is attached for reference.

4.6 Electrical system for Landscape Area

(b) The CSS shall be provided for stepping down the power from 11kV to 415V for suppling loads atthe landscape area.

(c) A DG Set rated to cater 100% load shall be considered. The DG shall be operated in Auto Mains Failure Mode.

(d) The Main Outdoor feeder pillar shall be considered with three incomers, one from the CSS , one from the solar combiner box and one from the DG

(e) For load distribution over the Beel, Sub feeder pillar shall be considered for further distribution of the power. This Sub feeder pillar shall be supplied through main feeder pillar which in turn is supplied through the CSS.

(f) This outdoor feeder pillar shall be distributed strategically for the distribution of the power to the load point.

(g) Independent Indoor lighting + Power panels shall be considered for the toilet, and forretail shops. Each retail shopshallbe metered separately with LT 3Ph or 1Ph meter based on the load requirement of individual shop as per the APDCL norms. Meter shall be as per the APDCL requirements.

(h) The solar energy shall be generated through the solar tree and shall be converted to AC supply from DC supply with help of Inverter. And the generation of the solar power and integration of it with grid shall be as per the AERC Norms.

(i) The solar combiner box shall be used to collect the power from solar trees. The output of this combiner box shall be then fed to the Main Outdoor feeder pillar.

(j) Refer Drawingfor Lighting of landscape area and area adjacent to the lake. This drawing is only an illustration; Bidder shall provide better alternatives for lighting concept and LED luminaires with optimized cost.

(k) The lighting concept, BOQ, Lighting Cost along with a 3D rendered view of the same shall be submittedfor various sections and areas along with the Bid.

(l) Schematic Single Line Drawing (SLD) - TCE.10477A-EL-4001-AU-40005 &TCE.10477A-EL-4001-AU-40006 - is attached for reference.

4.7 The HT cable from the Ring Main Unit to the HT Meter, from HT meter to CSS and LT cable from CSS to PCC, from PCC to shall be partially laid in the Trench indicated in the drawing TCE.10447A-CV-3000-LM-30207.

4.8 Wherever Trench is not available, the cable shall be buried underground at 750mm for LT and 900mm for the HT cable.

5.0 DESIGN CRITERIA

5.1 GENERAL

5.1.1 The Electrical Power Distribution System shall be designed to provide;

(a) Safety to Personnel and equipment during both operation and maintenance

(b) Reliability & Continuity of Service

(c) Minimal fire risk.

(d) Ease & flexibility of maintenance and operation.

(e) Protection of all electrical equipment

(f) Electrical supply to equipment and machinery within the design operating limits.

(g) Adequate provision for future extension and modification.

(h) Maximum inter-changeability of equipment.

(i) Fail safe feature.

(j) Energy efficient equipment/ system

(k) Suitability for applicable environmental factors

(l) Service Condition

5.1.2 All the components of the electrical system shall be sized to suit the maximum load under the most severe operating conditions. Accordingly, the maximum simultaneous consumption of power, required by continuously operating loads shall be considered and an additional margin shall be taken into account for intermittent service loads, if any. The amount of electrical power consumed by each area shall be calculated for its operation at the design capacity.

5.1.3 The equipment shall be designed and manufactured in accordance with the best engineering practices and shall be suitable for the intended purpose.

5.2 ESTIMATION OF LOAD/ MAX DEMAND:

5.2.1 The following considerations are to be followed to arrive at the maximum electrical demand.

(a) Load Factor

Main motors	:	0.9
Auxiliary load (valve actuators, Crane/ Hoist etc.)	:	1.0
Lighting load	:	1.0

(b) Diversity Factor

Main motors	:	1.0
Auxiliary load (valve actuators, Crane/ Hoist etc.)	:	0.1
Lighting load	:	1.0

(c) Power factor of Motors shall be as per the Manufacture's Data Sheets

(d) Efficiency of Motors shall be as per the IE2 standard

(e) Overall Diversity for final Demand calculation shall be considered based on the load distribution around the day.

5.3 TRANSFORMER SIZING

5.3.1 The capacity of the transformers shall be based on the total simultaneous maximum demand (calculated based on the load factors and diversity given above, PF, efficiency).

5.3.2 Additional 10% contingency is considered for deriving at transformer sizing.

5.3.3 Similarly, after consideration of 10% contingency over maximum demand (MD), sizing of the selected transformer shall be such that maximum transformer loading shall not exceed 90% (of the MD + 10% Contingency) load for the STP.

5.3.4 While for Landscape area, after consideration of 10% contingency over maximum demand (MD), sizing of the selected transformer shall be such that maximum transformer loading shall not exceed 80% (of the MD + 10% Contingency) load.

5.3.5 The adequacy of transformer sizing shall also be proved on the basis of % Voltage dip observed at the motor terminal. % voltage dip at motor terminal shall not exceed 15% i.e. with the use of appropriate starter & considering largest motor starting base load (all other loads except the highest rating motor are running);

5.3.6 The Voltage dip l calculations shall be derived from following actual data collected from nearest Substation and Grid.

(a) The fault level of 11kV HV bus of the APDCL substation from which power supply will be taken to the BorsolaBeel.

(b) Impedance of HV Overhead Line Conductor/ HV Cable.

5.4 DG SIZING

5.4.1 The capacity of the DG shall be based on the total simultaneous maximum demand of the loads specified in clauses above (calculated based on the load factors, PF, efficiency and diversity given above).

5.4.2 After consideration of 10% contingency over the above maximum demand (MD), sizing of the selected DG shall be such that the maximum loading of the DG shall not exceed 80% at 0.8 PF.

5.4.3 The adequacy of DG sizing shall also be checked on the basis of Voltage dip observed at the motor terminal during the starting of the largest motor. The Voltage dip at motor terminal shall not exceed 15% i.e. with the use of appropriate starter & considering largest motor starting & base load (all other loads except the highest rating motor are running).

5.5 FAULT LEVEL CALCULATIONS

5.5.1 The fault level at the primary of the transformer shall be calculated based on the Fault level at the APDCL substation and impedances of the intermediate bus, cable/ conductor etc.

5.5.2 Fault level at the secondary of the transformer and at 415V LT panels shall be calculated based on the transformer rating and impedances of transformer and connecting cables and busducts.

5.6 POWER FACTOR IMPROVEMENT:

5.6.1 APFC panel shall be considered for the STP and Landscape Area

5.6.2 Capacitor rating shall be based on the system power factor corrected for 0.99).

5.6.3 APFC Panel shall be sized considering following design criteria

(a) Optimum no of steps with minimum two (2) nos. of spare steps shall be considered

(b) Minimum steps of 5 kVAR and 10 kVAR bank in adequate nos. for fine regulation of power factor at low loads shall be considered. Balance capacity can be considered with 25 kVAR, 50 kVAR or 100 kVAR capacitor bank, as suitable.

(c) Rating of the APFC shall be based on the required running load for each bus section & not on the total connected load basis.

(d) A Fixed type capacitor rated approximately 5% of the transformer rating, with manual & auto switching and components, shall be provided at either the CSS in separate compartment or at the incomer of the Main PCC panel (LV) for transformer no load compensation.

(e) Capacitor shall be All Poly Propylene (APP), double layer type.

(f) Rating of APFC panel shall be based on 100% of total running load for each bus section & not on the total connected load basis. Number of stages / steps in a particular APFC panel shall be decided by the CONTRACTOR.

5.6.4 Scheme with Summation CT shall be provided to operate both the APFC while one of the transformers is in line.

5.6.5 Switchgear rating for individual capacitor bank shall be sized at 1.5 times the rated current rating.

5.7 CABLE AND WIRE SIZING:

5.7.1 The BIDDER shall ensure that cable and wires associated with the power distribution and control systems in all the installations throughout the Works are adequately rated for their use.

5.7.2 The following main aspects shall also be considered while deciding the final size of the cables/ wires -

(a) Supply voltage and frequency

(b) All cables shall be selected to carry the corresponding full load current under site conditions.

(c) Route length and disposition of cables

(d) Maximum short circuit current duration (fault clearing time) and final temperature of cable during short circuit current flowing through the cable.

(e) Fault clearing time of the upstream circuit breaker;

(i) Cables from transformer secondary to Main Power Control Centre (PCC) incomer, fault clearing time shall be 1sec

(ii) Cables emerging from ACB outgoing of the PCC, fault clearing time shall be considered as 0.16 second (for Tie feeders if any it shall be 0.5 second)

(iii) For Cables emerging from MCCB outgoing of the PCC, fault clearing time shall be considered as 0.01 second

(iv) For the HT incomer cables (metering kiosk to GOD, GOD to HT switchgear/ transformer) minimum fault clearing time shall be considered as 1 sec.

(v) For cable from RMU outgoing to transformer, fault clearing time shall be considered as 0.16 second.

5.7.3 BIDDERS to note that, the above fault clearing times are minimum to be considered. Actual fault clearing time shall be considered as per actual relay co-ordination.

5.7.4 Appropriate de-rating factors as per cable manufacturer's catalogue and enlisted below shall be considered for sizing the cable:

(a) Ambient Air Temperature (minimum 45^0 C).

(b) Ambient ground temperature (minimum 35^0 C to be considered)

(c) For Cables laid in air/ ducts/ directly in ground: De-rating factors to be consideredfor ambient temperature, grouping.

(d) Depth of cable burial (minimum 750 mm for LT and 900 mmfor 11KV HT)

(e) No. of cables in a group-touching each other or separated by a distance

(f) No. of cable trays in tier

(g) Any other de-ration factors as applicable & as per Manufacturer's catalogue.

5.7.5 Voltage dips at the time of starting the corresponding motor/ load shall be less than 15%.

5.7.6 In running condition, cumulative voltage drop (Including HV and LV at 100% rated load) shall not exceed 5% (measured at load end) for the LV loads.

5.7.7 All the HV cables shall be Earthed grade (as per system requirement), multi-stranded Al conductor, XLPE insulated, inner/ outer extruded PVC sheath ST2, galvanized steel flat strip armoured cables.

5.7.8 The LV cables shall be 1.1 kV grade, multi-stranded Copper/ Al conductor, XLPE insulated, colour coded, inner and outer extruded PVC sheathed, galvanized steel round wire/ flat strip armoured cables.

5.7.9 Cables up to & including 4.0 sq.mm shall be Cu multi-stranded conductor with galvanized steel round wire armoured& balance cables shall be Al multi-stranded conductor with galvanized steel round wire/ flat strip armoured.

5.7.10 Single core cable shall have non magnetic material armouring.

5.7.11 Control cables shall be Cu multi-stranded conductor with galvanized steel round wire/ flat strip

armoured. For cables above 7 cores, minimum two spare cores shall be considered.

5.8 LV SWITCHGEAR PANELS

5.8.1 The bus-bars shall be sized considering the following criteria:

(a) Sleeves made of insulating material on all bus bars.

(b) Design ambient temperature 45^0 C.

(c) Final temperature of the bus-bars complying with requirements of IS 8623 & IEC 61947.

(d) Bus bars being inside the panel; De- ration for enclosure and ventilation.

(e) Bus bar suitability for carrying rated current continuously. The current density (A/sqmm) of the bus bar shall not exceed 0.8 for Aluminium bus and 1.2 for Copper bus.

(f) Configuration of bus bars and Proximity effect

(g) The main bus shall be designed based on the load rating as well as the actual fault level for specified duration at the location of the Panel/ board with 10% tolerance

5.8.2 Earth bus of the panel shall be sized suitable for the above fault level for the same duration.

5.8.3 Switchgear Sizing/ Selection:

Switchgear shall be sized/ selected considering the following:

(a) Rating suitable for carrying full load current of the equipment.

(b) Suitability for Short Circuit Rating for specified duration.

(c) Switchgear for motors shall be suitable for motor duty application.

(d) Switchgear for all the motor feeders shall be Type-2 co-ordination

5.8.4 In-panel de-ration of minimum 20% or as provided in Manufacturer's catalogue, whichever is higher shall be considered.

5.9 Motors & Starters

5.9.1 All motors will be highly energy efficient (IE2) type and shall conform to IS: 9283.

5.9.2 Motors will be capable of giving rated output without reduction in the expected life span when operated continuously under either of the following supply conditions as specified in Data Sheet.

Supply Condition	
(a) Variation in supply voltage from rated voltage	±10%
(b) Variation in supply frequency from rated frequency	±5%
(c) Combined voltage and	

Frequency variation ±10%

5.9.3 The minimum permissible voltage shall be 85% of the rated voltage during motor starting.

5.9.4 Motors shall be capable of starting and accelerating the load with the applicable method of starting, without winding temperatures reaching injurious levels, when the supply voltage is in the range of 85% of the rated motor voltage to maximum permissible voltage.

5.9.5 The locked rotor current of the motor shall not exceed 600% of full load current (subject to tolerances as per the applicable standard) unless otherwise specified.

5.9.6 Motors shall be capable of developing the rated full load torque even if the supply voltage drops to 70% of the rated voltage. The pull out torque of the motor shall be at least 205% of full load torque.

5.9.7 Motors when started with the driven equipment coupled shall be capable of withstanding at least two successive starts from cold conditions & one start from hot condition without injurious heating of windings. The motors shall also be suitable for three equally spread starts per hour under the above referred supply conditions.

5.9.8 Motors shall have class F insulation with the temperature rise limited to class B.

5.9.9 Motors rated above 30 kW shall have space heaters suitable for 240V, single phase, 50 Hz, AC supply. Space heaters shall have adequate capacity to maintain motor internal temperature above dew point to prevent moisture condensation during idle period. The space heaters shall be placed in easily accessible positions in the lowest part of the motor frame. Separate terminal box shall be provided for space heaters.

5.9.10 Terminal boxes shall have a degree of protection of at least IP 55 for outdoor applicable. This shall be minimum IP 68 in case of submerged motors.

5.9.11 Motor starter selection shall be done as follows:

(a) Direct On Line (DOL) Starter – For motors rated up to 5.5 kW

(b) Star- Delta Starter - For motors rated above 5.5 kW to 45 kW

(c) Soft Starter – For all voltage motors above 45 kW rating.

(d) VVVF (Variable Voltage and Variable Frequency) Drives shall be provided for fluctuating loads for energy saving.

5.9.12 All the motor shall be 3-phase squirrel cage induction type totally enclosed fan cooled (TEFC) or as otherwise required by the duty.

5.9.13 Protection for Motors having rating less than 15 kW

(a) Thermal Overload (OL) Relay

(b) Single phasing Preventer.

5.9.14 Protection for Motors havingabove 15 kW and below 110kW

(a) Thermal Overload (OL) Relay

(b) Motor Control Unit (MCU)

(c) Motor Control Unit (MCU) shall provide the following protection :

(i) Earth fault (EF)

(ii) Phase currents out of balance

(iii) Single phasing Preventer.

5.9.15 Protection for Motors having rating above 110 kW

(a) Numerical protection relay shall be considered.

(b) Numerical relay shall provide the following protection

(i) Short circuit

(ii) Earth fault (E/F)

(iii) Thermal overload

(iv) Unbalance current

(v) Locked rotor

(vi) Number of start within a specified time interval

(vii) Under current function

(viii) Single phasing Preventer

5.9.16 Submerged Motors shall be provided with the following additional protection:

(i) Moisture sensor

(ii) Dry run protection

5.10 EARTHING & LIGHTNING PROTECTION SYSTEM

5.10.1 The safety earthing and lightning protection system shall be based on the latest version of the following codes and standard.

Table 1: Standard and Guidelines for Earthing and Lightning Protection

a)	IS 3043- 1987, (Reaffirmed in 2006)	Code of practice for Safety Earthing
b)	IS/ IEC 62305- 2013	Code of Practice for the protection of buildings and allied structures against lightning.
c)	CEA guidelines 2010	Measures related to safety & electric supply.
d)	IEEE 80-2000-2013	IEEE Guide for Safety in AC Substation
e)	CPWD Specifications - 2013	General Specifications for Electrical Works Part I – Internal
f)	NBC 2016	Level of Lightning Protection for Building

5.10.2 Soil Resistivity

(a) Measurement of soil resistivity shall be done using Wenner's 4 electrode method as described in IS 3043 -1987 (Reaffirmed in 2006) including its latest amendment.

(b) The soil resistivity of the proposed plot area has not yet been measured; the same should be carried out during detailed engineering by successful BIDDER. Test reports shall be certified by Govt. Authorised Laboratory/ Institutes/ Agencies.

(c) After soil resistivity measurement; no. of earth electrodes and no. of test pits shall be finalized based on these design criteria & the requirements specified in earthing requirements.

5.10.3 Size of Earthing Conductors

The earthing conductor sizes shall be calculated as per IS: 3043. Following factors will be considered for sizing the earthing conductor

Table 2: Parameters for Sizing of Earth Conductor

a)	Design Ambient Temperature	45°C
b)	Allowable temperature rise	500°C
c)	For steel welded joints	1 second

	Fault clearing time	
d)	Overall earthing resistance of the grid	Less than 1 Ohms

5.11 ILLUMINATION SYSTEM

5.11.1 Latest version of related IS Standards, NBC and National Lighting Code (NLC) shall be referred for designing Illumination for different areas.

5.11.2 Lighting design shall be performed using latest version of DiaLux Software/ Original Equipment Manufacturer (OEM) validated software. The Validation Report along with software and data files shall be acceptable to PURCHASER/ PURCHASER's representative.

5.11.3 The basis of design shall be based on the following lighting engineering criteria:

(a) Lighting lux level.

(b) Luminance distribution.

(c) Glare restriction.

(d) Direction of incidence of light and shadow effect.

(e) Colour appearance and colour rendering of the light source.

5.11.4 Lighting Design

(a) Following factors shall be considered while arriving at the utilization factor to determine the number of fixtures for each area/buildings.

(i) Maintenance Factor

a. Indoor Area Lighting with LED Luminaire: :0.8

b. Outdoor Area Lighting with LED Luminaire: : 0.8

(ii) Default Reflection factor for Indoor Lighting to be considered are as follows;

a. Ceiling : 0.5

b. Walls : 0.3

c. Floors : 0.1

(iii) However Reflection factor can be selected based on the Colour of the wall and Ceiling as given below;

a. White and very light colours :0.7

b. Light colours :0.5

c. Middle tints :0.3

d. Dark colours:0.1

(iv) Utilization factor considering the room index at applicable surface reflection factors.

(v) Uniformity factor shall be considered as per National Lighting code/NBC/IS code.

(vi) The illumination levels given in below table are considered for the illumination of the respective area. These are the illumination levels achieved at Work plane. Work plane height is considered as 0.76 m from FFL.

Table 3: LUX Requirement

Sr. No.	Area	Illumination Level (Lux) - Average values
1	Electrical/ Switchgear rooms;	200 Lux
2	Pump Room	200 Lux
3	Maintenance Workshop	200Lux
4	Laboratory/Office/Control Room	300 Lux
5	Guard Room	150 Lux
6	Sludge Dewatering Building	200 Lux
7	Chlorination cum Chlorine Tonner House	200 Lux
8	Lobby	150 Lux
9	Parking	50 Lux
10	Roads	15 Lux
11	Toilet/Building Entrance	100 Lux
12	Retail Shops	200 Lux
13	Critical Lighting with UPS/ battery back up	10 Lux
14	Garden Area	8-10Lux
15	Walkway	8-10Lux
16	Terrace	10 Lux

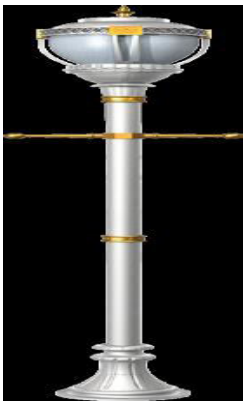
5.11.5 Selection Of Luminaires

For Indoor lighting, the luminaires shall be as mentioned in the table below. However, suggested Luminaries are indicated for landscape lighting in the table below; Bidder shall offer better alternatives with better concept as indicated above.

Table 4: Luminaries Selection

Sr No.	Type of fixture	Typical Fixture	Place
1	Indoor Recessed Mounted Luminaries Philips Make RC308B G2 LED35S-6500 PSU OD WH or equivalent		Office/workstation /Conference room
2	Downlighters Philips Make DN195B LED20S-6500 PSU WH S1 or equivalent		Office/Control Room
3	Battens Philips Make BN108C LED 40S PSU CDL WH or equivalent		Pump Room/Maintenance workshop/Guard Room/ Sludge Dewatering Building
4	Flame Proof Fixture Crompton make Fiamma II or equivalent		Chlorination cum Chlorine Tonner House

5	Down lighters Philips Make DN170C LED10S-4000 PSU WH or equivalent		Toilet/Retail
6	Bollard Philips Make BCP151 LED150/WW PSU 220-240V 7043 or equivalent		Lawn/Garden /Walkway/Outdoor parking
7	Uplighter Philips Make BBP330 HP/NW 220-240 121N or equivalent		Lawn/Garden /Walkway
8	Post Top Philips Make BGP151 LED2000/WW PSU 220-240V 7043or equivalent		Along the Road
9	Step Light Philips Make BWG150 LED50/WW PSU 220-240V IP 67 7043 or equivalent		Fragrance ,touch, herbal Garden
10	Under Water Light Klite Make under water light ID 6777 or equivalent		Fountain/Viewing Deck

11	Flood Light Philips Make BVP120 LED 35 CW FG S1 PSU GR or equivalent		Children park/ parking /gates
12	Spot Light Philips Make BG310 3xLED-HP/WW 220-240V 12 1N or equivalent		Gate/Plantation
13	Street Light Wipro Make LR02-331-XXX-57-XX or equivalent		Street Light
14	Decorative Street Light Pole Klite Make Decorative pole ID 6777 ;decorative fixture ID or equivalent		Bridge

The fixture indicated above are tentative and not limited to this .Bidder shall submit the detail lighting plan in consultation of landscape architect and take prior approval from PURCHASER .

5.12 SOLAR PV SYSTEM

5.12.1 As per the present AERC regulation aggregate solar panel capacity of grid interactive system shall be restricted to 40% of the contract demand. A notification of draft amendment, above mentioned AERC regulation, is publish by AERC indicating to relieve the restriction from 40% to 80%.

5.12.2 The capacity of the installed solar PV system shall be limited as per the latest AERC Regulation.

5.12.3 Photo-voltaic panel shall be installed on the roof of the Various Buildings and structure of STP as listed below.

(a) Admin Building

(b) HT Panel/MCC Room

(c) Sludge dewatering Building

(d) Sludge thickener Building

(e) Air Blower Building

(f) Maintenance Workshop

(g) Backwash Building

(h) Pump house

(i) SBR Basin

(j) Chlorine Tonner House

(k) Filter feed tank

(l) Chlorine contact tank

5.12.4 Although the list of building in STP area are mention above for solar PV installation, Based on the contract demand and AERC norms, the Contractor shall identify the adequate area for installation of the solar PV system. The list of identified building/structure along with its area and generation capacity shall be submitted for approval from PURCHASER

5.12.5 The solar PV system for the STP area shall consist of following components:

(a) Solar PV panel

(b) Inverter

(c) DC Distribution box

(d) AC Distribution box

(e) Cables for AC and DC connection

(f) Energy Meter

(g) Earthing& Lightning arrestor kit

5.12.6 The solar power generated in the STP area shall be connected to the mainelectrical panelcorresponding to that Building/structure.

5.12.7 For solar generation in the landscape area, Solar tree of rating 5kW shall be installed in the garden.

5.12.8 The solar PV system for the Solar Tree shall consist of following components:

(a) Solar PV panel

(b) Inverter

(c) Solar Combiner Box/Junction Box

(d) Cables for AC and DC connection

(e) Energy Meter

(f) Earthing& Lightning arrestor kit

(g) Single axis Sun Tracking system

5.12.9 The solar power generated from the solar treeshall be connected to the main Outdoor feeder pillar.

5.12.10 The solar energy shall not be fed to the System during the grid power failure.

2.0 TECHNICAL SPECIFICATION

2.1 COMPACT SUBSTATIONS (CSS)

2.1.1 Each CSS shall typically consist of the following parts:

(a) Metallic Enclosure with ventilation and rain/ dust protection as appropriate.

(b) Ring Main Unit (RMU).

(c) Oil type Transformer of respective rating with required accessories.

(d) LT switchgear.

(e) Power pack with One (1) Hr backup to take care of the DC load requirements within the CSS.

(f) FRTU for remote access and monitoring.

2.1.2 All the above components of each CSS shall conform to latest relevant standards and specifications and requirements of Local Power Company if required.

2.1.3 Civil works for the preparation of equipment foundation, cable trench, earth pits electrodes, earth grid around CSS and chain link fencing with gate for each CSS shall conform to latest relevant standards and State electricity board specifications and requirements.

2.1.4 CSS foundation shall be as per the applicable specification

2.1.5 Electrical Works like HT/LT cable termination in the respective boards inside the CSS shall conform to latest relevant standards and specifications and requirements of Local Power Company if required.

2.1.6 All SAFETY considerations in design and manufacturing for safe operation & maintenance by PURCHASER personnel and safe practices during installation at site shall be in the scope of the BIDDER. Cost towards accomplishing the same shall be included in the BID price and no extra claim shall be entertained later.

2.1.7 Equipments furnished shall be complete in every respect with all mountings, fittings, fixtures, and standard accessories normally provided with such equipment and / or needed for erection, completion and safe operation of the equipment as required by applicable codes though they may not have been specifically detailed in the Technical Specification unless included in the list of exclusions. Materials and component not specifically stated in the specification but which are necessary for commissioning and satisfactory operation unless specifically excluded shall be deemed to be included in the scope of specification and shall be supplied without any extra cost. All similar standard components/ parts of similar standard equipment provided shall be inter-changeable with one another.

2.1.8 The BIDDER shall be responsible for the selection and design of appropriate equipment to provide the best co-ordinated performance of the entire system. The design of various components, sub-assemblies and assemblies shall be so done that it facilitates easy field assembly and maintenance.

2.1.9 Codes And Standards:

(a) The design, manufacture and performance of equipment shall comply with latest applicable Codes of Standards.

(b) All components as well as the CSS as a whole shall be Type tested in accordance with the above standards.

(c) BIDDER shall submit the type test certificates for Heat run test, Short circuit test and Ingress protection test for the CSS components of similar equipment.

2.1.10 Specific Requirements Of Compact Substation:

(a) Enclosure For CSS:

(i) The CSS shall be skid mounted, metal clad housing, single enclosure with modular construction housing with all necessary requirements as specified in this specification.

(ii) The complete design shall be Compartmentalized design.The enclosure shall have three distinct compartments with two distinct access isolated from each other for HT RMU, Transformer and LV Switchboard along with their respective accessories. If APFC is to be incorporated then another compartment shall be carved out in the enclosure.

(iii) The CSS metal clad housing shall be fabricated of powder coated hot dipped galvanised CRCA sheet of minimum 4mm thickness for outer enclosure and base while minimum 2 mm thickness for the rest balance enclosure parts.

(iv) The base of the enclosure shall ensure rigidity for easy transportation& installation. The base frame shall be fabricated of Mild steel channel of minimum size ISMC 100 mm or suitable enough to bear the load of the entire components on ground as well as when lifted as one entity. The structure of the substation enclosure shall be capable of supporting the gross weight of all equipment.

(v) The structure of the enclosure shall be capable of supporting the gross weight of all the equipment & the roof of the enclosure compartment shall be designed to support adequate loads.

(vi) Intermediate water proof ceiling roof shall be provided. A minimum clearance shall be left between the top of any component installed in the substation and the roof of the substation.

(vii) The enclosure shall conform to IEC 61330 standards, for Prefabricated Secondary Substation and must provide high level of personal safety by protecting all live parts against any accidental contacts either during commissioning, operation or maintenance. All electrical clearances shall be as per relevant Standards for HV as well as for LV. All doors and ventilation grills shall be earthed to provide a fully earthed enclosure for better personal safety.

(viii) All non galvanised parts of the enclosure shall undergo rigorous seven tank process before applying epoxy powder coating of designated shade of RAL 7035(Siemens Grey) or as per PURCHASER's choice. Base frame shall be painted Tar Black.The paints shall be carefully selected to withstand tropical heat &rain. The paint shall not scale off or crinkle or be removed by abrasion due to normal handling.

(ix) The CSS enclosure shall be dust and vermin proof suitable for outdoor application, compact and easily portable. Long lasting and durable Neoprene gasket shall be provided on all doors, cut outs, louvers etc. to achieve internal protection.

(x) Access Doors of suitable/ convenient size for entry movement of respective components and humans in and out of the enclosure, shall be provided in each compartment with hinged construction with stoppers. All doors shall be provided with Pad locking and/or lock protected arrangement as well as an Internal Emergency handle so that door can be opened quickly in case of emergency.

(xi) The doors shall be provided with proper interlocking arrangement with the VCB for safety of operator.

(xii) Aluminium grilled Louvers with dust and vermin filter suitable for carrying out natural ventilation and adequate for limiting the temperature rise shall be provided in each compartment of the enclosure.No Forced cooling is allowed.

(xiii) The enclosure shall conform to IP54for RMU and LV compartment while the transformer compartment shall conform to IP34. The entire enclosure shall confirm to temperature class K10.

(xiv) All cable entry shall be from Bottom. All the trenches below shall be at least 800mm wide.

(xv) Climate proof connection equipment shall be used to avoid leakage current and flashovers due to moisture/ condensation/ dust.

(xvi) BIDDER shall submit the following type test reports carried out on the CSS.

- Temperature rise inside the enclosure
- Internal Protection Class

(xvii) Anodized Aluminium Sheet labels in English, Hindi and Local Languagefor warning, manufacturer's operating instructions etc., identifying the systems/ sub-systems inside/ outside the enclosureshall be provided in all the compartments as per state electricity board requirements or else with black engraving on white background of appropriate size. Danger boards on Anodized aluminium plate shall be provided on all Doors as well as on all four sides of the enclosure. The instructions shall be durable & clearly legible.

(xviii) Special care shall be taken by the manufacturer to ensure against rusting of nuts, bolts and fittings during operation. All current carrying parts shall be cleaned properly after final painting.

(xix) The fabrication process shall ensure that there are no sharp edges on the GI sheets used.

(xx) One(1) no. 11W LED Lighting fixture and protection MCB shall be provided in each compartment. The power for the same shall be tapped from the LT side of the CSS. One additional lamp shall be provided for the transformer compartment.

(xxi) One (1) no. Self contained, Non Maintained, Emergency lighting luminarie suitable for 1x20W FTL or 11W LED with 3 hr backup & sealed rechargeable Ni-Cd batteries (high temperature type) shall be provided in each compartment for Emergency lighting. Suitable charging point with 5A switch socket shall be provided for each such luminaire

(xxii) The supply for all accessories like lighting within the CSS shall be tapped through DP MCBs in order to restrict the fault level within that of available MCBs.

(xxiii) The connection of HT switchgear to Transformer shall be with the help of suitable size of cables from Transformer to LT switchgear with the help of suitable size of Aluminium/Copperbusbars.

(xxiv) The enclosure shall have terminal intended for connection to the earth system of the installation, by way of flexible jumpers/strips & Lug arrangement. The continuity of the earth system shall be ensured taking into account the thermal & mechanical stresses caused by the current it may have to carry. The components to be connected to the earth system shall include:

- The enclosure of Package substation, doors, ventilators etc.
- The enclosure of High voltage switchgear & control gear from the terminal provided for the purpose.
- The transformer tank or metal frame of transformer & transformer neutral.
- The frame &/or enclosure of low voltage switchgear.

(b) Ring Main Unit (RMU) For CSS

(i) The RMU shall consist of One Load Break Switch (LBS) and One Vaccum Circuit Breaker (VCB) housed in an enclosure as specified above.

(ii) The RMU shall be compact, maintenance free, reliable, easy to install, safe and easy to operate and complete with all necessary accessories and spares. The design, material and manufacturing of the RMU shall be of the highest order to ensure continuous and trouble free service over the years.

(iii) The RMU components viz., Load Break Isolator, VCB and Bus bars shall be sealed for life time in robotically welded 3mm thick stainless steel tankwith SF6 as insulating media and conforming to IP67. Above inner tank along with all essential indications, measuring and protection components enclosed in a compact metal enclosure made of galvanised sheet steel of 1.6mm thickness conforming to IP54.

(iv) The operating mechanism of the switches and breakers shall be outside the SF6 tank and accessible from front. There shall be provision for filling the SF6 gas at site. The Gas Tank shall confirm to the sealed pressure system as per IEC and ensure the gas leakage to 0.1 % per year as per IEC.

(v) Vaccum Circuit Breaker shall becomplete with operating mechanism;self powered, static type O/C,E/F protection relay with associated Current Transformers for control and protection of the distribution transformer. An integral cable earthing switch with full making capacity shall be provided.

(vi) The LBS, VCB and the bus bars shall have continuous ratingin accordance with relevant IS / IEC standard.

(vii) The Load Break Switches shall be capable for breaking rated full load current. Its earthing switch shall also be suitable for full making capacity of the system as

specified. The complete switchgear shall be suitable for breaking capacity of 25kA symmetrical at 11kV three phase.

(viii) Self-sufficient Power pack with One (1) Hr backup shall be provided in each RMU to take care of the DC load requirements within the CSS.

(ix) Provision shall be there for remote operation of the switchgears - Isolator & Breaker. It shall be possible to fit the motors either directly in manufacturing plant or on site as & when required. Installation on site shall be possible.

(x) Each Cable compartment shall be provided with three bushings of adequate sizes to terminate the incoming/ outgoing 11kV 3 Core cables. There shall be enough height from the base of the mounted switchgear so that the cables can be bent and taken vertically up to the bushings. Adequate clearances shall be maintained between phases for Termination. Access to all the cables should be possible from the front of RMU. Cable Termination boots shall be supplied by the switchgear manufacturer.

(xi) Suitable padlocking arrangements shall be provided as stated below…

- CB manual operating handle in the “OFF” position.
- Each isolator operating handle in ‘Closed’, ‘ Open’, or ‘Earth’ position.

(xii) System Particulars

- Frequency : 50Hz ±3%
- No. Of Phases: 3 Phase
- Neutral Grounding: Solidly Grounded
- Fault level:As per the APDCL network/ BIDDER calculationfor 1s
- Internal Arc Tested : As per IEC 61641 for 1s

(xiii) Equipment Particulars :

- RMU type : Non extendible type
- Bus rating : As per the BIDDER calculation
- Bus bar material : EC grade Copper
- Load Break Isolator rating : As per the BIDDER calculation
- Load Break Isolator type : Electrically operated Triple Pole with spring operated non automatic mechanism, quick break contacts with integral earthing arrangement. Interlock shall be provided between Earth and Main switch.

- Breaker type : VCB
- Breaker rating : As per the BIDDER calculation
- Breaker operation : O-3Min-CO-3Min-CO
- CT ratio/ Class : 5P10
- Protection relay : Numerical with 2OC (10%- 200%) and 1 EF (10%-40%).

(xiv) The VCB shall be interlocked with the door Limit switches of the RMU such that the VCB shall trip if the doors are opened.

(xv) The above requirements are project specific requirements. However, the same shall stand superseded as per Local Power supply Authority Guidelines & requirements if required.

(xvi) Voltage indications (VPI) and Fault Passage Indicators (FPI) shall be provided for all the RMU enclosure.

(xvii) Testing and warranty terms for equipment and components shall be as per Local Power supply Authority Guidelines &requirements if required.The Breaker and the components like energy meter and relay shall be SCADA compatible for remote control and operation.

(xviii) Field Remote Terminal Unit (FRTU) shall be provided for the remote monitoring and control.FRTU shall be as per APDCL specification and shall be provided if required by APDCL.

(xix) Data Sheet

1)	**Switchgear Data**	
a.	Service	Indoor
b.	Type	Metal clad
c.	Number of phases	3
d.	Voltage	11000V
e.	Rated Frequency	50 Hz

f.	Rated Current	By Bidder
g.	Short Circuit rating	
i.	Breaking	25 kA rms for Breaker
ii.	Short time withstand for 1 Sec.	25 kA rms
iii.	Rated S/c making	62.5 kA peak for Breaker
h.	Short duration power freq.	28 kV
i.	Insulation Level	75Kvpeak
j.	System earthing	Solidly earthed at substation
2)	**Breaker**	
a.	Type	VCB Circuit Breaker in SF6 tank
b.	Rated voltage	11 kV
c.	Number of breaker	As per SLD.
d.	Breaking current	
e.	i) Load breaking	25KArms.
f.	Making current	62.5KA peak
g.	Rated current	By Bidder
h.	No. of poles	3
i.	Operating mechanism.	Trip free & free handle type with mechanically operated indication & pad locking.

3)	**Isolators**	
a.	Type	Load Breaking & Fault Making in SF6 tank
b.	Number of Isolators	As per SLD.
c.	Rated current	By Bidder.
d.	Rated breaking capacity	By Bidder
e.	Fault making capacity	62.5KA peak
f.	No. of poles	3
g.	Operating mechanism	Operating handle with ON, OFF, Earth positions with arrangement for padlocking in each position.
4)	**Busbars**	
a.	Material	Copper
b.	Type	SF6 insulated
c.	Rated Current	By Bidder

2.1.11 Transformer

(a) Applicable Standards: Transformer shall comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment will be installed. Transformer rating shall be finalized based on the transformer design criteria, specified in this specifications

(b) % Impedance shall be as per IS 1180-2014/ IS 2026: 1977 – (Part-1).

(c) The values of load- losses and No-load losses shall be as given in IS 1180-2014.

(d) Transformers shall be oil-immersed type, hermetically sealed with corrugated tank.

(e) Equipment Particulars:

(i) Voltage Ratio: 11/0.433kV

(ii) Cooling: ONAN

(iii) Vector Group: DYn11

(iv) Tap Changer: -5% to +15% in steps of 2.5%

(v) Type of tap Changer: OCTC/OLTC.

(vi) Temperature Rise of top Oil: 40ºC

(vii) (above ambient temperature measured with thermometer)

(viii) Temperature Rise of winding: 45ºC

(ix) (above ambient temperature measured by resistance method)

(x) No load current: 1.5% of full load current

(xi) Max flux density: 1.55T

(xii) Current density: Max 2.8A/sq mm

(xiii) Clearances: As per relevant standards,

(xiv) Transformer Oil: As per IS 335 and MSEDCL requirements.

(f) General Constructional Features of Transformer:

All material used shall be of best quality and of the class, most suitable for working-under the conditions specified and shall withstand the variations of temperature and atmospheric conditions, overloads, over-excitation, short-circuits as per specified standards, without distortion or deterioration or the setting up of undue stresses in any part, and also without affecting the strength and suitability of the various parts for the work which they have to perform. The transformer construction shall be suitable for Seismic Data (As per latest edition of BIS) or mentioned elsewhere in the specification.

(i) Tanks:

- The transformer tank and cover shall be fabricated from robust M.S. plate steel without pitting and shall have adequate thickness, with external

cooling tubes or radiators. The tank and cover shall be of welded construction. All seams shall be welded and where practicable they shall be double welded. All edges shall be double welded. The tank wall shall be reinforced by stiffener to ensure rigidity, so that it can withstand without any deformation

(a) Mechanical shock during transportation

(b) Oil filling by vacuum.

- All removable covers shall be provided with weatherproof, hot oil resistant, resilient gaskets. The material used for gaskets shall be cork neoprene or approved equivalent.The design shall be such as to prevent any leakage of water into or oil from the tank.

- Air release plugs shall be provided on main tank top cover to cover entire area suitably.

- Inspection covers shall be provided to facilitate individual inspection, without lifting the tank cover, for the following:

  Connection of primary winding to disconnection chamber bushings.

  Connection of secondary winding to disconnection chamber bushings.

  Main tank center for core/winding inspection.

- The exterior of tank and other steel surfaces shall be thoroughly cleaned and have a priming coat of zinc chromate applied. The second coat shall be of an oil and weather-resistant nature, preferably of distinct colour from the prime and finish coats. The final coat shall be of a flossy, oil and weather resisting non-fading paint of specified shade. The interior of the tank shall be cleaned by shot blasting and painting with two coats of heat resistant and oil insoluble paint.

- Steel bolts and nuts shall be galvanized.

- Vacuum & Pressure Tests- Various Vacuum & Pressure Tests for tank, conservator, radiator, pipes etc. shall be as per mentioned in the CBIP Manual on Transformer – Publication no. 317: 2013 & latest edition thereof.

(ii) Core

- The magnetic circuit shall be constructed from high grade, cold-rolled, low loss, high permeability, non-ageing grain oriented silicon steel laminations.The transformer shall be designed to have minimum humming noise. The percentage harmonic potentials with the maximum flux density under any conditions shall be such that capacitors connected in the system shall not be overloaded.

- The coil assembly shall be supported suitably between adjacent sections by insulating spaces & barriers. Brazing shall be arranged to ensure a free circulation of the coil & to reduce the hot spot of the winding.

- The insulation structure for the core to bolts and core to clamp plates shall be such as to withstands BIL & Lightning Impulse Voltage

- Each lamination shall be coated with insulation which is unaffected by the temperature attained by the transformer during service.

- Core laminations shall be annealed and burrs removed after cutting. Cut edges shall be insulated.

- The core and coil assembly shall be securely fixed in position so that no shifting or deformation occurs during movement of transformer. The core and coil assembly shall be capable of withstanding without injury, the thermal and mechanical effects of short circuit at the terminals of any winding as per IS:2026.

(iii) Windings

- Windings shall be of electrolytic grade Copper of 99.9% purity unless specifically approved by the Purchaser.

- Windings shall be of insulated Copper wire or Copper strip.

- Windings and insulation shall be so arranged that free circulation of oil is possible between coils, between windings, and between winding and core.

- Winding shall be subjected to a shrinking and seasoning process, so that no further shrinkage occurs during service.

- The completed core and coil assembly shall be dried in vacuum and shall be immediately impregnated with oil after the drying process to ensure elimination of air and moisture within the insulation.

- High voltage end-windings shall be suitably braced to withstand short circuit stresses and stresses caused up by surges.

- Materials used in the insulation and assembly of the windings shall be insoluble, non- catalytic and chemically inactive in the hot transformer oil, and shall not soften or be otherwise affected under the operating conditions.

- Varnish application on coil windings may be given only for mechanical protection and not for improvement in dielectric properties. In no case varnish or other adhesive be used which will seal the coil and prevent evacuations of air and moisture and impregnation by oil.

- Permanent current carrying joints in the windings and leads shall be welded or brazed. Clamping bolts for current carrying parts inside oil shall be made of oil resistant material which shall not be affected by acidity in the oil. Steel bolts, if used, shall be suitably treated.

- Terminals of all windings, and if stated also of stabilizing windings, shall be Brought out of the tank through bushings for external connections.

- Windings conductors shall be transposed at sufficient intervals in order to minimize eddy currents and equalize the distribution of currents and temperatures along the windings.

- The sequence and orientation of HV/LV side phase and neutral bushings shall be as specified in the latest edition of relevant IS.

- All leads from the windings to the terminal board and bushings shall be rigidly supported to prevent injury from vibration or short circuit stresses. Guide tube shall be used wherever practicable.

- Transformer shall operate without injurious heating at the rated KVA and at any voltage up to ± 10 % of the rated voltage of any tap. Transformer shall be designed for 110 % continuous over-fluxing withstands capability.

(iv) Internal Earthing: The framework and clamping arrangement of core and coil shall be securely earthed inside the tank by Copper strap connection to the tank.

(v) Terminations:

Transformers shall be fitted either with bushing insulators or with air insulated cable boxes / air insulated cable box with disconnecting chamber, as per requirement based on transformer HV incomer.

The neutral of the star-connected winding shall be brought out to a separate bushing terminal. The neutral bushing shall be provided on the tank side to facilitate lead of the earth conductor down to the ground level. For transformers 1000 KVA and above, tank mounted insulators shall be provided for supporting the neutral earthing bar of specified section, along its run from the neutral bushing to ground-level.

(vi) Bushings:

Bushings shall be designed and tested to comply with the applicable standards specified in the specifications.

Bushing rated for 400A and above shall have non-ferrous flanges and hardware.

Fittings made of steel or malleable iron shall be galvanized.

Bushings shall be supplied with terminal connector clamp suitable for connecting the bushing terminal to the specified conductor/ cable.

Noise level of transformers shall be as per latest NEMA standard.

Oil - Transformers shall be supplied complete with transformer oil. Transformer oil shall be as per IS-335:1993, BS 148 or IEC 296. 10% extra oil shall be supplied with transformer in non-returnable drums.

2.1.12 Field Remote Terminal Unit (FRTU)

FRTU shall be as per APDCL specification

2.1.13 LV Switchboard For CSS

(a) The LV Switchboards housed inside the CSS enclosure shall be as per the requirements of this specification.

(b) All panels shall be Type tested in accordance with IS 8623/ IEC 61439-1 and Arc resistant tested in accordance with IEC 61641-part 500, supplement 2 for 0.3sec minimum.

(c) Provision for interlocking of LV Incomer breaker with HV side breaker shall be provided such that if the HV breaker trips then the LV breaker will trip and it shall not be possible to close the LV breaker unless the HV side breaker is closed.

(d) Constructional Requirements:

(i) Constructional requirements of the LV panel inside the CSS shall be similar to that specified for the other LV panels below.

(ii) One no. Circuit Breaker shall be provided with Microprocessor based Overload/ Short Circuit and Earth Fault (Inbuilt) releases.

(iii) Adequate space shall be provided for terminating the outgoing cables.

2.1.14 Installation Of CSS

(a) All installation works shall be carried out by Manufacturer's trained/ skilled personnel and supervised by Manufacturer Certified/ Approved Engineer as per good and safe engineering practices and relevant standards for installation of particular components.

(b) All routine and pre-commissioning tests shall be carried out by certified engineer of BIDDER at site and test reports shall be submitted duly signed and stamped. This is included in the scope and quoted price offered by BIDDER. Proper tools for unloading/ lifting and erection shall be arranged by BIDDER.

(c) All testing equipments and setups shall be arranged by BIDDER. This is included in the scope and quoted price offered by BIDDER.

(d) Proper unloading, handling, storage and security arrangement of all the materials/ equipment supplied are included in the scope and the BIDDER shall ensure the same without any additional extra cost to the PURCHASER.

(e) Assembly of the various sections of the equipment, either free issue by PURCHASER or supplied/ procured by BIDDER, dispatched separately from the factory shall be in the

scope of BIDDER.

(f) Installation shall be considered as being the erection of equipment at its permanent location. Thus, unless otherwise specified, shall include shifting from place of storage to the place of erection, unpacking, cleaning, assembly and lifting into position, grouting, leveling, aligning, coupling of or bolting down to previously installed equipment bases/ foundations, performing the alignment check and final adjustment prior to initial operation, testing & commissioning in accordance with MANUFACTURER's tolerances, instructions and the specifications.

(g) It is expected that equipment/ systems shall be installed as per the best engineering practice and in strict accordance with the MANUFACTURER's recommendation(s). PURCHASER shall have full authority to reject all/ any portion of the work that is considered bad in quality or workmanship. The rejected work shall be made good by the BIDDER free of cost. In this regard the decision of PURCHASER would be final and binding

(h) Pre-commissioning checks and final commissioning of the equipment's being supplied by the PURCHASER or the equipment/ system supplied by the BIDDER shall be carried out as per the provisions of this specification, relevant standards, APDCL Guidelines and MANUFACTURER's erection / commissioning manual.

(i) BIDDER shall submit site test reports & its test procedures; details of test equipment used etc. in printed format with sufficient no. of copies along with originals duly signed & stamped by appropriate authority as may be decided by relevant Statutory Bodies.

(j) BIDDER shall maintain necessary co-ordination with the PURCHASER and various other agencies working at the same site as the BIDDER.

2.1.15 Equipment Foundations:

(a) The foundation shall be designed for Seismic Zone for the location as per BIS.

(b) Foundation shall be proportioned in such a way that the allowable soil bearing capacity is not exceeded and the resulting settlement is within the acceptable limit in case of shallow foundation.

(c) EGL (Existing ground level) and FGL (Finished ground level) shall be marked on all drawings showing foundation/sub-structure details and related design documents. Machine/static equipment foundations shall be separated from adjoining parts of buildings, other foundations and floor/pavement slabs. Joints at floor/pavement slabs shall be suitably sealed.

(d) Foundations and structures for machines subject to vibrations shall be so proportioned that the amplitude and frequency of the foundation/structure are within the permissible limits as per relevant BIS codes (or as required by the machine vendor).

(e) Machine foundations shall be designed and detailed as per IS: 2974.

(f) Adequate reinforcement shall be provided around bolts subjected to high pull out forces.

(g) Minimum Depth of Foundation: GL- 1500mm for all major foundations to consider.

(h) Clear gap shall be provided in superstructure to avoid transmission of vibration to adjacent structures.

(i) Foundation shall be of uniform rectangular/ square shape and shall extend minimum 1000mm and 600mm from the edge of base frame along the length and breadth respectively.

(j) The Foundation shall be raised minimum 450mm above the FGL.

(k) The geometric layout of the foundation and structure shall be basically symmetric with respect to the vertical plane passing through the rotational axis of the equipment.

(l) Minimum reinforcement as per requirements of IS: 2974 shall be provided unless required otherwise by design.

(m) Block foundations shall be preferably cast in a single concreting operation.

1.1.2 Fencing and Gate

(a) The work of erecting chain link fencing includes excavation, UCR wall construction, erection of angle/ channel supports, providing chain link mesh on angle/ pipe frame barbed wire fencing at the top, concreting of support members, painting the complete structure and white washing the walls. All materials, hard wares, labours etc. are in the scope of BIDDER.

(b) Fencing height shall be minimum 2.5 meter (2m + 0.5m barbed wire) & shall be complying with CEA guide lines requirements.

(c) Gate for entry in the fenced compound shall be fabricated from pipes of heavy duty class. Design of gate shall be got approved from the engineer in charge before starting the fabrication work. All necessary hard wares, fittings, stoppers, locking arrangements with brass pad locks of 100 mm size are in the scope of gate works. Gates shall be self-supporting type.

2.1.16 Maintenance Requirements:

(a) Easy access shall be provided for all components in the CSS for maintenance.

(b) The BIDDER shall furnish operating and maintenance instructions manual to enable the PURCHASER to carry out maintenance of the equipment effectively and safely after the defect liability period.

(c) As far as possible the components & switchgears shall be so designed that no special tools are necessary for installation and maintenance. However, if special tools are required, the BIDDER shall include price of one complete set in his BID and indicate the same for PURCHASER's approval.

(d) BIDDER shall furnish detailed inter panel wiring diagrams, internal wiring diagrams, detailed component layout drawings to enable the PURCHASER to carry out maintenance work the defect liability period.

(e) Consumable required for installation like greases, jointing compounds or pastes, etc. shall be supplied along with the equipment including 10% extra and their prices shall be included in the offer. Detailed technical descriptions for future purchase shall be also submitted.

2.1.17 Performance Tests:

(a) Prices quoted shall include the cost of all Routine & Acceptance tests as per relevant IS standards.

(b) BIDDER shall carry out all Routine and Functional tests as specified in the relevant IS standard requirements on the completely assembled components of the CSS (RMU, Transformer and LV Panels) in the presence of the PURCHASER's representative or/ and APDCL representative as may be decided later, at its/ sub vendor's works before dispatch and furnish copies of test reports for approval.

(c) BIDDER shall quote separately for following tests for transformer-

(i) Heat run Test/ temperature rise test

(ii) Impulse test

(iii) Short Circuit Test

(iv) Vaccum and Pressure test

(d) BIDDER shall furnish copies of Routine and Type test report for all bought out items, as may be demanded by PURCHASER, for approval during the inspection or prior as instructed by them.

(e) The BIDDER shall also make available at works as well as at site various instruments, meters etc. necessary for testing and commissioning of the equipment under scope of work duly calibrated within not more than one (1) year from accredited laboratory.

2.2 TECHNICAL SPECIFICATIONS OF LT SWICTHBOARDS

2.2.1 GENERAL:

The scope of this specification includes design, engineering, manufacture/ assembly, installation, testing and performance demonstration of the LV Panel boards for various sizes and ratings to be provided for the distribution of the power supply i

The panels shall include

(a) Floor mounted compartmentalised panels –

(i) Power Control Centreof STP with two transformer incomers ,one DG incomer and bus couplers (PCC)

(ii) Main Outdoor Feeder Pillar (MFP) for Landscape Area

(iii) MCC Panels in STP

(iv) Power Distribution Board (PDB) in STP/ Landscape Area

(v) Auto Power Factor Control panels (APFC)

(b) Wall mounted Distribution Board for

(i) Indoor Lighting Panels (LP) for lighting fixtures

(ii) Raw Power DB for receptacles (RDB) for general and dedicated raw power points

(iii) Outdoor Lighting Panel (OLP) for outdoor lighting

(iv) Outdoor Feeder Pillar (FP)

2.2.2 Applicable Standards: The design, manufacture and performance of equipment shall conform to the latest standards specified below. In case of conflict between standards and this specification, this specification shall govern.

Metal enclosed switchgear General requirements	: IS: 3427
Factory Built Assemblies of SWGR and Control gear for Voltages up to and including 1000V AC & 1200VAC	: IS: 8623 / BS: 5486 / IEC: 61439
Air Break Switches	: IS: 13947-P3 / BSEN6049 / IEC: 60947-3
Miniature Circuit Breakers	: IS: 8828 / BSEN: 60898
Low Voltage Fuses	: IS: 13703 / BS: 1362 / IEC: 269-1
Contactors	: IS: 13947 / BSEN: 60947 4 / IEC: 60947-1
Starters	: IS: 13947 / BSEN60947-4/ IEC: 292-1 To 4
Control Switches & Push buttons	: IS: 6857 / BSEN: 60947
Current Transformer	: IS: 2705 / BS: 7626
Voltage Transformer	: IS: 3156 / BS: 7625 / IEC: 44, 186
Indicating instruments	: IS: 1248 / BS: 89 / IEC: 51
Marking and Identification of Conductors and Apparatus Terminals	: IS: 11353 / BS: 159
A.C. Electricity Meters	: IS: 722, 8530 / BS: 5685 / IEC 145,211
Degree of Protection	: IS: 13947 / IEC: 947-P1
Selection installation and Maintenance of switchgear and Control gear	: IS: 10118
Code of practice for Phosphating iron and steel	: IS: 6005 / BS: 3189
Specification for copper rods and bars for electrical purposes	: IS: 613
Control transformers for switchgear and control gear voltage not Exceeding 1000V AC	: IS: 12021

2.2.3 Constructional Features for Floor Mounted panels:

The switchgear shall be metal enclosed, modular type suitable for indoor/ outdoor installation, dust &burning proof, self-standing floor/ plinth mounting with a height not exceeding 2300 mm and shall have following features:

(a) Panels shall be complying to Form 3B as per IS 8623: 1993, Part I / IEC 61439-1

(b) Minimum clearance between live part shall be phase to phase 25.4 mm & phase to neutral 20 mm at any location & shall be complying with the BIL for the panel.

(c) Switchgear shall be divided into distinct vertical sections each comprising :

(i) A completely enclosed bus bar compartment running horizontally.

(ii) Enclosed vertical bus bars serving all modules in vertical section.

(iii) A separate horizontal enclosure for all auxiliary power and control buses.

(iv) Vertical cable alley of minimum 300 mm wide covering entire height

(d) Operating devices shall be incorporated only in the front of switchgear.

(e) Each shipping section shall have metal sheets at both ends

(f) Cable alley shall be provided with suitable hinged doors

(g) All doors shall be with concealed type hinges and captive screws

(h) Each vertical section shall be equipped with a space heater controlled by thermostat

(i) Each switchgear cubicle shall be provided with interior lighting with 7W LED luminaries inclusive of lamp with door limit - on/ off switch.

(j) A 240 V AC, 5/ 15 A sockets shall be provided in the interior of each cubicle with On-Off switch.

