SECTION -VII

TECHNICAL SPECIFICATIONS

TECHNICAL SPECIFICATIONS FOR STP-CIVIL WORKS

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1.0 TECHNICAL SPECIFICATION FOR CIVIL WORKS

The brief scope of the work shall include but not be limited to the following:

- Required site development including leveling and grading to improve the aesthetics and to facilitate the vehicular movement.
- Preparation of all civil drawings including construction and as built drawings.
- Construction of civil engineering works for all the units plus all the ancillary structures as detailed in Civil Specifications and as required in complete for plant operation.
- Supply, erection, testing & commissioning of all the piping & valves as specified in Civil Specifications and as required in complete for plant operation.
- Construction of internal, walkway, storm water drain, boundary walls and gates.
- Plinth protection along the periphery of all the units shall be provided as per technical specifications.
- The Contractor to submit all the loading calculation & detailed design, engineering drawings, shop drawings, construction drawings, fabrication drawings, as built drawings, complete engineering calculations files of all structural elements.
- Landscaping and gardening in the open area of the treatment plant site.
- Bidders are advised to visit STP site before quoting for the proposed STP.
- Any other items of work which have not been specifically mentioned in specifications but are necessary for construction of the plant as per engineering practice and safety norms and operation and guaranteed performance of the entire plant shall be deemed to be included within scope of work of these specifications and shall be provided by the contractor without any extra cost to the employer.

1.1 Detailed Civil Scope of Work

The brief scope of works covers design, supply, construction required for development of 4000 KLD Sewage Treatment Plant (STP) and associated work including buildings/Sheds. Contractor shall be required to study, design and execute every such item(s) of work(s) which are considered required or necessary for the satisfactory completion and functioning of the entire work, commissioning including Operation & Maintenance of the plant, pumping stations, rising main(s) and other appurtenances etc. even if such items of work are not specified in the bid document, but essential to complete the scheme. The contract shall be a Turnkey Contract and shall include the following:

- Clearing the site of trees/shrubs, debris etc.
- Carrying out necessary tree cutting, transplantation of trees, new plantation etc. as per guidelines and permission from the respective dept.
- Carrying out necessary site surveys and soil investigation.
- Preparation and submission of Civil and structural detailed design, engineering drawings, shop drawings, construction drawings, fabrication drawings, as built drawings, complete engineering calculations along with software analysis reports for 4000 KLD SEWAGE TREATMENT PLANT (STP) and related work including buildings/Sheds.
- Internal, pathways, Landscaping of the plant area.
- Submission of operation and maintenance manuals of instructions and all as built drawings for civil works.
- Cost of shifting of poles, cables, pipelines etc. if required shall be borne by the contractor.
- During construction period, required power and water shall be arranged by the Contractor at his own expense and at no additional cost to Owner.
- Facilities for Engineer-In-Charge, Staff and Labor at site, as detailed elsewhere in the bid document and as applicable in accordance with prevailing norms and standards
- Excavation, soil and sand filling, compaction, backfilling, and construction of Foundation of all building, sheds, processing units and Tanks of 4000 KLD Sewage treatment plant (STP).
- Design and Construction of RCC and steel components for 1000 KLD Sewage Treatment Plant for phase I in 2 modules 500 KLD each as shown in the plan layout, 1000 KLD Sewage Treatment Plant for phase II in 1 module and for Phase III 2000 KLD to be constructed in Phase III.
- Civil works for temporary barricades and scaffolding around proposed MLD Sewage Treatment Plant of required height as per client before starting construction activity and removing it after completion of construction.
- The maintenance and repair of damaged Road, landscape, and green area due to vehicle movement and construction activity.
- Waterproofing shall be done for all Tanks, building terrace as per technical specification and engineers' requirement. The waterproofing systems shall be guaranteed for a minimum period of ten (10) years against all defects and liabilities thereof from the date of completion of project.
- Geotechnical investigation report based on geotechnical investigation carried out by Contractor along with foundation recommendation for various Process units, sheds, buildings/structures/facilities.
- The loading calculation & design files including but not limited to Calculation of loads, codal compliances in spread sheets, software files used for Calculation, modelling, analysis, design

and drawing of all structural elements and other data and files as demanded by the approving Design Reviewer/Engineer/ Engineer's Representative for all buildings and structures, etc.

- Trial run, testing and commissioning of the Sewage Treatment Plant.

1.2 General Building Work

APPLICABLE CODES AND SPECIFICATIONS

The more important Codes, Standards and Publications applicable to this section are listed hereinafter:

Code Reference	Description
IS: 110	Ready mixed paint, brushing, grey filler, for enamels for use over primers
IS: 269	Specification for 33 grade Ordinary Portland Cement
IS: 280	Specification for mild steel wire for general engineering purposes
IS: 287	Recommendations for maximum permissible moisture content of timber used for different purposes
IS: 383	Specification for coarse and fine aggregates from natural sources for concrete
IS: 456	Code of practice for plain and reinforced concrete
IS: 712	Specification for building limes
IS: 1077	Specification for common burnt clay building bricks
IS: 1124	Method of test for determination of water absorption, apparent specific gravity and porosity of natural building stones
IS: 1200	Methods of measurement of building and Civil engineering works
IS: 1489 (Part 1)	Portland Pozzolana Cement: Flyash based
IS: 1489 (Part 2)	Portland Pozzolana Cement: Calcined clay based
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: 2074	Ready mixed paint, air drying, red oxide-zinc chrome, priming

Code Reference	Description
IS: 2116	Specification for sand for masonry mortars
IS: 2185	Specification for concrete masonry units (Parts 1 & 2)
IS: 2212	Code of practice for brickwork
IS: 2250	Code of practice for preparation and use of masonry mortars
IS: 2395 (Parts 1 & 2)	Code of practice for painting concrete, masonry and plaster surfaces (Parts 1 & 2)
IS: 2402	Code of practice for external rendered finishes
IS: 2572	Code of practice for construction of hollow concrete block masonry
IS: 2645	Specification of integral cement waterproofing compounds
IS: 2691	Specification for burnt clay facing bricks
IS: 2750	Steel Scaffoldings
IS: 3620	Specification for laterite stone block for masonry
IS: 3696	Safety code of scaffolds and ladders (Parts 1 & 2)
IS:3370	Code of practice for concrete structures for the storage of liquid (Part I to IV)
IS: 4082	Recommendation of Stacking and Storage of construction materials
IS: 5410	Cement paint, colour, as required
IS: 6041	Code of practice construction of autoclaved cellular concrete block masonry
IS: 6042	Code of practice for