(k) All identical equipment and corresponding parts be fully interchangeable without any modifications

(l) Main Bus bars:

(i) Switchgear bus bars shall be of uniform cross section throughout the length and made of Electric grade Aluminium (91 E – 63401)

(ii) All bus bars shall be covered with heat shrinkable black PVC sleeves. Coloured polyester tapes for phase identification shall be provided at suitable locations.

(iii) Bus bar shall be adequately supported to withstand stresses developed due to short circuits.

(iv) Bus bar joints shall be provided with contact grease at the joints and shall be complete with tensile steel bolts, washers and nuts

(v) The exposed bus live parts in the cable alley shall be totally covered against accidental contact by a shroud (and not by sleeve) to protect the workmen working on the switchgear.

(vi) Vertical bus bars shall have Short Circuit rating same as main bus bar and shall be suitable for all connected load of vertical section.

(vii) Neutral bus bar size shall be 50% of phase bus bar.

(viii) Termination on bus bars at ACB, MCCBs shall be as per IEC60947-2. For terminations on MCCBs, where phase- phase and phase to earth clearance are not possible, Cu spreaders of suitable size shall be used along with the use of separators.

(ix) Bus bar supports shall only be SMC irrespective of bus bar size. The span between the two insulators shall be adequate. Joint positions and insulators shall be properly adjusted so that they don't interfere.

(x) Wherever Cu bus bars are provided, it shall be tinned copper & not bare Cu.

(m) All mounting accessories like base channels, cross angles if required, nuts, bolts etc. shall be supplied by the Contractor.

(n) All the indoor switchgear panels shall be suitable for IP-54 degree of ingress protection for the enclosure. Outdoor panels shall be with minimum IP-55, degree of protection

(o) All panels shall be made up of CRCA sheet steel of following thickness -

(i) Load bearing members - 2.5 mm.

(ii) Doors and partitions - Doors – 2 mm, Partition - 1.5 mm.

(iii) Mounting plate - 2 mm.

(iv) Gland plate - 3 mm for both incomer and outgoing. For single core cable these plates shall be non-magnetic.

(v) Base frame – minimum ISMC 100

(p) All the panel wiring shall be done with PVC FRLS, multi-stranded copper wires

(q) Feeder shall have hinged open-able (more than 105˚) type door with panel locks. All bus-bar covers and other panel covers shall be screw fixed.

(r) Suitable barriers of FRP material shall be provided between two terminals connected to different voltage supplies.

(s) All doors and detachable components shall be earthed with flexible green coloured (with Yellow coloured band) PVC sheathed 2.5/ 4.0 sqmm. multi-stranded Copper cable.

(t) The equipment shall be given tropical and fungicidal treatment.

(u) Each compartment & component shall be provided with name plates (with blackletters on whitebackground) at front, inside & rear side.

(v) Equipment nameplates shall be fixed by screws/ rivets and shall not be pasted.

(w) Metallic Shrouding shall be provided for the isolation of main and vertical bus; as well as to avoid accidental contacts with live parts.

(x) Drawing pocket shall be provided on the inside of incomer feeder door.

(y) Provision for Top/ Bottom cable entry shall be made to suit the site condition.

(z) Lifting hooks/ eyes shall be provided in each shipping section of the equipment and shall be removable type.

(aa) All the panels shall be provided with 20% extra power & control terminals.

(bb) All unused contacts of the circuit breaker, protection, auxiliary, control relays shall be wired up to the terminal block.

(cc) All terminals of different control voltages shall be separate from each other.

(dd) Stud type terminals and ring type lugs shall be used for control cables.

(ee) All the control/ power wiring shall be dressed neatly & the wire running through troughs shall be provided with covers

(ff) Switchgear shall be easily extensible on both sides by the addition of vertical sections after removing the end covers. It shall be provided with a metal sill frame made of structural steel channel section properly drilled for mounting the switchgear along with necessary mounting hardware. Hardware shall be zinc plated or passivated. It shall be provided with labels on the front and rear indicating the switchgear designation.

(gg) Any operating handle of switchgear shall not be more than 1800 mm and not lower than 300 mm from base of the panel.

(hh) For individual feeder modules arranged in multi-tier formation, it is essential that the modules are integral multiples of the unit size to provide for flexibility in changes if any at site. For safety isolation of the vertical bus bars, insulating barrier with cut outs shall be provided to allow the power slab contacts to engage with vertical Bus bars. A vertical cable alley shall be sufficiently wide for motor control modules and for circuit breaker control modules.

(ii) A horizontal separate enclosure for all auxiliary power and control buses, as required shall be located so as to enable easy identification, maintenance and segregation from the main power buses. Tap off connections from these buses shall be arranged separately for each vertical section.

(jj) All equipment associated with a single circuit shall be housed in a separate module compartment of the vertical section.

(kk) For draw out type modules, only the handles of control and selector switches, push buttons, knobs & cut outs for lamps and meters shall be arranged on the front doors of the respective compartments to permit operation without opening the door.

(ll) On circuit breaker controlled circuits, protective relays shall be mounted on the front door of the compartment. All other equipment pertaining to a circuit shall be mounted on the withdrawal chassis. All cut outs shall be provided with gaskets for the purpose of dust proofing.

(mm) Current transformers shall not be directly mounted on the buses. Current transformer on circuit breaker controlled circuits shall be mounted on the fixed portion of the compartment.

(nn) In breaker compartments, external cable connections shall be carried out in separate cable compartments for power and control cables.

(oo) After isolation of the power and control connections of a circuit, it shall be possible to safely carry out maintenance in a compartment with the Bus bars and adjacent circuit live.

(pp) The withdrawals chassis shall move on suitable guides and on suitably plated steel or stainless steel rollers or balls to facilitate easy withdrawal.

(qq) Cable alleys shall be provided with suitable hinged doors. It shall be possible to safely carryout maintenance work on cable connections to any one circuit with the Bus bars and adjustment circuits live. Adequate number of slotted cable support arms shall be provided for cleating the cables.

(rr) Rear of single front switchgear shall be provided with removable panels. It shall be possible for one person to remove and fix the removable panel.

(ss) All doors shall be provided with concealed type hinges and captive screws.

(tt) The draw out contacts shall be only between copper/copper alloy/ aluminum fuses, which are silver or tinplated. The contact design shall be such that there should be no arcing/ deformation under the associated peak short circuit current.

(uu) Switchgear shall be designed in such a way that all components equipment and Bus bars operate satisfactorily without exceeding their respective maximum permissible rise in temperature under ambient temperature conditions prevailing within the switchgear cubical, with reference to ambient temperature outside the switchgear cubical.

(vv) Provision of ventilating louvers shall be provided with fine-screened brass or GI meshes to prevent entry of vermin and dust.

(ww) The various types of modules indicating the control requirements of each type together with the list of component equipment required for each type shall be as follows: -

(i) Incoming circuit - Draw Out type air circuit breaker for above 630A/ Fixed type MCCB for 630A & below

(ii) Outgoing feeder - ACB/ MCCB/ MPCB

(iii) Auxiliary services - Starters, capacitors, Distribution Boards and other auxiliary load

(xx) Physical size of compartment for each type of control and current rating shall be so chosen that all the basic and additional equipment can be housed in the compartment. No equipment associated with any particular circuit shall be permitted to be mounted in any other circuit module.

2.2.4 Outdoor Feeder Pillar:

(a) Feeder Pillars (FP) shall be Outdoor type, Wall/ Column/ Steel Support mounting, Weatherproof, single door, single front, non-compartmentalized enclosure with locking facilities with Din rail mounting arrangement.

(b) Enclosure should be with impact resistance of IK10 & Ingress protection of IP 55.

(c) The FP (Feeder Pillar) shall be of sheet steel enclosed and shall be fully dust and vermin proof, with canopy. The sheet steel used shall be cold rolled and 2 mm thick. The gland plate shall be 3mm thick.

(d) The feeder pillar shall have cable entry at the bottom suitable for terminating double compression glands for minimum 1 Runs of 3.5 C X 50 sq.mm Aluminium conductor, XLPE insulated armoured cable at the incoming terminal and minimum 6 Runs of 4 core 10 sq.mm. Aluminium conductor, XLPE insulated armoured cable at the outgoing terminal.

(e) The feeder pillar shall consist of Four Pole (FP) MCCB/MCB and RCCB and Outgoing of TPN MCB

(f) The power and control components are as listed below;

(i) Copper bus bar with SMC support insulators shall be provided for power distribution within the feeder pillar. The size of phase and neutral shall be equal.

(ii) All connecting power & control wiring shall be carried out with stranded copper conductor PVC insulted LSHF wires. Minimum size of control wiring shall be 1.5 sq. mm and power wiring shall be 4 sq. mm.

(iii) An Aluminium / GI Earth bus shall be run at the bottom of the Feeder Pillar which shall be connected to the earth leads at the two extreme ends for connecting the GI earthing strip from the electrode.

(iv) Two nos. Pipe Earthing electrode shall be provided for each Feeder pillar and connected with 25X6 mm GI earth strip. The pipe electrode shall be as per the latest version of IS 3043

The feeder pillar shall be mounted on prefabricated Galvanised Steel Support structure duly fastened with a concrete foundation with grade M20

2.2.5 Lighting Panel, Raw power distribution boards, outdoor lighting panel configuration shall decide by the contractor.

2.2.6 Distribution Boards

(a) Distribution Board shall be of industrial type, totally sheet steel enclosed of 2mm thick,

double door construction, fully dust and vermin proof, wall/column mounting type with a degree of protection of IP – 52. The boards shall have welded back and sides and hinged door with gasket at the front with door handle and suitable locking device. Detachable cover plates shall be provided at the top and bottom for cable/conduit entry and suitable knock out shall be provided for this purpose. The DB after fabrication shall be subject to rust removal treatment and provided with epoxy powder coating followed by baking. The board shall have 2 No. earthing terminals suitable for 25mm X 6mm GI flat and mounting arrangement for wall/column mounting.

(b) Protective cover plates shall be provided inside the board to shroud all the live parts with only the operating knobs of MCBs protruding outside the cover plate. Adequate space shall be provided within the board to facilitate termination of incoming and outgoing flexible cable/conductor. The board shall be factory assembled and wired with HFFR/ FR/ FRLS insulated stranded copper wires. The MCB phase feeders shall be suitable for mounting on the DIN rail provided in the board. Tinned copper bus bar shall be used in the board.

(c) 20% spare outgoing circuits shall be considered per phase in each LP as spare.

(d) For all Distribution Boards, RCCB sensitivity shall be 30mA.

(a) Separate L+PDB shall be considered for Electrical room, Pump House, maintenance workshop, Process Air Blower Building,Chlorination Cum Chlorine Tonner house,Sludge dewatering Building(one for each floor),Guard Room andAdministrative building

(b) The power to the lighting and receptacle shall be provided through this L+PDB (lighting and power distribution board). And L+PDB shall be supplied through PCC/MCC corresponding to that building/room.

(c) For Laboratory separate, LDB (lighting distribution boards) and RDB (Receptacle distribution boards) shall be provided. The power to the light point shall be provided through the LDB. While power to the receptacle shall be provided through RDB.

2.2.7 Separate instrument's compartment for indicators of flow meter (s), energy meter, level& pressure controller (if any) shall be provided as per actual requirement of suitable size.

2.2.8 Voltages : Following control voltages shall be used in LV panels

(a) All ACBs tripping / Closing shall be suitable for 110/ 240V AC (24/ 110VDC) as applicable. The trip coil and closing coils of ACBs shall operate satisfactorily under the following conditions of supply voltage:

(i) Closing coils - 85 % to 110 % of rated voltage

(ii) Trip coils - 70 % to 110 % of rated voltage.

(b) Indications/ Annunciator for LV Main PCC/ MCC – 110/ 240V AC (24/ 110VDC)

(c) Indications for auxiliary DBs - 240V AC

(d) Space heater, 5/15A socket, panel illumination lamp etc. - 240V AC derived from AC bus

(e) 240V AC, 110V AC and other voltages shall be segregated to avoid mix-up of voltages.

(f) Control transformers suitably rated of voltage ratio 415/240 or 110 V on the Incomer/ Bus shall be provided. For the control transformers, fuses shall be provided on the 415 V side and MCBs on the 240 or 110V side. The control transformer shall be cast resin type only.

2.2.9 Painting:

(a) All sheet steel work shall be paint through 7 tank electrostatic powder coating process in accordance with the required procedure and with the applicable standards. The switchgear enclosure shall be powder coated with shade as per RAL-7032.

(b) The final finished thickness of paint film on sheet steel enclosure shall not be less than 80 microns. Finished painted appearance of equipment shall present an aesthetically pleasing appearance, free from dents and uneven surfaces.

2.2.10 Interchangeability:

All identical equipment and corresponding parts including chassis of draw out modules of the same size shall be fully interchangeable without having to carryout modifications. For trouble free interchangeability, the draw out arrangements shall be designed such that normal dimensional variations are taken care of by self-aligning feature of the modules.

2.2.11 Drawings/ Documents Required:

Prior to fabrication of the switchgear, the contractor shall submit following for Purchaser Representative's approval - the dimensional drawing and design calculations indicating bus bar size, short circuit rating of all the electrical component used, internal wiring, components mounting details etc. The contractor shall submit manufacturers catalogues of the electrical components installed in the switchgear.

2.2.12 Inspection

At all reasonable times during production and prior to dispatch of the switchgear to site, the contractor shall arrange and provide all the facilities at their plant for inspection & testing of switchgear.

2.2.13 Earthing

(a) Al/ GI earth bus bars of adequate size shall be provided for the entire length of the panel. The framework of the enclosure shall be connected to this earth bus. Provisions shall be made for connection form this earth bus to the main earthing bus bar coming from the earth pit on both side of the switchgear.

(b) The earth continuity conductor of each incoming and outgoing feeder shall be connected to this earth bus bar. The armour of cables shall be properly connected with earthing clamp and the clamp shall be ultimately bonded with the earth bus bar.

2.2.14 Labels & Name Plate

(a) Engraved PVC labels shall be provided on all incoming and outgoing feeders. Single line circuit diagram showing the arrangements of circuit inside shall be pasted on inside of the panel door and covered with transparent laminated plastic sheet.

(b) A nameplate with the switchgear designation in bold letters shall be fixed at top of the central panel. A separate nameplate giving feeder details shall be provided for each feeder module door.

(c) Inside the feeder compartments the electrical components, equipments, accessories like switchgear shall be provided with stickers shall suitably identify control gear, lamps, relays etc.

(d) Engraved nameplates shall preferably be of 3-ply (Red-White-Red or Black-White-Black) lamicoid sheet however black engraved perplex sheet nameplates shall also be acceptable. Engraving shall be done with square grove cutters.

(e) Nameplate shall be fastened by counter sunk screws and not by adhesives.

2.2.15 Danger Notice Plates

(a) The danger notice plate shall be affixed in a permanent manner on operating side of the switchgear.

(b) The danger notice plate shall indicate danger notice in Local Language, Hindi and English.

(c) The danger notice plate, in general shall meet to requirements of local inspecting authorities.

(d) Caution name plate, “Caution Live Terminal” shall be provided at all the points where the terminals are likely to remain live and isolation is possible only at remote end i.e. incomer to the switchboard.

(e) The danger notice plate shall be made from minimum 1.6 mm thick steel sheet and after due pretreatment to the plate, the same shall be painted white with vitreous enamel paint on both front and rear surface of the plate.

(f) The letters, figures, the conventional skull and bones shall be positioned on the plate as per recommendations of latest edition of IS 2551-1982.

(g) The said letters, the figures and the sign skull and bonds shall be painted in signal Red color as per latest edition of IS 5 - 1978.

(h) The danger plate shall have rounded corners. Locations of fixing holes for the plate shall be decided to suit the design of the switchgear enclosure.

2.2.16 Cable Entry:

(a) The panel shall have provisions of cable entry from top/ bottom. The removable cable gland plate shall be provided to make entry dust and vermin proof.

(b) The panel shall have provisions for fixing the multi-core cable glands.

(c) The cable glands support plates shall be 3 mm thick.

(d) Cable entries to the panel shall be from the bottom unless otherwise specified. Cable gland shall be double compression screwed type and made of brass.

2.2.17 Mountings:

(a) All equipments in front of panel shall be of flush mounting type.

(b) All equipment shall be so mounted that the removal and replacement may be accomplished individually without interruption of services of others.

(c) All equipment inside the panel shall be so located that their terminals and adjustments are readily accessible for inspection or maintenance.

(d) The centerline of switches, push buttons and indicating lamps shall be matched to give a neat and uniform appearance. Likewise the top lines of all meters, relays and recorders etc. shall be matched.

2.2.18 Air Circuit Breaker (ACB)

(a) All the incomers & bus coupler ACBs shall be FP EDO type. All other ACBs shall be TPN EDO type.

(b) All the ACBs shall have Ics=Icu=Icw=100%

(c) Up to and including 630 A, Fixed Type FP/ TPN MCCB shall be considered, while above 630A FP/ TPN fully draw out type ACB shall be considered.

(d) All ACBs shall be provided with additional 6 NO + 6 NC contacts, exclusively for Purchaser's use.

(e) All the ACBs (except for APFC panel) shall be provided with microprocessor based O/L+ S/C + inbuilt E/F protections.

(f) ACBs/ MCCBs for APFC panel shall be provided with thermal magnetic based O/L+ S/C + E/F protections.

(g) Each ACB shall be provided with – On, Off, Trip, Spring Charged, Trip Coil Healthy, Service & Test Position indication lamps.

(h) For incomer feeders R, Y & B Phase indication lamps shall be provided.

(i) All ACBs shall be Schneider make 'Master pact NW' / Siemens '3WL' / L&T 'C Power' OR Equivalent from the make list.

(j) Circuit breaker shall be horizontal withdrawal type, comprising three/ four identical poles operated through a common shaft.

(k) It shall be suitable for switching duty of transformer and motors and other devices.

(l) It shall be possible to push in and withdraw the breaker easily and without much effort. Insulating plugs and sockets for power as well as for control circuits shall be of robust

design and fully self-aligning. Plugs and sockets for power circuits shall be silver faced, insulated with PVC or other insulating material.

(m) The breaker shall have three distinct positions namely services, test and fully withdrawn positions. In test position, it shall be possible to operate the circuit breaker without energizing the power circuits. Separate limit switches each having a minimum of 4 No contacts shall be provided for both service and test position of the circuit breaker. These contactors shall be rated for 10 Amp, 240 volts AC.

2.2.19 Operating mechanism

(a) The EDO type ACB shall be power operated by a motor charged spring operated mechanism & MDO type shall be manual type spring operated mechanism.

(b) The operating mechanism shall have anti-pumping features under every method of closing. The operating mechanism shall normally be operated by LOCAL/ remote electrical control, when the breaker is in service position. Shunt trip coils shall perform electrical tripping.

(c) The main poles of the breaker shall operate simultaneously. Also there shall not be any objectionable rebound of the moving contact in the fixed contacts.

(d) The mechanism shall be such that any failure of auxiliary spring shall not prevent tripping. When the breaker is in closed position, failure of any auxiliary spring shall not cause damage to the CB or danger the operation.

(e) A mechanical indicator shall be provided on the breaker operating mechanism to indicate open and closed position of the breaker. This shall be visible to a man standing in front of the cubical with the door closed.

(f) It shall be possible to operate the breaker mechanically. This shall be possible only after opening the cubical door. Provision shall be made for local electrical control also when the breaker is in the test position by a control switch on the cubical doors.

(g) All working parts of the mechanism shall be of corrosion resistance material. All split pins; bolts, nuts and other parts shall be properly pinned and locked to prevent loosening with repeated operation of the breakers.

(h) Auxiliary switch containing 6 No. +6 NC potential free contacts rated for 10 Amp 240 V AC (Inductive breaking).

2.2.20 Spring charged Mechanism

(a) Spring operated mechanism shall be complete with motor, opening spring, closing spring with limit switch for automatic charging and all necessary accessories to make the mechanism a complete operating unit.

(b) The breaker operation shall be independent of the motor, which shall be used only for tensioning/ compressing of the spring.

(c) The closing operation shall automatically charge the tripping spring. The closing, opening shall get charged immediately after a closing operation is performed.

(d) Motor used shall be preferably universal type operated on AC supply. The Motor shall operate satisfactory at all values “between” 85% to 110% of rated voltage.

2.2.21 Mechanical / Electrical Interlocking:

(a) Mechanical interlock arrangement shall be provided between two incomer breakers. Interlocking arrangement shall be robust, heavy-duty type and sturdy in construction.

(b) Interlocking between two-incomer breakers shall be provided in such a way that in normal condition bus coupler shall be in “ OFF “ position so that both the transformer can be kept charged and the total load can be divided equally between two circuits.

(c) During fault, maintenance or any other abnormal condition while one of the transformer is not in working mode, the bus coupler shall be in “ ON “position so that total load can be supplied by the remaining transformer circuit.

(d) Interlock shall be Mechanical and Electrical type. In case if one of the interlock fails the other way can be used for interlocking purpose.

2.2.22 Molded Case Circuit Breakers (MCCB)

(a) The MCCBs shall conform to IEC 60947 & the latest applicable standards.

(b) All MCCBs shall be of fixed type unless otherwise specified in the specifications elsewhere.

(c) MCCBs shall be of four pole/ triple pole with neutral construction arranged for simultaneous four/ three-pole manual closing and opening and for automatic instantaneous tripping on short circuit.

(d) All the incomer & bus coupler MCCBs for Main LT P~~M~~CC panels shall be FP type with microprocessor based O/L +S/C + inbuilt E/F release & all outgoings MCCBs shall be ~~TPN with thermal magnetic based O/L +S/C + E/F releases~~as indicated in the SLD.

(e) For achieving the Earth Fault protection in thermal magnetic (TM) based MCCBs, external CBCT, Earth Fault relay & shunt trip provision shall be considered as part of complete TM based MCCB.

(f) The ON, OFF and TRIP positions of the MCCB shall be clearly indicated by using LED indications.

(g) MCCBs shall be with ICS = ICU = 100%

(h) MCCB shall be capable of withstanding the thermal stresses caused by overloads and locked rotor currents of values associated with protective relay settings of the motor starting equipment and the mechanical stresses caused by the peak short circuit current of value associated with the switch gear rating.

(i) All the MCCBs shall be of current limiting type and shall provide a cut off in 4-8 milli seconds for prospective currents during faults.

(j) All the MCCBs shall be provided with rotary operating handle with door interlock.

(k) MCCB terminals shall be shrouded and designed to receive cable lugs for cable sizes relevant to circuit ratings.

(l) All MCCBs shall be provided with additional 2 NO + 2 NC contacts, exclusively for Purchaser's use.

(m) All the switchgear selection for motor feeders shall be Type-2 co-ordinated.

2.2.23 Entire LV system shall be fuse less type & fuses shall be used only for PT/ Control Transformer primary side. MCBs shall be provided on secondary of PT/ Control transformer

2.2.24 Miniature Circuit Breaker (MCB)

(a) MCB shall be hand operated, air break, quick make, quick break type.

(b) Operating mechanisms shall be mechanically trip-free from the operating knob to prevent the contacts being held closed under overload or short-circuit conditions.

(c) Each pole shall be fitted with a bi-metallic element for overload protection and a magnetic element for short-circuit protection. Multiple pole MCBs shall be mechanically linked such that tripping of one pole simultaneously trips all the other poles. The magnetic element tripping current classification shall be of the type suitable for the characteristics of the connected load. Where this is not specified, it shall be Type C.

(d) The short circuit rating shall be not less than that of the system to which they are connected.

2.2.25 Direct-On-Line Starters: Direct on line motor starter shall have following components/ features:

(a) Direct-on-line starters shall be suitable for Class AC 3 utilization category as per IS: 13947 (Part 4), unless otherwise mentioned in tender.

(b) DOL starter shall have MCCB/ MPCB, Overload Relay with SPP, Contactor etc.

(c) Type 2 Co-ordination shall be ensured.

2.2.26 Automatic Star-Delta Starters: Automatic star-delta motor starters shall have following components/ features:

(a) Three sets of contactors one for the line, one for the star point and one for the delta, and a timer to automatically change the connections from star to delta.

(b) Star Delta Starters shall consist of MCCB/ MPCB, Overload Relay with SPP, Contactors, electronic timer etc.

(c) Star-delta contactors shall be electrically interlocked to permit starting of the motor in the proper sequence, namely star contactor closing, line contactor closing, timer energized after time delay, timer contact de-energizing the star contactor, and delta contactor closing.

(d) Star-delta starters shall be suitable for AC 3 utilization category as per IS: 13947 (Part 4), unless otherwise mentioned in tender.

(e) Type 2 Co-ordination shall be ensured.

2.2.27 Reversing Starters: Motor Reversing starter shall have following components/ features:

(a) Forward and reverse contactors, electrically interlocked with each other.

(b) Reversing starters shall be suitable for Class AC 4 duty as specified in applicable standards, unless otherwise mentioned in tender.

2.2.28 Soft Starters: Fully automatic microprocessor based soft starters with built-in bypass terminals for pump control application shall be considered for the motors above 75 kW. The features/ requirements of the starters shall be as per following but not limited to:

(a) The soft starter shall be designed, built and tested according to the latest editions of applicable IEC standards/ IEC 947-4-UL, CE.

(b) Input Voltage – 3Ph, 415V, ±10%

(c) Input Frequency – 50 Hz, ±5%

(d) Control Voltage – 100 - 240 V AC

(e) Ambient Conditions:

(i) Temperature – 50 Deg C. (Operating range -5 to 70ºC)

(ii) Relative Humidity of 5 to 95%

(f) Control Method – Torque Control/ Reduced Voltage/ Ramp

(g) Motor Protection – Thermal overload protection

(h) Starter Protection – S/C, Phase imbalance, Phase failure, Phase reversal, O/ V, U/ V, Locked rotor, excessive starts per hour for application, Phase loss input/ output, Motor output loss.

(i) EMC standard – IEC 61000-4-2 level-3, IEC 61000-4-3 level-3

(j) Built-in communication port for RS 485.

(k) Type 2 Co-ordination shall be ensured.

(l) The soft starter shall be complete with the following acceleration and deceleration settings & display requirements as a minimum-

(i) Starting Torque: Initial torque shall be adjustable from 0-100% of maximum locked rotor torque.

(ii) Ramp Time: The time between starting torque and maximum torque shall be adjustable between 1 to 60 seconds. The time between maximum torque & stop shall be adjustable between 2 to 120 seconds

(iii) The current limit feature shall have the following characteristics:

a. The maximum allowed current during start shall be adjustable from 150% to 500% of soft-starter maximum current rating.

b. Starting torque shall be fixed at 40% when utilizing the current limit function.

(iv) Voltage Ramp start & Full voltage DOL start shall be possible.

(v) For stop function – Linear torque control, Quadratic Torque Control, Voltage ramp control, soft break etc. functions shall be provided.

(vi) The soft-starter shall be provided with a functional ground to remove and/ or minimize electrical noise injected on the soft starter control board.

(vii) Normally open output relays shall be provided for faults and status indications.

(viii) Normally closed contacts for fault relays shall be provided as an option.

(ix) The soft-starter shall be provided with a 2-position dip switch to select between the normal in-line connection (3-lead motor) and inside the delta (6-lead or 12-lead delta wound motors).

(x) The soft-starter shall be controlled completely through solid state design algorithms. No moving electromechanical contacts shall be allowed.

(xi) All adjustments shall be made from the front of the soft starter through keyboard (soft keys)

(xii) The Soft starter shall have remote display with following display parameters.

a. Three Phase Currents

b. Three Phase Voltages

c. Shaft Power in kW / HP (selectable)

d. Motor thermal capacity

e. Motor Energy consumption (kWh)

f. Power factor

g. Run time in hours

(xiii) The Soft starter shall have following fault indications

a. Line failure

b. Phase imbalance

c. Over temperature – Motor

d. Over temperature – Soft Starter

e. Shorted Thyristor

f. Open Thyristior

g. Locked Rotor

h. Motor output loss

i. Overload - Shaft Torque

j. Underload – Shaft Torque

k. Over voltage

l. Under voltage

m. Excessive Starts

n. Phase reversal

(xiv) Shaft Power measurement without the use of external electro mechanical sensors.

(xv) Shaft overload and under load protection shall be available through the controller, even in a by-pass configuration.

(xvi) When fault conditions are detected, the controller shall inhibit starting or shut down SCR pulse firing.

(xvii) The standard feature pump control shall be implemented to provide closed loop control of a motor to match the specific torque requirements of centrifugal pumps for both starting and stopping.

(xviii) The soft-starter shall be designed for three-phase control with two anti-parallel SCRs in each phase. SCR-Diode combination shall not be acceptable.

a. The PCB shall provide digital microprocessor control and supervision of all controller operation, including SCR pulse firing control.

b. The PCB power supply shall be self-tuning to accept control power input from 100 to 240 or 380 to 500 V AC, 50/ 60 Hz.

c. The SCR firing circuitry shall incorporate an RC snubber network to prevent false SCR firing.

d. When fault conditions are detected, the controller shall inhibit starting or shut down SCR pulse firing.

(xix) SCRs shall have the following minimum repetitive peak inverse voltage ratings:

a. 200 to 525V: 1600 V

b. 200 to 690V: 1800V

2.2.29 Variable Frequency drives: Variable Frequency system shall have provision such that inter-opera ability with instrumentation control system for flow control.

(a) Applicable Standards

(i) Specification for metal clad base materials for printed circuits for use in electronic and telecommunication equipment - IS:5921

(ii) Specification of Transformers and Inductors (Power, Audio, Pulse and Switching) for Electronic Equipment-IS:6297

(iii) Semiconductor rectifier equipment safety code for IS:6619

(iv) Specification for printed wiring Board -IS:7405

(v) Recommended practice for emergency and standby power systems for industrial and commercial application- IEEE:446

(vi) Semiconductor devices -IS:3700

(vii) Basic climate for mechanical durability tests for electronic components-IS:9900

(viii) Environmental requirements of semiconductor devices and integrated circuits IS:6553

(ix) Ambient temp. of electronic Equipment-IS:9676

(x) Terminal for electronic equipment-IS:4007

(b) Configuration

(i) Frequency drives shall have one of the two configurations given below suitable for induction Motor protection of all types confirming to IS 325 13947 (Part 4 /set 1) and 1993 / IEC 947-4-1 (1990)

a. Current source inverter.

b. Voltage source inverter.

c. Smoothing Reactors for Current and Voltage Source Inverter

(ii) The smoothing reactor shall be sized to avoid conditions of discontinuous current

(iii) Operation of the frequency converter at its lowest frequency of operation, which shall not be less than 5 Hz.

(iv) The smoothing reactor shall be uniformly insulated and shall be protected for voltage surges occurring during sudden load throw-off.

(v) The smoothing reactor shall be made from electrolytic grade copper/aluminum and shall be epoxy encapsulated with suitable class of resin decided from techno-economic considerations and performance requirements in conformity with IEC-146.

(c) Inverter: The inverter system suitable for three phase output shall consist of the following subsystems:

(i) The basic inverter circuit consisting of the switching device Thyristors / Transistors/IGBT/MOSFET, connected so as to supply three phase power.

(ii) The logic network to enable rapid transition of the main inverter switching devices from on-state to off-state.

(iii) Suitable feedback system to allow balance of reactive power flow during load power factor fluctuation as well as regeneration.

(iv) The filter system of the inverter output to suppress 5th, 7th, 11th, 13th harmonics at the output of the inverter to less than 5% of the fundamental amplitude.

(v) The ripple control system to limit current ripple to 4% at the input terminals of the inverter caused by distorted current output.

(vi) The output frequency of inverter shall be controlled to within the limits.

(d) Inverter for AC Drive

Current Source Inverter:
Constant Torque Operation
The current output by the DC link shall be accurately monitored so that the ratio of the terminal voltage of the motor and the corresponding frequency remains constant. Necessary protective features for tripping the frequency converter, alarm/annunciation and fault diagnostics shall be provided.

Constant Horsepower Operation
In this type of operation, the motor's internal voltage shall be maintained within + 1% while the frequency of the inverter is varied to meet the duty cycle requirements. Necessary protective features for tripping the frequency converter, alarm/annunciation and fault diagnostics shall be provided.

Voltage source Inverter:

Constant Torque Operation

The DC voltage input to the inverter shall be accurately monitored to maintain the ratio the terminal voltage of the motor to frequency at the rated/design value. The DC voltage input shall be maintained within + 1% of the required value. Should this fall for any reason, necessary action for tripping the frequency converter and initiation of annunciation/alarm and fault diagnostic shall be provided.

Constant Horsepower Operation

In this type of operation, the voltage at the terminals of the motor shall be maintained within +1% of the rated value while the frequency of the inverter is varied to meet the duty cycle requirements. Necessary protective features for tripping the frequency converter, initiation of alarm/annunciation and fault diagnostic shall be provided.

Output Over current Limit:

Unless otherwise stated, the inverter shall be capable of being temporarily overloaded to 150% of its full load ampere capacity for sixty (60) seconds beyond which a current limit action shall be initiated and an alarm contact initiated for annunciation.

Control Modules

All elements of the control system shall be mounted on epoxy laminate boards and each board shall be a plug in module mounted on a standard nineteen inch rack which shall be accessible from the front. Each card shall have LED indication on its front plate to indicate normal condition of the card. Readily accessible and clearly marked test pins shall be provided at the important points on the cards to enable signal analysis.

The epoxy laminates shall be free from manufacturing errors and shall be designed to prevent incorrect insertion in the card rack. The copper side of the card shall be suitably lacquered to prevent oxidation. The gap between two cards shall be sufficient to permit adequate ventilation.

Adjustments susceptible to change by accidental contact shall be lockable.

(e) Control Requirements:

Short time voltage dips up to 80% of nominal (e.g. in case of large motor start-up connected to same bus) shall not cause the control system to stop functioning and shall not trip the drive system.

The drive motor shall be speed regulated corresponding to 4-20mA or 0-10V reference input signal. Upon complete loss of users speed reference signal, the drive shall automatically run at constant speed as determined by the last speed reference available prior to loss of the signal.

The required provision for interfacing with PLC/DCS, including details of communication module and data transfer facility, I/O details shall be furnished by the Bidder.

(f) Protection

Protection of Power Semiconductor

Each power semiconductor shall be protected against short circuit. The fuse shall be sized so that its I^2t does not exceed the I^2t characteristic of the power semiconductor itself. The voltage and current rating of the fuse shall match the duty on the power semiconductor. The arc voltage, due to melting of the fuse shall not exceed the repetitive peak reverse voltage of the power semiconductor.

All fuses shall have a trip indicator to operate a suitable micro switch with at least 1 NO + 1 NC potential free contacts for annunciation and/or tripping.

A fast tripping feeder circuit breaker shall be used in case fuses for short circuit protection of thyristors are not used.

(g) Protective Systems for AC Inverter Drive

Fuses for all power semiconductors and/or other devices like commutation chokes, capacitors etc. which are not adequately protected against flow of abnormal currents.
Under voltage and over voltage protection on the input side. Loss of input voltage to inverter shall entail tripping of the inverter.
Protection for all control cards, power supply stabilizers, filter circuits etc. Protection shall be provided such that failure of a part does not cause damage elsewhere in the system.
Polarizing relay to prevent reversal of polarity on the input side of the inverter.Protection of inverter thyristor, commutating circuits and other inverter elements during regenerative operation of the inverter and also during sudden load throw-off.

Current limit fuses at the output of the inverter.
Commutation circuit under voltage
Inverter over frequency
Programmable over current
Phase sequence/loss of phase protection
Earth fault protection
DC link overvoltage protection
Specific motor protection
Incoming line surge protection
Ventilation Loss
Over temperature

(h) Cooling of Power Converters

Power semiconductors shall be mounted on heat sink which can be individual or common to a number of devices. Adequate provision for clamping and mounting the power semiconductors shall be available.

Cooling of power semiconductors can either be natural air cooled or forced air cooled. The BIDDER shall recommend the type of cooling. However, for power converters which exceed capacities of 2 kA continuous load, alternative cooling methods as oil or water cooling shall be considered. The power semiconductors shall preferably be double side cooled.

(i) Switching Devices

Switching devices such as circuit breakers, isolators, contactors; switch-fuse units etc. shall be considered in the scope of supply.

The switching devices shall be enclosed in a separate enclosure forming the set of panels for the power converters. They shall have adequate clearance both with adjacent devices and metalwork at earth potential. Connection between devices shall be by adequate size of electrolytic grade of copper/aluminum strips. These connections shall be adequately braced and insulated.

2.2.30 Contactors: The power contactors used in switchboard shall have following features:

(a) The contactors shall confirm to IS 13947 & the latest applicable standards

(b) The power contactors shall be of, air break, single throw, triple pole, electromagnetic type.

(c) The insulation class of contactor's coil should be B or higher.

(d) Operating coils of all contactors shall be suitable for operation on 110/240 V, single phase, 50 Hz supply.

(e) Contactors shall be provided with at least two pairs of NO and NC auxiliary contacts.

(f) Contactors shall not drop out at voltages down to 70 % of coil rated voltage.

(g) All the switchgear selection for motor feeders shall be Type-2 co-ordinated.

(h) Motor starters shall be complete with auxiliary relays, timers and necessary indications.

2.2.31 Relays:

(a) Main protective relays shall be Numerical type. They shall be suitable for semi-flush mounting with only flanges projecting on the front with connections from the rear.

(b) All relays shall be enclosed in rectangular shaped, dustproof cases and shall be suitable for flush mounting.

(c) All protective relays shall be in draw out cases with built in test facilities.

(d) Auxiliary relays and timers shall be rated to operate satisfactorily between 70 % and 110 % of the rated voltage

(e) Test block and switches shall be located just below each relay for testing unless otherwise specified. All auxiliary relay and timers shall be supplied in non-draw out cases.

(f) All protective relays shall be provided with at least two pair of potential free output contacts, exclusively for Purchaser's use.

(g) Relay cases shall have adequate number of terminals for making potential free connections, to the relay coils and spare contacts. Paralleling of contacts if any shall be done at the terminals on the casing of the relay.

(h) Each relay shall have provision for easy isolation of trip circuit for the purpose of testing and maintenance.

(i) All relays shall with stand out a test voltage of 2 KV, 50 Hz RMS voltages for one minute.

(j) Auxiliary seal in units provided on the protective relay shall be shunt reinforcement type.

2.2.32 Thermal Overload Relays:

(a) Starters shall be complete with a three element, positive acting, ambient temperature compensated, time lagged thermal overload relay with adjustable settings. The setting range shall be properly selected in accordance with the rating of the motor.

(b) Thermal overload relays shall be hand reset type

(c) 'Stop' push button of the starter and hand-reset device shall be separate from each other.

(d) Overload relay hand reset push button shall be brought out on the front of the compartment door. Overload relay shall be provided with at least 1 'NO' and 1 'NC' or one changeover contact.

2.2.33 Timers:

Thermal/ Electronics timer for change over in star-delta and ATS panel should be provided.

2.2.34 Switch And Contactor Ratings

Switch and contactor rating for various motor starter modules shall be selected by the Contractor, based on the specifications. CONTRACTOR shall also select appropriate ratings & ranges for thermal overload relays. These details shall be subject to the Purchaser's approval.

2.2.35 Single Phasing Preventers:

(a) Single phasing preventer relay shall be provided to protect motors against single phasing.

(b) It should operate satisfactory from 320/ 480V. Timing range of delay start 0 - 45 seconds.

(c) Toggle switch for Auto SPP by pass should be provided on front of unit.

(d) The relay shall not operate for supply voltage unbalance of ± 5%. After sensing single phasing, the relay shall operate with a time delay of 2 to 3 secs.

(e) The relay shall not operate for a 3- phase power supply failure. The relay shall be of the hand-reset type with a hand-reset push button. Resetting shall be instantaneous and independent of the adjusted time delay in the tripping of the unit. Visual indication for the operation of the relay shall be provided.

(f) The relay shall be suitable for application to protect reversible and non reversible motors.

(g) The relay operation shall be independent of the motor KW rating, the loading conditions prior to the occurrence of the single phasing and RPM of the motor.

(h) The relay shall be of the fail-safe type and shall operate to trip the motor when the relay internal wiring is accidentally open circuited.

2.2.36 Power & Control Wiring Connections:

(a) Terminals for both incoming and outgoing cable connections shall be suitable for 1.1kV grade Al/ Cu conductor XLPE armoured cable and shall be suitable for connections of solder less sockets for the cable size.

(b) Where the Bus duct is required for higher current carrying capacity, Main PCCincomer feeder shall be suitable for bus duct connections using Aluminum Bus bars

(c) Both control and power terminals shall be properly shrouded. Power terminals shall be of stud type.

(d) 20 % spare terminals shall be provided on each terminal block. Sufficient terminals shall be provided on each terminal block so that not more than one out going wire is connected to per terminal.

(e) Suitable barriers of enclosures shall preferably separate terminals strips for power and control from each other.

(f) Wiring inside the modules for power, control, protection and instruments etc shall be done with use of 1.1 kV grade, multistranded Cu, PVC FRLS wiring.

(g) Power wiring inside the starter module shall be rated for full current rating of respective contactor but not less than 4 Sq. mm. 2.5 Sq. mm copper wire shall be used for current transformer circuits.

(h) Other control wiring shall be done with 1.5 Sq. mm copper conductor wires.

(i) Wires for connection to the door shall be flexible. All conductors shall be crimped with solder less sockets at the ends before connections are made to the terminals.

(j) There shall be control transformer for control power supply (110/ 240V AC) and separate control bus.

(k) Particular care shall be taken to ensure that the layout of wirings is neat and orderly. Identification ferrules shall be filled to all the wirings terminations for ease of identification and to facilitate checking and testing.

(l) Washers shall be used for all Copper and Aluminum connections.

(m) Final wiring diagram of power and control circuit with ferrules nos.shall be submitted along with the panel as one of the documents against the contract.

2.2.37 Terminals:

(a) The outgoing terminals and neutral shall be brought to a cable alley suitably located and accessible from the panel front.

(b) The current transformer for instruments metering shall be mounted on the disconnecting type terminal blocks. No direct connection of incoming or outgoing cables to internal components of the distribution board is permitted; only one conductor may be connected in one terminal.

2.2.38 Wire Ways:

(a) The horizontal PVC wire way with screwed covers shall be provided at the top to take interconnecting control wiring between different vertical sections.

2.2.39 Indicating Instruments:

(a) All electrical indicating instruments shall be rectangular, Analogue type meter shall have 240 degree scale, taut band, minimum 144 x 144 mm size unless specified otherwise, moving coil instruments, suitable for semi flush mounting with only flange projecting on vertical panels.

(b) Ammeters for motor feeders shall have suppressed scale up to 6 times beyond full load.

(c) Dials shall be parallax free and white with black numbers and letterings & pointer shall be of knife-edge type. Such instruments shall be provided with zero adjustor accessible from the front.

(d) Instruments shall have an accuracy class 1.0 or better.

(e) Instrument dials shall be white with black numbers and lettering.

(f) Ammeter and current coils of wattmeter’s and ammeters shall continuously withstand 120 % of rated current and 10 times the rated current for 0.5 second without loss of accuracy.

(g) Voltmeters and potential coils of voltmeters shall withstand 120 % rated voltage continuously and twice the rated voltage for 0.5 seconds without loss of accuracy.

2.2.40 Metering Instruments:

(a) Multifunction meters shall be provided for all the feeders of 250A & above. For balance all feeders, kWh meters shall be provided. Size of the MFM shall be 96 x 96 sq. mm. MFM shall be provided with following metering features:

(i) Current, Voltage, Energy (kWh), MD (kW, kVA), PF & Hz etc.

(ii) MFM shall be L&T make 'Quasar' / Siemens OR equivalent.

(iii) MFM shall be with accuracy class 1.0 or better & having RS 485 communication port.

(b) Watt-hour meters shall be of 3-phase two- element type suitable for measurement of unbalanced loads in three phases, three wire circuits. They shall be suitable for semi flush mounting on vertical panels.

(c) Watt hour meters shall be of the induction type and shall be provided with reverse running stops.

(d) Watt-hour meters shall be suitable for operation from the secondary of CTs and PTs. They shall be provided with a separate 3 phases, 4 wires type test terminal blocks for testing of meters without disturbing CT and PT secondary connections.

(e) Meters shall be provided with potential indicating lamps and shall have reverse running stops.

(f) Meters shall have pointer as well as cyclometer type of register. They shall read KWH, KVARH, and PF as the case may be without the use of multiplication factor which, if unavoidable, shall be 10. The number of digits provided shall be adequate to cover 1000 hours of operation.

(g) Current coils of meters shall have a continuous overload capacity of 120 % for both accuracy as well as thermal limits. Also the coil shall withstand at least 10 times rated current for 0.5 second without loss of accuracy.

2.2.41 Current Transformers:

(a) Current transformers shall be of cast resin type. Insulation Class shall be Class 'E' or better.

(b) Current transformer shall have a short time withstand rating equal to the short time withstand rating of the associated switchgear for one second for breaker feeders.

(c) Unless otherwise specified, the minimum performance requirement of current transformers is as follows:

(d) Measuring CTs -15VA, accuracy class 1.0 and.

(e) Protective CTs - 15 VA, accuracy class 5P20.

(f) The above mentioned burdens are minimum required & it will be Contractor's responsibility to coordinate the current transformer burden with the requirements of relays, instruments and leads associated with that particular current transformer. Contractor has to provide sufficiency calculations for the same.

(g) Current transformer (CT) shall have polarity markings indelibly marked on each transformer and at the lead terminations at the associated terminal block

(h) CT shall be able to withstand the thermal and mechanical stresses resulting from the maximum short circuit current

(i) Test links shall be provided in both secondary leads of the CTs to easily carry out current and phase angle measurement tests.

(j) Identification labels giving type, ratio, output and serial numbers shall be provided.

2.2.42 Voltage Transformers:

(a) Voltage transformers shall be of cast resin type. Insulation Class shall be Class 'E' or better.

(b) Unless otherwise specified, the minimum performance requirements of Voltage transformers are as follows:

(i) Measuring VTs - 50 VA per phase and accuracy class 1.0

(ii) Protective VTs - 50 VA per phase and accuracy class 3.0.

(iii) Dual purpose VTs - 100 VA and dual accuracy class 1.0/ 3P for metering and protection respectively. VA is per phase.

(iv) The above mentioned burdens are minimum required & Contractor has to provide sufficiency calculations for the same.

(c) All secondary windings of voltage transformers including open delta windings shall be rated for 110 V /√3, 110V/ 3 per phase.

(d) Voltage transformer shall have a continuous over voltage factor of 1.2 and short time over voltage factor as follows:

(i) 1.5 for 30 seconds in case of effectively earthed system.

(ii) 1.9 for 8 hours in case of non-effectively earthed system.

(e) Voltage transformers shall be complete with suitable rated primary, fuses. Primary fuses shall have a rupturing capacity equal to the rupturing capacity rating of the associated switchgear. All the secondary circuits of the PT shall be protected by MCBs.

(f) It shall be possible to replace voltage transformers without having to de-energize the main bus bars.

(g) The terminals of PT secondary and tertiary windings, which are required to be connected to earth, shall be earthed by an isolating link without a fuse.

(h) Identification labels giving type, ratio, output and serial numbers shall be provided.

2.2.43 Push Buttons:

(a) Push buttons shall have two normally open and two normally closed contacts unless otherwise specified. The contacts shall be able to make and carry 5A at 110V DC and shall be capable of breaking 1A inductive load at 110V DC. They shall be provided with inscription plates engraved with their functions.

(b) Emergency stop' push buttons shall be of Mushroom type, lockable in the pushed position and shall be shrouded to prevent accidental operation. Key shall not be required for the operation of the push button.

(c) The Internal wiring and terminal blocks shall meet the relevant requirements.

2.2.44 Auxiliary Transformers:

(a) Any auxiliary voltage required for any of the component inside the switchgear shall be derived from the main supply by providing adequately rated auxiliary transformer mounted inside.

2.2.45 Indicating Lamps: Indicating lamps shall be:

(a) Clustered LED type and of low watt consumption.

(b) Provided with series resistors.

(c) Provided with translucent lamp covers of colors 'Red', 'Green' and Amber' etc. as required.

(d) Indicating lamp shall be of the double contact, bayonet cap type rated for operation at either 110 V AC or at the specified AC/ DC system voltage as applicable.

2.2.46 Control &Selector Switches: Control and selector switches shall be:

(a) Rotary type with enclosed contacts.

(b) Adequately rated for the purpose intended (Minimum acceptable rating is 10A continuous at 230V AC and 1A (inductive break) 220V D.C.

(c) Provided with escutcheon plates clearly marked to show the positions.

(d) Control switches shall be spring return to normal type & provided with pistol grip type handles.

(e) Selector switches shall be maintained contact stay put type. Switches in ammeter circuits shall be of break type contact. Selector switches shall be provided with oval handles.

2.2.47 Space Heaters:

(a) Adequately rated anti-condensation space heaters shall be provided, one for each control panel, for each switchboard and for each marshalling kiosk.

(b) Space heater shall be of the industrial strip continuous duty type, rated for operation on a 240 V, 1 phase, 50 Hz, AC system.

(c) Each space heater shall be provided with a single pole MCB with overload and short circuit release, a neutral link and a control thermostat to cut off the heaters at 350 C.

(d) Space heater indicated in the breaker modules represents the space heater for each vertical section of the switchboard. Where breakers are mounted in two-tier formation, then only one space heater with associated MCB and thermostat is adequate for the vertical section

2.2.48 Cubicle Lighting / Receptacle:

(a) Each control cabinet, marshalling box, etc. shall be provided with interior lighting by means of 7 W LED luminaries with door operated On/ Off switch.

(b) A 240 V, 1 phase, AC receptacle (socket) plug point shall be provided in the interior of each panel with a MCB.

2.2.49 Routine and Acceptance Tests to be conducted by the manufacturer at their own risk and cost in presence of Purchaser/ Purchaser's representative during inspection & testing at manufacturer's works:

(c) Following Routine tests as per IS: 13947 and IEC: 60947 standards & other specified relevant IS standards shall be performed by the manufacturer and witnessed by Purchaser/ Purchaser's representative on LV Switchgear panel complete with the accessories.

(i) Dielectric test on main circuit.

(ii) Test on auxiliary and control circuit.

(iii) Measurement of insulation resistance of the main circuit.

(iv) Tightness of main circuit.

(v) Design and visual check.

(vi) Dimensional check and BOM verification.

(vii) High Voltage test on power & control circuit.

(viii) Functional & mechanical operation test of all components.

(ix) Measurement of thickness of sheet steel & paint.

(x) Verification of wiring as per approved schematic.

(d) Following Type Tests reports as per IS: 13947 and IEC: 60947 to be submitted for the same rating & type of LV Switchgear panel conducted in past for review of Purchaser at the time of inspection & testing of equipment. Type test reports should be valid and not be older than the 5 years.

(i) Dielectric test on main and auxiliary circuit.

(ii) Temperature rise test.

(iii) Making and Breaking test of switching elements.

(iv) Degree of protection test.

(v) Short circuit withstand test.

(vi) Electromagnetic compatibility test.

(e) Certified copies of all type and routine test certificates and Calibration Certificates of measurement instruments which are used during inspection shall be submitted for the Purchaser's review/ approval before dispatch of the switchgear.

2.2.50 Test Certificates:

(a) Testing of switchgear shall be carried out at factory or at site as per standard in presence of Purchaser/ Purchaser's representative.

(b) The test results shall be recorded on prescribed forms. The certificates for the test carried out at factory or at site shall be submitted in duplicate to the Purchaser/ Purchaser's Representative for approval. Components and equipment that are not fully interchangeable are liable for rejection. Contractor shall replace all such non interchangeable equipment at his cost.

2.2.51 Drawings/ Documents Required: After award of contract Contactor has to submit drawings/ documents for Purchaser's approval as mentioned below but not limited to:

(a) General arrangement diagram showing dimensions of enclosure, length, widths and depth of enclosure and bill of quantity indicating the rating, make of each components and quantity.

(b) Complete assembly drawings of the switchboard/ distribution board/ MCC showing plan, elevation and typical sectional views and location of cable boxes and control cable terminal blocks for external wiring connections, etc.

(c) Foundation plan showing the location of channel sills, foundation, anchor bolts and anchors, floor plans and openings.

(d) Schematic power and control wiring diagrams with bus bar rating with material, instrument & control transformers, switchgear rating, control interlocks, relays, instruments, space heaters details etc.

2.3 LOCAL PUSH BUTTON STATIONS

2.3.1 Constructional Features: The constructional features of the local push button stations shall be as follows:

(a) Metal enclosed, weatherproof, suitable for mounting on wall or steel structures. The enclosure shall be die cast aluminum or sheet metal of 2 mm thickness.

(b) Dust and vermin proof.

(c) Provide a degree of protection of not less than IP55.

(d) Metal parts shall be given tropicalising treatment as per standards and painted with one coat of epoxy primer and two coats of light gray epoxy paint.

(e) Provided with inscription plates of rear engraved Perspex with white letters on black background. The letter size shall be 6 mm.

(f) Provided with two earthing terminals suitable for earthing wire /strip.

(g) Provided with removable undrilled gland plate and cable glands for two nos. 5C x 1.5 mm2 Copper conductor, XLPE insulated, armoured cable. The cable entry shall be from the bottom.

(h) Earthing shall be provided by 8 SWG GI wire and connected to earthing system.

2.4 APFC PANEL WITH CAPACITOR BANKS:

2.4.1 Scope of this specification covers design, manufacture, testing at manufacturer's works, supply, packing, forwarding and delivery from place of storage/ manufacturer's works to erection site including transit insurance, unloading, storage at site, assembly, erection, testing, installation, commissioning and performance demonstration of the following equipment with associated accessories.

2.4.2 Capacitor Banks:

(a) The type of capacitors shall be All Polypropylene type double layer conforming to IS 13585 - 1994 & having following specifications:

Supply	3 phase, 3 wire
Rated voltage	415 V
Rated frequency	50 Hz.
Permissible over voltage	1.1 Vn
Permissible over current:	1.5 In
Temperature category:	50º C

(b) The capacitor shall be vacuum impregnated with liquid dielectric having high thermal stability.

(c) The capacitors shall have Low Dielectric Loss of ≤ 0.5 W / kVAr.

(d) Each capacitor bank shall be provided with the 7% detuned filter.

(e) * kVAr is net reactive compensation required to maintain 0.98 PF at 415 V Bus, i.e. excluding compensation required for detuned filters.

(f) Bushing should have high mechanical strength & method of fixing should be proper so that no leakage occurs.

(g) Auto/ Manual switch shall be provided in the APFC panel. For manual switching, every capacitor bank feeder shall be provided with ON & OFF push buttons along with the ON & OFF indications.

(h) Minimum current rating under site conditions, of circuit breakers, contactors and cables shall be at least 150% of rated capacitor current, to take care of harmonics.

(i) Contactor for switching of capacitor banks shall have AC -6b utilization category according to IEC 60947-4-1 & sized accordingly.

(j) All the components shall be suitable for capacitor duty application.

(k) The capacitor banks shall be complete with all parts that are necessary or essential for efficient operation. Such parts shall be deemed to be within the scope of supply whether specifically mentioned or not. Capacitor shall be designed to improve the power factor to 0.98 lagging

(l) It shall be complete with the required capacitors along with the supporting post insulators, steel rack assembly, Al/ Cu bus bars, Al/Cu connecting strips, foundation channels, fuses, fuse clips, etc. The steel rack assembly shall be hot dip galvanized.

(m) The capacitor bank may comprise of suitable number of single phase units in series parallel combination. However, the number of parallel units in each of the series racks shall be such that failure of one unit shall not create an over voltage on the units in parallel with it, which will result in the failure of the parallel units. The assembly of the banks shall be such that it provides sufficient ventilation for each unit.

(n) Each capacitor case and the cubicle shall be earthed to a separate earth bus.

(o) Capacitor shall conform to IS 2834.

(p) The units shall be capable of continuously withstanding satisfactorily any overvoltage up to a maximum of 10 % above the rated voltage, excluding transients.

(q) Each capacitor unit/ bank shall be fitted with directly connected continuously rated, low loss discharge device to discharge the capacitors to reduce the voltage to 50 volts within one minute upon disconnection, in accordance with the provisions of the latest edition of IS:2834.

2.4.3 Control Cubicles:

(a) Capacitor and capacitor control shall be housed in a metal enclosed cubicle. Capacitor shall be housed in the lower compartment and capacitor control unit at the top compartment, the two compartments being segregated. Control cabinets shall be free

standing floor mounted type and shall meet the requirements of Metering, Protection & related provisions for APFC panel

Table 6: APFC Panel

Panel Name	Breaker Type	Protection	Metering	Indications	Other
Incomer	ACB (TPN, MDO) OR MCCB (TPN, Fixed Type)	TM based O/L, S/C release, APFC Relay, E/F Relay with CBCT & Shunt Trip	Analogue A,V	R Y B, On, Off, Trip	ETPB, A/M SS, Annunciator
Outgoing	MCCB (TP, Fixed Type)	TM based O/L, S/C release	A, AS	On, Off, Trip	Start, Stop Push Buttons

(b) APFC panel shall have Al bus bars sized for appropriate SC rating for 1 sec & to carry continuous rated current.

(c) All CTs / PTs shall be cast resin type.

(d) All the MCCB's shall be current limiting type. Necessary auxiliary contact block required is included in contractor scope.

(e) One contact of power factor correction relay shall be provided for annunciation "POWER FACTOR LOW". The relay shall switch-on / off capacitor banks for loads from 5% to 100%. The annunciation window shall be with test, accept and reset push button & hooter.

(f) Capacitor switching and automatic power factor correction panel shall be designed in such a way that power factor of 0.98 lagging shall always be maintained. Timings to cut in capacitors shall be provided in such a manner to facilitate capacitor discharging before next switching and shall also avoid hunting due to temporary fluctuations of load. The timer shall be provided in both auto and manual mode.

(g) The Automatic power factor correction panel and capacitor panel are integral type, prewired including power connections. Due consideration shall be given for adding/removal of capacitor or other components and maintenance considerations. Contractor shall submit GA drawings of capacitor and capacitor control panel, with description of power factor control panel with its components.

(h) For control circuit 415/ 240/ 110V control transformer shall be considered. VA burden to be decided by the Contractor.

(i) Minimum clearance between live parts shall be phase to phase 25.4 mm & phase to neutral 20 mm.

(j) Bus bars shall be sleeved with coloured heat shrinkable sleeves. All the Bus bar supports shall be SMC type only.

(k) Degree of protection shall be IP-42 for the enclosure, epoxy painted, powder coated with colour shade RAL- 7032 for exterior & interior with minimum thickness 80 micron.

(l) All necessary auxiliary contactors are included in scope.

(m) Contractor shall note that verification of double layer construction shall be done on any one of the capacitor bank during inspection by opening the capacitor bank at no extra cost.

(n) The cubicle shall be fabricated out of 2 mm thick cold rolled sheet steel & shall comprise of :

(i) Isolating ACB / MCCB

(ii) Contactors with overload element

(iii) Sequencing devices, timers and auxiliary relays for automatic sequential switching of capacitor units in and out of circuit.

(iv) Auto-manual selector switch

(v) Microprocessor based Automatic Power Factor Correction (APFC) Relay – minimum 10 stage relays.

(vi) Push button for opening and closing the power circuit

(vii) Red and Green lamps for capacitors ON/OFF indication

(viii) Protective relays to protect the healthy capacitor units when one unit fails in a series connection

(ix) Space heater and cubicle lighting & receptacles.

2.4.4 Principle of Operation:

On deviations from set power factor, the power factor controller shall release command signals to switch on/ switch off capacitor bank stages and maintain the set power factor.

2.4.5 APFC Relay: APFC relay shall have following standard features:

(a) The Automatic Power Factor Correction relay shall be of microprocessor based type and shall automatically switch ON/OFF the capacitor banks to attain the value of “pf” close to the set value.

(b) Switching shall follow first in first out (FIFO) method to ensure uniform use of all capacitor banks. At least eight steps shall be provided for switching.

(c) To measure/ monitor power factor and VAR continuously. Status of switching step shall be displayed through LED.

(d) Following adjustment shall be available in APFC Relay.

(i) Power factor

(ii) Dead band capacitive region with respect to set power factor (PF).

(iii) Inductive region with respect to set PF

(iv) Operating time for programmable switching steps.

(v) Auto/ manual selector switch.

(vi) Manual step control.

(e) All control knobs, LEDs for display and selector switches shall be mounted on the front face of relay casing/ panel.

(f) It should be fully programmable. There should be a choice for customer to select operating sequence up to 4 to 5 which will have maximum number of steps of capacitors equal to fourteen (14). The sequence shall be arithmetic 1, 2, 3…..13, 14.

(g) Operating time selection of time interval designation between switching stages shall be possible using time selector switches. The device shall take care that any stage which has just been switched out will only be reconnected by the pulse counter, after 60 sec. has elapsed so that it has safely discharged. This is a requirement for 415 V capacitors

(h) Loss of voltage element. This would prevent abnormal switching surges on loss of supply. Also it would control the switching on/off surges.

(i) Dead band features – Relay response sensitivity adjustable using dead band so that hunting is prevented.

(j) Auto/Manual control – This would help testing and commissioning at site as well as ease in operation when either mode fails during service time.

2.4.6 Performance Tests:

(a) Contractor shall carry out all routine tests as specified in relevant IS/ IEC standards on all major components and furnish copies of test reports for Purchaser's approval. Wherever required, Contractor shall conduct the necessary type tests in the presence of Purchaser/ Purchaser's representative.

(b) Contractor shall also carry out all routine and functional tests as specified in the relevant IS on the assembled switchgear panels in the presence of the Purchaser's representative at works before dispatch and furnish copies of test reports for approval. If required stage inspection will be carried out by the Purchaser.

(c) During inspection, Contractor shall furnish copies of routine test report for all bought out items for Purchaser's approval.

(d) Primary Injection Test for various currents & time settings shall be provided in routine test.

(e) All the components shall be tested for their entire operating range & certification for the same shall be provided at the time of inspection.

2.4.7 Maintenance Requirements

(a) As far as possible the switchgear shall be so designed that no special tools are necessary for installation and maintenance. However, if special tools are required, the Contractor shall supply one complete set of such tools along-with the equipment.

(b) Contractor shall furnish detailed inter panel wiring diagrams, internal wiring diagrams, detailed component layout drawings to carry out maintenance work.

2.4.8 Drawings / Documents Required:

(a) Dimensioned general arrangement drawings of capacitor and capacitor control panel.

(b) Justification for number of steps for switching.

(c) Fully dimensioned general arrangement drawings of capacitor and capacitor control panel with elevation side view, sectional view and foundation details.

(d) Complete schematic and wiring diagrams for capacitor control panel.

2.5 DIESEL GENERATOR

2.5.1 Applicable Standards :

The Diesel Standby Generator and its components shall conform to the latest applicable standards specified below:

Table 10: Standards for Diesel Generator

Diesel Engines for General Purposes	BS 5514 / ISO 3046
The Electrical Performance of Rotating Electrical Machinery	BS 5000
Rotating Electrical Machines	IS 4722
Circuit breakers	IS-13118, BS-5311, IEC-56 & 694, BSEN-60942 (P-2)
Air break switches air break disconnectors, air break switch disconnectors and fuse combination units for voltage not exceeding 1000 V	IS-13947 (P-3), BS-EN60947, IEC-60947-3

AC or 1200 V DC	
Current transformer	IS-2705/BS-7626, IEC-60185
Voltage transformer	IS-3156/BS-7625/IEC 60186
Electrical Relays	IS-3231, 3842/BS-142/IEC-60255
Contactors for voltage not exceeding 1000 V ac or 1200 VDC	IS-13947 Part-IV/ BSEN-60947-4-1/ IEC-60947-4-1
Control Switches	IS-6875/BSEN-60947 / IEC-60947-4-1
High Voltage Fuse	IS-9385/BS-2692/ IEC-60282
Low Voltage Fuse	IS-13703/BS-1362 IEC-269-1
Electrical direct acting indicating instruments	IS-1248/BS-89/IEC-6005
A.C. electricity metres of induction type voltage greater than1000 volts	IS722, 8530/BS-5685 / IEC-60145, 60211
Resistance wire, tapes and stripes for heating elements	IS-3725
Wrought aluminium and aluminium alloy bars, rods, tubes and sections for electrical purposes	IS-5082
Specification for copper rods and bars for electrical purposes	IS-613
Toggle switches	IS-3452/BS-3676
Control switches/push buttons Noise and Emission Limit	IS-6875/BSEN 60947 As per latest notification of ministry of Environment and Forests

2.5.2 General Requirements:

(a) The diesel engine and generator shall be located outdoors. The DG set shall be provided in a weatherproof and acoustically treated enclosure. The exhaust system shall be insulated to minimize the amount of heat entering the room and to prevent injury to

personnel. The silencer shall be of the 'residential' type and be located externally.

(b) The generation voltage shall be 415V for DG. At no point DG sets will be operating parallel with grid.

(c) Bulk fuel storage is not envisaged in this project and only Day tank with maximum allowable capacity as per Fire safety standards shall be provided along with the DG set along with all the accessories.

(d) A system shall be provided within the generator enclosure to detect fire, to raise a local audible alarm (manually silenced locally) and if the level of the day tank is above the permissible level beyond which it may overflow.

(e) The system shall be constructed such that leakage of water, fuel or oil within the generator room shall be routed to a local sump where a detector shall be provided to raise an alarm.

(f) The system shall be constructed such that the leakage of fuel or the accumulation of water within the fuel storage bund shall be detected and shall raise an alarm.

(g) All alarms shall be conveyed to the central HMI through the PLC.

2.5.3 Diesel Generating Set Automatic Control

(a) Auto Mains Failure (AMF) Diesel Generator Set capable of automatic starting and picking the load within 30 seconds shall be provided to cater for emergency loads and lighting during mains power failure. Diesel generating set for use in AMF mode shall have a three position automatic / off / manual selection and shall operate as follows:

(b) Automatic mode: On occurrence of mains failure the following sequence shall be followed.

(i) Mains to Generator changeover

a. Mains failure detected

b. Delay of 5 seconds

c. Generator is started and run up to speed

d. Time delay of 30 seconds

e. Mains supply is switched off

f. Generator supply is switched on

(ii) Generator to Mains changeover

a. Mains healthy detected

b. Manual changeover signal received,

c. Generator supply is switched off

d. Mains supply is switched on

e. Generator runs for 2 minutes and stops

(iii) All timer settings shall be adjustable.

(iv) If mains power is restored during the initial one minute delay then the power shall be monitored for a further one minute and if it is still healthy, mains power shall be restored. The generator shall be stopped after a further 2 minutes of running on no load. If the generator fails to start after an initial period of cranking, two further attempts shall be made with an appropriate interval between each attempt. If the engine fails to start after three attempts the system shall shut down and a local and remote alarm shall be annunciated.

(v) Manual mode: The generator shall run to the dictates of manual controls on the generator. No automatic changeover of mains to generator supply or vice versa shall take place. The generator shall be loaded by manual switching if required.

2.5.4 Alternator For Diesel Generating Set:

(a) The generation voltage shall be 415V. The operating duty for the Alternator shall be Prime or stand by duty.

(b) Alternator shall be 4 pole, 3 phase, 50 Hz, 0.8 P.F, salient pole, revolving field brushless type, self-regulating continuously rated and manufactured in accordance with IS 4722, BS 5000: Part 99 or IEC 60034-1. They shall be totally enclosed, screen protected, fan ventilated and vertical drip-proof conforming to IP 23.The Alternator shall be complete with excitation system, AVR and all necessary auxiliaries. The alternator shall be driven by diesel engine detailed below and shall match the same in all respects. The terminal box shall be dustproof with IP 54 degree of protection. The terminal box shall be suitably sized to terminate the size and number of cables involved. Alternators shall be capable of withstanding a 10% overload for 1 hour in any 12 hour Period under the specified conditions of temperature, humidity and atmospheric pressure.

(c) Alternator windings shall be of Class H insulation with Class F temperature rise andtropicalised. The alternator shall have pre-packed grease lubricated ball or roller bearingsand provided with facilities for regreasing whilst in service.

(d) The alternator shall be foot mounted on a common bed frame with the prime mover close coupled to the engine flywheel housing. The direction of alternator rotation when viewed from the driven end shall be clockwise and phase voltage sequence UVW. The alternator vibration level shall not exceed the values defined in IS 12075.

(e) The alternator shall be capable of maintaining a short circuit current of three times full load current for a period of 10 seconds. The alternator shall be fitted with an anti-condensation heater. No individual harmonic shall exceed 1% and the total harmonic shall not exceed 3%. The alternator, its neutral and control panel shall be earthed as per relevant standards.

(f) The alternator rotor assembly shall comprise exciter rotor, full wave silicon bridge rectifier surge protection device and salient pole rotating field system. The rotor shall be fitted with interconnected pole face damping windings. Voltage regulation shall be maintained to within ±2.5% for a power factor of 0.8 to unity, including hot to cold

variations. The steady state frequency droop between no load and full load shall not exceed 5%.Transient voltage deviation following a step load of 60% of rated at a power factor of between 0.4 and zero shall not exceed 15% with a voltage recovery time to 97% rated voltage not exceeding 0.5 second. The set shall be capable of continuous operation with a phase current imbalance of 33% of rated current whilst maintaining the output voltage within ±5% of rated.

2.5.5 Diesel Engine For Generating Set:

(a) Engine shall be four stroke, direct injection, turbocharged industrial machines. They shall be fitted with renewable wet cylinder liners if water cooled and shall be direct coupled to the alternator and mounted on a common rigid steel bedplate.

(b) Engines shall be rated for continuous duty at site ambient conditions with an inherent O/ L Capacity of 10% for 1 hour in any 12 hours. The engine shall be capable of running at full load for not less than 180 hours without maintenance adjustments and 10000 hours between major overhauls. The maximum operating speed shall be 1500 rpm. The range of manual adjustment shall not be less than ±5% of rated speed. The performance of engine governors under load conditions shall be to Class A2 in accordance with BS 5514: Part 4.

(c) Engine governors shall be suitable for remote control load sharing between identical engine units. In addition to any electrical over speed trips, there shall be a mechanical device which shall operate at 120% of the rated speed. Re-setting of the over speed trip shall be possible by hand only. The steady state output speed drop between no load and full load shall not exceed 5%. The transient output speed deviation shall not exceed 10% for a step of 60%. Engines shall be designed to run on fuel oil complying with IS 1460 or BS 2869, Class A2. Engines shall be cooled by means of a water jacket, heavy duty air blast radiator with integral radiator header tank, circulating pump and engine driven pusher type fan. The fan shall draw air in from the vicinity of the engine block and discharge it through the radiator core. The radiator shall be mounted on the same bedplate as the engine and alternator on suitable vibration isolators and be arranged so that it is located directly behind automatic louvers set into the external wall of the engine room. A thermostatically operated by-pass valve shall be fitted in the cooling system to maintain an optimum operating temperature during starting and running conditions. Drain cocks shall be provided so that all the water can be drained from the system. A separate oil cooler shall be used for cooling the engine oil. A thermostatic by- pass valve shall be incorporated. Engine lubrication shall be by a closed circuit wet sump, forced feed system supplied by an engine driven pump fitted with pressure regulating and relief valves, sump suction filter and changeover renewable micro-felt full flow line filters. A hand operated semi-rotary oil pump shall be installed to carry out initial priming or to fill or empty the sump as required. The sump shall be fitted with an easily accessible drain point. The oil shall be of the grade recommended by the engine manufacturer. The starting system shall comprise 12 or 24 V heavy duty lead acid batteries (positioned on a floor mounted stand adjacent to the engine) connected by heavy duty flexible butyl rubber cables. Batteries shall be sized to give six consecutive starts of the engine at 0°C. An engine driven alternator and charging system shall be provided. An automatic mains energised battery charger shall be provided, with sufficient capacity to maintain the battery in a condition to fulfil the starting requirements. Barring (hand turning) equipment shall be provided so that the engine can be manually rotated for maintenance purposes. It shall be arranged so that normal starting of the engine is inhibited whilst the

hand turning equipment is connected. Twin heavy duty air intake filters in accordance with IS 3169 or BS 7226 suitable for operating in dust laden atmospheres shall be fitted. The filters shall be of the paper element with pre-cleaner type. Turbocharger filters shall be fitted. Breathers shall be fitted with washable filters which are easily accessible for maintenance.

(d) Instrumentation shall be provided to monitor speed, oil pressure, oil temperature (sets larger than 250 kVA), water temperature and battery charge current. The bedplate shall be of heavy gauge steel construction, stress relieved and free from distortion.

(e) Machined surfaces shall be incorporated for mountings and for levelling. Anti-vibration mountings shall be fitted between the bedplate and the floor to prevent vibrations being transmitted to the building. The mountings shall be adjustable for leveling purposes and shall be designed to resist horizontal movement of the diesel set.

(f) The fuel System shall comprise an engine driven feed pump with duplex filters, 990 litres day tank with supporting structure or generator skid mounted day fuel tank, with all interconnecting pipe work, flexible engine connection pipe etc.

2.5.6 Diesel Generator Control Panel:

(a) The control panel shall be separately mounted on anti-vibration mountings and shall Comprise the following:

(i) Breaker incorporating short circuit, overload trip and

(ii) Earth fault protection for the Alternator

(iii) Alternator Over & Under Voltage Protection

(iv) Voltage Controlled Over Current Relay

(v) Voltmeter and seven position selector switch

(vi) Ammeter and 4 Position selector switch

(vii) Frequency meter

(viii) Power Factor Meter

(ix) KWh Meter

(x) Engine temperature and oil pressure gauge

(xi) Service hours run indicator

(xii) Key switch start and stop control

(xiii) Operational status indicator

(xiv) Anti-condensation heater and thermostat

(xv) Alternator anti-condensation heater controls

(xvi) Mains fed battery charger

(xvii) Auto start on mains power supply failure facility

(xviii) Fails to Start (Alarm)

(xix) Over / Under Voltage Alarm

(xx) Battery Charger Fault (Alarm)

(xxi) Low fuel Oil Level (Alarm)

(xxii) Over Load (Alarm)

(xxiii) Low Lube Oil Pressure (Trip)

(xxiv) High Water Temperature(Trip)

(xxv) High Lube Oil Temperature (Trip)

(xxvi) A reset button shall be provided to cancel the alarm /shut-down condition prior to re-starting.

(xxvii) Simple operating instructions shall be detailed on the fascia of the control panel.

(xxviii) Local Circuit Breaker incorporating short circuit, overload trip and Earth fault protection for the Alternator shall be provided within the Acoustic Enclosure.

2.5.7 Acoustic Enclosure

(a) The DG Set shall be provided with acoustic enclosure, fully integrated, weather proof with superior finish for long and durable life.

(b) The acoustic enclosure shall be CRCA sheet steel enclosed with necessary panels and doors, inside lining of fire retardant foam /glass wool as acoustic material.

(c) The sound level shall be restricted to 75 dB at a distance of 1 meter, under full load, free field conditions as per relevant standards.

(d) The acoustic enclosure shall be certified to meet the emission norms.

2.5.8 Drawings / Documents Required:

(a) All Drawings, data, technical particulars, calculations, detailed literature, catalogues Test certificates etc shall be submitted along with the bid/ after award of contract

2.6 CABLING SYSTEM

The scope shall be inclusive of supply, installation, testing & commissioning of power & control cables, cable terminations, cable accessories, stripping of cable insulation, supplying and fixing of Aluminium lugs for aluminium cables & tinned plated copper lugs for copper cables and crimping the same to the conductor, supply and fixing of double compression cable glands including all labour supply and consumable material required for jointing/ termination. The rate shall also include the laying of cable in ground/ in cable trays / cleating to structure etc.

2.6.1 Applicable Standards:

The cables shall confirm to the latest applicable standards specified below. In case of conflict between standards and this specification, this specification shall govern.

PVC insulated cables (For voltage up to 1100 V)	:	IS: 694
HRPVC & PVC insulated cables: Heavy duty	IS: 1554	
Cross linked polyethylene insulated PVC sheathed cables	:	IS: 7098
Low frequency cables and wires with PVC insulation and sheath	:	IEC: 189-1 & IEC-189-2
PVC insulation and sheath of electric Cables	:	IS: 5831
Polyethylene insulation and sheath for Electric cables	:	IS: 6474
Conductors for insulated electric cables	:	IS: 8130
Methods of test for cables	:	IS: 10810
Specification for drums of electric cables	:	IS: 10418
Specification for PVC insulated cables for electricity supply	:	BS: 6346
Specification for PVC insulation and Sheath of electric cables	:	BS: 6746

2.6.2 Constructional Features:

(a) The 11kV power cables shall conform to 11kV Earthed grade (E), three core, stranded, Aluminium conductor, screened by extruded semi-conducting compound, cross-linked poly ethylene (XLPE) insulated, cores screened with non-magnetic metallic tape laid up with inner and outer extruded PVC sheath compound Type-ST2 and galvanized steel strip armouring. The cables shall generally conform to IS 7098-1985 with relevant parts thereof.

(b) Armouring shall confirm to latest version of IS: 3975.

(c) The LV Power cables shall be 1.1kV grade, 4/ 3.5/ 3 Core, multi-stranded, Al/ Cu

conductor, XLPE insulated, extruded inner & outer PVC sheath compound type ST2 and galvanized wire (up to 6 sq mm) / steel strip(>6 sq mm) armoured cables. All single phase, Lighting cables, UPS cables shall have 100% Neutral.

(d) All the control cables shall be 1.1kV grade, no. of cores (as per requirement/ application with minimum 2 spare cores for 7C & above) multi-stranded, Copper conductor, XLPE insulated, extruded inner PVC & outer PVC FRLS sheath compound type ST2 and galvanized steel round wire armoured.

(e) All control cables shall be with following specific requirements:

(i) Copper conductor stranded class 2.

(ii) XLPE Insulated

(iii) Provided with inner extruded PVC and outer PVC FRLS sheath of extruded black PVC compound.

(iv) Galvanized steel armouring in the form of GI round wire.

(v) Core identification shall be by printed numerals.

(vi) The insulation over the individual conductor core will be colour coded.

(vii) Minimum 2 spare cores for above 7C.

(b) The DC power supply cable shall be two core, multistranded copper conductor, armoured cables with inner extruded PVC & outer PVC FRLS sheath. All control wiring shall be PVC FRLS insulated.

(c) All the power & control cables used in the Hazardous area shall be flame proof type suitable for the intended application.

(d) Earthing Cable shall be Single core multi-stranded Cu, 1.1 kV grade, XLPE insulated, un-armoured green coloured outer sheath with yellow strips/ band cable to be laid in trays, underground, trenches etc. as applicable.

2.6.3 Cable Colours:

(a) All cable cores shall be colour coded throughout their length and shall be so connected between switchboard, distribution board, plant and accessories, that the correct sequence or phase colours are preserved throughout the system.

(b) The colour coding should be as follows:

(i)	3 phase	Red, Yellow and Blue
(ii)	single phase or dc supply	Red and Black
(iii)	earth	Green/Green with Yellow coloured band

(iv) control Gray (DC)

2.6.4 Cable Conductors;

(a) Cables up to 4 sq.mm shall be Cu multi-stranded conductor with galvanized steel round wire armoured & balance cables shall be Al multistranded conductor with galvanized steel round wire/ flat strip armoured.

(b) Single core cable shall have non-magnetic material armouring.

(c) Lighting final distribution circuits shall be of a minimum cross-section of 1.5 mm2.

(d) Small control cables shall be of a minimum cross-section of 1.5 mm2.

(e) Internal wiring of control panels shall be of a minimum cross-section of 1.5 mm2 flexible and multistranded.

(f) Instrumentation and control cabling shall be of a minimum cross-section 1.5 mm2 for external use and 1.0 mm2 for internal use.

(g) Cable Sizing shall be done as per design criteria specified in specifications.

2.6.5 Cable Numbering: All cables shall be allocated a unique number which shall be fixed to each end of the cable using a corrosion resistant label. Necessary loop at both ends shall be provided for future use and cables of different categories shall be tagged with the following subscripts and three digit number.

HV power	HV-P_ _ _
LV power	P_ _ _
Control	C_ _ _
Instrumentation	I_ _ _
Protection	PR_ _ _
Telecommunication	T_ _ _

2.6.6 Cable Terminations:

(a) Cable Lugs

(i) Cable lugs shall be of tinned copper, solder less crimping type for Cu cables & AL lugs for the AL cables.

(ii) The current rating of the lugs shall be same as that of the respective cable conductors.

(iii) Bi-metal strip/ Bi-metallic lug shall be used whenever two different metals are to be connected together.

(iv) Double holes extended neck (long barrel neck) type lugs shall be used in case

of cables above 185 sq. mm.

(v) Anticorrosion/ anti-oxidation compounds shall be used for crimping lugs. This shall especially be ensured for Al cable terminations & bimetallic terminations shall be used wherever required.

(vi) If termination is done with crimping tool employing crimping die then forming dies shall be used to make the sector shaped conductor into a round conductor before crimping the lugs on the conductor. The lug must not be crimped directly on the sector conductor. Before crimping the lug, the conductor shall be thoroughly cleaned and special jelly applied over it to prevent further oxidation.

(b) Cable Glands

(i) Glands shall generally be of the double compression hexagonal type brass glands. Earth continuity of brass glands shall be assured.

(ii) Double compression type cable glands shall be used. Cable glands shall be brass casting, machine finished and Nickel-plated to avoid corrosion and oxidation. Rubber components used in cable gland shall be of neoprene.

(iii) For single core cables, gland shall be with brass ring.

(iv) Glands for single core cables shall be constructed from non-magnetic materials.

(v) Cable glands shall be with metric threads.

(vi) Where holes for cable entries are not provided it shall be the responsibility of the Contractor to mark out and drill such holes. Burrs and swarf shall be removed, care being taken to ensure that swarf and filings, etc do not enter the equipment.

(vii) For non-hazardous areas cable glands in situations where moisture may be present shall be double seal weatherproof type, gland shrouds shall be used and entry shall be sealed.

(viii) For dry indoor situations, standard industrial glands with shrouds are acceptable.

(ix) For hazardous areas, glands conforming to EEE standard shall be used with double seal and shroud.

(c) Trefoil Clamps for Single Core Cables.

(i) All the single core cables shall be laid in trefoil formation only.

(ii) The grouping & sequencing of three single core cables arranged in trefoil formation shall be done in such a way to ensure balanced current distribution.

(iii) Trefoil clamp of suitable size & having non-magnetic material shall be used.

(iv) The Trefoil groups shall be held in trefoil clamps at an interval not exceeding 3.0

meters.

(v) In addition to trefoil clamps as mentioned above, the tre-foil groups of cables shall be additionally tied by means of 3.0 mm dia. nylon cord clamp at an interval not exceeding 750 mm.

(d) Where ever applicable, supply & installation provision of bimetallic strip for connection between Al to Cu strip & GI to Cu strip shall be provided.

(e) Cable Drums:

(i) Cables shall be supplied in non-returnable wooden drums. The wood used for construction of the drum shall be properly seasoned and free from defects and wood preservative shall be applied to the entire drum. All ferrous parts shall be treated with a suitable rust preventive coating to avoid rusting during transit or storage.

(ii) Before winding the cables on drums, Contractor shall obtain Purchaser's approval for the drum lengths. Cable ends shall be sealed by non-hygroscopic sealing caps.

(iii) Contractor has to ensure reference of an arrow and suitable accompanying wording which shall be stenciled on the sides of the drums indicating which way it should be rolled. The number on each drum shall be either branded at the end of the drum or stamped on the metal attached to an end of the drum. The cable shall be placed on the drum in such a manner that it will be protected from injury during transit. Each end of the cable shall be firmly and properly secured to the drum. The drum shall be securely blocked in position so that the cable will not be displaced during transit. Cable ends shall be sealed by non-hygroscopic sealing caps.

(iv) It shall be the Contractor's responsibility to prepare the drum cutting schedule so that cable wastage is minimum while cutting.

(v) Contractor shall obtain Purchaser's approval for the drum lengths.

2.6.7 Tests Before and After Laying of Cables at Site: Following Routine & acceptance tests on each drums as per IS 10810, IS 7098 standard & other specified relevant standards shall be performed by the manufacturer and witnessed by Purchaser/ Purchaser's Representative.

(a) For 1.1 kV Power & Control cables:

(i) Dimensional & visual check

(ii) Conductor resistance test

(iii) Insulation Resistance Test

(iv) High voltage test

(b) For 11 kV power cables:

(i) Design and visual check

(ii) Conductor resistance test

(iii) Very low frequency AC HV test (instead of DC test)

(iv) Insulation resistance including P.I. at rated voltage

(v) Capacitance and tan delta

(vi) AC leakage current

(vii) Partial discharge measurement

(c) All HV cables shall be subjected to DC or AC (preferably DC) high voltage test after terminating but before commissioning as per Table 6.0 in IS: 1255 (Code of practice for Installation & Maintenance of Power Cables up to and including 33kV).

(d) Cables shall be checked for insulation resistance before and after jointing. The voltage rating of the Megger for cables of different voltage grades shall be as indicated below.

Table 11:Megger Rating

Voltage Grade	Megger rating
1.1kV	500V
11kV	1000V

(e) Following tests in the presence of Purchaser/ Purchaser's representative shall be carried out at site before commissioning of cables.

(i) Insulation Resistance test between phases and phase to Neutral and phase to earth.

(ii) Continuity test of all the phases, neutral and earth continuity conductor.

(iii) Sheathing continuity test.

(iv) Earth resistance test of all the phases and neutral.

2.6.8 Drawings / Documents Required:

(a) As a part of the Bid, Contractor shall furnish the following :

(i) General information

(ii) Principal technical data

(b) After award of contract it shall be the responsibility of Contractor to work out a detailed layout for the complete plant cabling system. The layout drawing shall be furnished for the approval of Purchase/ Purchaser's representative before commencement of

installation including cable trays, cable racks/ trenches, accessories, tray supports, conduits etc.

(c) Contractor to submit following Drawings /Details after award of contract

(i) Cable Sizing calculations

(ii) General Arrangement of the Cross section of Cable and Data sheet for each type and size of cables.

(iii) Details of Installation of Cables in Trenches, on Cable Trays, Directly buried etc at all locations inside the plant.

(iv) Cable routing lay out inside and outside the plant with route marker provided at 30 meter interval.

(v) Bill of quantities of cables, lugs and glands.

(vi) 11kV Cable termination and mounting Kit Layout drawing.

(d) Following Type Tests reports as per relevant standard to be submitted for the same rating & type of Cables conducted in past for review of Purchaser/ Purchaser's Representative by the Contractor at the time of inspection & testing of equipment. Type test reports should be valid and not be older than the 5 years.

(i) Annealing test

(ii) Tensile test

(iii) Wrapping test

(iv) Test for thickness of insulation & sheath

(v) Physical test for insulation & sheath

(vi) Tensile strength and elongation at break of insulation and sheath

(vii) Loss of mass test

(viii) Ageing in air oven

(ix) Shrinkage test

(x) Heat shock test

(xi) Insulation resistance test

(xii) High voltage test

(xiii) Flammability test

2.6.9 Cable Installation

(a) Cable installation shall be in accordance with IS 1255: 2001- latest edition.

(b) Cables shall be installed in such a way that the minimum bending radii are not reduced when installed or during installation. Cables shall not be installed in ambient temperatures below that recommended by the cable manufacturer.

(c) Cables grouped together shall have insulation capable of withstanding the highest voltage present in the group.

(d) Cables of different categories shall be installed so as to maintain satisfactory clearances for safety and in order to reduce the possibility of electrical interference. The following Table details the distances in mm that shall be maintained between the different categories of cable.

Table 12: Table of Separation Distance in mm between different Categories of Cable

Cable Category	HV Power	LV Power	C&I/ Protection	Tele-communication
HV Power	N/A	300	400	400
LV Power	300	N/A	300	300
C&I/ Protection	400	300	N/A	200
Tele-communication	400	300	200	N/A

(e) These separations are minimum and special circumstances such as the presence of high current flows, or harmonic content may necessitate larger separation distances.

(f) Minimum Clearance of 300mm shall be kept between any other utility & power cables.

(g) In order to make economic use of the cable support system, cables shall be arranged in groups of 50 mm maximum overall diameter. These groups shall be securely tied to the cable support system at intervals not exceeding 900 mm for horizontal runs and 300 mm intervals on vertical runs.

(h) Cables shall be laid in a manner such that any electrical interference between cables shall not have a detrimental effect on the life and operation of Plant.

(i) Where practical a separate cable support system shall be provided for power and non-power cables. Where this is not practical a separation as per indicated in above table shall be maintained between power and non-power cables when run on the same support system.

(j) Heavy duty galvanized iron cable tray and ladder racking shall be used for cable support systems. FRP/ GRP cable support systems shall be used in areas used for the storage and handling of chlorine. These systems shall be used to route cables around walls and within cable trenches. Cables shall be securely fixed to the support systems. Bundling of cables shall be permitted where allowance for this practice has been made in sizing

the cables.

(k) Instrumentation Cabling:

(i) In order to make the most economic use of cable ladder/tray and duct capacity, multicore cabling shall be utilized in order to connect instrumentation groups by using suitably located sub-distribution junction boxes. The junction boxes shall be suitable for the area in which they are to be installed and for the type of circuit. They shall be readily accessible for maintenance and clearly labeled junction boxes shall be constructed of die cast Aluminium and provide degree of protection IP 65.

(ii) Separate cables shall be used for digital and analogue signals at all times.

(iii) Instrumentation cables shall be continuous without any joints.

(iv) Digital and analogue signals shall be segregated within junction boxes.

(l) Cables Laid Direct in Ground

(i) Buried cable up to 1.1 kV shall have a laid at a minimum depth of 750 mm measured from FGL to the top of the highest cable. On crossing roadways the cable shall be run through a PVC-U duct of minimum diameter 100 mm with a minimum of 1000 mm cover and encased on all sides by 150 mm of concrete.

(ii) Cables of greater than 1.1kV shall be buried at a minimum depth of 1 meter.

(iii) The bottom of the cable trench shall be freed of sharp stones and such like and 75mm of sieved sand laid below the cable. After cable laying 75 mm of sieved sand shall be laid above the cable. For HT cables sand bedding shall be of 150 mm & cables shall be covered with half round Hume pipes of twice the diameter of cable.

(iv) Interlocking cable protective covers, minimum 1 m long x 300 mm wide, marked `Danger-Electric Cable' in English and the vernacular shall be laid on top of the sieved sand. Covers shall extend the whole length of the cable trench and shall overlap cables by a minimum of 50 mm.

(v) Warning tape shall be laid a minimum of 200 mm above the protective covers.

(vi) Cables are to be installed without tees or through joints unless otherwise approved by the Purchaser’s Representative. Single core cables shall be run in trefoil formation.

(m) Concealed Installation

(i) Concealed conduits shall be securely fixed to prevent movement before laying of screeds, floating of plaster, casting of columns or other building operations necessary after the conduit installation. Crumpets or similar fixings shall be used for attaching the conduit to blockwork, etc. Building nails will not be accepted.

(ii) At least 15 mm cover shall be allowed for finishes over the conduit. Where this cover cannot be maintained then expanded metal shall be fitted with the conduit. Conduit cast into reinforced concrete floors shall be fixed to the steel reinforcing with binding wire and the conduit boxes filled with expanded polystyrene or enclosed in a plastic bag to prevent the ingress of concrete when poured. Where possible, the conduit boxes shall be fixed to shuttering to give a flush finish.

(iii) Conduit installed in voids, false ceilings, and other concealed routes shall be installed as specified for the surface conduits. Wiring shall be carried out after the false ceiling or permanent ducts have been completed. Conduit installed in floors shall be sealed against ingress of moisture.

(iv) The conduit installation shall be inspected by the Purchaser's Representative before the building operation conceals the work.

(n) Cable Installed in Flexible Conduit

(i) Flexible conduit shall be of the waterproof galvanized type or PVC wire-wound type with cadmium plated mild steel couplings. Lengths of flexible conduits shall be sufficient to permit withdrawal, adjustment or movement of the equipment to which it is attached and shall have a minimum length of 300 mm. Flexible conduit shall not be used as a means of providing earth continuity. A single earth conductor of adequate size shall be installed external to the conduit complete with earth terminations.

(ii) Where conversion from rigid conduit to flexible metallic conduit is to be made, the rigid conduit shall terminate in a through type box and the flexible conduit shall extend from this box to the equipment, the earth continuity cable shall be secured to the box and to the piece of equipment by properly designed earthing screws. The use of lid facing screws, etc., will not be permitted. Adapters shall incorporate a grub screw or a gland to prevent the flexible conduit becoming loose.

(o) Cable Clipped Direct

All cable hangers, clips, cleats and saddles shall be of an approved type and appropriate to the type and size of cable installed. Their spacing shall be such as to ensure a neat appearance and prevent sagging of the cables at all times during their installed life.

(p) Cable Installed in Internal Floor TrenchIn shallow trenches (maximum depth 500 mm)

(i) In shallow trenches used for electrical services only, cables may be laid in a neat and orderly manner on the floor of the trench. One layer only shall be allowed. Additional cables shall be installed on the walls of the trench in an acceptable manner & such a way that, in no case the distance between two different types of cable shall not be less than the separation distance tabulated above.

(ii) Where the trench is shared by other services, cables shall be installed on the walls of the trench in an acceptable manner & such a way that, minimum

separation distance of 300mm shall be maintained.

(iii) All other trenches including walk through service ducts

(iv) Cable trenches & cable installation shall be in accordance with the attached typical cabling system drawings.

(v) Where other services are present the cables shall be segregated from them by separation distances as mentioned above and wherever possible kept above `cold' wet services. Cables should not be run if at all possible above or in close proximity to `hot' services.

(vi) The cabling shall be installed in such a manner as to allow access to the other services for normal maintenance without disturbance of the electrical installation

(q) Cable Terminations and Joints

(i) Power cables shall be terminated in suitable boxes arranged for bolting to switchgear, motor starters and motors.

(ii) Cores shall have either crimped lugs or sleeves to match either post terminals or bolted clamp terminals.

(iii) Each cable entry into a terminating box shall be made through a suitable gland, which shall have provision for securing the armour where applicable. Where single core glands are required these shall be of the non-magnetic type and the associated box bottom plate, where the core passes through, shall not have a continuous magnetic path.

(iv) Adequate provision shall be made to bond the cable armouring to the box and/or switchgear casing of a suitable size to withstand the prospective short circuit fault current of the system, glands shall be fitted with earth bonding tags where intimate screwed contact between gland and cable box is not possible.

(v) Where cable glands are exposed to the weather these shall be protected by heat shrink plastic sleeve or purpose moulded sleeves covering the gland continuously from overall sheath to the gland neck.

(vi) Where terminations of multicore type have to be made on to items of Plant which have to be dismantled for maintenance, these shall be made off through glands into an adaptable box containing terminals and flexible single cores taken into the equipment via flexible waterproof plastic covered conduit, and a separate earth core linking the box to the equipment.

(vii) Where single core cables are glanded to or pass through cabling plates the gland plate or cabling plate shall be constructed of non-magnetic material.

(r) Power Cable Joints

Through joints shall only be allowed with the approval of the Purchaser’s Representative. Where such joints are necessary in thermoplastic and elastomeric

cables, the cables shall be jointed with epoxy or acrylic resin cold setting compound, which has been premeasured and pre-packed ready for use. The boxes shall preferably be of split, moulded plastic type with filling vents for compound. Bonding straps shall be fitted with armour clamps across the joint and inspected by the Purchaser/ Purchaser's Representative prior to filling the box with compound. Wrapped pressure type joints will not be accepted.

(s) Multi-core or Control Cable Terminations

(i) A sufficient number of terminals shall be provided to terminate all cable cores. For control and auxiliary wiring an additional 20% of this number shall be provided as spares.

(ii) Not more than one core of internal or external wiring shall be connected on any one terminal. Where duplication of terminal blocks is necessary, purpose-made solid links shall be incorporated in the design of the terminal blocks.

(iii) Terminals which remain energized when the main equipment is isolated shall be suitably screened and labeled.

(iv) Terminal blocks for different voltages or circuit type shall be segregated into groups and distinctively labeled.

(t) Cable Fixings

(i) Ties and strapping shall be suitable for securing cable and cable groups to cable tray or ladder. They shall be resistant to chemical and marine corrosion. Plastic coated metal ties used in order to obtain corrosion resistance shall not be acceptable. Nylon ties shall be resistant to the effects of ultra-violet light and shall be self-extinguishing.

(ii) Large single cables shall be secured with cable clamps or cable cleats.

(u) Cable Identification

At each end of each cable, in a uniform and visible position a label shall be fixed on the cable in accordance with the cable schedule. Labels shall be made of PVC and shall be indelibly marked to the approval of the Purchaser's Representative. The label shall be retained using proprietary nylon strips passing through two fixing holes at either end of the label. If the cable gland is not normally visible, then the label shall be fixed inside the panel by means of screws.

(v) Marking Locations of Underground Cables

(i) The location of all underground cables shall be engraved on brass or other non-corrodible plates to be fixed to the exterior surface of all walls of buildings 300 mm above ground level and directly above the point where cables pass through the wall.

(ii) Cable route markers as per the attached drawing shall be installed at an interval not more than 30 meter & at bending / road crossings the interval shall be at

every 10 meter.

(iii) The minimum depth for laying of underground cable route markers shall be as per indicated in the typical drawings attached with this tender.

(w) Additional Requirements for Cable Installations

(i) The Contractor shall install, test and commission the cables specified in the specification. Cables shall be laid directly buried in earth, on cable racks, in built up trenches, on cable trays and supports, in conduits and ducts or bare on walls, ceiling etc. as per drawings, which are to be prepared by Contractor & approved by Purchaser's representative. Contractor's scope of work includes unloading, laying, fixing, jointing, bending, and termination of the cables & all related accessories. The Contractor shall also supply the necessary materials and equipment required for jointing and termination or the cables.

(ii) All apparatus, connections and cable work shall be designed and arranged to minimize risk of fire and any damage which might be caused in the event of fire. Wherever cables pass through floor or wall openings or other partitions, suitable bushes of an approved type shall be supplied and put into position by the Contractor.

(iii) Standard cable grips and reels shall be utilized for cable pulling. If unduly difficult pulling occurs, the Contractor shall check the pull required and suspend pulling until further procedure has been approved by the Engineer's Representative. The maximum pull tension shall not exceed the recommended value for the cable measured by the tension dynamometer. In general, any lubricant that does not injure the overall covering and does not set up undesirable conditions of electrostatic stress or electrostatic charge may be used to assist in the pulling of insulated cables in conduits and ducts.

(iv) After pulling the cable, the Contractor shall record cable identification with date pulled neatly with waterproof ink in linen tags. Identification tags shall be attached securely to each end of each cable with non-corrosive wire. The said wire must be non-ferrous material on single conductor power cable. Tags shall further be attached at 10 meter intervals on long runs of cables on cable trays and in pull boxes. Cable and joint markers and RCC warning covers shall be provided wherever required.

(v) Sharp bending and kinking of cables shall be avoided. The bending radius for various types of cables shall not be less than those specified below:

11 kV, XLPE insulated, multicore armoured cables	:	15 times the overall dia of the cable
1.1 kV, XLPE insulated, multicore armoured cables	:	12 times the overall dia of the cable

(If shorter radius appears necessary, no bend shall be made until clearance and instructions have been received from the Purchaser/ Engineer in charge)

(vi) Power, control and instrumentation cables shall be laid in separate cable racks/trays.

(vii) Where groups of HV, LV and control cables are to be laid along the same route, suitable barriers to segregate them physically shall be provided.

(viii) Where cables cross roads and water, oil, gas or sewage pipes, the cables shall be laid in reinforced spun concrete or steel pipes. For road crossings the pipe for the cables shall be buried at no less than one meter depth.

(ix) Cables laid in ground shall be laid on a 75 mm riddled earth bed. The cables shall then be covered on top and at their sides with riddled earth of depth of about 150 mm. This is then gently filled up to a depth of about 100 mm above the top of uppermost cable to provide bedding for the protective cable covers which are placed centrally over the cables. The protective cable covers for LV cables may be of earthenware and for HV cables of reinforced concrete. The RCC covers shall have one hole at each end, to tie them to each other with GI wires to prevent displacement. The trench is then backfilled with the excavated soil and well rammed in successive layer of not more than 300 mm in depth, with the trenches being watered to improve consolidation wherever necessary. To allow for subsidence, it is advisable to allow a crown of earth not less than 75 mm in the centre and tapering towards the sides of the trench.

(x) In each cable run some extra length shall be kept at a suitable point to enable one or two straight through joints to be made, should the cable develop a fault at a later date.

(xi) Cables on cable racks, on cable trays and conduits shall be formed to avoid bearing against edges of trays, racks, conduits or their supports upon entering or leaving trays, racks or conduits. Cables shall be racked or laid directory into cantilevered cable trays where practicable, but in some cases it may be necessary that cables are pulled or threaded into trays. To facilitate visual tracing, cables in trays shall be laid only in single layers and unnecessary crossing of cables shall be avoided. Cables on trays shall finally be clamped in an approved manner.

(xii) Cable splices will not be permitted except where permitted by the Purchaser/ Purchaser's Representative. Splices shall be made by Contractor for each type of wire or cable in accordance with the instructions issued by cable manufacturer's and the Engineer's Representative. Before splicing, insulated cables shall have conductor insulation stepped and bound or penciled for recommended distance back from splices to provide a long leakage path. After splicing, insulation equal to that on the spliced conductors shall be applied at each splice.

(xiii) Jointing of cables shall be in accordance with relevant Indian Standards Codes of Practice. Materials and tools required for cable jointing work, including cold setting bituminous compound shall be supplied by the Contractor. Cables shall

be firmly clamped on either side of a straight through joint at a distance of not more than 300 mm away from the joints. Identification tags shall be provided at each joint at all cable terminations.

(xiv) At cable terminal points where the conductor and cable insulation will be terminated, terminations shall be made in a neat, workmanlike and approved manner by men specialized in this class of work.

(xv) Control cable termination shall be made in accordance with wiring diagrams, using colour codes established by the Purchaser's Representative for the various control circuit, by code marked wiring diagram.

(xvi) When control cables are to be fanned out and cabled together with cord, the Contractor shall make connections to terminal blocks, and test the equipment for proper operation before cables are corded together. If there is any question as to the proper connection, the Contractor shall make a temporary connection with sufficient length of cable so that the cable can be switched to another terminal without splicing. After correct connections are established through operating the equipment, cables shall be cut to their correct lengths, connected to terminals in the specified manner, and corded together where necessary to hold them in place in a workmanlike manner.

(xvii) Cable seals shall be examined to ascertain if they are intact and that cable ends are not damaged. If the seals are found to be broken the cable ends shall not be jointed until after due examination and testing by the Purchaser/ Purchaser's Representative. Before jointing is commenced, insulation resistance of both sections of cables to be jointed shall be checked by megger.

(xviii) After installation and alignment of motors, the Contractor shall complete the conduit installation, including a section of flexible conduit between motor terminal box and trench/ tray. The Contractor shall install and connect the power, control and heater supply cables as per equipment manufacturer's drawings.

(xix) Metal sheath and armour of the cable shall be bonded to the earthing system of the station. The size of conductor for bonding shall be appropriate with the system fault current

2.7 CABLE TRAYS

2.7.1 The cable trays shall be pre-fabricatedgalvanized steel, perforated or ladder cable trays, suitably supported by primer coated (2 Coats) and epoxy painted (2 Coats) mild steel cable tray supports. Separate cable trays will be used for power, control, signalling and supervisory cables.

2.7.2 All cable trays will be earthed at minimum two places by suitable sized GI flats to main earthing system earth conductor. The cable trays shall also be earthed at a regular interval not more than 10m.

2.7.3 Cable trays of prefabricated perforated and ladder types and associated accessories such as

coupler plates, tees, elbow etc. fabricated from 14SWG MS sheet and then hot dip galvanised (2.0 mm thick) sheet steel. 50mm side flanges for perforated tray and 75 side flange (100 mm only for 750mm tray) for ladder tray shall be provided on both sides of the tray. All the cable trays shall be hot dip galvanised (Min. 80 micron thickness) after fabrication.

2.7.4 All the Vertical cable trays shall be provided with covers. All cable trays & covers (only for vertical drops) shall be MS sheet fabricated and then hot dip galvanised with thickness of minimum 70 Micron as per IS 4759:1996. Thickness for Cable tray shall be minimum 2 mm & for covers shall be min. 1.6 mm.

2.7.5 Cable trays shall be in standard length of 2500 mm and clear inside width of trays shall be

(a) Perforated type trays: 50, 75, 100, 150

(b) Ladder type trays: 300, 450, 600, 750

2.7.6 Only Pre-Fabricated bends, joints and reducers shall be used.

2.7.7 Two lengths of Cable trays shall be fixed with twin coupler plates (inner & outer) at each joint. Erection with just one coupler plate shall result in rejection of the entire installation.

2.7.8 Hardware (esp. bolts) for Joining of two lengths of cable trays shall be installed such that, not to damage the cables under any condition.

2.7.9 2 nos. of earth strips shall run through each cable tray. In case of multi-tier cable trays, 2 nos. of earthing strips shall run only through one of the cable tray. The balance cable trays of the multi-tier cable trays shall be connected with these earth strips at a distance not more than 10 meter. The cable tray earthing shall be interconnected to Main earth grid at least at two places.

2.7.10 The BIDDER shall ensure that, for all vertical drops no cable shall be seen uncovered i.e. all the vertical cable trays shall be covered with cable tray covers.

2.7.11 All the cable trays above 300 mm width shall be of ladder type

2.7.12 Cable tray for use in areas where chlorine gas may be present shall be constructed from U-PVC or GRP. Cable tray supports shall be of a compatible finish with the associated cable tray.

2.7.13 Tray shall only be joined by couplers supplied by the manufacturers. The joint shall be secured in accordance with the manufacturer's instructions.

2.7.14 Cable tray supports supplied by a manufacturer or made up on Site shall have adequate strength to maintain rigid support to the fully laden cable tray along its entire length and shall ensure that the deflection of any one section does not exceed 15 mm at mid span.

2.7.15 Wherever possible, cable trays shall be installed in full lengths without cutting. Should it be necessary to cut or drill a length of tray, the bared ends or damaged section of the tray shall immediately be given a coat of zinc rich cold galvanized paint. All site manufactured accessories, supports and metal fittings required to ensure correct installation of the cable trays shall be similarly treated.

2.7.16 All cables shall be firmly secured to the tray using purpose made saddles, as approved by the Purchaser's Representative, together with proprietary nylon fasteners and/or cable cleats. Following installation of cables, the tray shall remain rigidly supported and the deflection of any section shall not exceed 15 mm at mid span. All brackets and tray work shall be suitable for withstanding a temporary weight of 125 kg.

2.7.17 Cable trays shall not be cut to allow the passage of cables through the surfaces of the tray

2.7.18 The sizing of the cable tray shall provide a minimum of 20% spare capacity.

2.7.19 The tray shall be run at least 300 mm clear of plumbing and mechanical services.

2.7.20 Bends in the installation shall take account of the minimum bending radii of cables to be installed.

2.7.21 All the cable trays shall be supplied with cable tray supports (of adequate size) at no more than 1.2 meter interval.

2.7.22 Other cable tray details & cabling system shall be as per typical drawings attached with the specifications.

2.8 TECHNICAL SPECIFICATIONS - GRID CONNECTED SOLAR PV SYTEM

2.8.1 DEFINATION

A Grid Tied Solar Photo Voltaic power plant shall consists of solar PV array, Module Mounting Structure, Power Conditioning Unit (PCU) consisting of Maximum Power Point Tracker (MPPT), Inverter, and Controls & Protections, interconnect cables, Junction boxes, Distribution boxes and switches.

Grid tied solar PV system shall be without battery and should be designed with necessary features to supplement the grid power during day time.

Components and parts used in the solar PV power plants should conform to the BIS or IEC or international specifications. Solar PV system shall consist of following equipment/components.

2.8.2 SOLAR PHOTOVOLTAIC MODULES:

The PV modules used should be made in India.

The PV modules used must qualify to the latest edition of IEC PV module qualification test or equivalent BIS standards Crystalline Silicon Solar Cell Modules IEC 61215/IS14286. In addition, the modules must conform to IEC 61730 Part-1 - requirements for construction & Part 2 – requirements for testing, for safety qualification or equivalent IS.

For the PV modules to be used in a highly corrosive atmosphere throughout their lifetime, they must qualify to IEC 61701.

It should comprise of solar crystalline modules of minimum 200 Wp and above wattage. Module capacity less than minimum 200 Wp shall not be accepted.

Protective devices against surges at the PV module shall be provided. Low voltage drop bypass diodes shall be provided.

PV modules must be tested and approved by one of the IEC authorized test centers.

The module frame shall be made of corrosion resistant materials, preferably/ SHALL BE anodized aluminum.

Efficiency of PV modules at standard test conditions (STC) shall not be less than 15.0% and fill factor of the module shall not be less than 0.75.

Modules shall be made of light weight cells, resistant to abrasion, hail impact, rain, water and environmental pollution. The PV modules shall be provided with anti-reflection coating

2.8.3 Other general requirement for the PV modules and subsystems shall be the Following:

(a) The rated output power of any supplied module shall have tolerance within +/-3%.

(b) The peak-power point voltage and the peak-power point current of any supplied module and/or any module string (series connected modules) shall not vary by more than 2 (two) per cent from the respective arithmetic means for all modules and/or for all module strings, as the case may be.

(c) The module shall be provided with a junction box with either provision of external screw terminal connection or sealed type and with arrangement for provision of by-pass diode. The box shall have hinged, weather proof lid with captive screws and cable gland entry points or may be of sealed type and IP-65 rated.

2.8.4 I-V curves at STC should be provided by bidder.

2.8.5 Modules deployed must use a RF identification tag. The following information must be mentioned in the RFID used on each module. This should be inside the laminate only.

(a) Name of the manufacturer of the PV module

(b) Name of the manufacturer of Solar Cells.

(c) Month & year of the manufacture (separate for solar cells and modules)

(d) Country of origin (separately for solar cells and module)

(e) I-V curve for the module Wattage, I'm, Vm and FF for the module

(f) Unique Serial No and Model No of the module

(g) Date and year of obtaining IEC PV module qualification certificate.

(h) Name of the test lab issuing IEC certificate.

(i) Other relevant information on traceability of solar cells and module as per ISO 9001 and ISO 14001

2.8.6 Warranties:

(a) Material Warranty:

(i) Material Warranty is defined as: The manufacturer should warrant the Solar Module(s) to be free from the defects and/or failures specified below for a period not less than five (05) years from the date of sale to the original customer ("Customer")

(ii) Defects and/or failures due to manufacturing

(iii) Defects and/or failures due to quality of materials

(iv) Non conformity to specifications due to faulty manufacturing and/or inspection processes. If the solar Module(s) fails to conform to this warranty, the manufacturer will repair or replace the solar module(s), at the Owners sole option

(b) Performance Warranty:

The predicted electrical degradation of power generated not exceeding 20% of the minimum rated power over the 25 year period and not more than 10% after ten years period of the full rated original output.

2.8.7 CIVIL FOUNDATIONS AND ARRAY STRUCTURE

(a) All Civil foundations and structures shall be designed to last for a period of 30 years.

(b) The structures shall resist the worst combination of the required/ specified loads / stresses under test and working conditions; these include dead load, live load, equipment load, water pressure, soil pressure, wind load, seismic load, stresses due to temperature changes, shrinkage and creep in materials, dynamic loads.

(c) Hot dip galvanized MS mounting structures shall be used for mounting the modules/ panels/arrays. Each structure should have angle of inclination as per the site conditions to take maximum insulation. However to accommodate more capacity the angle inclination may be reduced until the plant meets the specified performance ratio requirements.

(d) The Mounting structure shall be so designed to withstand the speed for the wind zone of the location where a PV system is proposed to be installed (like Guwahati-wind speed of 180 km/ hour as per IS 875 Part 3). Bidder may design the structures to sustain wind speed of minimum 200km/ hour. It may be ensured that the design has been certified by a recognized Lab/ Institution in this regard and submit wind loading calculation sheet to PURCHASER. Suitable fastening arrangement such as grouting and calming should be provided to secure the installation against the specific wind speed.

(e) The structures shall be designed taking into considerations the Seismic zone (earthquake loading) for the region. This shall be computed as per I.S. 1893. The site falls in Zone V as per IS: 1893 (2002). An importance factor appropriate to the type of structure shall be considered for design of all the structures. Environmental condition shall be considered appropriate as per IS 456, IS 800.

(f) The individual members of the frame shall be designed for worst combination of forces such as bending moment, axial force, shear force and torsion as applicable. Permissible stresses for different load combinations shall be taken as per latest IS456.

(g) The mounting structure steel shall be as per latest IS 2062: 1992 and galvanization of the mounting structure shall be in compliance of latest IS 4759.

(h) As far as possible non penetrative methods shall be preferred for mounting the structures over conventional penetrative method for the foundations on roofs – GI sheet as well as RCC roofs tops.

(i) Structural material shall be corrosion resistant and electrolytic ally compatible with the materials used in the module frame, its fasteners, and nuts and bolts. Aluminum structures also can be used which can withstand the wind speed of respective wind zone. Necessary protection towards rusting need to be provided either by coating or anodization.

(j) The fasteners used should be made up of stainless steel. The structures shall be designed to allow easy replacement of any module. The array structure shall be so designed that it will occupy minimum space without sacrificing the output from the Solar PV panels

(k) Regarding civil structures the bidder need to take care of the load bearing capacity of the roof and need arrange suitable structures based on the quality of roof.

(l) The total load of the structure (when installed with PV modules) on the terrace should

be less than 75 kg/m2.

(m) The minimum clearance of the structure from the roof level should be 300 mm.

2.8.8 JUNCTION BOXES (JBs)

(a) The junction boxes are to be provided in the PV array for termination of connecting cables. The JBs shall be made of Polycarbonate/GRP/FRP/Powder Coated Aluminum /cast aluminum alloy with full dust, water & vermin proof arrangement.

(b) It should be UV resistant in accordance with suitable for outdoor application at an ambient of 50°C.

(c) The junction boxes shall have IP protection of IP 65

(d) All wires/cables must be terminated through cable lugs. The JBs shall be such that input & output termination can be made through suitable cable glands.

(e) Copper bus bars/terminal blocks housed in the junction box with suitable termination threads Conforming to IEC 62208 Hinged door with EPDM rubber gasket to prevent water entry. Double compression cable glands. Provision of earthlings. It should be placed at 5 feet height or above for ease of accessibility.

(f) All the component including the Hardware that are required for mounting shall be include in the scope of work.

(g) Each Junction Box shall have High quality Suitable capacity Metal Oxide Varistors (MOVs) / SPDs, suitable Reverse Blocking Diodes. The Junction Boxes shall have suitable arrangement for disconnection of each of the groups.

(h) Suitable markings shall be provided on the bus bar for easy identification and the cable ferrules must be fitted at the cable termination points for identification.

(i) The fuses shall be provided on both positive and negative terminal of the incoming string.

(j) All fuses (Input Side) shall have DIN rail mountable fuse holders and shall be housed in thermoplastic IP 65 enclosures with transparent covers.

(k) Array Junction Box shall have isolator that will be used to disconnect both positive and negative sides simultaneously on output side.

(l) Array Junction Box shall have the sensors to monitor below parameters

(a) Analog signals:

(i) String currents

(ii) String Voltage

(b) Digital signals:

(i) Isolator ON/OFF status

(m) There shall be provision for mounting RTD element on String Monitoring device

(n) Either shunt-based (or) CT/hall-effect sensor (LEM)-based Mechanism shall be employed for sensing string currents together with Analog to digital converters for converting above current, voltage and temperature signals.

(o) Monitoring of the following parameter shall be possible using SCADA

(i) DC Switch ON/OFF Status

(ii) SPD operated

(iii) Ambient and Junction box Temperature

(iv) Bus Voltage

(v) Current through individual string

(vi) Overall Output Current

(p) Insulated pin type and ring type lugs, ferrules, cable ties etc. required for connecting the communication cables to the combiner boxes shall be in the bidder scope.

(q) Routine tests shall be conducted, as per relevant standards (IS, IEC etc), shall be carried out on the string combiner box and all the tests may be witnessed by Client/ Client representatives. Vendor shall submit manufacturing quality plan, indicating relevant IS/IEC standards for Client's approval. Following shall be the minimum checks

(i) Visual inspection check

(ii) Bill of materials check

(iii) Electrical continuity check

(iv) HV insulation tests

(v) Functional checks

Test reports shall be submitted prior to dispatch of the system to the site

(r) Type test report for Temperature rise test performed at NABL accredited Lab shall be submitted for approval for Client/ Client's representative.

2.8.9 DC DISTRIBUTION PANEL BOARD:

(a) DC Distribution Board is required if there are large number of strings of PV array hence the large number of the Array junction box

(b) It receives the DC output from the array Junction box and supplies to the Inverter.

(c) DC DPBs shall have a dust & vermin proof enclosure of conform to IP 65 protection. The bus bars are made of copper of desired size. Suitable capacity MCBs/MCCB shall be provided for controlling the DC power output to the PCU along with necessary surge arrestors.

2.8.10 AC DISTRIBUTION PANEL BOARD:

(a) AC Distribution Panel Board (DPB) shall control the AC power from PCU/ inverter, and should have necessary surge arrestors. ACDB shall be connected to Main 415 V Power Distribution Panel or Power Control Centre (PCC) of the OWNER's system while in grid tied mode.

(b) All switches and the circuit breakers, connectors should conform to IEC 60947, part I, II and III/ IS60947 part I, II and III. The entire system shall be fuse less system.

(c) The changeover switches, cabling work should be undertaken by the bidder as part of the project.

(d) All the Panel's shall be metal clad, totally enclosed, rigid, floor mounted, air - insulated, cubical type suitable for operation on three phase / single phase, 415 or 230 volts, 50

Hz

(e) The panels shall be designed for minimum expected ambient temperature of 45 degree Celsius, 80 percent humidity and dusty weather.

(f) All indoor panels will have protection of IP54 or better. All outdoor panels will have protection of IP65 or better with rain canopy and double door. the panel shall be mounted at-least 300mm above the Finished Floor Level (FFL) on steel structural support.

(g) Should conform to CEA guidelines-2010 (till last amendment).

(h) All the 415 AC or 230 volts devices / equipment like bus support insulators, circuit breakers, SPDs, VTs etc., mounted inside the switchgear shall be suitable for continuous operation and satisfactory performance under the following supply conditions

Variation in supply Voltage : +/- 10 %

Variation in Supply Frequency : +/- 3 Hz

2.8.11 PCU/ARRAY SIZE RATIO:

(a) The combined wattage of all inverters should not be less than rated capacity of power plant under STC.

(b) Maximum power point tracker shall be integrated in the PCU/inverter to maximize energy drawn from the array.

2.8.12 PCU / Inverter:

(a) As Solar PV array produce direct current electricity, it is necessary to convert this direct current into alternating current and adjust the voltage levels to match the grid voltage. Conversion shall be achieved using an electronic Inverter and the associated control and protection devices. All these components of the system are termed the “Power Conditioning Unit (PCU)”. In addition, the

(b) PCU shall also house MPPT (Maximum Power Point Tracker), an interface between Solar PV array & the Inverter, to the power conditioning unit/inverter should also be DG set interactive, if necessary. Inverter output should be compatible with the grid frequency. Typical technical features of the inverter shall be as follows:

Table 17: Inverter Specification

Switching devices	IGBT/MOSFET
Control	Microprocessor /DSP
Nominal AC output voltage and Frequency	415V, 3 Phase, 50Hz (In case single phase inverters are offered, suitable arrangement for balancing the phases must be made.)
Output frequency	50 Hz
Grid Frequency Synchronization range	+ 3 Hz or more
Ambient temperature considered	-20 Deg C to 50 Deg C
Humidity	95 % Non-condensing
Protection of Enclosure	IP-20(Minimum) for indoor. IP-65(Minimum) for outdoor.
Grid Frequency Tolerance range	+ 3 or more
No-load losses	Less than 1% of rated power
Inverter efficiency(minimum)	>93% (In case of 10 kW or above with in-built galvanic isolation) >97% (In case of 10 KW or above without in-built galvanic isolation)
THD	< 3%
PF	> 0.9
Surge Protection	Required on both AC as well as DC side
Enclosure	Shall be made of non-corrosive material

(c) PCU/inverter shall be capable of complete automatic operation including wake-up, synchronization & shutdown.

(d) The output power factor of PCU inverter is suitable for all voltage ranges or sink of reactive power; inverter should have internal protection arrangement against any sustainable fault in feeder line and against the lightning on feeder.

(e) Built-in meter and data logger to monitor plant performance through external computer shall be provided. It shall have multi-line display to indicate following parameters

(i) Output Voltage

(ii) Output Current

(iii) Output frequency

(iv) Harmonics

(v) Power Factor

(vi) KW (Output)

(vii) kWH (Output)

(viii) DC Input Voltage

(ix) DC Input Current

(x) KW (input)

(xi) kWH (input)

(f) The inverter control system shall be fully compatible for remote operation via communication link.

(g) Bidder to indicate the type of communication protocol supported by the system along with the details of links provided in the system. The control system shall operate on windows or equivalent platform.

(h) Alarm shall be produce for the following operating conditions

(i) Inverter failure

(ii) IGBT/MOSFET over temperature

(iii) Breaker / Dis-connecter failure

(iv) Over load

(v) Over load shutdown

(vi) Emergency shutdown

(vii) DC circuit breaker/switch open

(viii) AC Main failure

(ix) Fan failure

(x) Asynchronous condition and Synchronous condition

(xi) Control power failure

(xii) DC ground fault

(i) The communication protocol in inverter shall be compatible with the Data acquisition system implemented for the entire solar plant.

(j) Anti-islanding (Protection against Islanding of grid): The PCU shall have anti-islanding protection in conformity to IEEE 1547/UL 1741/ IEC 62116 or equivalent BIS standard.

(k) Successful Bidders shall be responsible for galvanic isolation of solar roof top power plant with electrical grid or LT panel.

(l) In PCU/Inverter, there shall be a direct current isolation provided at the output by means of a suitable isolating transformer. If Isolation Transformer is not incorporated with PCU/Inverter, there shall be a separate Isolation Transformer of suitable rating provided at the output side of PCU/PCU units for capacity.

(m) The PCU/ inverter generated harmonics, flicker, DC injection limits, Voltage Range, Frequency Range and Anti-Islanding measures at the point of connection to the utility services should follow the latest CEA (Technical Standards for Connectivity Distribution Generation Resources) Guidelines and shall also be within the specified limits in IEEE 519.

(n) Power conditioning units / inverters should comply with applicable IEC / equivalent BIS standard for efficiency measurements and environmental tests as per standard codes IEC 61683/IS 61683 and IEC 60068-2 (1,2,14,30)/ Equivalent BIS Std.

(o) The MPPT units environmental testing should qualify IEC 60068-2 (1, 2, 14, 30)/ Equivalent BIS std. The junction boxes/ enclosures should be IP 65 (for outdoor) / IP 54 (indoor) and as per IEC 529 specifications.

(p) The PCU/ inverters should be tested from the MNRE approved test centers/ NABL/ BIS/ IEC accredited testing- calibration laboratories. In case of imported power conditioning units, these should be approved by accredited international test houses. Bidder shall furnish copies of all type test reports required.

(q) The Inverter shall have the option of Positive or Negative grounding. The inverter shall have less power consumption when in service and shall have minimum power consumption on standby mode. Inverter DC input side shall be provided with DC Circuit breaker and output side provided with AC circuit breaker

(r) The minimum following protection shall be provided to protect the inverter:

- (i) Reverse polarity
- (ii) Reverse power
- (iii) Short Circuit
- (iv) Over-current
- (v) Earth fault protection
- (vi) Islanding
- (vii) Under / Overvoltage
- (viii) Over / Under frequency
- (ix) Surge Protection on both AC and DC side

(s) The BIDDER shall clearly bring out the earthing philosophy to be adopted for the

Inverter electronics, protective earthing (PE) and neutral earthing. The requirement of separate earth pit independent of the plant electrical system earth pits shall be clearly brought out.

(t) Types including Heat run test and routine tests certificates for all components used in the inverter system shall be furnished. Testing of components shall be as per relevant standards.

(u) Bidder shall furnish copies of all type test reports required as per the relevant standards. The type test should have been carried out in last five years on equipment of similar rating. Without the type test reports, the Contract shall be considered incomplete.

(v) Bidder shall furnish his quality assurance plan for the equipment offered. The quality assurance plan shall include bought out component and assemblies used in the Inverter system.

(w) System tests shall be performed on the completely assembled inverter system. System tests shall include frequency regulations. Voltage regulation, current limiting feature and harmonic content tests in addition to the tests to prove the functional requirements such synchronization with range of adjustments, overload and under voltage conditions.

(x) Heat run test shall be carried out on inverter system at rated load under relevant ambient conditions for a period of 8 hours. This test shall be conducted as a routine test on all inverters being supplied.

2.8.13 INTEGRATION OF PV POWER WITH GRID:

The output power from Solar PV shall be fed to the inverters which converts DC produced by Solar PV array to AC and feeds it into the main electricity grid after synchronization. In case of grid failure, or low or high voltage, solar PV system shall be out of synchronization and shall be disconnected from the grid. 4 pole isolation of inverter output with respect to the grid power connection need to be provided.

2.8.14 DATA ACQUISITION SYSTEM / PLANT MONITORING

(a) Data Acquisition System shall be provided for each of the solar PV plant.

(b) Data Logging Provision for plant control and monitoring, time and date stamped system data logs for analysis with the high quality, suitable PC. Metering and Instrumentation for display of systems parameters and status indication to be provided.

(c) Solar Irradiance: An integrating Pyrometer / Solar cell based irradiation sensor (along with calibration certificate) provided, with the sensor mounted in the plane of the array. Readout integrated with data logging system.

(d) Temperature: Temperature probes for recording the Solar panel temperature and/or ambient temperature to be provided complete with readouts integrated with the data logging system

(e) The following parameters are accessible via the operating interface display in real time separately for solar power plant:

(i) AC Voltage.

(ii) AC Output current.

(iii) Output Power

(iv) Power factor.

(v) DC Input Voltage.

(vi) DC Input Current.

(vii) Time Active.

(viii) Time disabled.

(ix) Time Idle.

(x) Power produced

(xi) Protective function limits (Viz-AC Over voltage, AC Under voltage, Over frequency, Under frequency ground fault, PV starting voltage, PV stopping voltage.

(f) All major parameters available on the digital bus and logging facility for energy auditing through the internal microprocessor and read on the digital front panel at any time) and logging facility (the current values, previous values for up to a month and the average values) should be made available for energy auditing through the internal microprocessor and should be read on the digital front panel.

(g) PV array energy production: Digital Energy Meters to log the actual value of AC/ DC voltage, Current & Energy generated by the PV system provided. Energy meter along with CT/PT should be of 0.5 accuracy class.

(h) Computerized DC String/Array monitoring and AC output monitoring shall be provided as part of the inverter and/or string/array combiner box or separately.

(i) String and array DC Voltage, Current and Power, Inverter AC output voltage and current (All 3 phases and lines), AC power (Active, Reactive and Apparent), Power Factor and AC energy (All 3 phases and cumulative) and frequency shall be monitored.

(j) Computerized AC energy monitoring shall be in addition to the digital AC energy meter.

(k) The data shall be recorded in a common work sheet chronologically date wise. The data file shall be MS Excel compatible. The data shall be represented in both tabular and graphical form.

(l) All instantaneous data shall be shown on the computer screen. It shall show the mimic diagram indicating status of each system component and value of each system parameters

(m) Software shall be provided for USB download and analysis of DC and AC parametric data for individual plant.

(n) Provision for instantaneous Internet monitoring and download of historical data shall be also incorporated.

(o) Remote Server and Software for centralized Internet monitoring system shall be also provided for download and analysis of cumulative data of all the plants and the data of the solar radiation and temperature monitoring system.

(p) Ambient / Solar PV module back surface temperature shall be also monitored on continuous basis.

(q) Simultaneous monitoring of DC and AC electrical voltage, current, power, energy and other data of the plant for correlation with solar and environment data shall be provided.

(r) Remote Monitoring and data acquisition through Remote Monitoring System software at the PURCHASER location with latest software/hardware configuration and service connectivity for online / real time data monitoring / control complete to be supplied and operation and maintenance / control to be ensured by the bidder.

(s) The bidders shall be obligated to push real-time plant monitoring data on a specified intervals (say 15 minute) through open protocol at receiver location (cloud server) in XML/JSON format, preferably. Suitable provision in this regard will be intimated to the bidders.

(t) All the Alarm as indicated above shall be displayed on the computer screen.

2.8.15 METERING:

(a) The Meter shall be as per APDCL norms.

(b) The meter shall be CT-PT operated static trivector energy meter conforming to DLMS Indian Companion Standard-Category 'B'.

(c) The meter shall be conform to IS 14697:1999, CBIP Technical report No. 304 and IS 15959.

(d) The bidder must intimate to the APDCL for the connectivity, technical feasibility, and synchronization of Solar PV plant with distribution network and submit the same to PURCHASER before commissioning of Solar PV plant.

(e) The Reverse power relay shall be provided by bidder (if necessary), as per the local DISCOM requirement.

2.8.16 POWER CONSUMPTION:

Regarding the generated power consumption, priority need to give for internal consumption first and thereafter any excess power can be exported to grid. Finalization of tariff is not under the purview of PURCHASER or MNRE. Decisions of appropriate authority like DISCOM, state regulator need to be followed.

2.8.17 PROTECTIONS

The system should be provided with all necessary protections like earthing, Lightning, and grid islanding as follows:

2.8.18 LIGHTNING PROTECTION

The Solar PV power plants shall be provided with lightning & overvoltage protection. The main aim in this protection shall be to reduce the over voltage to a tolerable value before it reaches the PV or other sub system components. The source of over voltage can be lightning, atmosphere disturbances etc. The entire space occupying the Solar PV array shall be suitably protected against Lightning by deploying required number of Lightning Arrestors. Lightning protection should be provided as per IEC 62305 standards. The protection against induced high-voltages shall be provided by the use of metal oxide varistors (MOVs) and suitable earthing such that induced transients find an alternate route to earth.

2.8.19 SURGE PROTECTION

Internal surge protection shall consist of three MOV type surge-arrestors connected from +ve and –ve terminals to earth (via Y arrangement).

2.8.20 EARTHING PROTECTION

Each array structure of the PV yard should be grounded/ earthed properly as per IS: 3043-1987. In addition the lighting arrester/masts should also be earthed inside the array field. Earth Resistance shall be tested in presence of the representative of Appropriate Statutory Department/PURCHASER as and when required after earthing by calibrated earth tester. PCU, ACDB and DCDB should also be earthed properly.

Earth resistance shall not be more than 5 ohms. It shall be ensured that all the earthing points are bonded together to make them at the same potential.

2.8.21 GRID ISLANDING:

(b) In the event of a power failure on the electric grid, it is required that any independent power-producing inverters attached to the grid turn off in a short period of time. This prevents the DC-to-AC inverters from continuing to feed power into small sections of the grid, known as “Islands.” Powered Islands present a risk to workers who may expect the area to be unpowered, and they may also damage grid-tied equipment. The Rooftop PV system shall be equipped with islanding protection. In addition to disconnection from the grid (due to islanding protection) disconnection due to under and over voltage conditions shall also be provided.

(c) A manual disconnect 4-pole isolation switch beside automatic disconnection to grid would have to be provided at utility end to isolate the grid connection by the utility personnel to carry out any maintenance. This switch shall be provided with locking facility to be locked by the utility personnel for taking outage clearances.

2.8.22 CABLES

(a) Cables of appropriate size to be used in the system shall have the following characteristics:

(i) Shall meet IEC 60227/IS 694, IEC 60502/IS1554 standards

(ii) Temp. Range: –10 deg C to +80 deg C.

(iii) Voltage rating 660/1000V

(iv) Excellent resistance to heat, cold, water, oil, abrasion, UV radiation

(v) Flexible

(b) Sizes of cables between array interconnections, array to junction boxes, junction boxes to Inverter etc. shall be so selected to keep the voltage drop (power loss) of the entire solar system shall not exceed 2%.

(c) For the DC cabling, XLPE or, XLPO insulated and sheathed, UV-stabilized single core multi-stranded flexible copper cables shall be used; Multi-core cables shall not be used.

(d) For the AC cabling, PVC or, XLPE insulated and PVC sheathed single or, multi-core multi-stranded flexible copper cables shall be used; Outdoor AC cables shall have a UV-stabilized outer sheath.

(e) The cables (as per IS) should be insulated with a special grade PVC compound formulated for outdoor use. Outer sheath of cables shall be electron beam cross-linked XLPO type and black in color.

(f) The DC cables from the module array shall run through a UV-stabilized PVC conduit pipe of adequate diameter with a minimum wall thickness of 1.5mm.

(g) Cables and wires used for the interconnection of solar PV modules shall be provided

with solar PV connectors (MC4) and couplers

(h) All cables and conduit pipes shall be clamped to the rooftop, walls and ceilings with thermo-plastic clamps at intervals not exceeding 50 cm; the minimum DC cable size shall be 4.0 mm2 copper; the minimum AC cable Size shall be 4.0 mm2 copper.

(i) In three phase systems, the size of the neutral wire size shall be equal to the size of the phase wires.

(j) Cable Routing/ Marking: All cable/wires are to be routed in a GI cable tray and suitably tagged and marked with proper manner by good quality ferule or by other means so that the cable easily identified. In addition, cable drum no. / Batch no. to be embossed/ printed at every one meter.

(k) Cable Jacket should also be electron beam cross-linked XLPO, flame retardant, UV resistant and black in color.

(l) All cables and connectors for use for installation of solar field must be of solar grade which can withstand harsh environment conditions including High temperatures, UV radiation, rain, humidity, dirt, salt, burial and attack by moss and microbes for 25 years and voltages as per latest IEC standards. DC cables used from solar modules to array junction box shall be solar grade copper (Cu) with XLPO insulation and rated for 1.1kV as per relevant standards only.

(m) Bidder shall indicate size and length as per system design requirement. All the cables required for the plant shall be provided by the bidder. All cable schedules/ layout drawings shall be approved prior to installation.

(n) Multi Strand, Annealed high conductivity copper conductor PVC type ‘A’ pressure extruded insulation or XLPE insulation. Overall PVC/XLPE insulation for UV protection Armored cable for underground laying. All cable trays including covers to be provided. All cables conform to latest edition of IEC/ equivalent BIS Standards as specified below: BoS item / component Standard Description Standard Number Cables General Test and Measuring Methods, PVC/XLPE insulated cables for working Voltage up to and including 1100 V, UV resistant for outdoor installation IS /IEC 69947.

(o) The total voltage drop on the cable segments from the solar PV modules to the solar grid inverter shall not exceed 2.0%.

2.8.23 CONNECTIVITY

The PV system shall be connected to the Grid at 415V at the PURCHASER’s LT system at Main Distribution Board/ Power Control Centre (PCC)

2.8.24 TOOLS & TACKLES AND SPARES:

After completion of installation & commissioning of the power plant, necessary tools & tackles shall be maintained at the site by the Bidder for maintenance purpose.

A list of requisite spares in case of PCU/inverter comprising of a set of control logic cards, IGBT driver cards etc. Junction Boxes. Fuses, MOVs / arrestors, MCCBs etc along with spare set of PV modules be indicated, which shall be supplied along with the equipment. A minimum set of spares shall be maintained in the plant itself for the entire period of warranty and Operation & Maintenance which upon its use shall be replenished.

2.8.25 DRAWINGS & MANUALS:

(a) Two sets of Engineering, electrical drawings and Installation and O&M manuals are to

be supplied. Bidders shall provide complete technical data sheets for each equipment giving details of the specifications along with make/makes in their bid along with basic design of the power plant and power evacuation, synchronization along with protection equipment.

(b) Approved ISI and reputed makes for equipment offered/ to be used.

(c) For complete electro-mechanical works, bidders shall supply complete design, details and drawings for approval to PURCHASER before progressing with the installation work

2.8.26 PLANNING AND DESIGNING:

(a) The bidder should carry out Shadow Analysis at the site and accordingly design strings & arrays layout considering optimal usage of space, material and labour. The bidder should submit the array layout drawings along with Shadow Analysis Report to PURCHASER for approval.

(b) PURCHASER reserves the right to modify the landscaping design, Layout and specification of sub-systems and components at any stage as per local site conditions/requirements.

(c) The Bidder shall submit preliminary drawing for approval & based on any modification or recommendation, if any, shall submit three sets and soft copy in CD of final drawing for formal approval to proceed with construction work.

2.8.27 DRAWINGS TO BE FURNISHED BY BIDDER AFTER AWARD OF CONTRACT

The Bidder shall furnish the following drawings Award/Intent and obtain approval

(a) General arrangement of PV Panels and other equipment with dimensions and section layouts indicating all views for each location wherever Bidder's equipment shall be installed.

(b) Schematic drawing showing the requirement of SV panel, Power conditioning Unit(s)/ inverter, Junction Boxes, AC and DC Distribution Boards, meters etc.

(c) Detailed Single line Diagram (SLD) indicating the Rating of components including switchgear, bus-bar, CT, PT, cables etc.; Configuration of components; Protection details; interlocks; indications & annunciations provided; etc. for each system.

(d) Structural drawing along with foundation details for the structure.

(e) Itemized bill of material for complete SV plant covering all the components and associated accessories.

(f) Layouts of solar Power Array, cable tray routing, earthing including downcomers, lightning arrestors and earth pits with dimensions, inverters, lighting, metering etc.

(g) Shadow analysis of the roof

2.8.28 SAFETY MEASURES:

(a) The bidder shall take entire responsibility for electrical safety of the installation(s) including connectivity with the grid and follow all the safety rules and regulations applicable as per Electricity Act, 2003 and CEA guidelines etc.

(b) A write up of the steps to be followed and equipment to be used for installation, testing, operation and maintenance shall be provided as a part of evaluation document.

2.9 TECHNICAL SPECIFICATIONS –SOLAR TREE

2.9.1 "Solar Trees" shall have multiple modules of PV panels mounted on a single "Stem" giving it an appearance of a tree.

2.9.2 The Solar Tree consumes 10 times lower space to generate the same power than its conventional roof or ground mounted array.

2.9.3 The Solar Trees shall also serves as an umbrella for sit out for 4-6 people with various facilities like LED Luminaries, Mobile and Laptop Charging point, mounted on the same.

2.9.4 A Grid Tied Solar Tree shall consist of solar PV array, Inverter consisting of Maximum Power Point Tracker (MPPT), and Controls & Protections, interconnect cables, Junction boxes and Solar Combiner Box.

2.9.5 Grid tied solar PV system shall be without battery

2.9.6 The solar tree shall have self-powered single-axis azimuth sum tracking mechanism

2.9.7 The solar tree structure shall be designed to withstand the wind speed of 200km/hr

2.9.8 Components and parts used in the solar tree should conform to the BIS or IEC or international or MNRE specifications.

2.9.9 The interconnection components of the solar tree and interconnection of solar tree as whole with grid shall be as per AERC regulation.

2.9.10 Solar Photovoltaic Modules

It shall be as per the specification of the solar PV module specified in the grid connected solar system.

2.9.11 Junction Box

Refer the specification of junction box specified in the grid connected solar system.

2.9.12 Inverter

It shall be as per the specification of the inverter specified in the grid connected solar system.

2.9.13 Solar Combiner Box

It shall be as per the specification of the outdoor feeder pillar specified in the LV switchgear section.

2.9.14 Civil Foundations For Solar Tree

(a) The concrete foundation must be designed by a qualified engineer with knowledge of the local soil conditions. but sizes and grade of steel shall be limited to following

(i) Founding depth of shall be 1200 mm minimum.

(ii) Founding level to be finished with PCC of 75mm thk. before placing the foundation reinforcement.

(iii) Plan dimensions of footing should be 900mm x 900mm having depth D=250 mm Minimum

(iv) Steel in foundation base in both directions shall not be less than

(v) T10@150 mm c/c.

(vi) Size of base plate shall be 350mm x 350mm x 10mm thk. minimum

(vii) Anchor bolt diameter and length are specifically selected to withstand load

limitations listed in the solar tree catalogue but no any case it shall be less than four anchor bolts of minimum 20mm dia with 750 mm length to be used.

(viii) Minimum Grade of concrete to be used shall be M20 (1:1.5:3) and grade of reinforcement steel shall be Fe 500 or Fe415.

(ix) Main vertical reinforcement in 400 mm x 400 mm size pedestal shall be 4 nos. bars of 12mm dia and shear reinforcement (stirrups) shall be 6 mm dia bars at 150 mm c/c.

(b) The bolt circle template provided conforms to the bolt circle of the Tree base.

(c) When levelling nuts are used, the bottom of the lowest levelling nut should not be more than 25mm from the concrete surface.

(d) Pedestal top to be clean and free from any loose material before placing the grout. Rich mortar to be used for grouting below base plate.

Table 18: Solar Tree System

Sr. No.	DESCRIPTION	DETAILS
1	System Type	Grid Connected Without Backup
2	Illumination Below Solar Tree	Required(LED)
3	Mobile Charging Point	Required
4	WiFi	Not Required
5	Advertisement	Required
6	CCTV Monitoring	Not Required

Table 19: Solar Tree

Sr. No.	DESCRIPTION	DETAILS
1	Power Rating	5kWp
2	Inverter	Inbuilt
3	Battery	NA
4	Sun Tracking	Single Axis
5	Arrangement of solar Panel	NA

6	Tracking Mechanism	Fully automated Rack and Pinion with help of linear actuator
6	Tracking Response time	30min
7	Power Supply	
	Inbuilt LED Fixture	230V AC
	Inbuilt Mobile Charger	230V AC
	Sun Tracking Mechanism	230V AC
	Integration with Grid	415V AC
4	No. of Solar Panel	To be provided by Vendor
5	Power Rating of one Solar Panel	To be provided by Vendor
6	Array Junction Box	Required
7	Configuration of Array Junction Box	To be provided by Vendor
8	Type of Protection Provided by Array Junction Box	To be provided by Vendor
9	Remote Monitoring	Yes
10	Structure Material	Hot Dip Galvanized Steel
	Tree Stem Outer Diameter and Thickness	To be provided by Vendor
	Tree Branch Outer Diameter and Thickness	To be provided by Vendor
11	Maximum wind Bearing Capacity	200km/hr
12	Ground Footprint(L X W)	Maximum 0.5m X0.5m
13	Weight of solar Tree	To be provided by Vendor
14	Foundation Details for the Solar Tree	To be provided by Vendor
15	PV Panel Clearances (at Top)(L xW)	Maximum 9.5m x 8m
15	Height of Panels from ground	Minimum 2.2m

2.10 LIGHTING AND RECEPTACLE SYSTEM

2.10.1 The Lighting & Receptacle system includes luminaires & lamps, lighting and Raw power

distribution boards, modular switchboards, non-metallic industrial receptacles, JBs, PVC insulated FRLS copper cables/wires for lighting/receptacles, concealed conduits, support accessories etc.

2.10.2 It shall be the responsibility of the Contractor to work out complete detailed requirement of lighting and receptacle system for the entire BorsolaBeel as per specification and accordingly procure and install them.

2.10.3 Lighting design shall be performed using latest version of DiaLux Software (Version 12)/ Original Equipment Manufacturer (OEM) validated software. The Validation Report along with software and data files shall be acceptable to PURCHASER/ PURCHASER's representative.

2.10.4 The BIDDER shall carry out Lux Level test in each area and submit a report for the same to the PURCHASER as part of the performance demonstration. The same shall be compared with the guaranteed performance parameters for any deviation and due rectifications. The test shall be carried out as specified in the BIS standards.

2.10.5 Bid quoted for installation of lighting fixtures shall include the mounting & supporting heavy duty GI pipe, down rod, supporting chain, SS hardware, clamps/ connectors & all other accessories required for proper fixing of the lighting luminaries.

2.10.6 Supply of flexible metal conduit from junction box to fixture control gear box & up to fixture is included in the scope.

2.10.7 All necessary 3Cx2.5 sq.mm PVC FRLS copper conductor flexible wire from junction box to up to fixture/receptacle, assembly of fixture/ receptacle & integral wiring of fixture/receptacle & terminations are included in the scope.

2.10.8 Bidder shall consider supply and installation of cabling / Wiring and associated accessories up to Junction Box on Point wiring basis and all wiring, clamping arrangement, support structure, earthing from junction Box to light fitting/receptacle is included in the scope.

2.10.9 Demonstration & Sample approval of the light fittings/receptacle as per approved list of makes shall be arranged by the bidder at Site or to PURCHASER/ ENGINEER for approval before procurement.

2.10.10 After completing the erection work, the BIDDER shall carry out various pre commissioning checks and commissioning tests on the distribution boards, light fittings, sockets and cables and all other items, to ensure that these are fit for energizing and operation on load.

2.10.11 The luminaries, receptacle and all other necessary accessories shall be more rigidly mounted to avoid transit damages/ displacement of accessories. If required, separate protection should be provided.

2.10.12 Luminaries and Lighting system:

(a) The luminaire shall have a warranty period of 2 years and additional years of AMC period as decided

(b) Luminaire housing shall be strong enough as not to buckle/ twist while handling (including holding at two ends).

(c) Luminaires shall be suitable for loop-in & loop-out with suitable terminals & twin cable entry size.

(d) During installation of Light fittings, co-ordination with other utility shall be ensured by installation contractor

2.10.13 List of Standard for LED Luminaries

Table 20: Standard for LED Luminaries

Sr.No.	Brief Title	IS/IEC Code
1.	Testing procedure of photometric testing for LED luminaires	LM 79
2.	Testing procedure on the lifespan of LEDs	LM 80
3.	National Lighting Code	SP72
4.	Method of Measurement of Lumen Maintenance of Solid State Light (LED) Sources	IS:16105
5.	Method of Electrical and Photometric Measurements of Solid-State Lighting (LED) Products	IS:16106
6.	Limits of Harmonic Current Emissions	IS 14700-3-2
7.	DC or AC supplied electronic control gear for LED modules performance requirements	IEC 62384
8.	Lamp control gear: particular requirements for DC or AC supplied electronic control gear for LED modules	IEC 61347-2-13
9.	Environmental Testing: Test Z- AD: composite temperature/ humidity cyclic test	IEC 60068-2-38
10.	Electro Magnetic compatibility (EMC)- Limits for Harmonic current emission-– (equipment input current ≤ 16 A per phase)	IEC 61000-3-2
11.	EMC Immunity requirement	IEC 61547
12.	LED modules for general Lighting-Safety requirements	IEC 62031
13.	Classification of degree of protections provided by enclosures (IP Codes)	IEC 60529
14.	Fixed general purpose luminaries	IEC 60598-2-1
15.	General Lighting - LEDs and LED modules – Terms and Definitions	IS:16101 / IEC TS 62504
16.	LED Modules for General Lighting Part 1 Safety Requirements	IS:16103(Part1)
17.	LED Modules for General Lighting Part 2 Performance Requirements	IS:16103(Part2)
18.	Safety of Lamp Control Gear, Part 2 Particular Requirements Section 13 D.C. or A.C. Supplied Electronic Control gear for Led Modules	IS:15885(Part2/Sec13)

(a) Data Sheet for Indoor Luminaries

Table 21: Indoor LED Luminaries

Parameters	Requirements / Value
Type	LED Luminaries complete with all accessories for recess mounting
Rated Voltage	240V
Operating Voltage Range	220-240 volt AC.
Frequency	50±3 Hz
Driver Type	Constant Current based Electronic Driver
Housing Material	Metallic CRCA Powder Coated Body/Extruded aluminum frame
Diffuser	PC Glossy/Opal PMMA
Mounting	Recess/Surface Mounted
Compatibility for Dimming	Yes
Optics	Symmetric
System Power Efficiency	≥ 85%
Operating Temperature Range	-20 C to + 50 C
Operating Humidity	10% to 90% RH
System efficacy	≥90 Lm/Watt;(≥65 Lm/Watt for flame proof fixture)
Colour Temperature	≥5500K.
LED Drive Current	>350 – <750 mA
Leakage Current	As per IEC 60598
LED Wattage	1-3 W
Power Factor	≥0.90
Colour Rendering Index	≥70
Rated Minimum LED Life	50,000 Burning Hours (With only 30% Lumen Degradation) ;(>40,000 for flame proof fixture)

Driver Life	>20000 Burning Hours
Maximum temperature rise for the Driver	≤ 30 Deg C from ambient
Heat Sink Temperature	≤ 15 Deg C from ambient
Total Harmonics Distortion (THD)	<10%; (<15% for flame proof fixture)
IP Protection	IP 20
IK protection for Optic Cover	>IK05
Photometric measurements	LM-79/IS16105.
Minimum Surge Protection	>3kV
Protection Required in Driver Module	
Short Circuit	Yes; Constant current limit mode.
Over Voltage	Yes;
Over Temperature	Yes; Auto Shut Off.
Under Voltage	Yes;
String Open Protection	Yes;

(b) Specification for outdoor Luminaries

Table 22: Outdoor LED Fixture

Parameters	Requirements / Value
Type	LED Luminaries complete with all accessories for Street Lighting
Rated Voltage	230V
Operating Voltage Range	140-280 volt AC.
Frequency	50±3 Hz

Driver Type	Constant Current based Electronic Driver
Material	Die cast aluminium/ extruded Aluminium body with powder coated finish
System Power Efficiency	≥ 85%
Operating Temperature Range	-20 C to + 50 C
Operating Humidity	10% to 90% RH
LED Efficacy	≥130 Lm/Watt
System efficacy	≥100 Lm/Watt
Colour Temperature	≥5500K.
LED Drive Current	>350 –< 750 mA
Operating Hours	Dusk to Dawn (max 12 Hrs.)
Power Factor	≥0.90
Colour Rendering Index	≥70
Rated Minimum LED Life	50,000 Burning Hours (With only 30% Lumen Degradation)
Driver Life	>20000 Burning Hours
Luminaries body temperature after 12 hours of continuous operation	≤ 30 Deg C from ambient
Heat Sink Temperature	≤ 15 Deg C from ambient
Total Harmonics Distortion (THD)	<15%
IP Protection	IP 66
IK protection for Optic Cover	≥IK07
Photometric measurements	LM-79/IS16105.
Minimum Surge Protection	>3kV
Protection Required in Driver Module	

Short Circuit	Yes; Constant current limit mode.
Over Voltage	Yes;
Over Temperature	Yes; Auto Shut Off.
Under Voltage	Yes;
String Open Protection	Yes;

2.10.14 NORMAL AC LIGHTING - Normal lighting in all indoor areas shall be operated on normal 230V, 1Phase, 50 HZ A.C supply. The Luminaires shall work on single phase three wire system (phase, neutral & earth).

2.10.15 CriticalAC LIGHTING –

Critical Lighting shall be provided at all junctions, exit passages and near critical Work Places in each of the building. Critical Lighting shall be designed for around 10 Lux.

Non-maintained, 3 hrs backup suitable for 10W LED with decorative type mounting arrangement including connection from socket to fixture shall be provided.

2.10.16 OUTDOOR LIGHTING

The Lighting of the outdoor areas like landscape area,Parking area, approach roads, walkways/ jogging track, bridges, deckarea shall be operated with a time switch guided contactor.

(a) Street Light

It shall be used for the illumination of roads. This street light shall be mounted on minimum 4m and maximum 6m pole and shall be placed at minimum 20m apart. The cabling to the fixture from the junction box shall be done with 3C x 2.5Sqmm flexible cu cable. The looping of the cable from junction box to junction box shall be done with minimum 4C x 10 sq. mm. armoured Al cable laid in the 50mm Dia DWC pipe buried underground. The junction box shall be inbuilt in the street light pole.

(b) Post Top Light

It shall be used for the illumination of internal roads and pathway along the lake. This light shall be mounted on minimum 4m and maximum 5m pole and shall be places at minimum 10m apart. The cabling to the fixture from the junction box shall be done with 3C x 2.5Sqmm flexible cu cable. The looping of the cable from junction box to junction box shall be done with minimum 4C x 10 sq. mm. armoured Al cable laid in the 50mm Dia DWC pipe buried underground. The junction box shall be inbuilt in the light pole

(c) Bollards

It shall be used for illumination of Lawns, garden, walkway and parking. The bollard shall be minimum 800mm in height. The cabling to the fixture from the junction box shall be done with 3C x 2.5Sqmm flexible cu cable laid in Flexible conduit. The looping of the cable from junction box to junction box shall be done with 4C x 4Sqmm armoured Cu cable laid in 50NB DWC pipe buried underground. The junction box shall be buried

underground below or just near the fixture.

(d) Uplighter

It shall be used for illumination of Lawns, garden, walkway. The cabling to the fixture from the junction box shall be done with 3C x 2.5Sqmm flexible cu cable laid in Flexible conduit. The looping of the cable from junction box to junction box shall be done with 4C x 4Sqmm armoured Cu cable laid in 50NB DWC pipe buried underground.The junction box shall be buried underground below or just near the fixture.

(e) Spot Light

It shall be used for illumination of Gates. The cabling to the fixture from the junction box shall be done with 3C x 2.5Sqmm flexible cu cable laid in Flexible conduit. The looping of the cable from junction box to junction box shall be done with 4C x 4Sqmm armoured Cu cable laid in 25mm MS conduit concealed in the wall.The junction box shall also be concealed in the wall.

(f) Step Light

It shall be used for illumination of Fragrance, touch herbal garden. The cabling to the fixture from the junction box shall be done with 3C x 2.5Sqmm flexible cu cable laid in Flexible conduit. The looping of the cable from junction box to junction box shall be done with 4C x 4Sqmm armoured Cu cable laid in 25mmMS conduit concealed in the wall.The junction box shall also be concealed in the wall.

(g) Under water Light

It shall be provided for the viewing deck and the fountain.The cabling to the fixture from the junction box shall be done with 3C x 2.5Sqmm flexible cu cable laid in Flexible conduit. The looping of the cable from junction box to junction box shall be done with 4C x 4Sqmm armoured Cu cable laid in 25mm MS conduit concealed in the floor.The junction box shall also be concealed in the floor.

(h) Flood Light

It shall be provided for the children park.This flood light shall be mounted on minimum 8m and maximum 12m pole and shall be places at centre of park. The cabling to the fixture from the junction box shall be done with 3C x 2.5Sqmm flexible cu cable. The cable from feeder pillar to junction box shall be done with minimum 4C x 10 sq. mm. armoured Al cable laid in the 50mm Dia DWC pipe. The junction box shall be inbuilt in the light pole.

(i) Decorative Street Light

It shall be used for the illumination of Bridge. This street light shall be mounted on minimum 4m and maximum 6m pole and shall be places at minimum 15m apart. The cabling to the fixture from the junction box shall be done with 3C x 2.5Sqmm flexible cu cable. The looping of the cable from junction box to junction box shall be done with minimum 4C x 10 sq. mm. armoured Al cable laid in the 50mm Dia DWC pipe mounted outside the railing of bridge with clip and clamps. The junction box shall be inbuilt in the

street light pole.

2.10.17 Junction Boxes

(a) Junction boxes with terminals shall be supplied for branching and terminating lighting cables when required for outdoor areas etc.

(b) The junction boxes shall be dust and vermin proof and shall be fabricated from 14 SWG sheet steel and shall be complete with removable cover plate with gaskets, two earthing terminals each with nut, bolt and washer. Boxes shall be additionally weather proof. The Junction Box shall have ingress protection of IP66.

(c) The boxes shall have provision for wall, column, pole or structure mounting or buried underground and shall be provided with cable/conduit entry knock outs, terminal blocks, as required.

(d) The terminal blocks, with specified number of terminals, shall be mounted securely on brackets welded to the back sheet of the box. The terminals shall be 600 V, grade, one piece construction complete with terminals, insulation barriers, galvanised nuts, bolts and washers and provided with identification strips of PVC. The terminals shall be made of Copper alloy and shall be of box clamp type.

(e) The boxes shall be painted with one shop coat of red oxide zinc chromate primer followed by a finishing coat of paint.

2.10.18 Performance Requirements Of Luminaires:

(j) All Luminaires shall be Suitable to operate at 230V AC, 50 Hz power supply with the tolerances as mentioned in the data sheet.

(k) The LED luminaries shall be single, self-contained device with integral electronic control gear, without requiring on-site assembly for installation.

(l) All the Luminaire shall be complete with necessary accessories & mounting arrangements.

(m) Special measures for ease of maintenance of fittings/ control gear shall be ensured by the bidder.

(n) Year of Manufacture, Batch No., Serial Number or Identification No. Luminaire Manufactrer's Name / Logo, Wattage and Frequency should be embossed on the housing.

(o) Luminaires should conform to the IS standards for Safety & Performance and test certificates as per IS 16107 should be provided by the manufacturer. In case of luminaires are imported, the BIDDER shall conform to test parameters as per UL or equivalent standards.

(p) The electrical component of the LED and LED driver must be suitably enclosed in sealed unit to function in environment conditions mentioned earlier.

(q) All the connecting wires inside the Luminaire shall be low smoke halogen free, fire

retardant cable.

(r) Adequate protection against Overloading, Short Circuit, Over Voltage, Over temperature, Under Voltage, String Open shall be provided within the Luminiare.

(s) Design of the thermal management shall be done in such a way that it shall not affect the properties of the diffuser.

(t) The equipment should be compliant to IEC 60598-1, IEC 62031 and IEC/ PAS 62612 depending on the type of luminary.

(u) All the material used in the luminaries shall not contain any toxic material/ metal like mercury; shall be halogen free and fire retardant confirming to relevant standards.

(v) The Manufacturer shall have all the relevant testing facilities certified by an accredited laboratory and shall be offered for inspection to the PURCHASER for verification of the required parameters and tests. BIDDER shall confirm the same in the BID offer.

(w) The control gear shall comply to the provisions of IEC 61347-2-13, IEC 62031 and IEC 62384 as appropriate.

(x) Luminaries (including lamps, reflectors, control gear, etc) shall comply with RoHS, LM70, minimum Energy 5 star requirements. Additionally, lamps shall comply with US EPA guidelines and meet all TCLP – compliance regulations.

(y) During first year of regular operation, all failed lamps shall be replaced in case of failure of more than 2% lamps, of any type installed.

(z) All Luminaries under installation contractor's supply scope shall be guaranteed against quality (including any component failure and deterioration/appearance of corrosion symptoms. This shall also cover any fading (reduction)/ deterioration of reflector coating). In such case the defective luminaire shall be replaced without any cost. In case identical defects are observed on more than 5% of particular type of luminaire (installed quantity), then the complete lot of supplied/ installed luminaires of similar type shall be replaced free of charge).

(aa) Offers shall include comprehensive technical details of the luminaires being offered. The details must be sufficient to take in to consideration maximizing of energy efficiency and minimizing overall power consumption.

(bb) Where ever LED lamps are to be supplied they shall be TOP (temperature optimized) lamps, so that lumen output change due to change in ambient temperature shall not be affected.

(cc) Lumen output of the fixtures shall be specified for particular colour temperatures & after 100 burning hours (BH) & any deviation shall be brought to purchaser's notice.

(dd) Bidder to specify Light Output Ratio (LOR) & curves for –

Life expectancy with a 3 hr. switching cycle

Lumen maintenance curves - for all the luminaires.

2.10.19 Street Lighting Pole

Hot Dip Galvanised Octagonal Poles shall be used for outdoor lighting along all the roads. Poles shall be installed at the outer edge of the footpath, wherever footpath is aligned adjacent to the roads. The scope shall be inclusive of civil works such as making pit, foundation, concrete supply, supply & fixing, foundation bolts, base plate, welding, painting of base portion, supply and fixing of 2 nos. 50mm dia flexible DWC pipes for cable entry, integral type junction box with necessary MCB (Schneider / Legrand make MCB C-Curve type) protection, and terminal blocks shall be included. Terminal block (TB) shall be suitable for loop in loop out of the 4CX10/16/25 sq. mm Cu conductor, XLPE insulated, GI armoured cables as well as PVC FRLS wiring from the TB upto the street light luminaire. Each pole & integral JB shall have suitable studs for connection of earthing strip of 25 mm x 6 mm size. Similarly earthing shall be continued till the luminaire by using PVC FRLS wires.

The pole shaft shall be made of single piece MS structure continuously tapered having polygonal (8 sides) cross section and a single longitudinal welding. The welding shall be done as per IS 9595. No circumferential welding shall be allowed in the pole shaft. The MS shall conform to BSEN 10025. Min. sheet steel thickness shall be 3 mm. The structure shall be single section hot dip galvanized as per IS 2629. Internal & External surface of the poles shall be hot dip galvanized to Min. 80 micron DFT.

A suitably designed door shall be provided at 600mm height from the pole base. The door opening will be suitably reinforced for structural strength. The door shall be flushed with pole external surface and shall provide easy access for electrical connections at a maintainable height. Door shall have pad locking facility, which shall be operable using special key.

A Suitable base flange and a top flange shall be welded and suitable reinforcements shall be provided. Foundation accessories shall be as per IS 1367

Civil Works – All civil works shall be carried out in accordance with Civil Specifications

2.10.20 Receptacle

(a) The Contractor shall provide Switch socket of appropriate rating as per the requirement and application for entire STP and Landscape area.

Table 5: Minimum Requirement of General Receptacle

Sr. No.	Name of the Room/Building	Decorative 6A Raw Power	Decorative 16A Raw Power Point	Industrial 16A Raw Power Point	Industrial 32A 3 phase power point
1	Electrical/Switchgear Room	1 with each lighting switch board		1 per 25 Sq. mm area or 1 whichever is maximum	1 per 50 Sq. mm area or 1 whichever is maximum
2	Pump House	1 with each lighting switch board		1 per 30 Sq. mm area or 1 whichever is	1 per 50 Sq. mm area or 1 whichever is

				maximum	maximum
3	Maintenance Workshop	1 with each lighting switch board		1 per 25 Sq. mm area or 1 whichever is maximum	1 per 50 Sq. mm area or 1 whichever is maximum
4	Administrative building Offices	1 with each lighting switch board	1 per Plotter		
5	Administrative building Conference Room	1 with each lighting switch board	1 per conference room		
6	Administrative building Reception	1 with each lighting switch board			
7	Administrative building Pantry	1 with each lighting switch board	1 per 3 Sq. mm area		
8	Administrative building control room	1 with each lighting switch board			
5	Laboratory	1 with each lighting switch board	1 per 4 Sq. mm cable		1 per 25 Sq. mm area or 1 whichever is maximum
6	Process Air Blower Building	1 with each lighting switch board		1 per 30 Sq. mm area or 1 whichever is maximum	1 per 50 Sq. mm area or 1 whichever is maximum
7	Chlorination Cum Chlorine Tonner house	1 with each lighting switch board		1 per 25 Sq. mm area or 1 whichever is maximum	1 per 50 Sq. mm area or 1 whichever is maximum
8	Sludge dewatering Building(each floor)	1 with each lighting switch board		1 per 30 Sq. mm area or 1 whichever is maximum	1 per 50 Sq. mm area or 1 whichever is maximum
9	Guard Room	1 with each lighting switch board			

10	Toilet	1 with each lighting switch board			
11	Retail	1 with each lighting switch board	2		

(b) The requirements mentioned above in the table are excluding the receptacle required for dedicated usage like Critical Lighting, Air conditioning unit, workstation and Exhaust Fan.

(c) For Split Air conditioners minimum 32 A, 1 Ph decorative Switch Socket shall be provided per equipment.

(d) For Critical lighting, 6 A, 1 Ph decorative Socket shall be provided per equipment and shall be installed near the Critical light.

(e) For Exhaust fan,minimum 6 A, 1 Ph decorative switch Socket shall be provided per equipment and with socket installed near the exhaust fan. And switch installed in the switchboard.

(a) 32 A receptacle for the outdoor AC unit shall be 5 pin, 415V, 3- phase sheet steel enclosed metallic industrial type plug socket provided with neutral links, 20A FP MCB, 2 nosearthing terminals and provided with chain and cover including accessories for completion of receptacle box.

(b) Decorative type receptacle shall be 3 pin, 230V, 1-phase point consisting of piano switch with indicator and shuttered socket with suitable white coloured cover plate with frame, metal flush boxes & support plate with all accessories.

(c) Receptacle drawing for each building shall be submitted by the CONTRCTOR for the PURCHASER's approval.

(d) For Office & Reception workstation area –

(i) Three (3) Nos. points (3 nos. of 6 A Sockets with switches) shall be considered per workstation.

(ii) Two (2) nos. RJ-11Telephone outlets shall be provided from the proposed Krone Box per Workstation.

(iii) One (1) nos. RJ45 outlets for LAN connectivity shall be provided per Workstation connected by high speed Systimax Giga SPEED XL CAT-6 UTP cable or better option

(e) For Conference Work Station area –

(i) Three (3) Nos. points (3 nos. of 6 A Sockets with switchesshall be considered

(ii) Two (2) nos. RJ-11Telephone outlets shall be provided from the proposed Krone Box

(iii) One (1) nos. RJ45 outlets for LAN connectivity shall be provided per Workstation

connected by high speed Systimax Giga SPEED XL CAT-6 UTP cable or better option

(f) All receptacles and switches to be installed in offices and control rooms shall be flush mounted within the wall and those in other areas shall be surface mounted.

(g) All exposed metal parts of the plug, when the plug is in complete engagement with the socket outlet, shall be in effective electrical connection with the earthing pin.

2.10.21 Point Wiring

(a) Point wiring work shall include the, MS Black Enamelled conduit, joints, connectors, conduit accessories, FRLS PVC insulated stranded copper conductor wires and earthing wires, pull boxes, ceiling rose, clamps, cleats, hardware, accessories, anchor fasteners, modular switch boards with cover plates , switches, sockets, box, blank plates, receptacles and all other necessary accessories as per specifications etc.

(b) Wiring shall be done in wire colour codes. Colour code of wire for Phases, Neutral and Earth shall be separate. The necessary connector if found required for looping of wires from one switchboard to another switchboard shall be included in the scope.

(c) Different coloured switch plates shall be provided for lighting, raw power.

(d) Lighting fixtures, Exit light and toilet exhaust fans shall be grouped on the single circuit wherever required. However, separate circuits shall be used for receptacles wiring.

(e) Wires of the different phases shall not be laid in the same conduit.

(f) The switch boxes, receptacle boxes etc., shall be made up of 16 SWG sheet steel.

(g) The wire and cable indicated below for distribution of the power are the minimum requirement. The BIDDER shall arrive at the actual size based of the design criteria mentioned above

(h) Point wiring in the Administrative building, Laboratory and Retail area shall be done as per the following points

(i) Point Wiring for the luminaries from the DB to the switchboard and from the switchboard to the luminaries shall be done with 750V grade min 2.5 Sq.mm (2Nos.-Ph.+N) & 1.5 Sq.mm (for earthing of luminaire) PVC insulated, multistranded Cu conductor flexible wires running through 25mm inner dia.1.6mm thick, black stove enameled painted MS conduit running concealed/exposed in false ceiling and concealed on brick wall

(ii) Point Wiring for the 6A Raw power socket from the DB shall be done with 750V grade 2.5 Sq.mm (2Nos.-Ph.+N) & 1.5 Sq.mm (for earthing of luminaire) FRLS PVC insulated, multistranded Cu conductor flexible wires running through 25mm inner dia.1.6mm thick black stove enameled painted MS conduit running concealed/exposed in false ceiling and concealed on brick wall

(iii) Point Wiring for the 16A Raw power socket from the DB shall be done with 750V

grade 4 Sq.mm (2Nos.-Ph.+N) & 2.5 Sq.mm (for earthing of luminaire) PVC insulated, multistranded Cu conductor flexible wires running through 25mm inner dia.1.6mm thick black stove enameled painted MS conduit running concealed/exposed in false ceiling and concealed on brick wall

(iv) Cabling for the DB from the main panel shall be done with 1100V grade 4C x 4 Sq.mm PVC insulated, multistranded Cu conductor armoured cable running concealed/exposed in false ceiling and concealed on brick wall.

(v) Cabling for the 32A three phase industrial type receptacle from the DB shall be done with 1100V grade 4C x 4 Sq.mm PVC insulated, multistranded Cu conductor armoured cable running concealed/exposed in false ceiling and concealed on brick wall.

(i) Point wiring for the Electrical room, Pump House, maintenance workshop, Process Air Blower Building,Chlorination Cum Chlorine Tonner house,Sludge dewatering Building and Guard Room shall be as per the following points

(i) Point Wiring for the luminaries from the DB to the switchboard and from the switchboard to the luminaries shall be done with 750V grade min 2.5 Sq.mm (2Nos.-Ph.+N) & 1.5 Sq.mm (for earthing of luminaire) PVC insulated, multistranded Cu conductor flexible wires running through exposed 25mm inner dia.1.6mm thick, black stove enameled painted MS conduit

(ii) Point Wiring for the 6A Raw power socket from the DB shall be done with 750V grade 2.5 Sq.mm (2Nos.-Ph.+N) & 1.5 Sq.mm (for earthing of luminaire) PVC insulated, multistranded Cu conductor flexible wires running through exposed 25mm inner dia.1.6mm thick, black stove enameled painted MS conduit

(iii) Point Wiring for the 16A Raw power socket from the DB shall be done with 750V grade 4 Sq.mm (2Nos.-Ph.+N) & 2.5 Sq.mm (for earthing of luminaire) PVC insulated, multistranded Cu conductor flexible wires running through exposed 25mm inner dia.1.6mm thick, black stove enameled painted MS conduit

(iv) Cabling for the DB from the main panel shall be done with 1100V grade 4C x 4 Sq.mm PVC insulated, multistranded Cu conductor armoured cable cleated on the wall.

(v) Cabling for the 32A three phase industrial type receptacle from the DB shall be done with 1100V grade 4C x 4 Sq.mm PVC insulated, multistranded Cu conductor armoured cable cleated on the wall.

Table 5: Point wiring

Sr. No.	Name of the Room/Building	Point Wiring
1	Electrical/Switchgear Room	Cleated Multi-stranded, Cu armoured cables for three phase receptacle and for incomer to the distribution boards.

		Multi-stranded Cu conductor flexible wires laid in exposed conduit for light and single phase receptacle point
2	Pump House	Cleated Multi-stranded, Cu armoured cables for three phase receptacle and for incomer to the distribution boards. Multi-stranded Cu conductor flexible wires laid in exposed conduit for light and single phase receptacle point
3	Maintenance Workshop	Cleated Multi-stranded, Cu armoured cables for three phase receptacle and for incomer to the distribution boards. Multi-stranded Cu conductor flexible wires laid in exposed conduit for light and single phase receptacle point
4	Administrative Office	Concealed FRLS Multi-stranded, Cu armoured cables for three phase receptacle and for incomer to the distribution boards. FRLS Multi-stranded Cu conductor flexible wires laid in Concealed conduit for light and single phase receptacle point
5	Laboratory	Concealed FRLS Multi-stranded, Cu armoured cables for three phase receptacle and for incomer to the distribution boards. FRLS Multi-stranded Cu conductor flexible wires laid in Concealed conduit for light and single phase receptacle point
6	Process Air Blower Building	Cleated Multi-stranded, Cu armoured cables for three phase receptacle and for incomer to the distribution boards. Multi-stranded Cu conductor flexible wires laid in exposed conduit for light and single phase receptacle point

7	Chlorination Cum Chlorine Tonner house	Cleated FRLS Multi-stranded, Cu armoured cables for three phase receptacle and for incomer to the distribution boards. FRLS Multi-stranded Cu conductor flexible wires laid in exposed conduit for light and single phase receptacle point
8	Sludge dewatering Building(each floor)	Cleated Multi-stranded, Cu armoured cables for three phase receptacle and for incomer to the distribution boards. Multi-stranded Cu conductor flexible wires laid in exposed conduit for light and single phase receptacle point
9	Guard Room	Cleated Multi-stranded, Cu armoured cables for three phase receptacle and for incomer to the distribution boards. Multi-stranded Cu conductor flexible wires laid in exposed conduit for light and single phase receptacle point
10	Toilet	Cleated Multi-stranded, Cu armoured cables for three phase receptacle and for incomer to the distribution boards. Multi-stranded Cu conductor flexible wires laid in exposed conduit for light and single phase receptacle point
11	Retail	Cleated Multi-stranded, Cu armoured cables for three phase receptacle and for incomer to the distribution boards. Multi-stranded Cu conductor flexible wires laid in exposed conduit for light and single phase receptacle point

2.10.22 Maintenance Requirements:

(a) Bidder shall supply maintenance tools including special tools, if required, for attending to the equipment supplied at no extra cost. As far as practicable, the equipment and

accessories shall be so designed that no special tools are necessary for installation and maintenance of the equipment. However, if special tools are required, the Bidder shall include price of one complete set for each type of equipment

2.10.23 Storage At Site

(a) BIDDER shall indicate the specific requirements, if any for proper storage of the equipment supplied at site.

(b) In general, while shipping the equipment to site, Vendor shall ensure that each assembly or component shall be crated, boxed or otherwise suitably protected against damage or loss during shipment and to facilitate site storage. All openings shall be effectively sealed with temporary closures to prevent entry of dust, dirt, moisture and other foreign matter.

2.10.24 Documents to be submitted by BIDDER

(a) Contractor shall submit all following test reports for LED lighting fixtures before dispatching of material at site. All tests shall be carried as per IES/IEC/BIS approved methods defined in the respective standards (LM-82).

(i) LM-80 for measurement of lumen of LED source.

(ii) LM-79 for fixture-Electrical & Photometric measurement.

(iii) TM-21 test for LED life.

(iv) Thermal Characteristic- Test for Lumen output temperature dependency.

(v) Electrical Characteristic- Test for the calculation of efficacy.

(vi) Driver testing for Power factor, THD & Isolation.

(vii) IP Protection test against ingress of dust & solid objects for both indoor & outdoor LED fixtures.

(b) Data sheet of offered Luminaries along with GA dimensional drawings with all views of Luminary

(c) Operating/fixing manuals / technical leaflets giving all the details of Installation, operation and maintenance

2.11 EARTHING AND LIGHTNING PROTECTION SYSTEM

2.11.1 CODES AND STANDARDS:

The general design shall be on the basis of following codes and standards (their latest amendments) in line with design criteria & specification requirements.

(a) IS 3043-1987 – Re-affirmed in 2006: Code of practice for Safety Earthing

(b) IS / IEC 62305: Protection against lightning.

(c) IEEE 80 – 2000: IEEE Guide for Safety in Sub-station Earthing.

(d) Central Electricity Authority (CEA) Regulations – 2010

(e) IEEE 1100- Electronic earthing.

(f) National Building Code 2016

The maximum values of earth fault current for the design of the earthing system shall be calculated as per the design criteria.

2.11.2 The design basis for designing earthing conductor is indicated under design criteria for electrical system.

2.11.3 All materials and fittings used in the earthing installation shall conform to the relevant National and International Standards & shall be approved by the CEIG.

2.11.4 BIDDER has to carry out soil resistivity test at, at least 6locations in the site area, 75 m apart, for which locations shall be provided by PURCHASER.

2.11.5 Soil resistivity shall be carried out by Wenner four electrode method as described in IS 3043. BIDDER has to carry out the test in presence of PURCHASER's representative & test shall be carried out keeping electrode spacing as 1, 2, 4, 6, 8, 10, 15, 25 M (each, along all 8 directions) as per normal practice and report has to be submitted. Polar curves shall be used for measurement of mean soil resistivity, which shall be used in finding earthing resistance at a particular location. Mean soil resistivity values/ the results/ report shall be certified by Govt. Authorised Labs or agencies.

2.11.6 The BIDDER shall base his earthing calculations on actual measurement carried out as explained above.

2.11.7 Galvanized Iron flat / wire shall be used as earthing conductor. Copper flat / wire shall be used if specifically mentioned.

2.11.8 The underground joints in the system shall be properly welded or brazed and the bolted type connection shall be made with structures/ equipments. Welded and Bolted joints shall be covered with bituminous compound/ tapes as suitable. Welding shall be done as per IS 816.

2.11.9 Earthing conductor shall be protected against mechanical damages considering the installation conditions.

2.11.10 The earthing system shall comprise of earth electrodes, earthing grid or a combination of these in order to obtain the required earth electrode resistance of less than 1 Ohm.

2.11.11 For equipment earthing, two earthing leads will be used if rated voltage of the equipment is 250 Volts & above and one earthing lead will be provided for equipment rated below 250 Volts.

2.11.12 The earthing conductors in outdoor areas shall be installed at a minimum depth of 600 mm below FGL.

2.11.13 GI Pipe electrodes shall be provided for all the equipment and system earthingwhere as Copper plate earthing shall be provided for grounding the transformer Neutrals.

2.11.14 The earth plate shall be buried in specifically prepared earth pit 3 mtr. below ground with alternate layers of charcoal and salt, 40 NB GI pipe with funnel with a wire mesh for watering

and bricks masonry block CI Cover complete as per IS 3043 with necessary length of double Copper earth flat bolted with lug to the plate complete connected to the transformer neutral with end socket as per direction and duly tested by earth tester conforming to IS as per drawing and specifications complete with 600 x 600 x 3.15 mm Copper earth plate or as specified by CEIG.

2.11.15 Earth electrodes shall be of heavy duty galvanized mild steel pipe of not be less than 40 mm NB class B or as specified by CEIG. The earth electrode shall be complete with alternate layers of charcoal/ coke, salt and Black cotton soil; GI pipe with meshed funnel for watering; brick masonry block and CI Cover, with necessary test link conforming to IS 3043 or as specified by CEIG.

2.11.16 All electrodes shall be provided with a disconnecting link for isolating the electrode for resistance measurement.

2.11.17 Adequate number of earthing pits shall be provided in conjunction with earthing grid for the earthing system. The minimum spacing between two adjacent earthing pits shall not be less than 2000mm and shall be kept 1500 mm away from footings of the structure.

2.11.18 Earthing pits shall be located in ground, which has a reasonable chance of remaining moist. Watering arrangement comprising of 20 or 25mm GI pipe with valve tapings shall be made to facilitate pouring of water to keep earthing pit wet.

2.11.19 Earthing chamber shall be of RCC/ brick chamber of 600 mm x 600 mm, with Hinged cast Iron chequered cover plates. The covers shall have holes for handling. Earthing pits (chambers) shall be painted Green and the earth-pit number shall be marked on it.

2.11.20 All materials used for the earth electrode installation shall be purpose made for the application and site conditions and shall be approved by CEIG.

2.11.21 All civil works, such as excavation, boring, provision of charcoal & salt in adequate quantity, backfilling for the installation of the earth electrodes and the earth pit/ inspection pit shall be in the scope of BIDDER.

2.11.22 After the earth installation has been completed the BIDDER shall demonstrate to the PURCHASER/ PURCHASER's Representative that the resistance of the electrodes to earth and the continuity of the earth network are within the limits specified. Any additional earth electrodes and test instruments required for the tests shall be provided by the BIDDER.

2.11.23 Main equi-potential bonding conductors shall be provided to connect the earth electrode system to conductive parts forming the Works.

2.11.24 Instrumentation Earth:

(a) An instrumentation earth bus shall be provided in each control panel. This shall comprise a GI flat of cross section not less than 25 x 6 mm and length to suit the number of connections. It shall be mounted on at least two insulated supports and be provided with a single earth connection to the control panel electrical power earth.

(b) If due to the physical size of a control panel more than one instrument earth bar is required the additional bar shall be connected again with a single earth connection to the same point as before on the control panel electrical earth bar. In this fashion all instrument earths shall be connected radialy from the same earth point.

(c) All signal cable screens (analogue and digital) shall be terminated on to the instrument earth bar. Signal cable screens shall be earthed at the control panel end only. Screens at the field end shall be tied back and insulated.

(d) Surge Protector Devices (SPDs) associated with the control and instrumentation system shall be earthed to the instrument earth in accordance with the SPD manufacturer's recommendations.

2.11.25 Important Instructions for Earthing:

(a) Each pole of lightning arrestors shall be earthed with separate earth pit.

(b) All the earthing material with laying etc. shall be included in the scope.

(c) Earth grid shall be laid in trenches/ trays/ buried in the ground outside. The main earthing grid shall be embedded at a minimum depth of 600 mm below FGL which shall be connected to earth electrodes.

(d) All indoor earthing grids will be suitably interconnected to the external earthing grid.

(e) Each steel/ RCC column of the building will be interconnected to the floor-earthing grid. Steel columns, steel strips / conduits, cable trays etc. will not be used as earth continuity conductors.

(f) For CSS, Two pipe earth pit shall be provided for each LT and HT panel earthing. Two pipe earth pits shall be provided for the transformer body earthing and two plate earth pits shall be provided for the transformer neutral earthing.

(g) For DG,Two pipe earth pits shall be provided for the body earthing and two plate earth pits shall be provided for the neutral earthing.

(h) HT net meter shall be earth as per the APDCL specification.

(i) Minimum two earth pit shall be provided for the LT panel in the electrical and pump room.

(j) Each outdoor feeder pillar shall be provided with two pipe earth pits.

(k) Minimum 12 SWG GI wire shall be carried along with the cable in the DWC pipe laid for distributing power to the landscape area. Two pipe earth pits shall be provided at every 30m and this GI wire shall be connected to these earth pits.

(l) Minimum 8 SWG GI wire shall be carried along with the cable in the DWC pipe laid for distributing power to the decorative pole on bridge. For earthing of these decorative poles, two pipes earth pit shall be provided at both end of the bridge.

(m) Coil type earthing/ Rod earthing shall be provided for each street light pole.

(n) Disconnecting type facility shall be provided between Earthing grid & each earth electrode.

(o) All connection between the conductors shall be welded/ brazed type. Metallic pipe, conduit, structures shall be bonded to lightning protection conductors to prevent the side flashover. But no metallic pipe, conduit, structure shall be used as air termination conductor or down conductor.

(p) The down conductors shall be fixed with embedded brass posts (on concrete columns) with nuts & bolts used for fixing the saddle/ clamp (direct drilling of down comer and fixing with screw shall not be acceptable).

(q) Cleats for 'earthing and lightning protection systems' shall be of GI.

(r) The lightning protective conductor shall not be connected with the earthing above ground however both the systems shall be interconnected below ground.

(s) The earth pits may require boring & drilling in the soil & the same shall be considered in BIDDER's scope.

(t) Earth electrode with disconnecting facility shall be provided so that the resistance of the independent earth electrode may be measured.

(u) Internal earth Bus of each panel shall be connected to both ends to the earthing system by means of earthing conductor.

(v) Metallic frames of all current carrying equipment, structures supporting and adjacent to current carrying conductors, lightning protection system conductors, metallic structures, metallic stairs, hand rails, fences shall be connected to a single earthing system. Neutral points of various systems shall be connected to the dedicated treated earth pits and these earth pits shall be interconnected to each other below ground.

(w) All connections in the equipment earth conductors buried in ground (or otherwise) shall be cad welded/ brazed, whereas connection at equipment end shall be of bolted type. All connections shall be of low resistance. All bimetallic connection shall be treated with suitable compound to prevent moisture ingression. For Bimetallic bolted connection, bimetallic washers shall be used. All bolted joints shall have minimum two bolts to ensure proper surface contact. Termination of stranded conductors at earth inserts shall be with ring type/ lugs.

(x) Galvanized conductors shall be touched up with zinc-rich paint where holes are drilled at site for bolting to equipment/structure.

(y) Suitable earth risers approved by the Engineer shall be provided above finished floor/ ground level, if the equipment is not available at the time of laying of the main earth conductor. The minimum length of such risers inside the building shall be 200 mm and outdoor shall be 500 mm above ground level.

(z) Metallic conduits and pipes shall be connected to the earthing system unless specified otherwise.

(aa) All cable trays will be earthed at minimum two places by suitable sized GI flats to main earthing system earth conductor. The cable trays shall also be earthed at a regular interval of not more than 10 meters by the same size GI flat as run along the tray.

(bb) Wherever earthing conductor cross underground service ducts, pipes, trenches, tunnels, etc. or Road, it shall be laid in Hume pipes at minimum 600 mm below them. The earthing conductor shall be re-routed in case it fouls with equipment foundations.

(cc) Wherever earthing conductor passes through walls, floors, etc. galvanized conduit / HDPE pipe sleeves shall be provided for the passage of the conductor. Both ends of the sleeve shall be sealed to prevent the passage of water through the sleeves. The seals, in addition, shall be fire proof if required.

(dd) Water stops shall be provided wherever earthing conductor enters the building from outside, below grade level.

(ee) Earthing conductor around the building shall be buried in earth at a minimum distance of 1500mm from the outer boundary of the building. In case high temperature is encountered at some location, the earthing conductor shall be laid minimum 1500mm away from such location.

(ff) Earthing conductors embedded in the concrete floor of the building shall have at least 50mm concrete cover.

(gg) Earthing conductors along their run on columns, walls, etc. shall be fixed by suitable welding or cleating at intervals of 1000mm and 750mm respectively. Earthing cables crossing other metallic structures such as conduits pipelines etc shall be minimum 300 mm away from such structures. Earthing conductors shall be protected against mechanical damage. All earth lead connections shall be as short and direct as possible and shall be without kink.

(hh) The main earth loop in the plot area shall be generally routed along cables. When equipments are located away from main earth loops, suitable sub-loops shall be run up to them for deriving connections for individual equipment. The entire earthing system shall fully comply with the CEA guidelines and requirements.

(ii) The BIDDER shall have to carry out any changes as desired by the Electrical inspector or the Engineer in charge, in order to make installation conforming to the CEA guidelines 2010 and IS 3043.

2.11.26 Cable Earthing

Metallic sheaths, screens and armour of all multi-core power/control cables shall be earthed at both equipment and source/switchgear end. Sheath and armour of single core power cables shall be earthed at source/switchgear end only, unless other-wise stated elsewhere.

2.11.27 Lightning Protection:

(a) The lightning protection system need will be established by calculating the risk factor value of each building/structure, structure etc. as per procedure given in IS/IEC 62305-2010/ NBC 2016 and if found necessary, the same shall be provided by the BIDDER.

(b) For Lightning protection of Civil Structures including RCC Buildings/Structure, fixing of 25x6 mm GI earth strip to roof as per IS/ IEC std, saddle clamp, down comer connector etc. as required with all hardware shall be in BIDDER's scope

(c) Conductors of the lightning protection system shall not be connected with the conductors of the safety earthing system above ground level.

(d) Down conductors shall be cleated on outer side of the building wall/structure at 750 mm interval or welded to outside building columns/structure at 1000 mm interval.

(e) Connection between each down conductor and rod/pipe electrode shall be made via test link.

(f) Lightning conductors shall not pass through or run inside G.I. conduits.

(g) All metallic structures within a vicinity of 2000 mm in air shall be bonded to the conductors of lightning protection system.

2.11.28 Galvanizing:

(a) Wherever galvanizing has been specified, the hot dip process shall be used. The galvanized coating shall be of uniform thickness. Weight of Zinc coatings for various applications shall not be less than those indicated in the standard.

(b) Burrs shall be removed before galvanizing. Any site modification of galvanized parts should be covered well by zinc rich primer and aluminium paint.

(c) BIDDER shall ensure to use calibrated test equipment having valid calibration test certificates from standard laboratories traceable to National Standards.

2.11.29 Drawings/ Documents Required:

(a) The BIDDER shall submit the Earth resistivity measurement Report duly attested.

(b) Earthing calculations based on the above earth resistivity and the calculated or estimated fault level.

(c) The BIDDER should prepare Layout drawings, after award of contract and before commencement of work for PURCHASER's approval, showing the location of earthing grid, electrodes, interconnection grids and earthing leads to various equipment, down comers, isolating links etc. should be accompanied by design calculations.

2.12 MISCELLANEOUS

2.12.1 Below mentioned items shall also part of Supply & Installation scope of BIDDER

(a) 900 mm wide antiskid insulating mat as per IS 15652 and of reputed make to be spread in front of the 11 kV, 415V switch gear panels & power panels etc.

(b) First aid box with all the standard contents.

(c) Artificial Respirator

(d) First aid chart made of cloth for electrical shock treatment printed in English, Hindi and local language duly framed with front glasses.

(e) Charts / drawings duly framed with front glass.

(f) 11 kV and 415V Single line diagrams in adequate sizes.

(g) Routine maintenance schedule for High Voltage Switchgear, Distribution Transformers, Low voltage Switchgears, APFC panels, Fire Alarm System, UPS system, Battery, etc.

(h) Provision of portable type Class A, B, C, and D type fire extinguishers at various locations & as per elsewhere in the specification documents & in line with the statutory requirements.

(i) Emergency Exit signage of nonmaintained type with 3 hrs. Back up shall be provided at the Entry Exit routes on each floor.

2.12.2 All Junction boxes shall be made of powder coated 1.6mm thick Sheet steel with access on all four sides; mounting arrangement; terminals suitable for 4sqmm loop in- loop out facility.

2.12.3 Degree of Protection

The enclosures of the control cabinets, junction boxes and Marshalling boxes, panels other than mentioned above etc. to be installed shall provide degree of protection as detailed here under

(a) Installed outdoor – IP 65

(b) Installed indoor – IP 52

(c) The degree of protection shall be in accordance with IS 13947 (Part I)/ IEC 947 (Part I)/ IS 2063/ IEC 529

3.0 MAKE LIST

Table 23: Make List

Sr. No.	Material/ Equipment	Vendor
A	Compact Substation	Siemens, ABB, Schneider Electric, L&T
B	LT Panels(PCC/MCC/LDB/APFC/BUSDUCT)	Manufacturer with Type Tested Design at CPRI or equivalent labs for minimum Heat Run test, Shortcircuit test, and IP protection tests.
1	Switchgear	Siemens, ABB, Schneider Electric, L&T
2	Potential & control Transformer (PT)	Kappa, Pragati ,AE
3	Current Transformer (Cast Resin Epoxy Coated)	Kappa, Pragati ,AE
4	Load Manager	Schneider, Siemens, L&T, Secure
5	Electronic Digital Meter (A/V/PF/HZ/KWH) /MFM with LCD/LED Display.	Schneider, Siemens, L&T, Secure
6	Change over switch (automatic/ manual)	HPL, Hager, Socomec, GE
7	Indicating Lamps	Siemens, Schneider ,ABB ,L&T BCH, Tecknic
8	Selector Switches	Kaycee, ABB, Siemens, Salzer
9	Alarm Annunciators (solid state type with LED illumination) / Facia Annunciator	Minilec ,Yashmun

10	Push Buttons	ABB, L&T, Schneider ,Siemens, BCH, Tecknic
11	Capacitor (APP) / Series reactors / APFC relay	Schneider, EPCOS, ABB ,L & T
12	Space heater	Girishorequivalent
13	Soft Starter	APDCL Approved
14	Star delta starter	APDCL Approved
C	Distribution Boards	Legrand, Schneider ,Siemens ,ABB
D	DG	Cummins, Kirloskar Oil Engines, Caterpillar, Mitsubishi
E	Sealed Maintenance Free Batteries	Amar Raja, Exide, Hitachi, HBL
F	Lighting system	
1	LED Fixture	Wipro, Philips,Crompton Greaves, Bajaj ,Havel
2	LED	Cree, Nichia, Philips, Osram
3	Exit lights	Prolite, Legrand , Philips, Zumtobel
4	External & Street Lighting	Schreder, Wipro, BAJAJ, Philips
5	Landscape Lighting	BAJAJ ,Philips, Wipro
6	MS Tubular / Octagonal Poles	Bajaj, Philips,Schreder, Valmount
7	Astronomical Timer	ABB, Siemens, GIC

8	Timers	Schneider,Siemens ,L&T,Legrand
9	Terminal Blocks /connectors	Jainson ,Elmex, Connect well Wago
10	MS Black Stove Enameled ERW Conduits/GI pipes(ISI Approved) & accessories	AKG , Zenith , SAIL , TATA Steel
11	UPVC Conduit/JB/flexible conduit / tees/ Bevels, elbow & accessories	Precision ,Polycab
12	Copper Conductor PVC Insulated Wires/ Stranded Flexible Wires (FRLS) (including panel wiring)	Finolex, RR Kabel, KEI, Havel
G	Receptacle system	
1	Modular Switches, Socket Outlets And Wiring Accessories With Moulded Cover Plate.	Legrand , Crabtree , Clipsal , Anchor, MK
2	Metal Clad Plug & Socket (Industrial)	Legrand, Menekkes , Schneider , BCH
H	Cables	
1	HT Armoured Cable	CCI, Finolex, Universal, RPG, Sterlite
2	LT armoured Cable	Finolex, RPG ,Polycab,CCI, Universal
3	LT Flexible Cable	Finolex, RPG, Polycab, Universal
4	Cable Gland	Comet,Dowells, Braco
5	Cable Lugs	Comet, Braco, Dowells

6	Cable termination Kit	Raychem, 3M
7	Cable Jointing Kit	Raychem, 3M
I	Cable tray and its Supports	Shruti, Indiana, Profab, Sadhana, Sterlite
J	Raceways	Legrand , MK
K	Earthing Strip, and accessories	Shruti,Profab,Sadhana, Sterlite
L	Solar System Component	MNRE Approved
M	Misc.	
1	Fire Sealant & Fire Retardant Paint	3 M India Ltd., HILTI, Promat, OBO
2	Water barriers/sealing system	Roxtec, Rayflate
3	Insulating mat	Electromat / National or equivalent with Type test certificates

Note:-

(i) Only one of the above makes of the materials will be acceptable. The BIDDER has to comply with the approved makes given in the tender document.

(ii) The Bidder shall offer the equipment of makes mentioned above. Other makes are subjected to Client approval before procurement.

(iii) If any specific item is not mentioned in the make list. BIDDERshall submit the list of make to the CUNSULTANT/PURCHASER for the approval.

(iv) The items manufactured in India shall be permitted only if the items are ISI marked (any other definition of compliance to BIS shall not be acceptable).

(v) Samples from all the approved makes shall be offered for selection.

(vi) For standardization, inventory, electrical system coordination, the Employer/ Employer's Representative can insist on any one make from the makes indicated above.

(vii) The items shall meet specifications. Mere mention of a make as approved make in the above list does not qualify for acceptance of an item.

4.0 LIST OF DRAWING AND DOCUMENTS

4.1 Equipment Sizing calculations with assumptions made; General Arrangement; Equipment Data sheet indicating compliance to all the requirement as asked for in the specifications; Type test certificates as required for the key tests like SC test, Temperature rise tests, IP Protections tests; Foundation Drawings with calculations; Cable Schedules; Interconnection Schedule; and other construction drawings shall be provided.

4.2 The Following minimum Drawings shall be submitted by the BIDDER to CONSULTANT for the approval

4.3 Single Line Diagram for Power Distribution of the STP and Landscape area

4.4 Calculations

(a) Electrical Load List and demand Calculations

(b) Transformer Sizing calculations

(c) DG Sizing Calculations

(d) UPS Sizing Calculations

(e) Earthing Calculations for Electrical System & Instrumentation and Server System

(f) Lightning Protection Calculations

(g) Cable schedule with Sizing Calculations

(h) Lighting Calculations for each Area (Dilux Files shall be provided along with PDF)

(i) Capacitor Bank Sizing

4.5 Incoming power scheme (Incase Carried out by BIDDER)

(a) All drawings related to Capacity augmentation at the source substations

(b) Data sheet of major Equipments

(c) Cable or OH line routing

(d) Typical OH Pole or cable laying drawings

(e) Two pole or Four Pole structure

(i) GA Drawing of the structure with sections and dimensions
(ii) GA Drawings of the equipments GOD, DO, LA, Insulator
(iii) Data sheet of major Equipments
(iv) Type test certificates of the above equipments
(v) Earthing layout of the structure
(vi) Lighting layout
(vii) Civil Drawings of the Structure including Foundation, Chain link Fence, Gate etc.

4.6 CSS

(a) Overall GA
(b) Data sheet of major Equipments
(c) Single Line Diagram
(d) Type test Certificates
  (i) IP Protection
  (ii) Impact Withstand capacity
  (iii) Heat Run test
(e) Mounting Arrangement
(f) Foundation Detailswith calculations – GA; Civil Construction drawings
(g) Trench Details
(h) Earthing Layout
(i) Fence details if provided
(j) Bill of Materials
(k) Makes of Components offered
(l) RMU
  (i) GA drawings of the unit along with sectional view and foundation plan duly completed with dimensions.
  (ii) Type test certificates as specified above including but not limited to the following;
    1. Short circuit withstand test for the required rating of each component of the RMU unit.
    2. Internal Arc test for the required rating for the RMU unit
    3. Temperature rise test for the switchboard inside outdoor enclosure
    4. Enclosure protection class test
    5. SF6 tank pressure and vacuum test
  (iii) List of makes as will be offered
  (iv) Relay details
  (v) Auxiliary Power source details

(vi) Single line diagram

(vii) Adequacy calculations for Bus bars, CT, PT and control transformers.
(viii) Bill of material
(ix) Control schematic diagrams
(x) Instruction manuals
(xi) Interconnection diagrams
(xii) FRTU Data Sheets and catalogues

(m) Transformer
(i) General arrangement of Transformer and enclosure.
(ii) Rating & diagram plate
(iii) General arrangement of HV cable box.
(iv) General arrangement of LV termination box for bus duct arrangement.
(v) General arrangement of marshalling box & wiring diagram.
(vi) Core Coil Assembly Drawing

(n) LV Panels
(i) GA Drawing
(ii) Wiring Diagram
(iii) Type test Certificate for Short Circuit withstand capacity
(iv) Type test certificate for IP protection

4.7 DG

(a) Overall GA
(b) Single Line Diagram
(c) Data sheet of major Equipments
(d) Type test Certificates
(i) IP Protection
(ii) Impact Withstand capacity
(iii) Heat Run test
(e) Mounting Arrangement
(f) Foundation Details with calculations – GA; Civil Construction drawings
(g) Trench Details
(h) Piping layout – Diesel, Exhaust
(i) Chimney Structural Drawings with Foundation and Calculations
(j) Earthing Layout
(k) Fence details if provided

(l) Bill of Materials

(m) Makes of Components offered

(n) Engine Drawings and Test Certificates

(o) Alternator Drawings and Test Certificates

(p) AMF Panel

(i) GA Drawing

(ii) Wiring Diagram

(iii) Type test Certificate for Short Circuit withstand capacity

(iv) Type test certificate for IP protection

4.8 LV Panels – Floor Mounted and Wall Mounted

(i) GA Drawing

(ii) Door open view of Wall mounted Distribution boards

(iii) Data sheet of major Equipments

(iv) Data sheet of motor starter

(v) Wiring Diagram

(vi) Type test Certificate for Short Circuit withstand capacity

(vii) Type test certificate for IP protection

(viii) Bill of Quantities

(ix) Makes Of Components offered

(x) Bus bar sizing calculations

(xi) Foundation drawings

4.9 Construction Drawings of the following

(a) General arrangement of equipment Layout of the Electrical rooms/ Ducts/ UPS Rooms

(b) Lighting Layout

(c) Receptacle Layout

(d) Switch Board Schedule

(e) Point Wiring Drawing for Lighting and power

(f) Cable tray Layout

(g) Cable Trench Layout

4.10 UPS

(a) GA Drawing

(b) Single line diagram

(c) Wiring Diagram

(d) Data Sheet

(e) Battery Details – GA, Rack GA, Connection details

(f) Type Test Certificates – Heat run test, IP protection

4.11 Solar tree

(a) GA Drawing

(b) Single line diagram

(c) Wiring Diagram

(d) Data Sheet

(e) Inverter Details – GA, Connection details

(f) Type Test Certificates -Inverter

4.12 The BIDDER shall depute competent engineers to PURCHASER's / CONSULTANT's office for discussions and finalization of any outstanding issues when called upon by PURCHASER/CONSULTANT

4.13 Both hard and soft copies of all BIDDER drawings shall be furnished right from approval stage.

4.14 The BIDDER shall plan his manufacturing schedule so as to allow at least two weeks time for approval of the drawings after their receipt by the PURCHASER.

4.15 Upon completion of the installation, the BIDDER shall furnish the following;

(a) Three (3) Complete set of construction As Built drawings

(b) Soft copies of the construction As Built drawings in CDs.

(c) Four (4) Sets of All Instruction and Operation & Maintenance Manuals for each equipment

(d) Two (2) Sets of Test Certificates of equipments provided by the BIDDER along with that of the respective Components outsourced.

4.16 The PURCHASER shall reserve the right to comment on drawings and documents under information category and inform the BIDDER to treat these drawings and documents as approval category.

5.0 PRE COMMISSONING TESTS ON ELECTRICAL SYSTEM EQUIPMENT TO BE CARRIED OUT AFTER INSTALLATION:

5.1 PRE-COMMISSION TESTS: Pre-commissioning tests in addition to mentioned in the specification requirements for various equipments but not limited to following shall be carried out by Contractor in presence of Purchaser/ Purchaser's representative. Commissioning shall be carried out only after obtaining satisfactory results, acceptable to Purchaser/ Purchaser's representative.

5.2 11 KV Equipment (Lightning Arrestors, AB Switch/ Isolators & Insulators etc)

(a) Visual checks for cracks in insulators.

(b) Earth secured continuity check

(c) IR Test with 5KV Megger

5.3 Power / Distribution Transformer

(a) Insulation resistance test HV side, LV side and HV - LV.

(b) Magnetizing current test.

(c) Winding resistance test.

(d) Voltage Ratio & Tap continuity test at all tap.

(e) Vector group test.

(f) Magnetic Balance Test.

(g) Buchholz Relay Test (if any)

(h) Neutral CT Test (if any)

(i) Winding Temperature Indicator / Oil Temperature Indicator Test

(j) Polarization Index Test (For LV windings 3.3 KV and above)

(k) Local / Remote operations of OLTC (if any)

(l) Operational tests of RTCC panel (if any) as per schematic drawing.

(m) No load test and performance observations

5.4 HT Metal Enclosed Switchgear

(a) IR values of power and control circuits

(b) Local/ Remote operations in test as well as service position including all electrical interlocks

(c) Control circuit and operational tests as per schematic drawing.

(d) Tripping through relays and trip circuit health.

(e) Anti pumping device operation

(f) Protection system operation stability and sensitivity by primary injection testing method including testing of metering circuits

(g) HV Test on switchboard

(h) Panel indication, annunciation, space heater circuits

(i) Spare contact for customer use

(j) Termination correctness & proper installation.

5.5 LT Metal Enclosed Switchgears:

(a) IR Values of power & control circuits.

(b) Mechanical charging - closing - tripping of breaker.

(c) Electrical charging - closing - tripping of breaker.

(d) Trip circuit healthiness and tripping through relays.

(e) Remote closing / Tripping / Interlocks circuits

(f) Indication / Annunciation / Panel space heater circuit / Spare contacts for customer use

(g) Secondary injection testing of protective relays/ releases.

(h) CT testing for polarity, ratio, IR values and magnetization for class PS characteristics

(i) PT testing for ratio, IR values.

(j) IR Values of breaker.

(k) Testing of modules for DOL/ Star-Delta/ ATS/ Soft Starter starting or any other starting method as per the schematic drawings applicable.

5.6 Power and Control Cables:

(a) IR Values before Hipot

(b) Hipot Test - Measurement of leakage current

(c) IR Values after Hipot

5.7 Induction Motors:

(a) IR Values

(b) Polarization Index Test

(c) Interlocks and simulation tests local / remote operations

(d) No load test

5.8 Control Panels for Miscellaneous Equipment:

(a) IR Values of all power circuits

(b) Operational test and scheme - wiring testing as per control schematics

5.9 Lighting System:

(a) Visual inspection for operating problems

(b) System activation -burning in the lamps for 100 Hrs

(c) Measuring light level & reflectance.

5.10 Earthing System:

(a) Earthing resistance of each electrode.

(b) Earthing resistance of grid.

Request for Proposal

For

DEVELOPMENT OF BORSOLA BEEL

Design, Build and Operate Basis

Volume III C: Technical Specification for Instrumentation & Control

Client:

GUWAHATI SMART CITY LIMITED

GSCL,
Guwahati, Assam

DOCUMENT NO: 10477A-CV-3000-3102

CONTENTS

1. INSTRUMENTATION AND CONTROL - SCOPE OF WORK

a) The Contractor's scope under this enquiry covers the Design, Manufacture / Fabrication, Supply, Installation/erection, testing, commissioning, operation and comprehensive maintenance of Instrumentation and Control equipments for 1 No. 15 MLD Waste Water Treatment Plant and handing over the same to Owner i.e. GSCL. The Contractor shall provide all labour and required to calibrate, test, start-up and place in satisfactory operation a complete Supervisory Control And Data Acquisition (SCADA) System.

b) SCADA System shall be designed to control, monitor, store, display and log process and equipment operating information and to perform various process control functions and generate various reports. The unit processes, which the SCADA shall monitor, and control are shown in system architecture and described herein.

The SCADA System shall be furnished by a single Vendor who shall assume responsibility for providing a complete and integrated system.

c) Supply, installation, testing and commissioning of PLC based SCADA with 1 No. PLC with redundant processor, power and communication modules, integrated IO cards including system expandable IO modules (if required), floor mounted cabinets, terminal board within cabinets, Ethernet switch, LIU, patch cords (copper/ fibre), Interface Outlets, connectors and all necessary accessories, etc. for control, interlocking and monitoring, trends/ alarms annunciation, data logger etc. of STP.

d) The redundant communication port shall be provided at PLC to communicate with centralised SCADA expected in future City Control & Command Centre (C4) over OPC link/ Ethernet TCP/IP through Fiber optic cable shall be in the scope of bidder. The IO card shall be provided as per IO spare philosophy of PLC & IO list.

e) Supply, installation, testing and commissioning of 1 No. redundant SCADA server, 2 Nos. Operator-cum-Engineering workstation (EWS) along with SCADA software. The SCADA Software licensing and its management shall be easy to manage for licensing renewals with or without the maintenance. It shall be compatible and connected seamlessly with third party system i.e. PLC's of existing/ future STP, sub vendor package system and SCADA in City Control & Command Centre Control Room through OPC link or over Modbus TCP/IP.

f) User Friendly Upgradation of SCADA software must have life expectancy of at least 10 years. If there is change/ upgradation of software/ upgradation of version within life expectancy period must done by vendor at free of cost.

Programming of logic shall be as per requirement and shall be subject to approval of client/ consultant.

g) Supply, installation, testing and commissioning of pressure gauges, pressure indicating transmitter, Radar level transmitter, Magnetic float Level switches, Electromagnetic type flow meter, Total Suspended Solid, online Turbidity analyser, Free Residual Chlorine analyser, pH analyser.

h) Supply, installation, testing and commissioning of all erection hardware and accessories like branch cable trays, conduits, relays from field sensors to terminal board as required for erection of field instruments/ sensors/ PLC Control system/ local panel etc. for complete scope of work.

i) Supply, installation, testing and commissioning of Instrumentation, communication (Fiber optic and Cat-6 cable etc.), Control cables & Signal cables as required for complete control/ monitoring of STP. The scope also includes preparation of engineering documentation like cable schedule and inter-connection schedule.

j) The scope also includes ordering, fabrication, procurement, any import formalities, port clearances, packing and transportation to site, stores management which includes preservation and storage of equipments and materials in covered storage/ air conditioned storage (as required) and open storage.

k) Supply, installation, testing and commissioning of plant equipment/ systems shall be absolutely accident-free & shall be carried out maintaining all safety norms/ standards.

l) Co-ordination with other Vendors for connectivity (hardwired/ software) with others supplied system(s).

m) Factory Acceptance Test (FAT) and Site Acceptance Tests (SAT) shall be included in scope.

n) Supply of consumables, wherever required, shall be entirely the Contractor's responsibility. As a minimum these shall include.

   i. Teflon tape, insulation tape, welding rods, glass cutting sets, welding set.
   ii. Nuts & bolts for support, clamps for tubes & pipes, expansion bolts of various sizes for fixing to concrete structures.
   iii. Ferrules, sleeves, tag no plates, clamps for securing the cables, fasteners, marker plates required for installation of instruments, cables, trays, trenches, junction boxes.
   iv. Submission of engineering documentation as specified.

Provision of any other Instrumentation and control equipment not specified but required for proper functioning of the system.

2. APPLICABLE CODES & STANDARDS

The design, manufacture, performance and testing of all equipment, system, software and services covered under this specification shall comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment shall be installed. The equipment and systems shall also conform to the latest applicable standards. If such standards do not exist for any equipment or system, the same shall comply with the applicable recommendations of the following professional institutes:

a. National Electricity Manufacturers Association (NEMA).

b. The institute of Electrical and Electronic Engineers (IEEE).

c. Instrument Society of America (ISA).

d. American National Standards Institute (ANSI).

e. Deutsche Industries Norman (DIN).

f. International Electro technical Commission (IEC).

Nothing in this specification shall be construed to relieve the VENDOR of this responsibility.

3. OPERATION PHILOSOPHY

The Local Centralised Control Room (LCR) shall be located in Administration building within plant premises. Two (2) Nos. EWS with redundant SCADA servers (1:1), and PLC's shall be located inside LCR. The SCADA servers shall be loaded with SCADA software which shall be act as central engineering system to configure a complete process control system from hardware configuration, communications, application software and graphics as the basis of operation. Animated '.gif' or '.jpg' pages with active graphic controls shall be used to enhance usability. Non-proprietary Graphics tools shall be used to create Web Browser graphics. The SCADA software shall be supporting Standard Web Browser User Interface, Secure User Access, Long-Term trend Data Storage and IT Standards.

Augmentation/ future expansion of in SCADA must be hassle free/ user friendly and must be technically compatible with existing system.

The STP PLC with I/Os shall be provided with floor mounted cabinets, terminal board within cabinets, Ethernet switch, LIU, patch cords, connectors and all necessary

accessories, etc. for control, interlocking and monitoring, electrical system status monitoring and trends/ alarms annunciation, data logger etc. The STP operation parameter shall be displayed at EWS's for any abnormality. The IO shall be provided as per IO spare philosophy of PLC IO. Complete operation & monitoring of the STP shall be carried out at OWS.

4. CONTROL PHILOSOPHY

Refer process section for detailed plant control philosophy.

5. I&C CABLES SPECIFICATIONS

I & C cables usage shall be as follows:

a. For analog & other low level signals (4-20 mA, DC), mV etc. with circuit voltage up to 48 V DC, individual pair shielded & overall shielded instrumentation cables to be used
b. For circuit voltage above 48 V DC/ power supply applications etc. control cables to be used.

In all I&C cables, spare cores/ pair to be provided as follows:

a. Up to 5 signals, only 1 pair/ 2 cores spare to be provided. Above 5 signals, 2 pairs/ 4 cores spare to be provided. Even for a single signal, 1 pair/ 2 cores spare shall be provided.
b. 230 V AC UPS power supply to be used for I&C system equipment. For all other I&C equipment 230 V AC, single phase UPS power supply to be used. Any other voltage required for Bidder's equipment is to be derived from 230 V AC UPS power supply. Distribution of complete power supply for Bidder's equipment is included in Bidder's scope of work.
c. Name tag (Name Punch in metallic tag plate) and ferrule shall be provided for all instruments, control equipment and cable etc.

All panels, cabinets local panels, JBs etc. shall comply with protection class indicated below:

d. Indoor air-conditioned area – IP 42
e. Outdoor – IP 65

6. SPECIFICATION OF I&C SYSTEM EQUIPMENT

Refer Datasheets for Instrumentation and Controls specifications and provide necessary data in the specified columns.

7. FUNCTIONAL REQUIREMENTS OF PLC

Data Acquisition and Monitoring systems shall process following types of information available as its inputs

(a) Analog values measured through transducers such as current, voltage, active power, reactive power and frequency and parameters measures through sensor such as temperature.

(b) Digital commands signals such as -

i. Commands to operational equipment to take a definite position such as open/close.

ii. Commands to actuators to advance in steps in the required direction like transformer on load tap changers.

iii. Check commands.

(c) Indication signals of the following type:

i. Single state indications such as alarm and relay operation.

ii. Two state indications such as information about the status of devices/operational equipment.

iii. Numeric values such as indications regarding the position of transformers tap or setting value of relays used in protection system.

iv. Derived messages such as exceeding set values which are generated by software during monitoring and processing of process information.

v. Alarms generated within the system.

7.1 <u>Sensors/ Transducers</u>

(a) Various parameters of the system like voltage, current, active power/reactive power flow, frequency and temperature for power system, Pressure, Velocity, Flow, Temperature etc. for water systems shall be measured. In case of power system, voltage and current inputs shall be from voltage and current transformers respectively. Armoured copper cables shall be provided for connecting each transducer from particular CT/ VTs. Suitable transducers shall be provided to convert the signals suitable to I/O modules of

PLC before taking into the system. All transducers related to a particular circuit shall be mounted in the PLC cubicle along with the I/O cards for the particular circuit

(b) All contacts shall have change over contacts. For change over contacts, mum field interrogation voltage of 48 V DC shall be provided.

(c) Interfacing Relays

Interfacing relays shall be provided for converting the final control drive ON/OFF or OPEN/CLOSE command outputs from RTUs to actuate the closing and opening coils of equipment like circuit breakers, isolators or earth switches, i.e. switchgears for power system and valve actuators for water supply system. Rating of operating coils of interfacing relays and their contacts shall be suitable for interfacing between two different voltage levels, namely SCADA system voltage and switchgear, actuator control voltage. All interfacing relays related to a particular circuit shall be housed in the PLC circle along with the I/O cards for the particular circuit. Also all interconnecting cabling between drive control modules and interfacing relays in the PLC cubicle shall be provided.

8. DESIGN & PERFORMANCE REQUIREMENTS OF TRANSDUCERS

(a) Transducers for converting current transformer secondary currents of 1/5 A and voltage transformer secondary voltage of 230 V to 4-20 mA DC analog signals or to a suitable signal from acceptable to I/O modules of RTUs shall be provided.

(b) The Transducers shall be either multi-purpose type microprocessor based or a single purpose zener diode network based, in which they shall be of active type.

(c) Galvanic isolation shall be provided between the input and output.

(d) Transducers shall comply with IEC 60688 requirements.

9. DESIGN AND PERFORMANCE REQUIREMENTS OF INTERFACING RELAYS

(a) Interfacing relays shall be two element relays having suitable number of contacts for each element.

(b) Interfacing relays should be compact in size.

(a) The relay shall be compatible in all respects with respect to I/O boards microprocessor based SCADA system with which it shall be interfaced.

10. TRAINING REQUIREMENT

Two training sessions shall be provided by the contractor to the Owner's personnel free of cost, which shall be suitable to the type of system installed. The first training

session shall be conducted at Contractor's local office in India. All the travelling and living expenses shall be borne by the Contractor.

These sessions shall include, but not be limited to:

a) Written training material

b) Hands-on Lab exercise

c) Quiz Test

The following duration of training schedules shall be offered :

Operators - 80 Hours

Supervisors - 70 Hours

Managers - 60 Hours

Second training session shall be conducted at site partly during system installation and partly after system completion/ testing/ commissioning.

The Contractor shall furnish the services of competent instructors who shall give instruction in the adjustment, operation and maintenance, including pertinent safety requirements, of the equipment and system specified. The training shall be oriented toward the system installed rather than being a general training course. Each instructor shall be thoroughly familiar with all aspects of the subject matter they are to teach. All equipment and material required for classroom training shall be provided by the Contractor.

The training program shall be accomplished in two phases for the time interval specified for each phase:

A Priority shall be given to the acceptance test period at a time mutually agreeable between the Contractor and the Owner, and shall be at least five (5) days (8 hours/ day) in length. Operating personnel to be trained in the functional operations of the system installed and the procedures that the operators shall employ for system operation. The training shall include but not be limited to:

a. General I&C System Configuration.

b. Operation of Computer and Peripherals.

c. Command Line Mnemonics.

d. Report Generation.

e. Operator Control Functions.

f. Graphics Generation.

g. General equipment layout.

h. Troubleshooting procedures.

i. Preventive Maintenance procedures.

j. Sensor maintenance and calibration.

k. Proper use of service kit.

l. PLC Programming

m. Data Base Generation

n. Supervisory Level Operator Commands

o. Topics requested by Owner

11. O & M ACTIVITIES – INSTRUMENTATION SYSTEM

The Contractor shall carry out the operation and maintenance of the installed plant for a period of **Sixty (60) Months** from the date of commissioning and handing over the entire system, i.e. during the defects liability period. Further, he may also be required to carry out operation and comprehensive maintenance of the entire system for a period of contractually agreed duration beyond the defects liability period**.**

Operation contract:

i. 24 hours a day, year round during working office hours for full load.

ii. All stand-by equipment to be operated as per mutually agreed program.

iii. Proper entry and upkeep of relevant log books.

iv. Maintain complaints register. Submit weekly report.

v. Proper housekeeping of all areas under the contract.

vi. Prepare daily consumption report and summary of operation.

Comprehensive Maintenance:

a. Scope

- The maintenance activities shall cover all the items installed by the Contractor including consumable.

b. Routine Preventive Maintenance Schedule to be submitted

- Schedule to cover manufacturer's recommendation and/ or common engineering practice (for all plant and machinery under contract).
- Monthly status report.

c. Uptime during maintenance contract

- 98% uptime of all systems under contract.
- Up time shall be assessed every month and in case of shortfall during any month the contract shall be extended by a month.
- There shall be no reimbursement for the extended period.
- Break-downs shall be attended to within ten hours of reporting.

d. Manpower

- Adequate number of persons to the satisfaction of the Owner's site representative shall be provided including relievers.
- Statutory requirements of EPF, ESIC and other applicable labour legislations

to be complied with; and monthly certification to that effect to be submitted.

- Duty allocation and Roaster control shall be contractor's responsibility.
- No overtime shall be payable by Owner for any reason whatsoever.

e. Shut Downs

- Routine shut downs shall be permitted in consultation with Owner.
- The Contractor shall be at liberty to carry out routine maintenance as and when required but with prior permission of the Owner.

12. TESTING AND COMMISSIONING

Bidder shall include Integrated factory acceptance test (FAT) of the system at his works. This shall include inspection by Purchaser or Purchaser's representatives. FAT procedure is subject to Purchaser's approval and the duration of FAT shall be minimum 7 days.

Panel, software and control component modifications and corrections required as a result of testing shall be completed and documented before shipment. Panels shall not be shipped from the factory, until two (2) copies of certified Factory Test reports indicating satisfactory performance have been submitted to and approved by Owner/ Consultant.

Factory Test reports shall include the following information:

1. List of tests performed.
2. Certified check lists or documentation verifying all I/O has been tested, as specified above.
3. Documentation verifying all panel wiring has been checked.
4. List of required modifications or corrections identified during the Factory Test and corrective action taken.
5. Factory test reports shall be signed and dated by an authorized representative of the System Supplier and CONTRACTOR.

On site tests: Bidder shall include testing and commissioning of the PLC at site as Site Acceptance Test (SAT). Inspection of equipment on arrival/ Preliminary on site checks/ tests/ Start-up test/ Trial operation test/ System documentation checks/ Acceptance tests-Similar to the authorisation to ship test but with actual inputs/

outputs.

Availability Guarantee test: System availability shall not be less than 99% and shall be demonstrated by an analysis of system availability during system design.

Tests to be included for individual instruments shall be as per applicable international and Indian standards.

The contractor shall indicate to the Consultant's/ Owner's site representative his readiness for commissioning of the system and shall commission the system only upon obtaining written approval for the same.

As part of Calibration & Commissioning exercise, contractor shall be required to carry out the following:

a. Perform a three-phase commissioning procedure consisting of field points commissioning, system commissioning and integrated system program commissioning.

   Documents all commissioning information on commissioning data sheets that shall be submitted prior to acceptance testing. Notify the Owner in writing of the testing schedule so that operating personnel may observe calibration and commissioning.

b. Field points Commissioning.

c. Prior to system program commissioning, verify that each control panel has been installed according to the shop drawings and test, calibrate, and bring on-line each control device.

d. Record calibration and test data on commissioning data sheets and submit. Data sheets shall include the device designation, the date of commissioning and the name of person who performed commissioning.

Upon completion, devices subject to manual operation shall be operated in presence of Consultant's/ Owner's Representative to demonstrate satisfactory operation.

13. SPARES

Start-up spares shall be as required

Essential spares shall be supplied as detailed below:

(a) For field instruments, air filter regulators, E/P converter and junction box and drive modules a minimum of one (1) No., or 10% of the quantity of each type and range, whichever is higher, shall be provided.

(b) PLC System

(i) All modules like Signal distribution modules, signal conditioning modules, I/O modules, Processor modules, Power supply modules, Network cards etc., – 10% of each type, or minimum one (1) No. whichever is higher.

(ii) Each type of fuse – 5 Nos., or 30% of each, whichever is higher.

(c) Local Panels, System Cabinets

10% of each type, or minimum one (1) No. whichever is higher shall be supplied for the following

(i) Fuses of each type and rating.

(ii) MCB of each type.

(iii) Terminals of each type

(iv) Male & female parts of pre-fabricates Cables – 6 Nos., of each type.

(d) Wiring, Termination & Accessories.

10% of each type, or minimum one (1) No. whichever is higher shall be supplied for the following

(i) Fuses of each type & rating.

(ii) Miniature circuit breaker of each type & rating

(iii) Terminals of each type.

(iv) Space heater with thermostatic controls.

(v) Sensors.

(vi) Blower.

(vii) Blank DVD's for software back-up: 30 Nos.

(viii) Cable clamps each type.

(ix) Male & female pre-fabricated cables – 6 Nos., each type.

(x) Spare terminal in each terminal block in all cabinets.

(xi) Spare space for counting additional terminal blocks in all cabinets.

(xii) Wiring raceways to accommodate additional 30% space of total quantity.

14. DOCUMENTS TO BE SUBMITTED ALONG WITH BID

(a) System PIDs

(b) System write up

(c) Control/ Operation/ Design Philosophy

(d) PLC system configuration With Technical Literature & PLC Requirements

(e) PLC Sizing Details

(f) List of Spares

(g) Quantity of PLC Cabinets With tentative dimensions

(h) Power consumption details for I&C equipments-List of Feeders with Feeder Loads

(i) Confirmation of all the clauses of the specification/ deviations

15. DOCUMENTS TO BE SUBMITTED BY VENDOR AFTER AWARD OF CONTRACT

Following documents shall be furnished by vendor

(a) System PIDs

(b) System write up

(c) Control Schemes/ Control logics with write-up

(d) Detailed PLC I/O List

(e) G.A Drawing For PLC cabinets and Control room

(f) List of Feeders with Feeder Loads for 230 V AC (UPS) power supply

(g) Time stamping protocol required for PLC system from GPS master clock supplied by Purchaser.

(h) Data sheet along with catalogues of manufacturer's for all field instruments and equipments supplied by vendor.

(i) Junction Box Grouping Details

(k) Cable Schedule

(l) Interconnection Schedule

(m) Data sheet along with catalogues of manufacturer's for all field instruments and equipments supplied by vendor

(n) QA Plan For I&C Equipment

(o) Final List Of Essential Spares

(p) Earthing requirement for PLC system cabinets.

16. CYBER SECURITY REQUIREMENTS FOR CONTROL SYSTEM

- This specification deals with cyber security applied to Industrial Network System (INS) used for Control System.

- The INS network for the control system, shall be physically and functionally independent from the Enterprise Information System (SIE i.e. GSCL network).

- The INS shall not be connected to the SIE network unless a specific need for transferring data has been identified and is required.

- The INS shall have one connection point to the SIE network through a dedicated security device (i.e. Firewall) whose purpose is to filter the traffic between INS and SIE network.

- Architecture of this connection shall be designed to allow for physical disconnection from the SIE network at any time in case of high cyber risk coming from the SIE. However the main Control System or packages system functions shall not be affected after disconnecting the link.

- Architecture shall be designed in such a way that all functions shall be implemented on the appropriate equipment, in accordance with the reliability/safety and cyber security levels. As an example, Operator workstations shall not be used for production management and control function shall not be performed from SCADA Data Server.

Antivirus Software

- Antivirus software shall be installed on all workstations and servers.

- Configuration of the antivirus software is the responsibility of Vendor, in order not to impair the behaviour of the device (specifically the Operator-cum-Engineering workstations).

- The Vendor shall specify which directory/files not to scan (with justification), the scanning periodicity and sequence for several workstations, automatic action to be taken after detection, etc.

- The Client could specify the preferred antivirus brand to be used for the project; in this case the Vendor shall validate the specified software.

- Tools and procedure for updating the antivirus knowledge base shall be provided and tested.

- An Operator-cum-Engineering workstation/ Servers connected to the INS shall allow for regular & automatic updates after downloading the server with the Antivirus file/directory data base.

- Logging of events shall be configured in order to report any detection on the Antivirus server.

- Any Control Systems specific workstations, if existing and not connected to the SII network, shall be updated manually and individually.

Network Components

- All network components (hubs, switches, routers, etc.) shall be of industrial type: either rack or DIN mounted with redundant power supplies.
- They shall not downgrade the whole reliability. They shall be validated and fully supported by Vendor.

17. SCADA Software features

(a) The HMI/ SCADA software shall be 32-bit software capable of running on Windows 2013 and Windows Server 2016.

(b) SCADA software shall have Modular architecture based on Microsoft's Distributed Internet Applications (DNA) architecture and plug & play features.

(c) SCADA software shall permit the user for flexibility to purchase only the modules and components necessary for the application.

(d) SCADA software shall offer separate stand-alone modules for:

i) Dynamic Graphic Displays
ii) Real-Time Trending and Historical Data Logging
iii) Alarm Management
iv) Project Level Scripting
v) Security
vi) Real-time OPC Servers
vii) OPC Redundancy
viii) OPC Data Bridging
ix) Screen Management
x) Process Control
xi) Project Management
xii) Visual Control Replay

(e) SCADA software shall have a scalable architecture so that the user can start with a small application and later grow the application and database to any size by upgrading the license.

(f) SCADA software shall be able to integrate Microsoft Access, Microsoft SQL Server, Open Database Connectivity (ODBC), Object Linking and Embedding (OLE), ActiveX Technologies, OLE for Process Control (OPC) & Visual Basic for

Applications (VBA).

(g) Connectivity to Data Sources shall be through a Universal Data Browser that provides the ability to specify the tag or point name using point and click selection with the mouse.

(h) All modules and applications in the HMI/ SCADA system must utilize the Universal Data Browser for data connectivity.

(i) SCADA software shall implement Client/ Server Distributed Networking and support industry standard network protocols such as TCP/IP, RS485/ RS232, etc.

(j) SCADA software shall be able to Plug and Play with standard routers, network Intranets and the Internet.

(k) SCADA software shall be capable of storing and managing its database on a redundant file server.

(l) SCADA software shall be able to connect to a large number of I/O Device Interfaces via OPC Servers across the network.

(m) SCADA software shall not require hardware "dongle" key for licensing (like those plugged into the parallel port). Software-based licensing is all that should be required.

(n) SCADA software shall provide an option for hardware "dongle" key for licensing (like those plugged into the parallel port) as an alternative to any software-based licensing.

(o) SCADA software shall be supplied as a complete package. No additional software should be required to configure or run the features of the system.

18. Minimum Specifications for Engineering & Operator Workstations

FEATURES	DESCRIPTION
Processor	Intel i7 processor/ Latest Generation Technology (64 Bit processor)
Memory	8 GB (4 x 4gb) dual channel and Max. memory expandable through four DIMM slots
Cache (External)	2x 2 MB L2 Cache, as per processor (8 MB)
ROM (BIOS)	512 MB Flash ROM, Can be upgraded from a diskette
Expansion Bus	1 No. Parallel Port, 2 Nos. PCI Express (x16 slots), 4 Nos. 32 bit PCI slots, 33 MHz PCI 2.2 slots, 1-graphics slot
Graphic Accelerator Multi graphics Technology	N-vidia Quadra with 2GB Memory with dual monitor capable graphics card – Maximum display can be connected.

Hard Disk	1 TB 7.2K rpm SATA hard disk
Power Supply	500 W switchable/ 50 Hz with dual power supply provisions
Keyboard	104 keys window 98 keyboard, PS/2 Compatible/ USB keyboard
Operating System	Supports (64 Bit OS)Windows7 Professional (with recovery disc) or latest with Life time Licensed
Software	Microsoft Internet Explorer / MS Office
Power Management	EPA compliant
Desktop Manager	Based on SNMP protocol
Antivirus Software	McAfee Virus Scan Enterprise Version 8.7.0i with license version or equivalent pre-loaded from OEM.
Diagnostic Software	PC diagnostic software or equivalent pre-loaded from OEM.
Network	Broad cam 10/100/1000 Mbps Ethernet adapter Network Interface Card with wake on LAN support NIC with GB support
Interfaces	1 parallel, 8 USB 2.0, 1 serial, 2 Ultra ATA/100,2 optional IEEE1394, 1 PS/2 Keyboard, 1 PS/2 Mouse, 1 video, 1 Microphone jack, 1 Line-in jack, 1 RJ-45, 1 Headphone jack & 1 line-out jack (analog/SPDIF digital) with 1GBits/sec or greater
Audio Card	Integrated AC 97/16 bit Stereo full-duplex and integrated speaker
Mouse	-USB mouse. 2.0 V supported
Monitor	Monitors shall be with a minimum 24 inch color LED flat panel display.
CD DVD Writer	DVD- RW (Dual Layered) /CD-RW Combo Drive with speakers
Printer	Laser Jet 20 ppm, A3 paper size.

a) Key board: The central station shall be complete with detached 104-keys keyboard USB support 2.0 which includes full upper/ lower case ASCII key set, a numeric pad, dedicated cursor control pad, and a minimum of 10 programmable functional keys.

b) Colour Monitor: The colour LED screen shall be with a minimum 32 inch diagonal no glare screen and minimum resolution of (1920 x 1080) 1080p pixels horizontal, minimum 65K colour & it should support USB 3.0 with remote. The monitor shall be with tilt and swivel facilities with the required accessories to make the system functional for wall as well as Desk along with HDMI & DVI ports.

c) Mouse (Optical): For USB keyboard support 2.0 less operation, in addition to the enhanced keyboard, a mouse shall also be provided as an alternative user interface for day to day system operation. 2 Nos. mouse pads shall be provided for each mouse & it should support USB 3.0 with remote

d) Printers: The contractor shall provide A3 paper size laser printers as specified in the schematic diagram for printing alarms, operator transactions and reports.

The printer shall be configuring for alarm printing reports, trend log, summary, total logging, recording alarms and providing system reports etc.

e) Ethernet Card, 100 Mb/ 1 Gb Onboard NIC or 3-Com Etherlink III .Intel Pro/100 S Dual Port Server Adapter (PCI) NIC with 10GB support

g) Due to the nature of rapid change in manufacturer specifications and software operating system requirements, contractor shall submit at the time of bid and the time of engineering submittal detailed workstation hardware and software specification sheet clearly indicating deviation from the specification.

h) Provide an integral audio tone generator to activate on detection of an alarm. Audio tone shall be capable of being enabled or disabled on operator command.

i) Provide software and hardware as required to make the system internet accessible via web browser. Include firewall software to prevent unauthorized access.

19. Minimum Specifications Server Specifications - Application/ Database (N:N)

Minimum Server Specification:

FEATURES	MINIMUM SPECIFICAITONS
Processor	Blade Server Min Intel ®Xeon ® Min 2.4GHz Quad Core or Latest generation of 64 bit chip set
Memory	12GB dual channel DDR3 1333/1600,with memory expandable through four DIMM slots
Cache (External)	Min 6MB Cache or More
Graphic Accelerator	Graphics card with 2 GB video memory (non shared) (with connectivity to 2 monitors)
Hard Disk	Min2TB 7.5K rpm SATA hard disk
Power Supply	dual power supply 375 W switchable/50 Hz
Keyboard	Cordless 104 keys, PS/2 Compatible
Operating System	Supports (64 Bit OS)Windows10 Professional (with recovery disc) or latest with Life time Licensed & should be Windows Hardware Quality Lab (WHQL) certified.
Power Management	AC 230 V @ 50Hz (1+1 Redundant power Supply)
Desktop Manager	Based on SNMP protocol
Antivirus Software	MacAfee Enterprise version or equivalent Reputed pre-loaded Life time Licensed
MS Office	With Licensed latest MS office software
Network Card	Dual Gigabit Ethernet Card
Interfaces	Min 2 HMI,1 parallel, 8 USB 2.0, 1 serial, 2 Ultra ATA/100,2 optional IEEE1394, 1 PS/2 Keyboard, 1 PS/2 Mouse, 1 video, 1 Microphone jack, 1 Line-in jack, 1 RJ-45, 1 Headphone jack & 1 line-out jack (analog/SPDIF digital
Audio Card	Integrated AC 97/16 bit Stereo full-duplex and integrated speaker
Mouse	Cordless Mouse

FEATURES	MINIMUM SPECIFICAITONS
Dual Monitor Card	Dual Monitors shall be with a minimum 1 no 32 inch color LED flat panel display. (16:9) monitor, Minimum 1920 x1080 resolution, 5 ms or better response time, Energy Star compliant.
Combo Writer	DVD/CD-RW Combo Drive with speakers Out

LED Display

PARAMETERS	MINIMUM SPECIFICAITONS
Technology	HD LED display (Basel free)
Screen Size	32" diagonal, 16:9 Widescreen
Resolution	Full high definition (Minimum 1920 x 1080)
Input Signal Level	HDMI/VGA etc
Operations	24x7 (Industrial Grade Monitors)

20. COLOR LASER PRINTER

a) Provide equipment to operate on 230 VAC, single phase, 50-hertz electrical service.
b) Provide all necessary items for installation, including mounting brackets, interconnecting cables, hardware and appurtenances.
c) Self-contained unit to generate colour graphic and text prints.
d) Print Speed (Normal mode): 22 pages per minute (black text); 22 pages per minute (colour).
e) Print Modes: Portrait and landscape
f) Print Resolution: 600x600 dots per inch (black text), 600x600 dots per inch (colour).
g) Memory: 160 MB, minimum.
h) Print Language: Enhanced HP PCL6 and Adobe postscript level 3.
i) Paper Trays: Two minimum, 300 total sheets minimum.
j) Paper: Plain paper, 8.5 by 11 inches.
k) Mounting: Desktop.
l) Provide a printer which is "network ready", with a pre-installed internal network interface card to allow easy connection to an Ethernet-based local area network. Include any required related network printer management utilities.
m) Provide cables and any other required devices to connect the printer to an Ethernet-based local area network.

21. TYPICAL IO LIST

PART A: SIGNAL EXCHANGES BETWEEN PLC & MCC FOR DRIVE CONTROL

Sr. No.	From	To	Signal Description	Remarks	PLC Signal Type
A	**FOR LT UNI-DIRECTIONAL MOTOR DRIVES**				
1	PLC	MCC	Command To Start/ Stop	CMD to MCC	DO
2	MCC	PLC	Motor Running/ Stopped	Feedback to PLC	DI
3	MCC	PLC	Motor Tripped (Thermal Overload)	Feedback to PLC	DI
4	MCC	PLC	Motor Ready To Start (By anding Thermal O/L not Operated/ Control Supply	Feedback to PLC	DI

Sr. No.	From	To	Signal Description	Remarks	PLC Signal Type
			available/ MCC not isolated)		
5	MCC	PLC	Motor Torque Switch Operated**	Feedback to PLC	DI
6	MCC	PLC	Motor Current (4-20 mA DC)	Feedback to PLC (For Motor KW> 30)	AI
7	MCC	PLC	Local/ Remote Selection Switch in REMOTE mode	Feedback to PLC	DI
8	LPB	MCC	Emergency Stop Command	Wired to MCC	-
9	LPB	PLC	LPB Emergency Stop Command Operated	LPB Stop Operated Feedback to PLC	DI
10	N/E SWGR.	PLC	N/E Bus Undervoltage	Feedback to PLC (Common for all applicable N/E Swgr. Service drives)	DI
	**: Applicable for selected motorised drives only. Bidder to state.				
B	**FOR LT UNI-DIRECTIONAL VFD DRIVES**				
1	PLC	VFD	Command To Start/ Stop	CMD to VFD	DO
2	VFD	PLC	Motor Running/ Stopped	Feedback to PLC	DI
3	VFD	PLC	Motor Tripped (Thermal Overload)	Feedback to PLC	DI
4	VFD	PLC	Motor Ready To Start (By anding Thermal O/L not Operated/ Control Supply available/ MCC not isolated)	Feedback to PLC	DI
5	VFD	PLC	Speed Feedback (4-20 mA DC)	Feedback to PLC	AI
6	PLC	VFD	Speed Control (4-20 mA DC)	CMD to VFD	AO
7	VFD	PLC	Motor Current (4-20 mA DC)	Feedback to PLC (For Motor KW> 30)	AI
8	VFD	PLC	Local/ Remote Selection Switch in REMOTE mode	Feedback to PLC	DI
9	LPB	VFD	Emergency Stop Command	Wired to MCC	-
10	LPB	PLC	LPB Emergency Stop Command Operated	LPB Stop Operated Feedback to PLC	DI
C	**FOR MOV WITH BI-DIRECTIONAL MOTOR DRIVE**				
1	PLC	MCC	Command To Open/ Close	CMD to MCC	DO
2	MCC	PLC	Motor Tripped (Thermal Overload)	Feedback to PLC	DI
3	MCC	PLC	Motor Ready To Start (By anding Thermal O/L not	Feedback to PLC	DI

Sr. No.	From	To	Signal Description	Remarks	PLC Signal Type
			Operated/ Control Supply available/ MCC not Isolated)		
4	Actuator	PLC	Open Limit Switch Operated	Feedback to PLC	DI
5	Actuator	PLC	Close Limit Switch Operated	Feedback to PLC	DI
6	Actuator	PLC	Open Torque Switch Operated	Feedback to PLC	DI
7	Actuator	PLC	Close Torque Switch Operated	Feedback to PLC	DI
8	Actuator	MCC	Open Limit Switch Operated	For power cut-off in MCC	-
9	Actuator	MCC	Close Limit Switch Operated	For power cut-off in MCC	-
10	Actuator	MCC	Open Torque Switch Operated	For power cut-off in MCC	-
11	Actuator	MCC	Close Torque Switch Operated	For power cut-off in MCC	-
12	MCC	PLC	Local/ Remote Selection Switch in REMOTE mode	Feedback to PLC	DI
13	LPB	MCC	Emergency Stop Command	Wired to MCC	-
14	Actuator	PLC	Position Feedback (4-20 mA DC)	Feedback to PLC (For Inching services)	AI
15	N/E SWGR.	PLC	N/E Bus Undervoltage	Feedback to PLC (Common for all applicable N/E Swgr. Service drives)	DI
D	**FOR HEATER**				
1	PLC	MCC	Command To Start/ Stop	CMD to MCC	DO
2	MCC	PLC	Heater ON/ OFF	Feedback to PLC	DI
E	**FOR PNEUMATIC/ HYDARULIC BI-DIRECTIONAL DRIVE/ SOLENOID DRIVE**				
	I. SINGLE COIL SOV WITH OPEN STATUS FB				
1	Actuator/ SOV	PLC	Open Limit Switch Operated	Feedback to PLC	DI
2	PLC	SOV Through Power Board	Command To Open/ Close	CMD to SOV	DO
	II. SINGLE COIL SOV WITH OPEN/ CLOSE STATUS FB				
1	Actuator/ SOV	PLC	Open Limit Switch Operated	Feedback to PLC	DI

Sr. No.	From	To	Signal Description	Remarks	PLC Signal Type
2	Actuator/ SOV	PLC	Close Limit Switch Operated	Feedback to PLC	DI
3	PLC	SOV Through Power Board	Command To Open/ Close	CMD to SOV	DO
	III. DOUBLE COIL SOV WITH OPEN/ CLOSE STATUS FB				
1	Actuator/ SOV	PLC	Open Limit Switch Operated	Feedback to PLC	DI
2	Actuator/ SOV	PLC	Close Limit Switch Operated	Feedback to PLC	DI
3	PLC	SOV Through Power Board	Command To Open/ Close	CMD to SOV	DO
4	PLC	SOV Through Power Board	Command To Open/ Close	CMD to SOV	DO
F	**FOR MANUALLY OP. BI-DIRECTIONAL DRIVE**				
1	Actuator	PLC	Open Limit Switch Operated	Feedback to PLC	DI
2	Actuator	PLC	Close Limit Switch Operated	Feedback to PLC	DI

NOTES (FOR TYPICAL I/O LIST):

1. All 'DI' signals to be interfaced to PLC are Potential Free Contact (PFC) type.
2. In case of Uni-directional & Bi-directional motor drives, all 'DO' commands from PLC to SWGR./ MCC/ VFD are 24 V DC logic level type. 24 V DC IPR located in SWGR./ MCC/ VFD & in Bidder's scope of supply.
3. In case of SOVs, all 'DO' commands from PLC are potential free contact type taken from 24 V DC IPR (in PLC vendor's scope of supply).

PART B: PROCESS SIGNALS MINIMUM REQUIRED FOR INTERFACING WITH PLC

1) Mechanical course screens differential level (AI 4-20 mA)
2) Raw sewage sump level (AI 4-20 mA)
3) Raw sewage sump pumps common discharge pressure (AI 4-20 mA)
4) Raw sewage flow (AI 4-20 mA)

5) Mechanical fine screens differential level (AI 4-20 mA)
6) Decanter level (AI 4-20 mA)
7) Decanter position (AI 4-20 mA)
8) SBR basins level (AI 4-20 mA)
9) SBR basins dissolved oxygen (AI 4-20 mA)
10) SBR air blowers common discharge pressure (AI 4-20 mA)
11) SAS pumps common discharge pressure (AI 4-20 mA)
12) Chlorine contact tank level (AI 4-20 mA)
13) Backwash collection sump level (AI 4-20 mA)
14) Gravity sand filters differential pressure switch (DI)
15) Filters air blowers common discharge pressure (AI 4-20 mA)
16) Final disposal flow (AI 4-20 mA)
17) Final disposal pH (AI 4-20 mA)
18) Final disposal residual chlorine (AI 4-20 mA)
19) Final disposal ORP (AI 4-20 mA)
20) Final disposal turbidity/ TSS (AI 4-20 mA)
21) $FeCl_3$ Dosing tanks level switch (DI)
22) Polymer Dosing tanks level switch (DI)
23) Sludge sump level (AI 4-20 mA)
24) Sludge sump air blowers common discharge pressure (AI 4-20 mA)
25) Thickener feed pumps common discharge pressure (AI 4-20 mA)
26) Thickened sludge sump level (AI 4-20 mA)
27) Centrifuge feed pumps common discharge pressure (AI 4-20 mA)
28) Chlorine detectors at Chlorination plant

PART C: PROCESS LOCAL INDICATORS MINIMUM REQUIRED FOR LOCAL MONITORING

1) Pressure indicators at each pump/ blower/ fan discharge
2) Level gauge at each storage tank/ sump
3) Flow indicator at dosing pumps common discharge

22. LIST OF RECOMMENDED MAKES FOR I&C EQUIPMENT SYSTEM

Sr. No.	Item	Recommended make
1.	Pressure indicator	• General instruments • AN instruments • M Guru
2.	Pressure transmitter	• Yokogawa • ABB • Emerson process • Honeywell
3.	Level Indicator	• Gauges Bourdon (India) Ltd • Nivo Controls • Pune Techtrol • SBEM • Baumer Technologies
4.	Level Switch – Magnetic Float type	• Chemtrols • Levcon • Magnetrols • Pune Techtrol • SBEM
5.	Level Transmitter - Radar	• Forbes Marshall • E&H • Emerson Process • Vega India • Siemens
6.	Resistance Temperature Detector – RTD	• General Instruments • AN Instruments • Pyro Electric • Waree • Wika • M Guru • Toshbro Controls
7.	Flow Transmitter – Electromagnetic	• Forbes Marshall • E&H • Foxboro • SBEM • Instrumentation Engineers Ltd
8.	DO Analyser	• Mettler Toledo • Hach • E&H • Danfoss A/S

Sr. No.	Item	Recommended make
9.	pH & ORP Analyser	• Forbes Marshall • E&H • Hach
10.	Residual Chlorine Analyser	• Emerson Process • Forbes Marshall • Hach
11.	Turbidity/ TSS Measurement	• Emerson Process • Forbes Marshall • Hach
12.	PLC & SCADA System	• ABB • GE • Rockwell Automation • Schneider • Siemens
13.	System/ Marshalling Cabinet	• Rittal India • Pyrotech Controls • Flameproof Equipment • Industrial & Commercial Enterprises
14.	Junction Box	• Hensel Electric India • Flameproof Equipment
15.	Instrumentation Cable	• Associated Cables • Associated Flexibles & Wires • Cords India • Delton Cables • TCL Cables • Udey Pyrocables
16.	Control Cable	• Associated Cables • Associated Flexibles & Wires • Cords India • Delton Cables • TCL Cables • Udey Pyrocables
17.	Interposing Relay (IPR)	• O.E.N India • Jyoti Ltd • Omron Automation Pvt Ltd • Phoenix Contacts (india) Pvt Ltd • Connectwell

Sr. No.	Item	Recommended make
18.	Solenoid Valve (SOV)	• Avcon Controls • Dembla Valves • Rotex Automation
19.	Instrument tubes & fittings	• Swagelok
20.	System Integration Units And Networking accessory (Network Switch with LIU, Gateway, Fiber optic converter etc.)	• CISCO • HP • D-Link • Schneider
21.	SCADA server/EWS/OWS workstation	• DELL • Hewlett Packard • IBM
22.	Colour Monitor	• DELL • Hewlett Packard • IBM • Samsung
23.	Printer	• Hewlett Packard • Cannon
24.	Fibre optics cable	• Systimax • R&M • Belden • Rosenberger
25.	Cat 6 cable	• Systimax • R&M • Belden
26.	HDPE Conduits	• BEC • Precision • Duraline

Request for Proposal

For

DEVELOPMENT OF BORSOLA BEEL

Design, Build and Operate Basis

Volume IID: Functional Guarantee

Client:

GUWAHATI SMART CITY LIMITED

GSCL,

Guwahati, Assam

DOCUMENT NO:10477A-CV-3000-3102

FUNCTIONAL GUARANTEES OF THE PLANT
(To be completed by the Bidder)

1 General

This document sets out the functional guarantees required to be provided by the Bidder for assessing the performance of the Works. These guarantees shall be used by the Employer to evaluate Bidder's satisfactory performance during the Tests after Completion, and also throughout the Operation and Maintenance Period.

The Bidder shall complete the following sections and provide values for the electrical energy usage and chemical usage for the Works covered under the contract, based on the raw sewage flows and characteristics and specified effluent and sludge quality requirements as given in Part - 2 of Volume 3A of bid document.

1.1 Functional Guarantees

1.1.1 Plant Effluent and Sludge Quality

The Bidder guarantees that the plant effluent and sludge quality (20% dry solids content) requirements specified in Part 2 of Volume 3A will be fully and completely met, under either actual or simulated design raw sewage flows, loadings, and characteristics, as demonstrated by the Tests after Completion. The bidder further guarantees that the specified requirements will continue to be fully and completely met throughout the Operation and Maintenance Period.

1.1.2 Electrical Energy Usage per Unit Volume of Raw Sewage

The Bidder guarantees that electrical energy usage of various components of the Works will not exceed the values listed in the table below, as demonstrated by the Tests after Completion and throughout the Operation and Maintenance Period.

STP Name	BOROSOLA	Total Guaranteed Power Consumption (kWH/day)
STP including pumping station Capacity (cum/day)	**15000**	
The consumption of **Energy** during the Tests after Completion is guaranteed to be:	Not more than: ……kWH/per cubic meter (cum) of plant effluent	

The Guaranteed power consumption for all the units in the STP shall be justified as per Electrical load list provided below.

(BOD removal of 250mg/l to be considered while calculating aeration power requirement)

Item No	Equipment Name	Working units (Nos.)	Efficiency of Equipment (%)	B kW for operation	Motor Efficiency (%)	Combined Efficiency Pump/Equipment (%)	Motor Rating (kW)	Operating hours (h/day)	Total Power Consumption (kWh/day)
1	Raw Sewage Transfer Pumps								
2	Mechanical Coarse Screen								
3	Mechanical Fine Screen								
4	Belt Conveyor								
5	Grit Collector								
6	Grit Separator								
7	Organic Return Pump (Grit Chammber)								
8	Oil & Grease Separator								
9	Process Air Blower								
10	Decanters								
11	Primary Sludge Pumps								
12	Pump Thickener Feed/WAS								
13	RAS								

14	Flash Mixer								
15	Flocculator								
16	Filter Feed Pumps								
17	Backwash Pumps								
18	Air Scour Blowers								
19	Gravity Sludge Thickener								
20	Digester Feed Sludge Pumps								
21	Sludge Digester mixers								
22	Sludge Digester Accessories								
23	Gas Holder Accessories								
24	Flaring System								
25	Pump Dewatering unit Feed								
26	Dewatering Unit								
27	Pump Filtrate transfer								
28	Agitator PE preparation								
29	Pump PE dosing								
30	Agitator Coagulant preparation								
31	Pump Coagulant dosing								
32	Pump Chlorine Booster								
33	NaOH recirculating Pumps								
34	Service Water pumps (utility purpose)								
35	Drain Pumps (for filtration gallery)								
36	Lighting / Misc Load								
37	Auto valves/ Sluice gates								

38	EOT crane for blowers/pumps/equipments								
39	Other Miscellaneous Load								
	Total								

1.2 Chemical Usage per Unit Volume of Plant Effluent

1.2.1 Chlorine Usage per Unit Volume of Plant Effluent

STP Name	**BOROSOLA**	**Total Guaranteed Chlorine Consumption in the Contract (Kg/day)**
STP Capacity (cum/day)	**15000**	
The consumption of **Chlorine** during the Tests after Completion is guaranteed to be:	Not more than: ……kg per cubic meter (cum) of plant effluent	

1.2.2 Dewatering Polymer Usage per Unit Volume of Plant Effluent for Biological Sludge

STP Name	BOROSOLA	Total Guaranteed Polymer Consumption in the Contract (Kg/day)
STP Capacity (cum/day)	15000	
The consumption of dewatering **Polymer (polyelectrolyte)** during the Tests after Completion is guaranteed to be:	Not more than: ……kg per cubic meter (cum) of plant effluent	

1.2.3 Dewatering Polymer Usage per Unit Volume of Plant Effluent for Chemical Sludge (if Required)

STP Name	BOROSOLA	Total Guaranteed Polymer Consumption in the Contract (Kg/day)
STP Capacity (cum/day)	15000	
The consumption of dewatering **Polymer (polyelectrolyte)** during the Tests after Completion is guaranteed to be:	Not more than: ……kg per cubic meter (cum) of plant effluent	

1.2.4 Coagulant Usage per Unit Volume of Plant Effluent (if required)

STP Name	BOROSOLA	Total Guaranteed Coagulant Consumption in the Contract (Kg/day)
STP Capacity (cum/day)	**15000**	
The consumption of **Coagulant** during the Tests after Completion is guaranteed to be:	Not more than: ……kg per cubic meter (cum) of plant effluent	

Request for Proposal

For

DEVELOPMENT OF BORSOLA BEEL

Design, Build and Operate Basis

Volume II D: Datasheet for Process and Civil

Client:

GUWAHATI SMART CITY LIMITED

GSCL,

Guwahati, Assam

DOCUMENT NO: .10477A-CV-3000-3102

Technical Datasheet for Process and Civil (To be furnished by Bidder for Each STP covered in this tender)

S. No.	Units		STP-1
1	**General and Process**		
	Average Flow (MLD)		
	Peak Flow (MLD)		
	Raw Sewage BOD5 at 20°C (mg/lit)		
	Raw Sewage TSS (mg/lit)		
	Raw Sewage TKN (mg/lit)		
	Raw Sewage Total Phosphorus (mg/lit)		
	Treated Sewage BOD (mg/lit)		
	Treated Sewage Total nitrogen (mg/lit)		
	Treated Sewage Total Phosphorus (mg/lit)		
2	**Total head loss (m) in STP (from water level in inlet chamber of STP to water level in effluent channel of chlorine contact tank) at peak flow with one unit of each process out of service**		
3	**Total Land Area Proposed for entire STP facility (Including SPS + STP), in Sq.m.**		
4	**Sewage Pumping Station (STP)**		
(a)	Receiving Chamber		
	(i)	Size of channel (m)	
	(ii)	Size of incoming pumping main (m)	
	(iii)	No. and size of gated openings weir gates	
	(iv)	Max, Average, and Min water levels (m)	
(b)	Trash & Coarse Screen Channels		
	(i)	No. of units	
	(ii)	Capacity of each unit (MLD)	
	(iii)	Size of channel (m)	

	(iv)	Max, Average, and Min water levels (m)	
	(v)	Head loss (m)	
(c)	Manual Grit Removal Channel (Before Pumping station)		
	(i)	Particle size to be removed (mm)	
	(ii)	Specific gravity	
	(iii)	Efficiency of removal (%)	
	(iv)	Size of grit basin influent structure (m)	
	(v)	Grit Basins - Number - Capacity, each MLD - Size, each (m)	
	(vi)	Surface overflow rate (m^3/m^2/day)	
	(vii)	Max, Average, and Min water levels in grit chamber (m)	
(d)	Raw Sewage Sump		
	(i)	No. of units	
	(ii)	Design Flow (MLD)	
	(iii)	HRT at Peak & Average flow (min)	
	(iv)	Size of wet well (m)	
	(v)	Liquid depth (m)	
	(vii)	Material of Construction	
5	**Sewage Treatment Plant (STP)**		
(a)	Fine Screen Influent Channel		
	(i)	Size of channel (m)	
	(ii)	Size of incoming pumping main (m)	
	(iii)	No. and size of gated openings weir gates	
	(iv)	Max, Average, and Min water levels (m)	
(b)	Fine Screen Channels		
	(i)	No. of units	
	(ii)	Capacity of each unit (MLD)	
	(iii)	Size of channel (m)	
	(iv)	Max, Average, and Min water levels (m)	
	(v)	Head loss (m)	

(c)	Fine Screen Effluent/Grit Basin Effluent Channel		
	(i)	Size of channel (m)	
	(ii)	No. and size of gated openings and type of gates – Screen Effluent	
	(iii)	No. and size of gated openings and weir gates – Grit Basin Influent	
	(iv)	Max, Average, and Min water levels (m)	
(d)	Grit Basins		
	(i)	Particle size to be removed (mm)	
	(ii)	Specific gravity	
	(iii)	Efficiency of removal (%)	
	(iv)	Size of grit basin influent structure (m)	
	(v)	Grit Basins - Number - Capacity, each MLD - Size, each (m)	
	(vi)	Surface overflow rate (m^3/m^2/day)	
	(vii)	Max, Average, and Min water levels in grit chamber (m)	
(e)	Grit Basin Effluent Channel		
	(i)	Size of channel (m)	
	(ii)	No. and size of gated openings and type of gates	
	(iii)	Max, Average, and Min water levels (m)	
	(v)	Size of Bypass channel/pipe (m)	
(f)	Distribution Chamber/Box		
		- Size of inlet channel - No. of branches - Size of each branch (m) - Size of weir gates (m)	
(g)	Aeration Basin Influent Channel		
		- Size of channel - No. of distribution branches - Size of each branch (m) - No. and size of gated openings and weir gates (m) - Size of Bypass channel/pipe (m) - Max, Average, and Min water levels (m)	
(h)	Secondary biological treatment Basins		

	(i)	- No. of basins
		- Max, Average, and Min water levels (m)
		- Volume per basin at (m^3)
		  - Min water level
		  - Average water level
		  - Max water level
		- Total volume at (m^3)
		  - Min water level
		  - Average water level
		  - Max water level
		- Total HRT at max water level (Hrs)
		- Total SRT excluding settling, decant, waste, and idle times (days)
		- SRT (days)
		- MLSS at (mg/L)
		  - Min water level
		  - Average water level
		  - Max water level
		- MLVSS at (mg/L)
		  - Min water level
		  - Average water level
		  - Max water level
		- No. of cycles per day per basin
		- Total cycle time (minutes)
		- Detailed breakdown of cycle time components (e.g., fill, react, mix, aerate, settle, decant, idle, waste, etc.) (minutes)
		- Length, width, and side-water depth of each basin (m)
		- Overall Length and Width for all basins (m)
		- Overall F/M ratio (Kg BOD removed/ Kg MLVSS/ day)
		- Mixed Liquor Recycle (MLR) ratio (if applicable)
		- MLR “From” and “To” locations	

(i)	Process Air Blower Building		
	(i) (ii) (iii)	Inside dimensions of blower/ MBR equipment room (Length x Width) (m) Inside dimensions of panel room (Length x Width) (m) Area allocated for loading / unloading (m^2) Height of Building (m)	
(j)	Return Activated Sludge Pumping Station		
	(i)	Dia. (mm) and length (m) of rising main for RAS	

	(ii)	Dia. (mm) and length (m) of rising main for WAS	
	(iii)	Size of RAS Pumps Station Building (m)	
	(iv)	All building slab elevations (m)	
(k)	Chlorine Contact Tank Influent Channel		
		- Size of channel - No. and size of gated openings and weir gates (m) - Size of bypass channel/pipe (m/mm)	
(l)	Chlorine Contact Tank(s)		
	(i)	Number of tanks	
	(ii)	Volume of each tank (m^3)	
	(iii)	Total hydraulic retention time (all tanks) at peak flow (min.)	
	(iv)	Overall Length and Width of all tanks (m)	
	(v)	No. of passes per tank	
	(vi)	Pass width (m)	
	(vii)	Max, Average, and Min water depth (m)	
	(viii)	Total length of travel of liquid per tank (m)	
	(ix)	Effective length-to-width ratio	
	(x)	Length and size, invert level of final effluent pipe/conduit to disposal point (m)	
(m)	Chlorine Contact Tank Effluent Channel		
		- Size of channel (m) - No. and size of gated openings and weirs or gates (m) - Diameter (mm) and length (m) of effluent outfall pipe to receiving water body	
(u)	Chlorination Building		
	(i) (ii) (iii)	Inside dimensions of chlorinator room (m) Inside dimensions of chlorine tonner room (m) Area allocated for loading / unloading (m^2) Height of Building (m)	
(n)	Chemical Building		
	(i) (ii) (iii)	Inside dimensions of alum storage room (m) Inside dimensions of alum solution tank room (m) Area allocated for loading / unloading (m^2) Height of Building (m)	
(o)	Gravity Sand Filters		

	(i) (ii) (iii) (iv) (v) (vi) (vii) (viii)	Design Flow No of unit Flow rate in GSF Backwash rate in GSF Duration of backwash Iodine Number Effective Size Uniformity Coefficient	
(w)	Gravity Sludge Thickener Distribution Structure		
		- Size of inlet chamber (m) - No. of branches - Size of each branch (m) - No. and size of gated openings and weir gates (m)	
(x)	Gravity sludge thickeners		
		- No. of thickeners - Diameter each (m) - Surface area each (m^2) - Side water depth (m) - Surface overflow rate ($m^3/m^2/day$) - Solids loading rate ($Kg/m^2/day$) - Bottom floor slope	
(y)	Thickened Sludge Pumping Station		
	(i)	Building inside dimensions (m)	
	(ii)	All building slab elevations (m)	
	(iii)	Dia. (mm) and length (m) of rising main	
(z)	Anaerobic Sludge Digester(s)		
		- Type/Shape - No. of units - Full inside dimensions, each (m) - SRT (days) - Side water depth (m) - Bottom floor shape and description - Diameter (mm) and length (m) of inlet and outlet pipes	
(aa)	Digested Sludge/Bioas Storage Tank(s)		

		- Type/Shape - No. of units - Full inside dimensions, each (m) - Sludge HRT (days) - Gas HRT (hours) - Side water depth (m) - Bottom floor slope - Diameter (mm) and length (m) of inlet and outlet pipes	
(ab)	Digester Building		
	(i)	Building inside dimensions (m)	
	(ii)	Height of Building (m)	
	(iii)	All building slab elevations (m)	
	(iv)	Dimensions of all internal areas and spaces within building (m)	
(af)	Sludge Dewatering Building		
	(i)	Building inside dimensions (m)	
	(ii)	Height of Building (m)	
	(iii)	All building slab elevations (m)	
	(iv)	Dimensions of all internal areas and spaces within building (m)	
(ag)	Plant Water Pumping Station		
	(i)	Full dimensions of structure (m)	
	(ii)	All structural slab elevations (m)	
	(iii)	Dia. (mm) and length (m) of rising main	
(ah)	Plant Drain Pumping Station		
	(i)	Full dimensions of structure (m)	
	(ii)	All structural slab elevations (m)	
	(iii)	Dia. (mm) and length (m) of rising main	
(ai)	Administration cum Laboratory Building		
	(i) (ii) (iii) (iv) (v) (vi) (vii) (viii) (ix) (x) (xi)	Inside Dimensions of building (m x m) Inside Dimensions of office room (m x m) Inside Dimensions of SCADA room (m x m) Inside Dimensions of laboratory room (m x m) Inside Dimensions of conference hall (m x m) Inside Dimensions of administrative room (m x m) Inside Dimensions of store room (m x m) Inside Dimensions of Pantry/Kitchen (m x m) Inside Dimensions of Toilet (m x m) Inside Dimensions of other room if any (m x m) Height of Building (m)	

(aj)	Maintenance Workshop/ Store room (for plant capacity equal to and more than 20 MLD)		
	(i)	Inside Dimensions of Maintenance Workshop/Store room (m x m)	
	(ii)	Height of Building (m)	
	Area allocated for transformer yard (m^2)		
(ak)	Size of DG set room for STP (m x m x m)		
(al)	Size of Switch Gear room (m x m x m)		
(am)	Area allocated for transformer yard (m^2)		
(an)	No. and Size of MCC rooms (m x m x m)		
	Width and Height of entrance gate (m) and wicket gate (m) with arrangement for cow guard		
(ao)	Size of security shed (m x m x m)		
(ap)	Area allocated for green belt (m^2)		
(aq)	Area allocated for two wheeler and four wheeler parking (m^2)		
(ar)	Width and length of approach road to site (m)		
(as)	Width and length of roads inside the plant (m)		
(at)	Internal drainage, water supply, and waste water disposal		
	(i)	No. and Size of bore/tube well (mm)	
	(ii)	Storm water drain provision (size, length in m)	
	(iii)	Water Supply and Sewerage Provision (Yes/No) - Capacity and size of water storage tank (m^3) - Capacity and size of overhead tank (m^3) - Capacity and size of septic tank (if required) (m^3)	
	(iv)	Nos. and size of Culverts, road crossing, etc.	
(au)	Reclamation / Site Development – If Applicable		
	(i)	Proposed area of Reclamation (m^2)	
	(ii)	Top levels after Reclamation (m)	
	(iii)	Average depth of filling (m)	
	(iv)	Total quantity of earth required (m^3)	
	(v)	Side slope of the filling	
	(vi)	Slope protection measures	
	(vii)	Proposed compaction equipment to be deployed (Type and No.)	
	(viii)	Test apparatus to be provided in field soil laboratory	
	(ix)	Proposed open channel dimension - Top width (m) - Bottom width (m) - Side slope - Longitudinal slope - Length (m)	

	(x)	Bottom slope protection for open channel	
	(xi)	Proposed equipment (type and number) for excavation, handling, transporting	
	(xii)	Borrow pit - Name of the Location (s) - Area (m^2) - Type of soil in general	
(av)	Miscellaneous		
	The Bidder shall list here details of any other / additional items required for a complete installation.		

Note: 1) Sizes of units shall mean Length x Width x Depth/Height as applicable and shall be expressed in “metres” unless otherwise stated.

2) Bidder shall furnish details in above table and write “NIL” wherever not applicable to the respective plant depending upon the process.

Request for Proposal

For

DEVELOPMENT OF BORSOLA BEEL

Design, Build and Operate Basis

Volume II D: Technical Datasheet for Mechanical

Client:

GUWAHATI SMART CITY LIMITED

GSCL,
Guwahati, Assam

DOCUMENT NO: 10477A-CV-3000-3102

Technical Datasheet for Mechanical (To be furnished by Bidder for SPS & STP covered in this tender)

3.1.1 Mechanical Coarse Screen – Bar Screen

S. No.	Description		Units	Particulars
(a)	**General**			
	(i)	Make		
	(ii)	Model		
	(iii)	Quantity (W+S)	Nos.	
	(iv)	Type		
(b)	**Screen**			
	(i)	Clear Spacing	mm	
	(ii)	Width	mm	
	(iii)	Height	mm	
	(iv)	Raking speed	m/min	
	(v)	Motor rating	kW	
	(vi)	Water Level	m	
(c)	**Materials of Construction**			
	(i)	Frame		
	(ii)	Rake carriage		
	(iii)	Screen bars		
	(iv)	Fasteners		
	(v)	Canopy		
(d)	**Belt Conveyor System**			
	(i)	Material of belt		
	(ii)	Width of conveyor	mm	
	(iii)	Speed of conveyor	m/sec	
	(iv)	Thickness of belt and ply rating		
	(v)	Make of the belt		
	(vi)	Motor rating	kW	
	(vi)	Safety device		
(e)	**Screw Conveyor System**			
	(i)	Make		
	(ii)	Material		

S. No.	Description		Units	Particulars
	(iii)	Speed	rpm	
	(iv)	Motor rating	kW	
	(v)	Size of screw	mm	
	(vi)	Angle of screw	deg	
(f)	**Unit Control Panel**			
	(i)	Make		
	(ii)	Over all dimensions	mm x mm x mm	
	(iii)	Degree of protection		
	(iv)	Timer		
		• Make • Type		
(g)	**Wash System (water)**			
	(i)	Operating Pressure	bar	
	(ii)	Flow Rate	ltrs./sec	
	(iii)	Source for Back Wash		

3.1.2 Manual coarse bar screen

Sr. No.	Description	Units	Particulars
(a)	**General**		
	(i) Make		
	(ii) Model		
	(iii) Quantity (W+S)	Nos.	
	(iv) Type		
(b)	**Screen**		
	(i) Clear Spacing	mm	
	(ii) Width	mm	
	(iii) Height	mm	
	(iv) Bar size (front x back x deph)	m/min	
(c)	**Materials of Construction** (i) Frame		

Sr. No.	Description	Units	Particulars
	(ii) Screen bars		
	(iii) Tines		
	(iv) Fasteners		
	(v) Canopy		

3.1.3 Submersible (Non-Clog) Raw Sewage Transfer Pump set

S. No.	Description	Units	Particulars
(a)	**General**		
	(i) Make		
	(ii) Model		
	(iii) Type		
	(iv) Quantity (W+S)	No.s	
(b)	**Performance**		
	(i) Capacity	cu.m/hr	
	(ii) Total head	mlc	
	(iii) Speed	rpm	
	(iv) Overall efficiency (Pump + Motor)	%	
	(v) Motor Rating	kW	
(c)	**Materials of Construction**		
	(i) Casing		
	(ii) Rotor		
	(iii) Stator		
	(iv) Line Shaft		
	(v) Mechanical Seal		
	(vi) Base Plate		
	(vii) Delivery pipe and diameter		
(d)	Weight	Kgs	
(e)	**Testing & Inspection:**		
	(i) Pump performance testing standard		

S. No.	Description	Units	Particulars
	(ii) Maximum Noise level	dB(A)	
	(iii) Maximum velocity of vibration	mm/sec	

3.1.4 Mechanical Fine Screen – Bar Screen

S. No.	Description		Units	Particulars
(a)	**General**			
	(i)	Make		
	(ii)	Model		
	(iii)	Quantity (W+S)	Nos.	
	(iv)	Type		
(b)	**Screen**			
	(i)	Clear Spacing	mm	
	(ii)	Width	mm	
	(iii)	Height	mm	
	(iv)	Raking speed	m/min	
	(v)	Motor rating	kW	
	(vi)	Water Level	m	
(c)	**Materials of Construction**			
	(i)	Frame		
	(ii)	Rake carriage		
	(iii)	Screen bars		
	(iv)	Fasteners		
	(v)	Canopy		
(d)	**Belt Conveyor System**			
	(i)	Material of belt		
	(ii)	Width of conveyor	mm	
	(iii)	Speed of conveyor	m/sec	
	(iv)	Thickness of belt and ply rating		
	(v)	Make of the belt		
	(vi)	Motor rating	kW	
	(vi)	Safety device		

S. No.	Description		Units	Particulars
(e)	**Screw Conveyor System**			
	(i)	Make		
	(ii)	Material		
	(iii)	Speed	rpm	
	(iv)	Motor rating	kW	
	(v)	Size of screw	mm	
	(vi)	Angle of screw	deg	
(f)	**Unit Control Panel**			
	(i)	Make		
	(ii)	Over all dimensions	mm x mm x mm	
	(iii)	Degree of protection		
	(iv)	Timer		
		• Make • Type		
(g)	**Wash System (water)**			
	(i)	Operating Pressure	bar	
	(ii)	Flow Rate	ltrs./sec	
	(iii)	Source for Back Wash		

3.1.5 Mechanical Fine Screen – Rotary Drum Screen (For MBR process)

S. No.	Description		Units	Particulars
(a)	**General**			
	(i)	Make		
	(ii)	Model		
	(iii)	Quantity (W+S)	Nos.	
	(iv)	Type		
(b)	**Screen**			
	(i)	Width	mm	
	(ii)	Height	mm	
	(iii)	Spacing/opening	mm	
	(iv)	Water Level	m	

S. No.	Description	Units	Particulars
	(v) Drum size		
	(vi) Raking speed	m/min	
	(vii) Motor rating	kW	
(c)	**Materials of Construction**		
	(i) Screen		
	(ii) Drum		
	(iii) Rake		
	(iv) Fasteners		
	(v) Screw conveyor		
	(vi) Chute		
	(vii) Canopy		
(d)	**Screw Conveyor System**		
	(i) Type		
	(ii) Width/diameter of conveyor	mm	
	(iii) Speed of conveyor	m/sec	
	(iv) Motor rating	kW	
(e)	**Unit Control Panel**		
	(i) Make		
	(ii) Over all dimensions	mm x mm x mm	
	(iii) Degree of protection		
	(iv) Screen operations control • Make • Type		
(f)	**Wash System**		
	(i) Operating Pressure	bar	
	(ii) Flow Rate	ltrs./sec	
	(iii) Source for Wash water		

3.1.6 Manual fine bar screen

Sr. No.	Description	Units	Particulars
(a)	**General**		
	(i) Make		
	(ii) Model		
	(iii) Quantity (W+S)	Nos.	
	(iv) Type		
(b)	**Screen**		
	(i) Clear Spacing	mm	
	(ii) Width	mm	
	(iii) Height	mm	
	(iv) Bar size (front x back x deph)	m/min	
(c)	**Materials of Construction**		
	(i) Frame		
	(ii) Screen bars		
	(iii) Tines		
	(iv) Fasteners		
	(v) Canopy		

3.1.7 Grit Removing Equipment

S. No.	Description		Units	Particulars
(a)	**General**			
	Make			
	Model			
	Quantity (W+S)			
	Type			
(b)	**Reduction Gear**			
	(i)	Make		
	(ii)	Type		
(c)	**Drive Motor**			
	(i)	Make		
	(ii)	Speed	rpm	
	(iii)	Rating	kW	

S. No.	Description		Units	Particulars
(d)	**Materials of Construction**			
	(i)	Scraper		
	(ii)	Frame		
	(iii)	Walkway		
(e)	**Classifier Mechanism**			
	(i)	Make		
	(ii)	Type		
	(iii)	Peripheral velocity	m/sec	
	(iii)	Size of the Equipment • Diameter • Height	 mm mm	
	(iv)	Drive System • Make of reduction gear • Make of motor		
	(v)	Material of rake		
	(vi)	Safety device		
(f)	**Screw Conveyor System**			
	(i)	Type		
	(ii)	Width/diameter of conveyor	mm	
	(iii)	Speed of conveyor	m/sec	
	(iv)	Motor rating	kW	
(g)	**Organic Return Pumpset**			
	(i)	Make &Type of • Pump • Motor		
	(ii)	Motor rating	kW	
	(iii)	Materials of Construction • Casing • Impeller • Shaft • Seal		

S. No.	Description		Units	Particulars
(h)	**Belt Conveyor System**			
	(i)	Material of belt		
	(ii)	Width of conveyor	mm	
	(iii)	Speed of conveyor	m/sec	
	(iv)	Thickness of belt and ply rating		
	(v)	Make of the belt		
	(vi)	Motor rating	kW	
	(vi)	Safety device		

3.1.7.1 Grit Mechanism

S.No.	Grit removal system	Units	Technical Particulars
	No of units		
	Type		
	Design criteria		
	Degree of separation b/w inlet and outlet		
	Head loss		
	Grit removal efficiency		
	Grit chamber upper section diameter		
	Inlet/effluent width		
	Max flow level upper chamber		
	Min. Total vormax depth		
	Lower chamber depth		
	Inlet height		
	Lower chamber diameter		
	Performance p		
	Voltage		
	Frequency		
	Nominal current		

S.No.	Grit removal system	Units	Technical Particulars
	Rotational speed		
	Make		
	No of units		
	Type		
	Design criteria		
	Degree of separation b/w inlet and outlet		
	Head loss		
	Grit removal efficiency		
	Grit chamber upper section diameter		
	Inlet/effluent width		
	Max flow level upper chamber		
	Min. Total vormax depth		
	Lower chamber depth		
	Inlet height		
	Lower chamber diameter		
	Performance p		
	Voltage		
	Frequency		
	Nominal current		
	Rotational speed		
	Make		

3.1.7.2 Grit Classifier cum Washer

S.No.	No of unit	Units	Technical Particulars
	Feed with grit/water mix		
	Maximum possible solid amount (dependent on raw material)		

S.No.	No of unit	Units	Technical Particulars
	Reductions of organics to		
	Guaranteed separation efficiency of		
	For grit or grain size		
	Surface overflow rate		
	Overflow weir load		
	Maximum handle able mineral grain size		
	Connection dimensions:		
	Inflow		
	Process flow		
	Organic discharge outlet		
	Connection for service water		
	Wash water demand		
	Drain outlet for complete for complete plant evacuation		
	Overall dimensions (mm) l x w x h		
	Through screw drive motor:		
	Performance p		
	Voltage u		
	Frequency		
	Nominal current in		
	Rotational speed n		
	Make		
	Protection grade		
	Stirrer drive motor:		
	Performance p		
	Voltage u		
	Frequency		
	Nominal current in		
	Rotational speed n		
	Make		
	Protection grade		
	Drive motor for organic discharge (electric valve):		
	Performance p		
	Voltage u		
	Frequency		
	Make		
	Protection grade		
	Pressure probe:		
	Supply voltage		
	Output signal		
	Measuring range		
	Make		
	Process connection		

S.No.	No of unit	Units	Technical Particulars
	Solenoid valve:		
	Supply voltage		
	Performance		
	Make		
	Process connection		

3.1.8 Clarifiers

E	Sub S. No.	Description	Units	Particulars
(A)		**Primary Clarifiers**		
(a)		**General**		
	(i)	Number		
	(ii)	Flow per clarifier	cum/hr	
	(iii)	Up flow rate	m/h	
	(iv)	Diameter	m	
	(v)	Liquid depth each	m	
	(vi)	Free board	m	
	(vii)	Volume	cum	
(b)		**Scraping mechanism:**		
	(i)	Make		
	(ii)	Type		
	(iii)	Size (Diameter x SWD x FB)	m	
	(iv)	Scraper speed	rpm	
	(v)	Peripheral velocity	m/sec	
	(vi)	Design Torque	N-m	
	(vii)	Feed well size	mm	
	(viii)	Walkway (width x Height)	mm	
	(ix)	Weir plate size(Thick x width)	mm	
	(x)	Safety device		
(c)		**Speed reduction drive**		
	(i)	Make		
	(ii)	Type		
	(iii)	Speed reduction ratio		
	(iv)	Torque		
	(v)	Lubrication type		

E	Sub S. No.	Description	Units	Particulars
(d)		**Surface preparation & Protection:**		
	(i)	Wetted parts		
	(ii)	Exposed parts		
(e)		**Material of construction:**		
	(i)	Bridge and Superstructure		
	(ii)	Feed well		
	(iii)	Walkway Chequered Plates		
	(iv)	Squeegees		
	(v)	Weir plate		
	(vi)	Clamps & Hardware		
(f)		**Motor:**		
	(i)	Motor rating	kW	
	(ii)	Motor speed	rpm	
	(iii)	Motor Make		
	(iv)	Protection		
(B)		**Secondary Clarifiers**		
(a)		**General**		
	(i)	Number		
	(ii)	Flow per clarifier	cum/hr	
	(iii)	Diameter	M	
	(iv)	Up flow rate	m/h	
	(v)	Liquid depth each	M	
	(vi)	Free board	M	
	(vii)	Volume	cum	
	(vii)	Safety device		
(b)		**Scraping mechanism:**		
	(i)	Make		
	(ii)	Type		
	(iii)	Size (Diameter x SWD x FB)	M x M x M	
	(iv)	Scraper speed	rpm	
	(v)	Peripheral velocity	m/sec	
	(vi)	Torque rating	N-m	
	(vii)	Feed rate per Clarifier	cum/hr	
	(viii)	Feed well size	Mm	
	(ix)	Walkway (width x Height)	Mm	

E	Sub S. No.	Description	Units	Particulars
	(x)	Weir plate size (Thick x width)	Mm	
(c)		Speed Reduction Drive		
	(i)	Make		
	(ii)	Type		
	(iii)	Speed Reduction Ratio		
	(iv)	Torque		
	(v)	Lubrication Type		
(d)		**Surface preparation & Protection:**		
	(i)	Wetted parts		
	(ii)	Exposed parts		
(e)		**Material of construction:**		
	(i)	Bridge and Superstructure		
	(ii)	Feed well		
	(iii)	Walkway Chequered Plates		
	(iv)	Squeegees		
	(v)	Weir plate		
	(vi)	Clamps & Hardware		
(f)		**Motor :**		
	(i)	Motor rating	kW	
	(ii)	Motor speed	Rpm	
	(iii)	Motor Make		
	(iv)	Protection		

3.1.9 Primary Sludge Pumpset

S. No.	Description		Units	Particulars
(a)	**General**			
	(i)	Make		
	(ii)	Model		
	(iii)	Type		
	(iv)	Quantity (W+S)	No.s	

S. No.	Description		Units	Particulars
(b)	**Performance**			
	(i)	Capacity	cu.m/hr	
	(ii)	Total head	mlc	
	(iii)	Speed	rpm	
	(iv)	Overall efficiency (Pump + Motor)	%	
	(v)	Motor Rating	kW	
(c)	**Materials of Construction**			
	(i)	Casing		
	(ii)	Rotor		
	(iii)	Stator		
	(iv)	Line Shaft		
	(v)	Mechanical Seal		
	(vi)	Base Plate		
	(vii)	Delivery pipe and diameter		
(d)	Weight		Kgs	
(e)	**Testing & Inspection:**			
	(i)	Pump performance testing standard		
	(ii)	Maximum Noise level	dB(A)	
	(iii)	Maximum velocity of vibration	mm/sec	

3.1.10 Fine Bubble Air Diffusers

S. No.	Description		Units	Particulars
(a)	**General**			
	(i)	Make		
	(ii)	Model		
	(iii)	Type		
	(iv)	Diffuser OD x Length	mm x mm	
	(v)	Aeration/SBR Basin Dimensions (L x W x SWD)	mm x mm	

S. No.	Description		Units	Particulars
	(vi)	Design Air-Flow per Aeration/SBR Basin (Maximum/Average)	Nm^3/hr	
	(vii)	Quantity per Aeration/SBR Basin	No.	
	(viii)	Quantity in Aeration Basin Zone 1/Zone 2/...	No.	
	(ix)	Weight per Diffuser	Kg	
	(x)	Design air flow per diffuser	m^3/hr	
	(xi)	Efficiency per diffuser	%	
(b)	**Diffuser Membrane**			
	(i)	Type-self cleaning (Yes/No)		
	(ii)	No. of Membranes - Total	No.	
	(iii)	Membrane Material		
	(iv)	Means of attachment		
	(v)	Membrane OD X Length	mm x mm	
	(vi)	Pore size (Average)	mm	
	(vii)	No. of Pores per length of Diffuser	No./m	
	(viii)	Bubble size (Avg)	mm	
(c)	**Diffuser Assembly**			
	(i)	Make		
	(ii)	Type		
	(iii)	Length x Width	mm x mm	
	(iv)	Material of Construction		
	(v)	Coupling Type • Make • Model/Size		
	(vi)	Diffuser Assembly Weight	Kg	
(d)	**Materials of Construction**			
	(i)	Diffuser Tube		
	(ii)	Membrane		
	(iii)	Pipe clamps & Hardware		
	(iv)	Pipe Grid		
(e)	**Performance**			

S. No.	Description		Units	Particulars
	(i)	SOTE Oxygen transfer rate • Clear water • Field	%	
	(ii)	Zone of influence	m	
	(iii)	Zone of oxygenation	m	
	(iv)	Depth of mixing	m	
	(v)	Velocity thro' the Diffuser	m/sec	
	- -	Diffuser Head loss & Efficiency V/s Submergence Curve attached Diffuser Grid Drawing with retrievable arrangement details attached	Yes/No Yes/No	

3.1.11 Process Air Blowers

S. No.	Description		Units	Particulars
(a)	**General**			
	(i)	Make		
	(ii)	Type		
	(iii)	Quantity (W+S)	Nos.	
	(iv)	Capacity at NTP	m^3/min	
	(v)	Design maximum discharge pressure	mlc	
	(vi)	Efficiency	%	
	(vii)	Speed, blower	rpm	
	(viii)	Absorbed power	kW	
	(ix)	Motor rating	kW	
	(x)	Speed, motor	rpm	
	(xi)	Noise level at Duty Point in dB(A) at 1.86 m from the unit	dB(A)	
	(xii)	Vibration	mm/sec	
	(xiii)	With Acoustic Hood	dB(A)	
	(xiv)	Without Acoustic Hood	dB(A)	
	(xv)	Weight – Blower	kgs	
	(xvi)	Maximum lifting weight	kgs	

S. No.	Description		Units	Particulars
	(xvii)	Dimensions (L x W x H)	m x m x m	
	(xviii)	Coupling Type		
	(xix)	Coupling Make		
	(xx)	Cooling System		
(b)	**Material of construction:**			
	(i)	Casing		
	(ii)	Impeller/Lobes		
	(iii)	Shaft		
	(iv)	Common Base frame		
	(v)	Orientation		
(c)	**Acoustic Hood:**			
	(i)	Type		
	(ii)	Material of Construction		
(d)	**Inlet/Outlet silencer**			
	(i)	Type		
	(ii)	Make		
	(iii)	Filter media		
	(ii)	Mean air velocity	m/s	
(e)	**Noise reduction (mean) Air release valves**			
	(i)	Number	Nos.	
	(ii)	Diameter	mm	
	(iii)	Type		
	(iv)	Set pressure	bar	
	(v)	Make		
(f)	**Delivery non-return valves**			
	(i)	Number	Nos.	
	(ii)	Diameter	mm	
	(iii)	Type		
	(iv)	Make		
(g)	**Delivery isolation valves**			
	(i)	Number	Nos.	
	(ii)	Diameter	mm	
	(iii)	Type		
	(iv)	Make		

3.1.12 RAS Pump set

S. No.	Description	Units	Particulars

(a)	**General**			
	(i)	Make		
	(ii)	Model		
	(iii)	Type		
	(iv)	Quantity (W+S)	No.s	
(b)	**Performance**			
	(i)	Capacity	cu.m/hr	
	(ii)	Total head	mlc	
	(iii)	Speed	rpm	
	(iv)	Overall efficiency (Pump + Motor)	%	
	(v)	Motor Rating	kW	
(c)	**Materials of Construction**			
	(i)	Impeller		
	(ii)	Casing		
	(iii)	Shaft		
	(iv)	Delivery pipe and diameter		
	(v)	Mechanical Seal		
(d)	Weight		Kg	
(e)	Accessories and piping as specified (Provided / Not provided)			
(f)	**Testing & Inspection:**			
	(i)	Pump performance testing standard		
	(ii)	Maximum Noise level	dB(A)	
	(iii)	Maximum velocity of vibration	mm/sec	
(g)	**Motor :**			
	(i)	Make		
	(ii)	Type		
	(iii)	Model		
	(iv)	Quantity (W+S)		
	(v)	Rating	kW	
	(vi)	Weight	kgs	

3.1.13 Manually Operated Travelling Crane/Monorail Travelling Trolley – RASPS

S. No.	Description		Units	Particulars
(a)	**Make**			
	(i)	Crane		
	(ii)	Chain pulley block		
	(iii)	Trolley		
(b)	**Crane**			
	(i)	Capacity	Tonne	
	(ii)	Type		
	(iii)	Lift	m	
	(iv)	Span	m	
	(v)	Hook approach	m	
	(vi)	Rail size	kg/m	
	(vii)	Crane girder size	mm	
	(viii)	Type of brake		

Note : RASPS - Return Activated Sludge Pumping Station

3.1.14 Chlorination System

S. No.	Sub S. No.	Description	Units	Particulars
(a)		**Automatic Changeover Device**		
	(i)	Make		
	(ii)	Type		
	(iii)	Quantity (W+S)		
	(iv)	Model		
(b)		**Chlorinator**		
	(i)	Make		
	(ii)	Type		
	(iii)	Quantity (W+S)		
	(iv)	Model		
	(v)	Max capacity	kg/hr	
	(vi)	Min Capacity	kg/hr	
	(vii)	Accuracy as a percent of actual rate in the operating range	±%	
	(viii)	Details of Instruments		

S. No.	Sub S. No.	Description	Units	Particulars
		mounted		
	(ix)	Cabinet Material		
(c)		**Chlorine load Cell (weighing scale)**		
	(i)	Make		
	(ii)	Type		
	(iii)	Range		
	(iv)	Quantity (W+S)		
(d)		**Chlorine leak detector**		
	(i)	Make		
	(ii)	Type		
	(iii)	Range		
	(iv)	Quantity (W+S)		
	(v)	Location		
	(vi)	Adjustable range of Alarm		
	(vii)	State whether separate alarms for leak detection and leak detector equipment failure are provided		
(e)		**Chlorine Tonners and Roller supports**		
	(i)	Make		
	(ii)	Type		
	(iii)	Quantity (W+S) - Chlorine tonners - Roller supports	Nos	
	(iv)	Tonner capacity	Kgs	
	(v)	Material of construction:		
		Body		
		Rollers		
		Bush		
(f)		**Liquid Chlorine Pipe work, valves and fittings:**		
	(i)	Make		
	(ii)	Type		
	(iii)	Quantity (W+S)	Nos	
	(iv)	Rating		
(g)		**Material of construction:**		
	(i)	Pipe		

S. No.	Sub S. No.	Description	Units	Particulars
	(ii)	Fittings		
	(iii)	Valves		
	(iv)	Type		
	(v)	Body		
	(vi)	Shaft		
	(vii)	Plug/Disc/Diaphragm		
(h)		**Valve Actuator:**		
	(i)	Make		
	(ii)	Type		
	(iii)	Model		
(i)		**Pressure Gauges:**		
	(i)	Make		
	(ii)	Type		
	(iii)	Range		
(j)		**Gas Chlorine Pipe work, valves and fittings:**		
	(i)	Make		
	(ii)	Type		
	(iii)	Quantity (W+S)		
	(iv)	Rating		
(k)		**Material of construction:**		
	(i)	Pipe		
	(ii)	Fittings		
	(iii)	Valves		
	(iv)	Type		
	(v)	Quantity		
	(vi)	Body		
	(vii)	Shaft		
	(viii)	Plug/Disc/Diaphragm		
(l)		**Valve Actuator:**		
	(i)	Make		
	(ii)	Type		
	(iii)	Quantity (W+S)	Nos	
	(iv)	Model		
(m)		**Pressure Gauges:**		
	(i)	Make		
	(ii)	Type		
	(iii)	Range		
(n)		**Chlorine Ejectors:**		

S. No.	Sub S. No.	Description	Units	Particulars
	(i)	Make		
	(ii)	Type		
	(iii)	Quantity (W+S)	Nos	
	(iv)	Model	Nos	
	(v)	Rating		
	(vi)	Material of construction :		
	(vii)	End connections		
(o)		**Tonner lifting Beam with Hooks**		
	(i)	Make		
	(ii)	Quantity (W+S)		
	(iii)	Material of construction		
(p)		**Chlorine Tonner weighing equipment**		
	(i)	Make		
	(ii)	Type		
	(iii)	Quantity (W+S)		
	(iv)	Range		
	(v)	Accuracy		
(q)		**Safety Equipment:**		
	(i)	Make:		
	(ii)	Quantity:		
	(iii)	Type:		
	(iv)	Self contained breathing apparatus quantity		
	(v)	Positive air-line breathing apparatus quantity		
	(vi)	Instant action resuscitators quantity		
	(vii)	Safety clothing complete set quantity		
	(viii)	Emergency showers quantity		
	(ix)	Eye Baths quantity		
	(x)	Portable compressor, recharging cylinder, quick release coupling complete set quantity		
(r)		**Chlorine Gas scrubber :**		
	(i)	Make		
	(ii)	Type		
	(iii)	Model		

S. No.	Sub S. No.	Description	Units	Particulars
	(iv)	Quantity (W+S)		
	(v)	Rating	kW	
	(vi)	Weight	kg	
	(vii)	Capacity	Kgs	
	(viii)	Caustic pump capacity/head	Cum/hr	
	(ix)	Blower capacity/pressure	Cum/hr	

3.1.15 Chlorine Building Ventilation

S. No.	Sub S. No.	Description	Units	Particulars
		Chlorine cylinder room		
(a)		**Exhaust fans:**		
	(i)	Make		
	(ii)	Model		
	(iii)	Quantity(W+S)		
	(iv)	Capacity	m^3/s	
	(v)	Speed	rpm	
	(vi)	Motor rating	kW	
(b)		**Ducting :**		
	(i)	Standard		
	(ii)	Type		
	(iii)	Dimension		
	(iv)	Material		
(c)		**Chlorinator Room:**		
	(i)	Exhaust fans		
	(ii)	Make		
	(iii)	Model		
	(iv)	Quantity (W+S)		
	(v)	Capacity	m^3/s	
	(vi)	Speed	rpm	
	(vii)	Motor rating	kW	
(d)		**Ducting :**		
	(i)	Standard		
	(ii)	Type		
	(iii)	Dimension		
	(iv)	Material		

3.1.16 Cranes Hoists

S. No.	Sub S. No.	Description	Units	Particulars
(a)	**Chemical Handling Crane**			
	(i)	Make		
	(ii)	Type and class		
	(iii)	Safe working Load	tonne	
	(iv)	Hoist speed high/low	m/min	
	(v)	Long Travel speed	m/min	
	(vi)	Cross travel speed	m/min	
	(vii)	Span	m	
(b)	**Hoisting Rope:**			
	(i)	Diameter		
	(ii)	Construction		
	(iii)	Quality of steel		
	(iv)	Minimum Breaking Load	Kgs	
	(v)	Factor of safety		
(c)	**Motors for Hoist/Long travel/cross travel :**			
	(i)	Make		
	(ii)	Type		
	(iii)	Rating		
(d)	**Details of Brakes for Hoist/cross travel/Long travel:**		kW	
	(i)	Make		
	(ii)	Design Holding Torque		
	(iii)	Net weight		
(e)	**Electric Hoist – MLR Pump Area**			
	(i)	Make		
	(ii)	Type and class		
	(iii)	Safe working Load	tonne	
	(iv)	Hoist speed high/low	m/min	
	(v)	Long Travel speed	m/min	
	(vi)	Cross travel speed	m/min	
	(vii)	Span	m	
(f)	**Hoisting Rope:**			
	(i)	Diameter	mm	
	(ii)	Construction		
	(iii)	Quality of steel		
	(iv)	Minimum Breaking Load	kgs	

S. No.	Sub S. No.	Description	Units	Particulars
	(v)	Factor of safety		
(g)	**Motors for Hoist/Long travel/cross travel :**			
	(i)	Make		
	(ii)	Type		
	(iii)	Rating	kW	
(h)	**Details of Brakes for Hoist/cross travel/Long travel:**			
	(i)	Make		
	(ii)	Design Holding Torque	N-mm	
	(iii)	Net weight	kgs	
(i)	**Dewatering Building-Crane**			
	(i)	Make		
	(ii)	Type and class		
	(iii)	Safe working Load	tonne	
	(iv)	Hoist speed high/low	m/min	
	(v)	Long Travel speed	m/min	
	(vi)	Cross travel speed	m/min	
	(vii)	Span	m	
(j)	**Hoisting Rope:**			
	(i)	Diameter		
	(ii)	Construction		
	(iii)	Quality of steel		
	(iv)	Minimum Breaking Load	kg	
	(v)	Factor of safety		
(k)	**Motors for Hoist/Long travel/cross travel :**			
	(i)	Make		
	(ii)	Type		
	(iii)	Rating	kW	
(l)	**Details of Brakes for Hoist/cross travel/Long travel:**			
	(i)	Make		
	(ii)	Design Holding Torque	N.m	
	(iii)	Net weight	kg	
(m)	**EOT Crane– Process Air Blower Room**			
	(i)	Make		
	(ii)	Type and class		

S. No.	Sub S. No.	Description	Units	Particulars
	(iii)	Safe working Load	tonne	
	(iv)	Hoist speed high/low	m/min	
	(v)	Long Travel speed	m/min	
	(vi)	Cross travel speed	m/min	
	(vii)	Span	m	
(n)	**Hoisting Rope:**			
	(i)	Diameter	mm	
	(ii)	Construction		
	(iii)	Quality of steel		
	(iv)	Minimum Breaking Load	kgs	
	(v)	Factor of safety		
(o)	**Motors for Hoist/Long travel/cross travel :**			
	(i)	Make		
	(ii)	Type		
	(iii)	Rating	kW	
(p)	**Details of Brakes for Hoist/cross travel/Long travel:**			
	(i)	Make		
	(ii)	Design Holding Torque	N-mm	
	(iii)	Net weight	kgs	

3.1.17 Plant Water Pumps

S. No.	Sub S. No.	Description	Units	Particulars
(a)	(i)	Tank capacity	cum	
	(ii)	Tank Dimensions	mm	
(b)		Pump		
	(i)	Pump Make		
	(ii)	Type		
	(iii)	Model		
	(iv)	Quantity (W+S)	Nos.	
	(v)	Capacity	m^3/s	
	(vi)	Head	mlc	
	(vii)	Shut off Head	metres	
	(viii)	NPSH required	metres	
	(ix)	Submergence required	metres	
	(x)	Efficiency	%	
	(xi)	Absorbed power at duty point	kW	
	(xii)	Motor rating	kW	

S. No.	Sub S. No.	Description	Units	Particulars
	(xiii)	Speed	rpm	
(c)		**Material of construction:**		
	(i)	Casing		
	(ii)	Impeller		
	(iii)	Shaft		
	(iv)	Sleeves		
	(v)	Sealing		
	(vi)	Discharge size	mm	
	(vii)	Suction size	mm	
	(viii)	Flange Drilling standard:		
	(ix)	Weight (Pump + Motor)	kgs	
(d)		**Testing & Inspection:**		
	(i)	Pump performance testing standard		
	(ii)	Maximum Noise level	dB(A)	
	(iii)	Maximum velocity of vibration	mm/sec	
(e)		**Motor :**		
	(i)	Make		
	(ii)	Type		
	(iii)	Model		
	(iv)	Quantity (W+S)		
	(v)	Rating	kW	
	(vi)	Weight	kgs	

3.1.18 Gates+

S. No.	Sub S. No.	Description	Units	Particulars
(a)	(i)	Make		
	(ii)	Model		
	(iii)	Quantity (W+S)		
	(iv)	Service		
	(v)	Type		
	(vi)	Spindle Type		
	(vii)	Size	mm x mm	
	(viii)	Weight	kgs	
	(ix)	Seating Head	m	
	(x)	Unseating Head	m	
(b)		**Material of construction:**		
	(i)	Wall Thimble		
	(ii)	Gate		
	(iii)	Frame		

S. No.	Sub S. No.	Description	Units	Particulars
	(iv)	Spindle		
	(v)	Stem coupling		
	(vi)	Seating face		
	(vii)	Wedge		
	(viii)	Headstock		
	(ix)	Gear House cover & stem guide		
	(x)	Lift Nut		
	(xi)	Fasteners & Anchors		
	(xii)	Lifting mechanism, Gear House & stem guide		
(c)		**Gate Actuators +**		
	(i)	Make		
	(ii)	Type		
	(iii)	Model		
	(iv)	Service		
	(v)	Number	Nos	
	(vi)	Motor Rating	kw	
	(vii)	Motor speed	rpm	
	(viii)	Protection		
	(ix)	Gear Reducer Make		
	(x)	Type		

+Bidder to provide above details for each size of Gate and Service

3.1.19 Valves #

S. No.	Sub S. No.	Description	Units	Particulars
(a)		**Butterfly valves :#**		
	(i)	Make		
	(ii)	Type		
	(iii)	Model		
	(iv)	Service		
	(v)	Quantity (W+S)	Nos.	
	(vi)	Size	mm	
	(vii)	Rating	PN	
	(viii)	Test pressure	bar	
		Material of construction		

S. No.	Sub S. No.	Description	Units	Particulars
	(ix)	Body		
	(x)	Disc		
	(xi)	Sealing face		
	(xii)	Shaft		
		Gear Reducers		
	(i)	Make		
	(ii)	Material		
	(iii)	Flange Drilling standard		
(b)		**Butterfly Valve Actuators #**		
	(i)	Make		
	(ii)	Type		
	(iii)	Model		
	(iv)	Service		
	(v)	Quantity (W+S)	Nos.	
	(vi)	Motor rating	kW	
	(vii)	Design Torque	N-m	
	(viii)	Time for full open to full close	seconds	
(c)		**Plug valve**		
	(i)	Make		
	(ii)	Type		
	(iii)	Model		
	(iv)	Service		
	(v)	Quantity (W+S)	Nos.	
	(vi)	Size	mm	
	(vii)	Rating	PN	
	(viii)	Test pressure	bar	
	(ix)	Body material		
(d)		**Non-return valves #**		
	(i)	Make		
	(ii)	Type		
	(iii)	Model		
	(iv)	Service		
	(v)	Quantity (W+S)	Nos.	
	(vi)	Size	mm	
	(vii)	Rating	PN	
	(viii)	Test Pressure	bar	
	(ix)	Design standard		
	(v)	Flange drilling standard		
(e)		**Material of construction:**		
	(i)	Body		
	(ii)	Disc/plates		
	(iii)	Spring		

S. No.	Sub S. No.	Description	Units	Particulars
	(iv)	Shaft		
(f)		**Sluice valves :#**		
	(i)	Make		
	(ii)	Type		
	(iii)	Model		
	(iv)	Service		
	(v)	Number	Nos	
	(vi)	Size	mm	
	(vii)	Rating	PN	
	(viii)	Test pressure	bar	
		Material of construction		
	(ix)	Body		
	(x)	Gate		
	(xi)	Sealing face		
	(xii)	Shaft		
		Gear Reducers		
	(i)	Make		
	(ii)	Material		
	(iii)	Flange Drilling standard		
(g)		**Sluice Valve Actuators #**		
	(i)	Make		
	(ii)	Type		
	(iii)	Number		
	(iv)	Motor rating	kW	
	(v)	Design Torque	N-m	
	(vi)	Time for full open to full close	seconds	
(h)		**Knife Gate valves :#**		
	(i)	Make		
	(ii)	Type		
	(iii)	Model		
	(iv)	Service		
	(v)	Number		
	(vi)	Size	mm	
	(vii)	Rating	PN	
	(viii)	Test pressure	bar	
	(ix)	Body material		
	(x)	gate material		
	(xi)	Sealing face material		
	(xii)	Shaft material		
	(xiv)	Gear Reducers :		
	(xv)	Make		

S. No.	Sub S. No.	Description	Units	Particulars
	(xvi)	Material		
	(xvii)	Flange Drilling standard		
(i)		**Knife Gate Valve Actuators #**		
	(i)	Make		
	(ii)	Type		
	(iii)	Number		
	(iv)	Motor rating	kW	
	(v)	Design Torque	kg-m	
	(vi)	Time for full open to full close	seconds	
(j)		**Telescopic valve**		
	(i)	Make		
	(ii)	Quantity (W+S)	Nos.	
	(iii)	Type		
	(iv)	Pressure rating	PN	
	(v)	Diameter /size	m	
	(vi)	End connection		
	(vii)	Material of construction:		
	(viii)	Valve Body		
	(ix)	Spindle		
	(x)	Disc/gate		
	(xi)	Lining		
	(xii)	Fasteners		

Bidder to provide above details for each size, type of Valve and Service

3.1.20 Gravity Thickeners

S. No.	Sub S. No.	Description	Units	Particulars
(a)	(i)	Make		
	(ii)	Type		
	(iii)	Quantity (W+S)	Nos.	
	(iv)	Size (Diameter x SWD x FB)	m	
	(v)	Scraper speed	rpm	
	(vi)	Peripheral Velocity	m/s	
	(vii)	Design Torque	N-m	
	(viii)	Feed rate per thickener	cum/hr	
	(ix)	Feed well size	mm	

S. No.	Sub S. No.	Description	Units	Particulars
	(x)	Walkway (width x Height)	mm	
	(xi)	Weir plate size (Thick x width)	mm	
(b)		**Surface preparation & protection:**		
	(i)	Wetted parts		
	(ii)	Exposed parts		
(c)		**Material of construction:**		
	(i)	Bridge and Superstructure		
	(ii)	Feed well		
	(iii)	Shaft		
	(iv)	Walkway Gratings		
	(v)	Squeegees		
	(vi)	Weir plate		
	(vii)	Clamps & Hardware		
(d)		**Motor :**		
	(i)	Motor rating	kW	
	(ii)	Motor speed	rpm	
	(iii)	Make		
	(iv)	Protection		

3.1.21 Thickened Sludge Pumps

E	Sub S. No.	Description	Units	Particulars
(a)	(i)	Make		
	(ii)	Type		
	(iii)	Model		
	(iv)	Quantity (W+S)		
	(v)	Capacity	cum/hr	
	(vi)	Head	mlc	
	(vii)	Efficiency	%	
	(viii)	Max.solid size	mm	
	(ix)	Speed	rpm	
	(x)	Motor rating	kW	
(b)		**Material of construction :**		
	(i)	Casing		
	(ii)	Rotor		
	(iii)	Stator		

E	Sub S. No.	Description	Units	Particulars
	(iv)	Line shaft		
	(v)	Sealing		
	(vi)	Base Plate		
	(i)	Protection		
	(ii)	Flange drilling standard		
	(iii)	Suction diameter	mm	
	(iv)	Discharge diameter	mm	
	(xi)	Coupling type/make		

3.1.22 Sludge Storage Tank Stirrer

S. No.	Sub S. No.	Description	Units	Particulars
(a)	(i)	Make		
	(ii)	Type		
	(iii)	Model		
	(iv)	Quantity (W+S)		
(b)		**Material of construction**		
	(i)	Casing		
	(ii)	Impeller		
	(iii)	Shaft		
	(iv)	Mechanical seal		
	(v)	Guide mechanism with winch		
(c)		**Design/Construction features**		
	(i)	Impeller Diameter	mm	
	(ii)	Rotation speed	rpm	
	(iii)	Immersion depth	mm	
	(iv)	Absorbed power	kW	
	(v)	Maximum Lifting weight	kgs	
(d)		**Motor**		
	(i)	Make		
	(ii)	Rating	kW	
	(iii)	Protection		
	(iv)	Voltage	V	
	(v)	Frequency	Hz	
	(vi)	Insulation		
	(vii)	Rated speed	rpm	

3.1.23 Polyelectrolyte Dosing Pumps

S. No.	Sub S. No.	Description	Units	Particulars
(a)		**Pumps**		
	(i)	Make		
	(ii)	Type		
	(iii)	Quantity (W+S)	nos	
	(iv)	Model		
	(v)	Capacity max/min	l/s	
	(vi)	Head	mlc	
	(vii)	Stroke adjustment	mm	
	(viii)	Stroking speed max/min	spm	
	(ix)	Casing material		
	(x)	Diaphragm material		
	(xi)	Shaft material		
	(xiii)	Motor rating	kW	
	(xiv)	Motor Make		
(b)		**Polyelectrolyte preparation Tank:**		
	(i)	Make		
	(ii)	Model		
	(iii)	Quantity (W+S)		
	(iv)	Size (Diameter x Height)	m x m	
	(v)	Material of construction		
(c)		**Poly solution Agitator**		
	(i)	Make		
	(ii)	Model		
	(iii)	Type		
	(iv)	Quantity (W+S)		
	(v)	Motor rating	kW	
	(vi)	Motor speed	rpm	
	(vii)	Mixer speed	rpm	
	(viii)	Impeller material		
	(ix)	Shaft material		
	(x)	Solids recovery		

3.1.24 Centrifuge Feed Pumps

S. No.	Sub S. No.	Description	Units	Particulars

S. No.	Sub S. No.	Description	Units	Particulars
(a)	(i)	Make		
	(ii)	Type		
	(iii)	Model		
	(iv)	Quantity (W+S)		
	(v)	Capacity	l/s	
	(vi)	Head	mlc	
	(vii)	Efficiency	%	
	(viii)	Max. Solid size	mm	
	(ix)	Power absorbed	kW	
	(x)	Speed	rpm	
	(xi)	Motor rating	kW	
	(xii)	Motor Make		
(b)		**Material of construction**		
	(i)	Casing		
	(ii)	Rotor		
	(iii)	Stator		
	(iv)	Line shaft		
	(v)	Sealing		
	(vi)	Base Plate		
(c)		**Construction Features**		
	(i)	Flange drilling standard		
	(ii)	Suction diameter	mm	
	(iii)	Discharge diameter	mm	
	(iv)	Coupling type/make		

3.1.25 Centrifuges / Filter Press

S. No.	Sub S. No.	Description	Units	Particulars
(a)	(i)	Make		
	(ii)	Type		
	(iii)	Model		
	(iv)	Quantity (W+S)	No.s	
	(v)	Feed rate per centrifuge	cum/hr	
	(vi)	Mass feed rate		

S. No.	Sub S. No.	Description	Units	Particulars
	(vii)	% dried solids		
	(viii)	Noise level (dBA) at 1m distance from the machine	dB(A)	
	(ix)	Vibration level		
	(xi)	Bowl Diameter	mm	
	(xiii)	Bowl length	mm	
	(xiv)	Taper Angle	degrees	
	(xv)	Bowl speed	rpm	
	(xvi)	Centrifugal force	Kgf	
	(xvii)	Gear Box ratio		
	(xviii)	Overall Dimension	mm	
	(xix)	Weight (Centrifuge + Motor)	kgs	
	(xx)	Protection of centrifuge		
(b)		**Material of Construction:**		
	(i)	Bowl		
	(ii)	Scroll		
	(iii)	Blade		
	(iv)	Scroll lead face protection		
	(v)	Casing-Upper & Lower		
	(vi)	Wear protection		
(c)	I	Motor :		
	(i)	Make		
	(ii)	Motor rating(Main Drive)	kW	
	(iii)	Motor speed	rpm	
	(iv)	Make of Motor		
	(v)	Insulation class		
	(vi)	Enclosure		
	(vii)	Voltage & Frequency		
	II (i)	Motor -Main drive Make		
	(ii)	Motor rating	kW	
	(iii)	Motor speed	rpm	
	(iv)	Make of Motor		
	(v)	Insulation class		
	(vi)	Enclosure		

S. No.	Sub S. No.	Description	Units	Particulars
	(vii)	Voltage & Frequency		
		Motor -Back drive Make		
	(i)	Motor rating	kW	
	(ii)	Motor speed	rpm	
	(iii)	Make of Motor		
	(iv)	Insulation class		
	(v)	Enclosure		
	(vi)	Voltage & Frequency		

3.1.26 Cake Hopper

S. No.	Sub S. No.	Description	Units	Particulars
	(i)	Make		
	(ii)	Model		
(a)	(iii)	Type		
	(iv)	Capacity	Kgs/min.	
	(v)	Dimensions	mxm	
	(vi)	Material of Construction		
(b)		**Motor**		
	(i)	Make		
	(ii)	Rating	kW	
	(iii)	Speed	rpm	
	(iv)	Insulation class		
	(v)	Enclosure		
	(vi)	Voltage & Frequency		

3.1.27 Belt Conveyor system

S. No.	Sub S. No.	Description	Units	Particulars
(a)	(i)	Make		
	(ii)	Model		

S. No.	Sub S. No.	Description	Units	Particulars
	(iii)	Type		
	(iv)	Quantity (W+S)	nos	
	(v)	Capacity	Kgs/min.	
	(vi)	Length of conveyor	m	
	(vii)	Angle of Inclination		
	(viii)	Belt width	mm	
	(ix)	Jointing detail/type		
	(x)	Belt rating		
	(xi)	Belt speed		
	(xiii)	Belt scraper-Type / No.		
(b)		**Motor**		
	(i)	Make	`	
	(ii)	Rating	kW	
	(iii)	Speed	rpm	
	(iv)	Insulation class		
	(v)	Enclosure		
	(vi)	Voltage & Frequency		

3.1.28 Air-conditioning Equipment (For SCADA Room)

S. No.	Sub S. No.	Description	Units	Particulars
(a)	(i)	Make		
	(ii)	Model		
	(iii)	Type		
	(iv)	Capacity	TR	
	(v)	Quantity	Nos.	
	(vi)	Motor Rating	kW	
	(vii)	Air-Ducting :		
	(viii)	Material		
	(ix)	Size		
	(x)	Quantity		
	(xi)	Whether all the required accessories are provided	Yes/No	

3.1.29 Gas Flare system

S. No.	Sub S. No.	Description	Units	Particulars
(a)	(i)	Make		
	(ii)	Model		
	(iii)	Type		
	(iv)	Capacity		
	(v)	Quantity (W+S)		
	(vi)	Height		
	(vii)	Diameter		
	(viii)	Material of Construction :		
	(ix)	Frame		
	(x)	Flame Tube		
	(xi)	Combustion Chamber		

3.1.30 Plant water Pumps

S. No.	Sub S. No.	Description	Units	Particulars
(a)	(i)	Make		
	(ii)	Type		
	(iii)	Service/Location		
	(iv)	Quantity (W+S)	Nos.	
	(v)	Capacity	cum/hr	
	(vi)	Head	mlc	
	(vii)	Efficiency	%	
	(viii)	Power absorbed	kW	
	(ix)	Speed	rpm	
	(x)	Motor rating	kW	

Note: Bidder shall furnish details in above table and write “NIL” wherever not applicable.

Request for Proposal

For

DEVELOPMENT OF BORSOLA BEEL

Design, Build and Operate Basis

Volume III A: Data Sheets for Instrumentation & Control System

Client:

GUWAHATI SMART CITY LIMITED

GSCL,
Guwahati, Assam

DOCUMENT NO: 10477A-CV-3000-3102

TECHNICAL DATA SHEETS

(TO BE FILLED IN BY THE BIDDER)

INSTRUMENTATION & CONTROL SYSTEM

CONTENTS

1. RADAR LEVEL TRANSMITTER

1.	**GENERAL**	
2.	MANUFACTURER :xxxx	*
3.	MODEL NO.: xxxx	*
4.	SERVICE : REFER P&ID	
5.	ACCURACY : +/-3 MM WHEN DISTANCE ≤ 10 MTRS ☐ 0.1% OR BETTER WHEN DISTANCE ≥ 10 MTRS ☐	✓
6.	SIL ___ CERTIFIED AS PER IEC 60508 / 60511	x
7.	LEVEL SENSOR ASSEMBLY	
8.	RANGE :xxxx	*
9.	RADAR SIGNAL TYPE: FMCW (FREQUENCY MODULTED CONTINUOUS WAVE ☐ PULSE ☐	*
10.	RADAR SIGNAL FREQUENCY:xxx	*
11.	TYPE OF ANTENNA : PARABOLIC ☐ ROD ☐ CONE ☐ OTHER ☐	*
12.	DEAD ZONE DISTANCE:xxx	*
13.	BEAM ANGLE:xxxx	*
14.	SENSOR HOUSING PROTECTION CLASS: IP-65 OR EQUAL	✓
15.	MATERIAL: A) HOUSING :xxxx B) FLANGE :xxxxx C) ANTENNA :xxxx	*
16.	WEIGHT:	*
17.	PROCESS CONNECTION A) FLANGE SIZE:xxxx B) FLANGE RATING/ STANDARD:xxxx	*
18.	MAXIMUM PERMISSIBLE CABLE DISTANCE BETWEEN SENSOR AND TRANSMITTER UNIT :xxxx	*
19.		
20.	**LEVEL TRANSMITTER** (REFER NOTE 4)	
21.	ENCLOSURE PROTECTION CLASS: IP-65 OR EQUAL	✓
22.	ENCLOSURE MATERIAL :xxxx	*
23.		
24.	AREA CLASSIFICATION: ZONE 0 ☐ 1 ☐ 2 ☐ ; GROUP IIA ☐ IIB ☐ IIC ☐ ; TEMP. CLASS T1 ☐ T2 ☐ T3 ☐ T4 ☐ T5 ☐ T6☐	x
25.	POWER SUPPLY: 24 V DC	✓
26.	OUTPUT SIGNAL: A) 4-20 mA DC ☒ B) ALARM OUTPUTS : HI ☐ LOW ☐	✓
27.	NO. AND TYPE OF CONTACTS :xxxx	x
28.	CONTACT RATING :xxxx	x
29.	PROTOCOL TYPE: HART ☒ FOUNDATION FIELDBUS ☐ PROFIBUS PA ☐ PROFIBUS DP ☐	
30.	TYPE OF DISPLAY: BACKIT LCD ☒ LCD ☐ LED ☐	✓
31.	DISPLAY ENGINEERING UNITS :xxxx	*
32.	TEMPERATURE COMPENSATION :	✓
33.		
34.	ACCESSORIES (REFER NOTE-6)	
35.	STILLING PIPE	*
36.	INTEGRAL CABLE BETWEEN SENSOR AND TRANSMITTER	✓
37.	DIGITAL PANEL METER	*
38.	CABLE GLANDS: SS	✓
39.	NAME PLATE: REMOVABLE – SS	✓
40.	METAL TAG: SS	✓
41.		
42.	**CODES AND STANDARDS**	
43.	REFER NOTE 5	✓
44.		
45.	**TESTS :**	
46.	CALIBRATION	✓
47.	PERFORMANCE TEST	✓
48.		
49.		

NOTES:

1.0 (*) - BIDDER TO FURNISH DETAILS; (✓) - REQUIRED; (-) - NOT REQUIRED / NOT APPLICABLE.

2.0 FOR QUANTITY REFER ENCLOSED P&ID.

3.0 INTRINSIC SAFE INSTRUMENTS IF PROVIDED FOR INSTRUMENTS LOCATED IN HAZARDOUS AREAS SHALL COMPLY WITH RELEVANT HAZARDOUS AREA CLASSIFICATION CODES.

4.0 THE RADAR TYPE LEVEL SENSOR AND LEVEL TRANSMITTER MAY BE COMBINED INTO ONE UNIT.

5.0 THE VENDOR SHALL INDICATE ALL APPLICABLE CODES AND STANDARDS.

6.0 ALL ACCESSORIES SHALL BE SUPPLIED AS SPECIFIED. IN ADDITION, ANY OTHER ACCESSORIES REQUIRED TO MAKE THE INSTALLATION COMPLETE SHALL BE SUPPLIED WITHOUT ANY COST IMPLICATION.

2. PRESSURE INDICATOR

1.	**GENERAL**	
2.	MANUFACTURER :	*
3.	MODEL NO.:	*
4.	TYPE	
5.	SENSOR TYPE: BOURDON ☒	✓
6.	DIRECT READING ☒ RECEIVER ☐	✓
7.	GLYCERIN FILLED: YES ☒ NO ☐	✓
8.	WITH SWITCHING CONTACTS : YES ☐ NO ☒ HI ☐ LO ☐	x
9.	CHEMICAL DIAPHRAGM SEAL : DIRECT MOUNTING ☒ REMOTE WITH CAPILLARY ☒ CAPILLARY LENGTH : 10 mtr FILL FLUID : SILICON	✓
10.	MOUNTING : DIRECT ☒ SURFACE ☐ PANEL ☐	✓
11.		
12.	**FEATURES**:	
13.	DIAL SIZE: 150 MM ☐ 100 MM ☒	✓
14.	ACCURACY : +/- 1% of FS or better	✓
15.	OVER RANGE PROTECTION : 130% of full range	✓
16.	BLOW OUT DISC :	✓
17.	**ENCLOSURE PROTECTION**	
18.	FOR PRESSURE INDICATOR WITH SWITCHING CONTACTS: WEATHER PROTECTION: IP 65 ☒ EX-PROOF TO ZONE __ ☐ GROUP IIA ☐ IIB ☐ IIC ☐ TEMPERATURE CLASS :	✓
19.	SWITCH DETAILS: NO. OF CONTACTS : 2 NO + 2 NC ☐ 2 CHANGEOVER ☐ CONTACT RATING :	x
20.	**MATERIAL OF CONSTRUCTION**	
21.	**HOUSING: DIE CAST ALUMINIUM** ☒	✓
22.	PRESSURE ELEMENT: SS 316 ☒ NEOPRENE DIAPHRAGM ☐ PTFE COATING ☐ PHOSPHOR BRONZE ☐	✓
23.	MOVEMENT : SS 316 ☒ SS 304 ☐	✓
24.	SOCKET : SS 316 ☒ SS 304 ☐	✓
25.	GLASS : SHATTERPROOF ☒	✓
26.	CHEMICAL DIAPHRAGM SEAL : SS316 ☒ HASTELLOY ☐ TANTALUM ☐ ☐	✓
27.	**CONNECTION & DIMENSIONS**	
28.	PROCESS CONNECTION: THREADED ☒ FLANGED ☐	✓
29.	THREADED PROCESS CONNECTION: ½ "NPT (M) ☒ ¼ " NPT (M) ☐ 1" NPT (M) ☐ ☐	✓
30.	FLANGED PROCESS CONNECTION: FLANGE RATING : FLANGE SIZE :	*
31.	PROCESS CONNECTION LOCATION: BOTTOM ☒ BACK ☐	✓
32.	CABLE ENTRY: ½" NPT (F) ☐ ☐	x
33.	ACCESSORIES (REFER NOTE 3)	
34.	NAME PLATE / METAL TAG : (Refer note 6)	✓
35.	MOUNTING BRACKET:	✓
36.	SYPHON : (Refer note – 4)	✓
37.	SNUBBER : (Refer note – 4)	✓
38.	2 VALVE MANIFOLD : ☐ BLOCK & BLEEDS☐ ISOLATION VALVE : ☒	✓
39.	ALL INSTALLATION HARDWARE	✓

40.	CODES AND STANDARDS (REFER NOTE 2)	
41.	SPECIFICATIONS – IS 3624	✓
42.	SELECTION & INSTALLATION – BS EN 837	✓
43.	WEATHER PROOF – IS 13947 PART I	✓

44.	EXPL. PROOF–IS 2148/ BS EN 50014/ BS EN 50020	✓
45.	**TESTS :**	
46.	CALIBRATION : Required	✓
47.	HYDRO TEST : Required at 1.5 times the max pressure	✓
48.	REPEATABILITY : Required	✓

NOTES:

1.0 (*) - BIDDER TO FURNISH DETAILS; (✓) – REQUIRED; (X) – NOT REQUIRED / NOT APPLICABLE

2.0 THE BIDDER SHALL INDICATE ALL APPLICABLE CODES AND STANDARDS.

3.0 ALL ACCESSORIES REQUIRED TO MAKE THE INSTALLATION COMPLETE SHALL BY SUPPLIED BY BIDDER.

4.0 REFER P&ID TO DERIVE BOQ.

5.0 IBR CERTIFICATION SHALL BE CONSIDERED FOR STEAM SERVICES.

6.0 FOLLOWING DETAILS MINIMUM SHALL BE AVAILABLE ON THE TAG PLATE:-

- TAG NUMBER, MANUFACTURER'S NAME OR TRADEMARK.
- MODEL NUMBER, SERIAL NUMBER, PRESSURE & TEMPERATURE RATING.
- DIAPHRAGM MATERIAL.
- PROCESS CONNECTION/RATING.
- OPERATING PRESSURE & RANGE VALUES.

3. PRESSURE INDICATING TRANSMITTER

1.	**GENERAL**	
2.	**Manufacturer:**	
3.	Model no.:	
4.	**FEATURE**	
5.	Type: Microprocessor based Smart (2-wire) ,indicating	✓
6.	Mounting: pipe mounted ☒	✓
7.	External Zero and Span adj.: Required	✓
8.	Accuracy: ± 0.075% of span	✓
9.	Over range Protection: 130% of full range	✓
10.	Stability: ±0.125% of FSR for minimum 5 years	✓
11.	Operation Principle:	*
12.	Display: Backlit LCD with Engineering units	
13.	SIL ___ compliance ☐ SIL Not required ☒	X
14.	Isolation Min : 500Vac & EMC compatibility as per EN 61326	✓
15.	**ENCLOSURE**	
16.	Case protection class: IP-65	✓
17.	Case Colour: Grey ☒ Black ☐	*
18.	Area classification: Zone 0 ☐ 1 ☐ 2 ☐ ; Group IIA ☐ IIB ☐ IIC ☐ ; TEMP. CLASS T1 ☐ T2 ☐ T3 ☐ T4 ☐ T5 ☐ T6☐ Refer follow up sheet (Refer note 3)	X
19.	Intrinsic safe certified: For Hazardous area	X
20.	**SUPPLY / SIGNAL**	
21.	Power Supply: 24V DC	✓
22.	Output signal: 4-20mA HART ☒	✓
23.	**MATERIAL**	
24.	Housing: Aluminum with epoxy coating	✓
25.	Body: SS	✓
26.	Sensing Element: SS 316☒	✓
27.	Diaph. Seal / Body: SS 316☒	✓
28.	Capillary and Armour: SS 316	✓
29.	Fill fluid : (Refer note -7)	X
30.	Wetted part: Refer follow-up sheet	X
31.	**CONNECTIONS & DIMENSIONS**	
32.	Process Conn: Flanged ☒	✓
33.	Process conn. details: Refer follow-up sheet	X
34.	Location: Bottom ☒ Back ☐	*
35.	Cable entry : ½" NPT(F) (2 nos.) with SS double compression type cable glands with PVC shroud. Spare entry shall be plugged with SS plug.	✓
36.	**ACCESSORIES** (Refer note-4)	
37.	Name Plate: Removable - SS	✓
38.	Mounting Bracket: SS (2" pipe bracket)	✓
39.	Diaphragm Seal : Refer follow-up sheet	✓
40.	Armoured Capillary – Refer follow-up sheet	✓
41.	2 Valve manifold: SS	✓
42.	Flushing ring : SS	✓
43.	Syphon: Refer follow-up sheet	✓
44.	Snubber: Refer follow-up sheet	✓
45.	Application : Raw Water	✓

NOTES:

1.0 (*) - Bidder to furnish details; (✓) - Required; (x) - Not required / Not applicable.

2.0 For quantity refer enclosed P&ID.

3.0 Intrinsic Safe Instruments if provided for instruments located in hazardous areas shall comply with relevant hazardous area classification codes.

4.0 All accessories shall be supplied as specified. In addition, any other accessories required to make the installation complete shall be supplied without any cost implication.

5.0 Chemical seal diaphragm shall be used when the fluid is corrosive or viscous.
All wetted parts for sea water application shall be of SS316L with COMPLIANCE TO NACE-MR-01-75 (latest edition).

6.0 Field bus / Profibus PA based transmitter shall meet following requirement
All instrument must satisfy the requirement of field bus registration laboratory with applicable check marks like foundation field bus, profibus PA or as specified.
All instrument shall have two analog input block as minimum. In addition when specified the transmitter shall also have PID controller block, arithmetic block, Input selector and signal characterizer block shall be provided
All instrument must be interoperable and shall have valid interoperability test clearance like ITK 4.6 for foundation field or equivalent for profibus PA as applicable.
The field bus instrument shall support peer to peer communication.
Field bus instrument offered shall not be polarity sensitive or reverse polarity protection should be available.

7.0 Fill fluid selection shall be suitable for process fluid temperature and for hygiene application such as Food, Parma and Beverage.

8.0 For pressure transmitter, the normal operating pressure shall be within 40% to 70% of the calibrated scale range. The selected range shall be subjected to purchaser/ consultant approval.

4. ELECTROMAGNETIC FLOW METER

1.	**GENERAL**	
2.	Manufacturer :	*
3.	Model no.:	*
4.	Quantity:	**
5.	Tag no	**
6.	Area classification: ZONE 0 ☐ 1 ☐ 2 ☐; GROUP IIA☐ IIB☐ IIC☐ ; TEMP. CLASS T1☐ T2☐ T3☐ T4 ☐ T5☐ T6☐	x
7.	Weather protection class: IP 65 ☒ IP 66 ☐	✓
8.	Ex-Proof : Exd ☐	✓
9.	SIL Level (Note-7): Required as minimum SIL-__ as per IEC 61508 & IEC 61511 Required ☐ Not Required ☐	
10.	Accuracy : Better than +/- 0.5% of flow rate	✓
11.	Repeatability : ±0.25% of reading	✓
12.	Automatic zero provision	✓
13.	Online electrode cleaning arrangement: Refer Note- 6	✓
14.	Maximum permissible cable distance between flow tube and transmitter: 5 Meter ☒	✓
15.	Empty tube detection: Required ☒	✓
16.	Rangeability:	*
17.	**PROCESS DATA**	**
18.	**FLOW TUBE**	
19.	Process connection : Flanged	✓
20.	Electrical connections : ½" NPTF	✓
21.	Electrode type: EMF Meter ☒	✓
22.	Liner: Required ☒	
23.	Grounding type: Grounding Ring ☒ Grounding Electrode ☐	✓
24.	Coil insulation: Class F suitable for high temperature as per IEC60085 / IS 1271	✓
25.	**MATERIAL OF CONSTRUCTION**	
26.	Metering tube: SS316	✓
27.	Liner: Teflon ☐ PTFE ☐ PFA ☐ Hard Rubber ☒	✓
28.	Electrodes:	**
29.	Flanges:	**
30.	Coil housing: Di Cast Al ☒	✓
31.	Jacket: Required ☒ Not Required ☐	✓
32.	Converter/ electronic housing: Di Cast Al	✓
33.	**FLOW TRANSMITTER**	
34.	Mounting: Integral ☒ Separate ☒	✓
35.	Type of transmitter: 4 Wire ☒	✓
36.	Display on transmitter : Flow Rate ☒ Flow Totalizer ☒	✓
37.	Type of display: LED ☐ Backlit LCD ☒ LCD ☐	✓
38.	Battery backup for flow tantalizer : Required ☐	✓
39.	Power supply : Power Supply (four wired) : 24V DC ☒ Power Supply (for wireless) : Easy to replace Lithium batteries (Note – 10) ☐	✓
40.	Output signal: 4-20mA HART ☒ Fieldbus ☐ Profibus PA ☐ Wireless ☐	✓
41.	Alarms : Hi ☐ Low ☐	x
42.	No. and type of contacts : 1 No SPDT ☐ 1 No DPDT ☐	x
43.	Contact rating : 2A@24VDC ☐	
44.	Material of housing: Di Cast Al ☒	✓
45.	Maximum load: >500 Ohms	✓
46.	Cable entry : ½" NPT (4 Nos) with Double compression cable gland	✓
47.	Diagnostic information :	✓
48.	Reverse flow :	✓
49.	Transmitter fault :	✓
50.	Coil circuit fault :	✓
51.	Ground/wiring fault (applicable for slurry application)	✓
52.	High process noise (applicable for slurry application)	✓
53.	**WIRELESS TRANSMITTER**	x
54.	Transmitter update rate : Selectable between 4 sec to 60 sec	
55.	Battery Voltage and Drain time:	x

56.	Battery life: Min. 2yrs with 4 sec. update rate or better (Note-8)	x
57.	Antenna type : Integrated Omni directional Antenna ☐ Remote mount Omni directional Antenna ☐	x
58.	Signal Range: Minimum 200m or better without any repeater & with clear line of sight	x
59.	Wireless Frequency : 2.4GHz license free ISM Band	x
60.	Radio security : AES 128 bit encryption	x
61.	Wireless Protocol: ISA 100.11a (IEC 62734) / Wireless HART (IEC62591-1)	x
62.	Transmitter Configuration : via gateway over wireless network	x
63.	Device programming: Transmitter to work as input device, repeater and Access point	x
64.	Network: Note-9	x
65.	**ACCESSORIES**	
66.	Spool piece for start-up use	✓
67.	Matching flanges, nuts and bolts	✓
68.	Name plate/ metal tag	✓
69.	Cable between flow tube and transmitter unit: Required ☒ Not Required ☐	
70.	Remote flow indicator & integrator : Required ☒ Not Required ☐	
71.	Mounting brackets : Required ☒ Not Required ☐	
72.	**CODES AND STANDARDS**	
73.	Test and calibration : IEC 17025	✓
74.	Ex-Proof protection : IEC 60079	✓
75.	Weather protection class : IEC 60529	✓
76.	EMC requirement: IEC 61326-1	✓
77.	Shock & vibration Resistance: IEC 60068-2-6	✓
78.	**TESTS**	
79.	Calibration test certificate: 5 Points Calibration ☒	✓
80.	Hydrostatic:	✓
81.	Test certificate from CMRI / ERTL for equipment manufactured in India	✓
82.	Certificate of conformity from LCIE, BASEEFA, PTB, CSA, UL, ATEX for equipment manufactured outside India	✓

Notes:

1. (*) - Bidder to furnish details; (✓) - Required; (x) - Not required / Not applicable.
2. The bidder shall indicate all applicable codes and standards.
3. The velocity limits to be considered for meter sizing shall be as mentioned below
   a) For slurries and viscous flow: 4 to 5 m/s
   b) For all other service: 2 to 3 m/s
   Velocities beyond these limits shall not be considered.
4. Field bus based transmitter shall meet following requirement
   a) All instruments must satisfy the requirement of field bus registration laboratory with applicable check marks like foundation field bus, Profibus PA or as specified.
   b) All instruments shall have two analog input blocks as minimum. in addition when specified the transmitter shall also have PID controller block
   c) All instruments must be interoperable and shall have valid interoperability test clearance like ITK 4.6 for foundation field or equivalent for PA as applicable.
   d) The field bus instrument shall support peer to peer communication.

e) Field bus instrument offered shall not be polarity sensitive

5. The configuration data for the instrument shall be stored in non volatile memory.
6. Whenever process fluid has coating characteristics, where cleaning of electrode is necessary because of coating, vendor shall offer online removable electrode.
7. TUV / EXIDA certification as per IEC 61508 & IEC 61511 for SIL rated flow transmitters shall be provided by vendor. Vendor to provide safety manual as per IEC 61508 for all the applicable tags which shall contains at least.
   a) SIL rating, HFT value, Device Type, Mode of operation
   b) Safety parameters: β, βD λDU , λDD , λSU, λSD , PTR, MTBF, MTTR, DC, PFD SFF, RRF
   c) Possible design / architectural constraints
8. All the transmitters supplied for wireless network shall come with same type of batteries so that spare maintenance could be easier (These batteries should be compatible for all the models of Pressure, Temperature, Adaptor supplied in this network) Transmitter shall be supplied with battery removed during shipping.
9. Wireless connectivity and all devices shall be pre configured / field configurable with Mesh / Star / combination of both topologies with all devices configured as Transmitter, repeater based on application requirement.
10. Adapter is required for converting an existing wired transmitter to wireless complying with IEEE 802.154.
11. Self diagnostics features such as Sensor Failure, amplifier failure, configuration error, battery alarm, and wireless communication alarm and over-range error for process variables.

5. ON-LINE TURBIDITY/ TSS METER

1.	**GENERAL**	✓
2.	MANUFACTURER:	*
3.	MODEL NO.	*
4.		
5.	**FEATURES**	
6.	SENSOR	✓
7.	TYPE : OPTICAL SENSOR	✓
8.	MEASURING PRINCIPLE : RATIO-METRIC ☒ ☐	*
9.	SENSITIVITY : 0.2 NTU OR +/- 2.0 % OF READING ☒ ☐	✓
10.	CLEANING FACILITY : WIPER ☒	✓
11.	COLOUR COMPENSATION :	✓
12.	RANGE SETTING: SELECTABLE TURB: 0-1, 0-10, 0-100 NTU ☒ TSS: 0-10, 0-1000, 0-5000 PPM ☒	✓
13.	TYPE OF LIGHT SOURCE : TUNGSTEN LAMP ☐ LED ☒ ☐	✓
14.	INTEGRAL CABLE CONNECTING SENSOR AND TRANSMITTER	✓
15.	TRANSMITTER	✓
16.	MICROPROCESSOR BASED :	✓
17.	INTEGRAL DISPLAY: BACKLIT LCD☒ LCD ☐ ☐	✓
18.	ZERO & SPAN ADJUSTMENT :	✓
19.	OVERALL ACCURACY OF MEASUREMENT LOOP 0.2 NTU OR +/- 2.0 % OF READING☒ ☐	✓
20.	ALARMS : YES ☐ NO ☐ HI ☐ LO ☐ FAULT ☐	x
21.	MOUNTING : PANEL ☐ FIELD ☒	✓
22.		
23.	**ENCLOSURE PROTECTION**	✓
24.	WEATHER PROOF TO IP 68 ☒	✓
25.		
26.	**SIGNAL & POWER SUPPLY DETAILS**	✓
27.	POWER SUPPLY : 230 V AC ☒	✓
	110 V AC ☐ ☐	
28.	OUTPUT SIGNAL : 4-20 mA DC ☒	✓
29.	COMMUNICATION PORTS : RS 232 ☐ RS 485 ☒ ☐	✓
30.	ALARM SWITCH DETAILS	
31.	NO. OF CONTACTS 1 NO + 1 NC ☐ 1 CHANGEOVER ☐ ☐	x
32.	CONTACT RATING :	x
33.		
34.	**MATERIAL OF CONSTRUCTION**	
35.	TRANSMITTER ENCLOSURE : NON-CORROSIVE	*
36.	WETTED PARTS : NON-CORROSIVE	*
37.		
38.	**ACCESSORIES (REFER NOTE 3)**	✓
39.	NAME PLATE / METAL TAG	✓
40.	BUBBLE TRAP	✓
41.	SAMPLING SYSTEM COMPRISING OF : SAMPLING PUMPS, ROTAMETER, STRAINER, ADJUSTMENT VALVE ETC. (REFER NOTE 5) PRESSURE REDUCING VALVE, ROTAMETER, STRAINER, ADJUSTMENT VALVE ETC. (REFER NOTE 6) SAMPLE FLOW RATE PRESSURE	 * *
42.	STANDARD GLASS CUBE OR FORMAZINE SOLUTION FOR CALIBRATION	✓
43.	DIGITAL PANEL METER (REFER NOTE 4)	x
44.	ALL INSTALLATION HARDWARE	✓
45.		
46.	**CODES & STANDARDS (REFER NOTE 2)**	✓
47.	WEATHER PROOF : IS 13947 - PART I	✓

48.		
49.	**TESTS**	✓
50.	PERFORMANCE	✓

51.	CALIBRATION	✓
52.	HYDRO TEST	✓

NOTES :

1.0 * BIDDER TO STATE.

2.0 THE BIDDER SHALL INDICATE ALL APPLICABLE CODES AND STANDARDS.

3.0 ALL ACCESSORIES SHALL BE SUPPLIED AS APPLICABLE.

4.0 DETAILED SPECIFICATIONS FOR THIS ITEM IS GIVEN SEPARATELY.

5.0 SAMPLING SYSTEM COMPRISING OF SAMPLING PUMPS, ROTAMETER, STRAINER ADJUSTMENT VALVE ETC. SHALL BE PROVIDED WHERE THE SAMPLE IS TO BE TAKEN FROM AN OPEN CHANNEL OR FROM AN UNPRESSURISED LINE.

6.0 SAMPLING SYSTEM COMPRISING OF PRESSURE REDUCING VALVE, ROTAMETER, STRAINER, ADJUSTMENT VALVE ETC. SHALL BE PROVIDED WHERE THE SAMPLE IS TO BE TAKEN FROM A PRESSURISED LINE.

7.0 A MOUNTING RACK SHALL BE PROVIDED FOR MOUNTING OF STRAINER, ROTAMETER, ADJUSTMENT VALVE, SENSOR HOLDER FLOW THROUGH ASSEMBLY, TRANSMITTER ETC.

8.0 REFER P&ID TO DERIVE BOQ.

6. pH ANALYSER

1.	**GENERAL.**	
2.	MANUFACTURER :	*
3.	MODEL NO. :	*
4.	QUANTITY & RANGE : REFER NOTE-2	✓
5.	**SENSOR**	
6.	ELECTRODES [COMBINED pH ELECTRODE AND REFERENCE ELECTRODE] & INTEGRAL TEMP. COMPENSATOR ASSY	✓
7.	TYPE : FLOW THROUGH TYPE ☐ SUBMERSION ☒ INSERTION ☐	✓
8.	PRESSURE LIMITATION :	✓
9.	TEMPERATURE LIMITATION :	*
10.	TEMP. COMPENSATING ELEMENT :	*
11.	SENSOR CLEANING: AUTOMATIC CLEANING WATER JET ☐ ULTRASONIC CLEANING ☒	✓
12.	DETACHABLE CABLE AT CELL	✓
13.	**ANALYZER**	✓
14.	TYPE : MICROPROCESSOR BASED	✓
15.	DISPLAY : BACKLIT LCD DISPLAY ☒ LED ☐	✓
16.	ACCURACY :	✓
17.	AMBIENT TEMP. :	✓
18.	AMBIENT HUMIDITY :	✓
19.	MOUNTING : PANEL ☐ WALL☒ PIPE ☐	✓
20.	TEMPERATURE COMPENSATION: AUTO ☒ MANUAL ☐	✓
21.	CALIBRATION CHECK : AUTO ☒ MANUAL ☐	✓
22.	INBUILT SLOPE CALCULATION (REF. NOTE – 3)	✓
23.	INTEGRAL ISOPOTENTIAL ADJUSTMENT	✓
24.	ENCLOSURE PROTECTION :	✓
25.	SELF DIAGNOSTIC FEATURES (REF. NOTE – 4)	✓
26.	**MATERIAL**	
27.	ELECTRODE MATERIAL : GLASS	✓
28.	ELECTRODE BODY & HOLDER MATERIAL: PP ☒ SS316 ☐ OTHERS ☐	✓
29.	GASKET & `O'RINGS : 'VITON' ☒ OTHERS ☐	✓
30.	ENCLOSURE: DIE CAST ALUMINIUM ☒ ABS PLASTIC ☐ OTHERS ☐	✓
31.	**SUPPLY/SIGNAL**	
32.	POWER SUPPLY : 240V AC ☒ 24V DC ☐	✓
33.	OUTPUT : 4-20mA ☒ HART ☐	✓
34.	ALARM CONTACTS : HI ☐ LO ☐	x
35.	NO OF CONTACTS : SPDT 2 nos.	x
36.	CONTACT RATING : 5 A, 240 VAC ☐ 5A, 24 VDC ☐	x
37.	**CONNECTIONS & DIMENSIONS**	
38.	FOR CELL : 1"NPT ☐ 3/4"NPT ☐ 1 1/2 "NPT ☐	*
39.	CONDUIT SIZE AT ANALYSER : ½" NPT fittings with SS-316 gland	✓
40.	TERMINAL : REF. NOTE 7	✓
41.	**ACCESSORIES**	
42.	MOUNTING BRACKETS	✓
43.	NAME PLATE : SS316	✓
44.	METAL TAGS : SS316	✓
45.	JUNCTION BOX FOR ELECTRODE ASSY : REFER BOM	✓
46.	INTEGRAL PREAMPLIFIER: REFER BOM	✓
47.	GROMMETS & WASHERS	✓
48.	INTER CONNECTING CABLES BETWEEN CELL AND ANALYSER	✓
49.	ONE BOTTLE EACH OF BUFFER TABLETS FOR 4 pH & 9.2 pH	✓
50.	**CODES & STANDARDS**	
51.	Enclosure Protection: IEC 60529	✓
52.	ASTM D1293	✓
53.	ASTM D1129	✓

54.	ASTM D3370	✓

NOTES:

1.0 * BIDDER TO STATE.

2.0 FOR QUANTITIES & RANGES REFER P&ID.

3.0 APPLICABLE IF AUTO CALIBRATION IS SELECTED.

4.0 FAULT DIAGNOSIS DATA SHALL INCLUDE FAULTS IN ANALOGUE / DIGITAL CIRCUITS, FAULTS IN CALIBRATED VALUES, AND POWER SUPPLY FAILURE.

5.0 EACH pH ANALYSER SHALL BE SUPPLIED AS A COMPLETE SYSTEM. PURCHASER'S TERMINAL POINTS ARE ONLY THE ROOT VALVES AT THE PIPES, DRAIN HEADERS, PLANT COOLING WATER HEADER, CHILLED COOLING WATER HEADER AND CABLE TERMINATION AT THE ANALYSER PANEL FOR PURCHASER'S USE.

6.0 ANY ACCESSORIES OTHER THAN SPECIFIED AND ARE REQUIRED FOR THE FUNCTIONING OF THE SYSTEM SHALL ALSO BE SUPPLIED ALONG WITH THE EQUIPMENT.

7.0 TERMINAL SIZE SHALL BE SUITABLE TO ACCEPT 0.5SQ. mm CABLE FOR SIGNALS AND 1.5/2.5SQ.mm CABLE FOR POWER SUPPLY.

7. ORP Analyser

Sr. No.	Description	Employer's requirement
	GENERAL	
1.	Manufacturer	*
2.	Model No.	*
	FEATURE	
3.	Measuring principle	Metal electrode method
4.	Type	Flow through
5.	Measurement	Continuous
6.	Measuring range	- 1500 mV to + 1500 mV
7.	Accuracy	± 2% of FSD
8.	Repeatability	± 0.3% of span
9.	Pressure limitation	*
10.	Temperature limitation	*
11.	Temperature compensation range	Same as operating temperature range
12.	Temperature compensating element	Pt 100 integral to cell
13.	Analyser unit with HMI	Required
14.	Circuits	Microprocessor based
15.	Auto zero check	Required
16.	Manual zero and calibration check	Required
17.	Electrode housing	IP 65
18.	Analyser housing	IP 65 with corrosion proof casing
19.	Display	Integral display
	MATERIAL OF CONSTRUCTION	
20.	Electrode Body	Ryton
21.	Measuring surface	Platinum or gold
22.	Holder	SS 316
	SUPPLY/ SIGNAL	
23.	Power supply	230 V AC, 1Ph, 50Hz
24.	Output	Isolated 4-20 mA DC
25.	HI & LO alarm contact	Changeover, pot free, 2 contacts per alarm
26.	Analyser fault annunciation contact	Required
27.	Contact rating	0.2A, 220 V DC
28.	Preamplifier	Required
29.	Inter connecting cables between cell and analyser	Required
	CONNECTION & DIMENSIONS	
30.	For cell	*
31.	Conduit size	1" ET
32.	Sample/ drain connection	¼ " NPT
33.	Name plate/ metal tag	Fixed SS304

Sr. No.	Description	Employer's requirement
	Installation hardware	Required

8. ON-LINE RESIDUAL CHLORINE MEASUREMENT

1.	**GENERAL**	
2.	Manufacturer:	*
3.	Model no.	*
4.	Tag No:	*
5.	Quantity :	*
6.	Area classification: Zone 0 ☐ 1 ☐ 2 ☐; Group IIA☐ IIB☐ IIC☐ ; Temp. Class T1☐ T2☐ T3☐ T4☐ T5☐ T6☐	x
7.	**ENCLOSURE PROTECTION**	✓
8.	Weather protection class: IP 65 ☒ IP 66 ☐	✓
9.	Ex-Proof : Exd ☐	x
10.	**PROCESS DATA**	*
11.	**FEATURES**	✓
12.	**SENSOR**	✓
13.	Type : Amperometric ☐ Colorimetric ☐	*
14.	Sensitivity : 0.05 PPM ☐ 0.005 PPM ☒	✓
15.	Response time :	*
16.	Integral cable connecting sensor & transmitter	✓
17.	Operating life :	*
18.	Ambient temperature : 0º C to 60º C	✓
19.	**TRANSMITTER**	✓
20.	Type of microprocessor based transmitter: 2 Wire ☐ 4 Wire ☐	*
21.	Integral display : Backlit LCD ☒ LED ☐	✓
22.	Zero & Span adjustment :	✓
23.	Automatic temperature compensation :	✓
24.	Automatic pH compensation :	✓
25.	Overall accuracy of measurement loop : ±2% of reading ☒	✓
26.	Mounting : Panel ☐ Field ☒ Rack ☐	✓
27.	Inlet/ Outlet connection :	*
28.	Calibration interval :	*
29.	Calibration method :	*
30.	Self diagnostic features :	✓

31.	**SIGNAL & POWER SUPPLY DETAILS**	✓
32.	Power supply : 24V DC ☐ 110 VAC ☐ 230 VAC ☒ Power Supply (for wireless) : Easy to replace Lithium batteries (Note – 10) ☐	✓
33.	Output signal : 4-20 mA HART Loop Power ☒ Field Bus ☐ Modbus RS-485 ☐ Wireless HART ☐ Wireless ISA 100.11a ☐	✓
34.	**ALARM SWITCH DETAILS**	x
35.	Alarms : Yes ☐ No ☐ HI ☐ LO ☐ Fault ☐	x
36.	No. and type of contacts: 1 No SPDT ☐ 1 No DPDT ☐	x
37.	Contact rating: 5A@ 230 V AC ☐ 2A@24VDC ☐	x
38.	**MATERIAL OF CONSTRUCTION**	✓
39.	Measurement electrode (cathode) : platinum ☐ gold ☐	*
40.	Reference electrode (anode) : Silver ☐ Copper ☐	*
41.	Wetted parts : SS316 ☒ PVC ☐ polycarbonate ☐	✓
42.	Transmitter enclosure : ABS plastic ☐ Epoxy coated die cast aluminium ☒ Epoxy coated MS ☐	✓
43.	**CONNECTION & DIMENSIONS:**	
44.	Instrument Process connection type : Flanged ☒ Threaded ☐	✓
45.	Threaded size :	x
46.	Flange size & rating :	*
47.	Cable entry: 1"ET ☐ ½ " NPT ☐ others ☐	*
48.	**WIRELESS TRANSMITTER**	x
49.	Transmitter update rate: Selectable between 4 sec to 60 sec	x
50.	Battery Voltage and Drain time:	x
51.	Battery life: Min. 2 yrs with 4 sec. update rate or better	x
52.	Antenna type : Integrated Omni directional Antenna ☐ Remote mount Omni directional Antenna ☐	x
53.	Signal Range: Minimum 200m or better without any repeater & with clear line of	x

	sight	
54.	Wireless Frequency : 2.4GHz license free ISM Band	x
55.	Radio security : AES 128 bit encryption	x
56.	Wireless Protocol: ISA 100.11a (IEC 62734) / Wireless HART (IEC62591-1)	x
57.	Transmitter Configuration : Via gateway over wireless network	x
58.	Device programming: Transmitter to work as input device, repeater and Access point	x
59.	Network: Note-10	x
60.	**ACCESSORIES (REFER NOTE 3)**	✓
61.	Name plate / metal tag :	✓
62.	Ph sensor :	✓
63.	RTD temperature sensor :	✓
64.	All installation hardware :	✓
65.	**CODES & STANDARDS (Refer Note 2)**	✓
66.	Weather proof – IP / NEMA IS 13947 :1993	✓
67.	Explosion proof - IS 2148-1981/ BS EN 50014:1998 / BS EN 60079-0:2004/FM/CSA	✓
68.	Electrical compliant with IEC / EN 61326-3-2	✓
69.	**TESTS**	✓
70.	Performance	✓
71.	Calibration	✓
72.	Hydro test	✓

Notes :

1. (*) - Bidder to furnish details; (✓) - Required; (x) - Not required / Not applicable.
2. The bidder shall indicate all applicable codes and standards.
3. All accessories shall be supplied as applicable.
4. Sampling system comprising of sampling pumps, rotameter, strainer, adjustment valve etc. shall be provided where the sample is to be taken from an open channel or from an unpressurised line.
5. Sampling system comprising of pressure reducing valve, rotameter, strainer, adjustment valve etc. shall be provided where the sample is to be taken from a pressurised line.
6. A mounting rack shall be provided for mounting of strainer, rotameter, adjustment valve, sensor holder, flow through assembly, transmitter, holders for ph & temperature sensor etc.
7. Bidder shall consider acidification unit assembly for fluid ph correction beyond allowed/ recommended sample ph value.
8. Self diagnostic features shall include alarm for, calibration fault and measuring parameter low / high.
9. Field bus based transmitter shall meet the following requirement :
   a) All instruments must satisfy the requirement of field bus registration laboratory with applicable check marks like foundation field bus, profibus PA or as specified.
   b) All instruments shall have two (2) analog input blocks as minimum. Also if specified the transmitter shall have PID controller block.
   c) All instruments must be interoperable and shall have valid interoperability test clearance like ITK 6.1.1 or latest for foundation field bus or equivalent for PA as applicable.
   d) The field bus instrument shall support peer to peer communication.
   e) Field bus instrument offered shall not be polarity sensitive

10. All the transmitters supplied for wireless network shall come with common batteries so that spare maintenance could be easier (These batteries should be compatible for all the models of Pressure, Temperature, Adaptor supplied in this network) Transmitter shall be supplied with battery removed during shipping.
11. Wireless connectivity and all devices shall be pre configured / field configurable with Mesh / Star / combination of both topologies with all devices configured as Transmitter, repeater based on application requirement.
12. Adapter is required for converting an existing wired transmitter to wireless complying with IEEE 802.154.
13. Self diagnostics features such as configuration error, battery alarm, and wireless communication alarm and over-range error for process variables

9. MAGNETIC FLOAT TYPE LEVEL SWITCH

	GENERAL	
	Manufacturer :	*
	Model No:	*
	Tag No:	*
	Quantity:	*
	Area classification: Zone 0 ☐ 1 ☐ 2 ☐; Group IIA☐ IIB☐ IIC☐ ; TEMP. CLASS T1☐ T2☐ T3☐ T4☐ T5☐ T6☐	x
	Weather protection class: IP 65 ☒ IP 66 ☐	✓
	Ex-Proof : Exd ☐	x
	Enclosure material: Di Cast Al ☐ Epoxy coated aluminium ☒ Polyurethane Covered Aluminium ☐	✓
	PROCESS DATA:	*
	FEATURES:	✓
	Type: Magnetic float with guide tube ☒ Tilt type ☐	✓
	Accuracy: ± 2 mm	✓
	Mounting: Direct ☒ External chamber ☐	✓
	Switch Diff: Fixed ☐ Adjustable ☒	✓
	GUIDED FLOAT TYPE	
	Switch type: glass encapsulated hermetically sealed reed switch ☒	✓
	No. of floats with stopper: single ☐ multiple ☐	*
	C-C distance for external chamber mounted switches: …….mm	*
	TILT TYPE	x
	Switch type: Microswitch encapsulated in float	x
	No. of floats: single ☐ multiple ☐ Refer followup sheet	x
	MATERIAL OF CONSTRUCTION:	
	External chamber with drain/ vent arrangement: CS A105 ☐ SS 316 ☐ PP ☐	x
	Float: 316 SS ☐ PP ☒ Others ☐	✓
	Guide tube: 316 SS ☐ PP ☒	✓
	Bolts & nuts : ASTM A 193 Gr.B7 / A194 Gr.2H	✓
	Gaskets : PTFE ☒ OTHERS ☐	✓
	Wetted parts: SS 316 ☐ PP ☒	✓
	OTHERS ☐	
30.	Flange: SS 316 ☐ PP ☒	✓
	Cable for tilt switch:	x
	Counter weight for tilt type switch:	x
	CONNECTION & DIMENSIONS	
	External chamber connection type: Upper side - lower side ☐ Upper side - lower bottom ☐	x
	External chamber process connection size: ½" ☐ 1" ☐ others ☐ Type : NPT ☐ flange ☐ SW ☐	x
	Drain arrangement for external chamber Valve ☐ Plug ☐	x
	Vent plug :	x
	Instrument Process connection (**Refer note 3.0**): 4" ANSI class 150 RF flanged ☐ 3" ANSI class 150 RF flanged ☐	*
	Cable entry: 1"ET ☐ ½ " NPT ☐ others ☐	*
	SWITCH DETAILS:	✓
	Controller : Required for converting reed switch to POT Free Relay Output	✓
	Alarms : HI ☐ LO ☐	*
	No. and type of contacts: 1 No SPDT ☐ 1 No DPDT ☒	✓
	Contact rating: 5A@ 230 V AC ☐ 2A@24VDC ☐	✓
	ACCESSORIES:	
	Still well for direct mounting	✓
	Counter weight to keep tilt type switch cable and float in position	x
	Name plate : Removable – SS	✓
	Metal tag – SS	✓
	CODES AND STANDARDS (REFER NOTE 2)	
	Weather proof – IP / NEMA IS 13947 :1993	✓
	Explosion proof - IS 2148-1981/ BS EN 50014:1998 / BS EN 60079-0:2004	x
	Electrical compliant with IEC / EN 61326-3-2	✓
	TESTS	

	Calibration	✓		Performance test	✓
	Material test certificate	✓			

NOTES:

1. (*) - Bidder to furnish details; (✓) - Required; (x) - Not required / Not applicable.
2. The bidder shall indicate all applicable codes and standards.
3. Float size shall be suitable to process conditions and tank height. Accordingly, instrument flange size shall be selected.
4. Terminal size shall be suitable to accept 1.0 mm^2 cable for signal and 2.5 mm^2 cable for power supply.
5. Bidder to specify requirement of any special tools & tackles required at site during erection, commissioning and maintenance of the instrument.
6. Bidder to include list of spares and consumable required during erection & commissioning till handing over of the instrument.
7. Abbreviation used under switch action are as follows

   OFL- opens on falling level

   CFL- closes on falling level

   ORL- opens on rising level

   CRL- closes on rising level

10. JUNCTION BOX

Sr. No.	Description	
	GENERAL	
1.	Manufacturer	
2.	Model No.	
	FEATURE	
3.	Mounting	Wall/ column
4.	No. of terminals	32 (2x16)
5.	Terminal type	Screwed
6.	Terminal size	Suitable for 2.5 sq. mm. wire
7.	Mounting plate	Required
8.	Cable entry	Bottom
9.	Gland plate	Removable
10.	Door	Single lockable door with gasket
11.	Lock & key	Required
12.	Sheet thickness	3 mm
13.	Painting	Inside: glossy white; Outside: RAL 7032
14.	Protection class	Weather proof to IP 65
	MATERIAL OF CONSTRUCTION	
15.	Enclosure	MS with epoxy painting
16.	Gasket	Neoprene
17.	Cable entry sealing	Fire proof compound
18.	Name plate/ metal tag	Fixed SS304
	Installation hardware	Required

11. INTERPOSING RELAY (IPR)

Sr. No.	Description	
	GENERAL	
1.	Manufacturer	
2.	Model No.	
	FEATURE	
3.	Type	Electromagnetic
4.	Connections	Plug-in type
5.	Mounting	channel/ rail mounting in cabinet
6.	Coil rating	24V DC
7.	Change over contacts	2 sets
8.	Contacts rating	0.2A, 220V DC
9.	Freewheeling diode	Across relay coil
10.	Status indicator flag	self reset type (electronic)
	Installation hardware	Required

12. INSTRUMENTATION & CONTROL CABLES

		Description	Power Cables (for 24V DC)	Control cable	Signal cable	Triad Cable
	1.	Type		Screened, armoured	Twisted, screened, armoured	
GENERAL	2.	Voltage grade	1100 V	1100 V	500 V	
CONDUCTOR	3.	Material	Annealed Tinned Copper as per IEC 60288		Annealed Tinned Copper as per BSEN-50288-7	
	4.	Shape of conductor	Stranded circular – Class 2		Stranded circular – Class 2	
	5.	Size	Refer follow up sheet		Refer follow up sheet	
	6.	No. of strands	7 nos.		7 nos.	
PRIMARY INSULATION	7.	Material	XLPE as per IEC 60502-1		Extruded Polyethylene (PE) as per BS-EN 50290-2	
	8.	Thickness of insulation (Nominal)	As per IEC 60502-1	As per IEC 60502-1	As per BSEN-50288-7	
	9.	Colour code	Red, yellow, blue	Grey	White +ve, Black –ve (For each pair)	Brown, Black and blue
INDIVIDUAL PAIRS / TRIADS	10.	Twist	NA	NA	Min. 10 nos. twist / meter for each pair	
	11.	Identification	NA	NA	Numbers at not more than 250mm length	

	12.	Material		NA	NA	Al Mylar tape applied helically with metallic side down in contact with drain wire			
	13.	Tape thickness		NA	NA	mum 0.075 mm thick for single pair cables			
						mum 0.05 mm thick for multipair cables			
	14.	Overlap	Coverage	NA	NA	Min.25%	100%	Min. 25%	100%
	15.	Polyester tape		NA	NA	Polyester tape of 0.05 mm thick each. one tapes with min. 25% overlap & 100% coverage			
	16.	Drain wire							
	17.	Material		NA	NA	Annealed Tinned Copper			
INDIVIDUAL PAIR / TRIAD SCREENING	18.	Size		NA	NA	0.5mm^2, with 7 strands, each of 0.3 mm dia.			
	19.	Material			AL Mylar tape applied helically with metallic side down in contact with drain wire				
	20.	Tape thickness			mum 0.075 mm				
	21.	Overlap	Coverage	NA	Min.25%	100%	Min.25%	100%	Min. 25%	100%
	22.	Drain wire							
OVERALL SCREENING	23.	Material		NA	Annealed Tinned Copper				
	24.	Size		NA	0.5mm^2, with 7 strands, each of 0.3 mm dia.				

13. PROGRAMMABLE LOGIC CONTROLLER (PLC)

Sr. No.	Description			Bidder to state/confirm
1.0	**GENERAL**			
1.1	Project Name	:		
1.2	Customer Name	:		
1.3	Manufacturer	:	*	
1.4	Model no.	:	*	
1.5	Proven track record	:	Latest system and system configuration available/ being marketed in the international market by the bidder/ collaborator with 1 year of proven performance record. The offered hardware & software shall have a proven track record of one installation which is currently functional. The offered configuration with the offered models of the modules – controller, IO interface modules, Ethernet interface modules, serial link modules, IO modules, power supply modules, etc & the offered type of data highway & its type of network, type of IO bus & its type of network, type of OPC links, no. of remote IO links, maximum distance of remote link, etc, shall be in operation for mum period of 1 year in a similar application.	✓
1.6	Criteria for proven track record	:	Same controller as per the proven performance record.	
1.7	System configuration	:	TCE Drg No.: TCE.10477A-IC-5007-CC-50001	
1.8	List of users. Also specify about the manufacturing setup.		To be enclosed by Bidder Indicate the users where it is supplied for a similar application with similar configuration & indicate the no. of successful years of operation.	
1.9	Control room environment	:	$24^0C \pm 1^0C$	
1.10	Total nos. of cabinets	:	*	
1.11	System power supply	:	Redundant from UPS - AC DB 240 V AC ☒	
1.12	Card replacement with power on for systems	:	Required, Hot-swapping.	

Sr. No.	Description			Bidder to state/confirm
1.13	Configuration diagram	:	Bidder to enclose the configuration diagram for the system offered.	
1.14	System Expandability	:	Modular system design with capability and facility for modular expansion is required.	
1.15	PLC with open system architecture to enable integration of third party system	:	Required.	
1.16	Open Protocols to be supported by PLC system for third party interface	:	Required through a) Modbus TCP – IP b) Ethernet connectivity	
1.17	Spare nodes in the IO bus	:	20%	
1.18	Spare capacity for system memory and user memory	:	50% (After configuring the system and application software, considering the installed spares) The same shall be indicated in Bidder's offer by means of calculations and shall be demonstrated at site during Site Acceptance Tests.	
1.19	Surge withstand capability as per IEEE Standard	:	Required	
1.20	Special tools and tackles	:	Bidder to quote special tools and tackles required for installation, testing, commissioning & future maintenance.	
1.21	Posting of 1 hardware and 1 software engineer during erection, commissioning & final acceptance test	:	1. Bidder to indicate organisation chart at site 2. During warranty period, the maintenance call must be attended within 24 hours. The plan from the bidder must be submitted to support this requirement. 3. Subsequently bidder must separately quote for comprehensive AMC rate valid for one years. 4. Contractor's engineer shall be made available for assistance in operation, maintenance, tuning & training of Purchaser's personnel at Site after commissioning of PLC. Rates for the same shall be	

Sr. No.	Description			Bidder to state/confirm
			indicated in schedule of personnel. 5. Training of owner's engineer for both hardware & software development at site. Duration: 2 Weeks No. of engineers: 04	
2.0	**CONTROLLER SUB-SYSTEM**			
2.1	Microprocessor based	:	Yes	
2.2	Configurable multi loop controller	:	Required, PLC shall be capable of running multiple loops of different scan times with assigned priority.	
2.3	Scan time	:	All I/Os shall be scanned Interlocking I/Os: within 50 ms Sequential logic: within 100 ms PID control: within 250 ms Analog Monitoring: within 500 ms It shall be possible to allocate different scan times to different I/O points.	
2.4	Controller redundancy	:	Required	
2.5	Power supply dual redundancy (controller)	:	Required	
2.6	Power supply dual redundancy (I/O racks)	:	Required	
2.7	Status monitoring of power supply modules of CPU & I/O modules	:	Required for monitoring at the HMI	
2.8	**Processor**			
2.8.1	Model no.	:	*	
2.8.2	Processor and word length	:	32 bit ☐ 64 bit ☐	.
2.8.3	I/O redundancy	:	Required for critical IOs based on project specific requirement.	
2.8.4	Processor redundancy	:	Not Required	
2.8.5	Primary & Secondary indication on controllers	:	LED indication required.	
2.8.6	I/O capacity of each controller	:	*	
2.8.7	Logic changes possible through laptop/HMI	:	Yes, with necessary security	
2.8.8	Debugging/ simulation software	:	Should be preloaded in HMI as a system feature	
2.8.9	Self-diagnostics software required	:	In each processor	

Sr. No.	Description			Bidder to state/confirm
2.8.10	Online configuration possibility	:	Required	
2.8.11	Logic changes in main processor	:	Required	
2.8.12	Simultaneous Downloading of programs into both the Processors (main & redundant) by one click.	:	Not Required.	
2.8.13	Online logic changes or Manual data entered (as set point or A/M selection, forcing the outputs to some value, etc.,) done in primary controller	:	Required	
2.8.14	Output status on loss of power	:	Outputs shall go to fail safe position which shall be user defined	
2.8.15	Sequence control functions	:	Required	
2.8.16	Control modes	:	Auto, Menu driven, Discrete	
2.8.17	User memory	:	*	
2.8.18	Memory type for configuration	:	*	
2.8.19	Battery type	:	1 year lifetime: Ni-Cd ☐ other proven options ☐	
2.8.20	Battery drain alarm/ indication	:	Required, on HMI	
2.8.21	Estimated CPU load with furnished configuration	:	CPU loading shall not exceed 50% under worst data loading condition considering used IOs, spare IO channels, spare IO modules, spare IO slots & specified scan time. The same shall be indicated in Bidder's offer by means of calculations and shall be demonstrated at site during Site Acceptance Tests.	
2.8.22	Synchronisation of real time clock	:	Not Required	
3.0	**ALGORITHMS REQUIRED AS A MUM**			
3.1				
A	Alarm check functions	:	Input/ output open check	
		:	High-high, high,	
		:	Low-low, low	
		:	Velocity & deviation	
		:	Hysteresis	
		:	Bypass	
		:	Output open	
B.	Output processing Function	:	High/low alarm	

Sr. No.	Description			Bidder to state/confirm
		:	High/low limiter	
		:	Velocity limiter	
C.	Control algorithms	:	Proportional control	
		:	PI, PID, PD and adaptive gain	
		:	External feed back facility	
		:	Sample & hold PID, PID with batch switch	
		:	Ratio control	
		:	PID with dead band	
		:	Cascade control	
		:	On-off control	
		:	Feed forward control	
		:	Mathematical Functions	
		:	Logic Functions	
D.	Selector	:	Low	
		:	High	
		:	Mean value	
		:	Median	
		:	Over ride	
3.2	Galvanic isolation for input/output & power supply	:	Required	
3.3	Self diagnostic tests			
A.	Input diagnostics	:	Required	
B.	Configuration diagnostics	:	Required	
C.	Memory diagnostics	:	Required	
D.	System hardware check	:	Required	
E.	Output diagnostic	:	Required	
F.	External hardware check	:	Required	
G.	Power system Diagnostics	:	Required	
H.	Alarm indication in MMI when any self-diagnostic test fails	:	Required	
4.0	**COMMUNICATION SUB-SYSTEM**			
4.1	Architecture	:	Bus structure required	
4.2	Type of protocol for communication between MMI & controller	:	Ethernet, IEEE 802.3 u	
4.3	Speed between HMI & controller	:	* Min. 100 Mbps	
4.4	Redundant communication between HMI & controllers	:	Required	
4.5	Method of communication	:	*	

Sr. No.	Description			Bidder to state/confirm
	Ring / Mesh / Star Type			
4.6	Communication modules for controllers for communicating with I/O bus	:	Required	
4.7	Communication modules in I/O or Remote I/O panels for communicating with controllers	:	Not Required	
4.8	Type & speed of communication between I/Os and controller Method of communication Ring / Mesh / Star Type	:	* Min. 10 Mbps. In case of lower speed. Bidder will justify how the functional requirement will be met.	
4.9	Type of I/O bus communication	:	Ethernet, IEEE 802.3 u ☒ Modbus TCP/ IP ☒ OPC ☒ Modbus RTU ☒	
4.10	Maximum no. of nodes (Controller/I/O modules) on the system bus	:	*	
4.11	No. of I/O modules per node	:	*	
4.12	Maximum length of the system cable I/O bus	:	*	
4.13	Bus loading allowed	:	≤ 50% under worst data loading condition. The same shall be indicated in Bidder's offer by means of calculations and shall be demonstrated at site during Site Acceptance Tests.	
4.14	Levels of protection for message transmission			
A	Hand shaking	:	Required	
B	Errors by external noise	:	Required	
C	Checks on data acquired	:	Required	
D	Message retransmission Or other schemes for Orderly recovery if a Message is lost	:	Required	
5.0	**Human MACHINE INTERFACE SUB-SYSTEM (HMI)**		Centralised SCADA interface purpose	
5.1	Quantity	:		
5.2	Make/model	:		
5.3	Type	:	Refer Clause No. 18: 'Minimum Specifications for Engineering & Operator Workstations'	

Sr. No.	Description			Bidder to state/confirm
5.4	**Features of Data Acquisition & Control System Software**		**Centralised SCADA software**	
5.4.1	Trending function	:		
A	Real time	:	Required	
	Trend assign parameters as min.	:	PV, MV, SEV etc.	
	No. Of parameters	:	*	
	Sampling time	:	*	
	Time base	:	*	
B	Historical trending			
	No. of parameters	:	*	
	Sampling time	:	*	
	Time base	:	*	
C	No. of points per trend page	:	*	
	Trend points for sampling time of 1 sec to 10 sec and full scale time base of 4,6,16,32 minutes/ hours/ days for tuning the process loops	:	Required	
5.4.2	Logging functions			
A.	Log formats	:	User definable	
B.	Event logging	:	Required	
C.	Hourly logs	:	Required	
D.	Shift logs	:	Required	
E.	Daily logs	:	Required	
F.	Weekly logs	:	Required	
G.	Logging frequency	:	* (User selectable)	
H.	Operator actions	:	To be logged	
5.4.3	Alarm display function			
A.	Last alarm always to Appear on top of screen	:	Regardless which page is being seen	
B.	No. Of alarms / page	:	*	
C	No .of Alarms Stored	:	*	
D.	Differentiation between Process & system alarms	:	Required	
E.	Alarm return to normal	:	Required. To appear in a separate line with time.	
F.	Group display function	:	Required	
G.	Total no. of groups	:	*	
H.	No. of loops per group	:	*	
5.4.4	No. of windows opened at a time	:	*	
5.4.5	Information display group	:	8 faceplates per window with following details	

Sr. No.	Description			Bidder to state/confirm
A	Input	:	Required	
B	Output	:	Required	
C	Set point	:	Required	
D	Tag nos.	:	Required	
E	Set point status	:	Required	
F	Mode status	:	Required	
G	Service description	:	Required	
5.4.6	Print message history required	:	Yes	
5.4.7	Alarm handling while continuous alarm condition	:	Required	
5.4.8	Faceplate details should be user selectable	:	Required	
5.4.9	Faceplate indication colors selection	:	Easy, Menu driven required	
5.4.10	Tag security for individual tags	:	Required	
5.4.11	MMI database should be selectable	:	Possible by assigning MMI name/PC no.	
5.4.12	Control drawing & logics for engineering & use	:	High level language (like Ladder/Function blocks / Other as per Manufacturer Standard)	
5.4.13	Change in Engg. Unit of any tag is made should get reflected in the graphics also	:	Required	
5.4.14	Change of operation mode : auto, manual, cascade	:	Required	
5.4.15	Alarm priorities and levels	:	Min. 5 levels	
5.4.16	Operation mark on the tag : Faceplates & Graph	:	Required – e.g. - service, repair, calibration, maintenance, no operation etc.	
5.4.17	Safe operation range indicators on tag's faceplate	:	Required for safe operating range : low & high	
5.4.18	Alarm & trip mark indicators on tag's faceplate	:	Required for : low-low, low, high & high-high level	
5.4.19	Clamp input facility	:	Required to be clamped if goes beyond certain range/value	
5.4.20	Repeat alarm after preset time for critical poll	:	Required, even if it is acknowledge by operator but still in alarm stage	
5.4.21	Pass, fail, stuck up status for every sequence	:	Required, to know where the process sequence has stuck up	
5.4.22	Scan time setting for individual sequence table	:	Required	
5.4.23	Timers counting capacity	:	Upto 9999 seconds and/or 9999 minutes	

Sr. No.	Description			Bidder to state/confirm
5.4.24	Generate flags from timer status	:	Required from : on, stop, deviation, pause	
5.4.25	Pause facility in the timer	:	Required	
5.4.26	Counter counting capacity	:	Upto 9999 (0 to 9999 or 9999 to 0)	
5.4.27	Functional blocks	:	Readymade library for ease of engineering	
5.4.28	Faceplate to appear on trend display on call	:	Required	
5.4.29	Scrolling facility in the stored trend	:	Required	
5.4.30	Trend pause, compress/ expand 'x' & y axis	:	Required	
5.4.31	History storage	:	Required for all process parameters, all process/ system alarms, operator action, upsets, changes etc. 6 GB storage capacity for history storage Sampling rates shall be user selectable	
5.4.32	Search feature on alarm, history, operator action etc.	:	Required	
5.4.33	Connected with	:	Engineering Station ☒ Operating Station Network ☒ Other ☐	
5.4.34	HMI Compatible with	:	OPC/ UA	
6.0	**ETHERNET SWITCH (LAYER-2)**			
6.1	Bidder shall submit Ethernet switch – Layer – 2 & Layer – 3 level configuration for Purchaser's approval. Grouping of different controllers, HMIs under Ethernet switch shall be subjected to Purchaser's approval during detailed engineering.	:	*	
6.2	Type	:	Industrial Grade, Manageable, Layer-2 Fast Ethernet switches, with at-least 2 Fibre Optic Port	
6.3	Make	:	As per Approve make list	
6.4	Model No.	:	*	
6.5	Number of Ports	:	8 ports (10/100 Mbps) full duplex electrical ports and 2 uplink ports	

Sr. No.	Description			Bidder to state/confirm
			(FO) (1Gbps).	
6.6	Auto sensing & Auto-negotiating ports	:	Required	
6.7	SNMP management features	:	Required	
6.8	Power	:	230 V AC, UPS required, dual intake (Redundant)	
6.9	Diagnostics	:	LEDs for Power, duplex mode indication, flow control activation, collision indication (when working in half duplex), CRC indication	
6.10	Security	:	Port Security	
6.11	Quality of Services (QOS)	:	Required	
6.12	Spanning tree protocol	:	Required	
6.13	1 No. Licensed copy of management software	:	Required of the same make as the Ethernet switches	
6.14	Type of communication on LAN	:	Ethernet, IEEE 802.3 u	
6.15	Communication Protocol for LAN	:	TCP/IP	
6.16	Virtual LAN capability	:	Required	
6.17	Operating Temperature	:	Up to +60° C ambient	
6.18	Quantity	:	* Nos. 1 No. to be provided separately.	
7.0	**FIBRE OPTIC CONVERTERS**		**INTEGRAL TO NETWORK SWITCH WITH LIU & FO PATCH CORDS**	
8.0	**INPUT/OUTPUT SYSTEM**			
8.1	I / O series (model no)	:	Bidder shall offer IO module series that are latest & best suitable for the offered controller. Subjected to Purchaser's approval.	
8.2	Signal isolation for all I/Os	:	Optical or galvanic	
8.3	Individual fuse for each I/O point	:	Required, Fused Terminals shall be provided.	
8.4	Module failure indication in module and PLC	:	Required	
8.5	Indication and alarm in PLC for module failure	:	Required	
8.6	Channel – to –channel isolation	:	Required for each input & output modules	
8.7	Chanel to back plane isolation	:	Required	
8.8	Fault status of each channel of each input/output module	:	Required for monitoring on MMI	
8.8.1	Intrinsic safe barrier for instruments	:	Required	

Sr. No.	Description			Bidder to state/confirm
	located in Hazardous area			
8.8.2	Type of isolation	:	Optical/Galvanic	
8.8.3	Support HART Protocol to carry out all diagnosis & calibration	:	Required	
8.9	**Analog output module**			
8.9.1	Model No.	:	* (Same series as that of Controller)	
8.9.2	No. of points per module	:	6 / 8	
8.9.3	Type of outputs	:	4-20 mA	
8.9.4	Resolution	:	12 bit including sign	
8.9.5	Accuracy	:	± 0.1% of full scale	
8.9.6	Intrinsic safe barrier for instruments located in Hazardous area	:	Required	
8.9.7	Type of isolation	:	Optical/Galvanic	
8.9.8	Support HART Protocol to carry out all diagnosis & calibration	:	Required	
8.10	**Digital input module**			
8.10.1	Model No.	:	* (Same series as that of Controller)	
8.10.2	No. of inputs / module	:	16 / 32	
8.10.3	Type of input	:	Potential free contacts	
8.10.4	Type of isolation	:	Optical	
8.10.5	LED status indication for each input	:	Required	
8.10.6	Interrogation voltage	:	External 24V DC	
8.10.7	Filtering at input stage	:	Required	
8.11	**Digital output module**			
8.11.1	Model No.	:	* (Same series as that of Controller)	
8.11.2	No. of outputs per module	:	16	
8.11.3	Type of outputs	:	Relay outputs (TTL outputs not acceptable)	
8.11.4	Output contact rating of interposing relays	:	2A, 220 V DC for Breaker operated drives and 5A, 230 V AC for rest application (2CO for each relay)	
8.11.5	Discrete relays/relay boards	:	Relays mounted on relay boards to be provided (maximum of 8 in a board).	
8.11.6	LED status indication for each output	:	Required.	
8.11.7	Output Status	:	Outputs shall change to fail-safe position in case processor failure or module failure.	
8.11.8	Power Supply	:	*	

Sr. No.	Description			Bidder to state/confirm
8.11.9	Interface Module	:	*	
8.12	**I/O Summary**			
8.12.1	Analog inputs (4-20 mA)	:	Refer Clause No. 21: 'Typical I/O list' of facility.	
8.12.2	Analog outputs (4-20 mA)	:		
8.12.3	Digital inputs (24V DC)	:		
8.12.4	Digital outputs (potential free)	:		
9.0	**APPLICATION PROGRAMME**	:	To be provided in R/W DVDs (2 Nos.) for each facility.	
10.0	**PROGRAMMING UNIT (preferably LAPTOP)**			
10.1	Make	:	Compaq/Toshiba/HP/IBM (Lenovo)/Dell	
10.2	Quantity	:	**Not required**	
10.3	CPU	:	Core i7 or better	
10.4	CPU speed	:	1.5 G Hz or higher.	
10.5	DDR RAM	:	4 GB or better as per availability in market	
10.6	Cache memory	:	mum 6 MB	
10.7	Hard disk	:	500 GB	
10.8	Combo drive	:	DVD/CDRW Combo drive	
10.9	VDU	:	14 inch colour, LED display with 1366 x 768 or better resolution.	
10.10	Integrated	:	10/100 Mbps Ethernet LAN interface card IEEE 802.3 u, 802.11 b wireless Ethernet.	
10.11	Additional Communication ports	:	mum one parallel, one serial (RS 232) and two USB ports.	
10.12	Mouse	:	Optical mouse	
10.13	Power supply	:	Universal AC adapter: 100 to 240 V AC (50 Hz) input; rechargeable lithium-ion battery with up to 4 hour run time, upto 7 hour total run time with primary and secondary batteries, fast battery recharge, low-battery warning	
10.14	External speakers	:	2 Nos. required. The Laptop shall be provided with necessary sound cards & drivers.	
10.15	Any other features	:	All standard features available on a laptop	
10.16	Minimum accessories to be provided			

Sr. No.	Description			Bidder to state/confirm
A	Carry case	:	Required.	
B	Battery adapter	:	Required.	
C	Power chord	:	Required.	
D	LAN cable with connectors	:	Required.	
E	All cables & accessories required for connecting to PLCs/MMIs/ Ethernet switches	:	Required.	
13.0	**Spares**			
13.1	Input and output modules wired up to marshalling panels	:	20% of used I/Os of each type	
13.2	Wired slots for mounting the spare modules	:	20 % of used slots	
13.3	Interposing relays wired in cabinet for all wired spare digital outputs	:	Required	
13.4	Terminals mounted in each panel	:	20 % of used terminals	
13.5	MCBs mounted in each panel	:	20 % of used MCBs	
13.6	Spare space in the cabinets to install additional relays in future	:	20 % of used relays	
13.7	Unused node addresses in communication network	:	____%	
14.0	**Spares to be kept in store**			
1.1	Modules	:	20 % of used modules of each type or 1 No. of each type whichever is higher	
1.2	Interposing relays	:	25 % of used relays	
1.3	Terminals of each type	:	20 % of used terminals	
1.4	Safety Barriers, Signal Converters, Trip Amplifiers, Relays etc.	:	20 % of used	X
1.5	Operating workstation along with monitor, mouse, keyboard & 1 TB portable hard disk	:	1 No.	
1.6	Fuses of each rating	:	30 % of used	
1.7	Bulk power supply unit of each rating	:	1 No. of each rating	
1.8	Communication system components such as hubs, switches, router	:	10 % of used	
1.9	Disks, disk drives, switches, lamps, push buttons, etc	:	10 % of used	
1.10	Consumable including printer cartridges, Paper or any other consumable items	:	For 07 ~~months~~ / years after handing over.	
2.	**MCBs**	:	20 % of used MCBs	

Sr. No.	Description			Bidder to state/confirm
2.1	Separate MCBs for isolating each device	:	Required.	
2.2	Separate redundant SMPS for Controller, I/O Modules & SOV	:	Required.	
2.3	Shall supply 230 V AC Non-UPS power supply to fan, panel heater, sockets and illumination lamp in all panels	:	Required.	
16.0	**FACTORY ACCEPTANCE TEST**			
16.1	FAT procedure shall be submitted for Purchaser's approval before commencement of FAT	:	Required	
16.2	A 100% integrated system simulation test shall be carried out in the shop to test all the hardware and software including all communication links to third party systems	:	Required.	
16.3	PURCHASER /CONSULTANT's representative shall participate in the FAT at works, prior to despatch	:	Required.	
16.4	FAT shall be carried out as per final approved drawings / documents	:	Required.	
16.5	Various tests to be covered in FAT shall be as per FAT procedure	:	Required.	
16.6	VENDOR should have performed all standard basic functional tests prior to start of FAT	:	Required.	
16.7	Throughout the FAT supply all necessary test equipment and consumable	:	Required.	
16.8	VENDOR shall be responsible for making all connections between system components, peripherals and test equipment, including foreign device interfaces	:	Required.	
16.9	Supply software and hardware technical support of sufficient standard to ensure mal delays during the interface-testing program	:	Required.	
16.10	Calibration certificates traceable to National/ international Standards for test instruments used during inspection	:	Required.	

Sr. No.	Description			Bidder to state/confirm
17.0	**SITE ACCEPTANCE TEST (SAT)**			
17.1	Close loop checking, Open Loop and Interlock checking	:		
17.2	System loading (CPU, bus & memory) after commissioning	:		
17.3	Control Loop update time	:		
17.4	Screen update time	:		
17.5	VENDOR shall submit a SAT Procedure for PURCHASER/ Consultant's review. The final SAT shall be carried out on the basis of this approved document	:		
18.0	**DOCUMENTS**			
18.1 1	**Following documents to be furnished by VENDOR along with the bids**			
18.2	System architecture/Configuration drawing indicating redundancy at all levels and all hardware components	:		
18.3	System-wise Bill of Material (BOM).	:		
18.4	Catalogues of all products listed in the BOM	:		
18.5	System-wise Power distribution & power consumption	:		
18.6	Number and size of each panel offered	:		
18.7	List of Deviations	:		
18.8	Delivery Schedule	:		
18.9	List of documents required by the VENDOR	:		
18.10	List of calibration equipment available with the VENDOR along with valid calibration certificates	:		
18.11	Data duly filled in the data sheets enclosed with entire data sheet stamped & signed	:		
18.12	Mandatory spare parts list	:		
18.13	Recommended spare part list	:		
18.14	Control Room Layout	:		
18.15	**Following drawings / documents to be furnished by VENDOR after award of contract**			
18.16	Bar chart for the design, manufacturing, erection,	:		

Sr. No.	Description			Bidder to state/confirm
	commissioning, trial operation and performance testing of the system offered.			
18.17	Overall System Architecture	:		
18.18	System Functional Write-up	:		
18.19	Unpriced purchase order copy for various bought out /sub contracted equipment / services	:		
18.20	Following drawings for PLC System Cabinets, I/O racks, Marshalling cabinets, Control desks & Power distribution boards	:		
a)	Front facia layout showing all instruments with cut-outs, bezel dimensions, construction details, foundation details and interior G.A. drawings showing interior layout of various modules on racks			
b)	Internal wiring diagrams indicating termination details of each component.			
c)	Bill of Material (B.O.M.) indicating tag no., quantity, service & model no. of the various instruments/items.			
18.21	Power Supply Distribution Scheme for the entire I&C system indicating quantity of feeders and type & rating of each feeder in each PDB			
19.0	**Following drawings / documents for PLC system**			
a)	Configuration drawing			
b)	Make Model No., Catalogues, Data sheets for CPU modules, I/O modules, Communication modules and all other modules of the PLC system and engineering stations			
c)	I/O list indicating grouping of various signals in each module (I/O assignment).			
d)	Nest Loading drawings/documents			
e)	Sequence & logic diagrams and control schemes			
f)	Operating manual for PLC system			
g)	Hardware and software manuals			

Sr. No.	Description			Bidder to state/confirm
h)	Configuration data			
i)	Trouble shooting manual			
j)	Network Topology			
k)	Arrangement of cabinets with dimensions			
l)	Alarm wiring			
m)	Material List			
n)	Software Installation List			
o)	Fuse List			
p)	Printer settings			
q)	Description of software protocols			
r)	Settings of DIP-Switches			
s)	Cable List			
19.1	Following drawings for Operator Stations:			
a)	Data sheets of hardware including communication protocol details			
b)	Listing of alarm messages.			
c)	Catalogues			
d)	Screen Layout			
e)	Log sheets & report sheets			
f)	Control Schemes for Operator Stations			
g)	Details of Software Package in the Operator Stations indicating various functions & facilities available			
h)	Wiring Diagram			
19.2	Data sheets & details of software packages for Engineering Station and Asset Management System / Alarm management system.			
19.3	Heat load and Power consumption for A.C. & D.C. loads			
19.4	Data sheet and load calculations for DC power supply units			
19.5	Data sheets for Ethernet switches			
19.6	QAPs for all items like panels, control desks, junction boxes, cables			
19.7	Earthing diagrams for cabinet & entire system			

Sr. No.	Description			Bidder to state/confirm
19.8	Loop diagrams, Cable Schedules and Interconnection cable schedules.			
19.9	Standard FAT & SAT for the specified systems			
19.10	Detailed instruction manual for the entire PLC (operation & maintenance)			
19.11	As Built' drawings			
19.12	Instruction manual for installation and start-up.			
19.13	System operation and maintenance manual			
19.14	Protocol listing (hard and soft) copies			
19.15	Copy of licences for various software to be supplied			
19.16	Guarantee certificate			
20	**The product warranty must include following points:**			
a)	Provide 10 years warranty from the date of acceptance of the system after installation, integration, commissioning			
b)	Include comprehensive preventive and break down maintenance including all types of spares and software. The software up-gradation is to be free of cost during this period			
c)	The supplier engineer shall make quarterly visit to check the healthiness of the system and shall submit the reports of the same to PURCHASER during his quarterly visit.			
d)	Supplier has to provide on-site various operation and maintenance support like programming of various features, changing class of services, reconfiguration, including modifications, creations, up-dating and expansion			
e)	Vendor to quote for Comprehensive Maintenance Contract rate valid for **7** years after the warranty period			

14. NETWORK SERVER CABINET

1.	Make:	*
2.	Model number:	*
3.	Type: Metal enclosure	✓
4.	Panel size: Refer notes	*
5.	Ingress Protection IP-42 : In conditioned area/ Control room IP-65 : In field / un-conditioned areas	✓
6.	Colour shade : Powder coated RAL 7035	✓
7.	Construction features : (a) All round solid construction (b) Single hinged door (middle portion of door shall be transparent for making internal indications visible) (c) All round foamed-in PU seal (d) Screwed gland plate with knock out openings (e) Fans with filters shall be provided as per heat dissipation calculation (f) Louvers with mesh shall be provided	✓
8.	Light & receptacles : (a) Required for panel with height more than 600 mm (b) Required near both the doors (front and back) for floor mounted panel	✓
9.	Material of construction: (a) CRCA sheet steel enclosure (b) CRCA Gland plate zinc plated, passivated (c) CRCA Door with middle transparent portion for indication visibility	✓
10.	Thickness: (a) Enclosure: 1.2mm thick (b) Door : 2mm thick (c) Gland plate : 3mm thick (single piece)	✓
11.	Cable entry: (a) For armoured cables: Double compression type cable glands of nickel plated brass material (b) For unarmoured cables: Single compression type cable gland of nickel plated brass material (Panels shall have 20% spare cable entries provided for each type of cable)	✓
12.	Ambient temperature : 0º C to 60º C	✓
13.	Humidity : 10% to 80% Rh	✓
14.	Eyebolts : 4 Nos. required for floor mounted cabinet	✓
15.	Mounting accessories: (Refer notes) (a) Base (b) Lock (c) Interior accessories like mounting brackets, angles, clamps, cable ties,etc. (d) Cable manager (separate for power & signal cables)	✓
16.	Nameplate: For panel - Stainless steel (1.6mm THICK) with black coloured letters engraved on the plate For all the components mounted inside the panel - Phenolic overlays (1.6mm THICK), Black background with white lettering and shall be fixed to the panel by stainless steel screws	✓
17.	Weight of the cabinet (as per size) Wall mounted : Floor mounted :	*
18.	Dimensions & Quantity:	*
19.		
20.		

Sr. No.	L x W x H	QTY	AC/ Non-AC
(a)			
(b)			
(c)			
(d)			

NOTES

1.	'*' - Bidder to state, 'NA' – Not Applicable
2.	To fulfill the power requirement necessary power convertor/ amplifiers/ adapter shall be provided by the vendor.
3.	Purchaser reserves the right to ask the OEM to conduct the Proof Of Concept/Live Demo of the proposed Products and Solution, failing which the OEM shall be technically rejected.
4.	The size selection for all the network cabinets will be subjected to clients/ consultants approval.
5.	Panel size shall be selected such that it shall have adequate maintenance space as well space shall be available to mount 20% of each type of component in the panel if required in future.
6.	Following tests shall be carried out on the cabinet (a) Verification of degree of protection (test certificate) (b) Physical & dimensional checks (Test certificate) (c) All other electrical test related to panel enclosure as per standards (Witnessing)
7.	For floor mounted cabinet, maximum allowable height for the cabinet shall be 2100 mm from finished ground level. In case of false/ raised floor structural steel base shall be provided (Depending upon the weight of the fully loaded cabinet, adequate MC channel shall be used for the base).
8.	Requirement of doors (front & rear) for the floor mounted network racks shall be decided at the time of detail engineering.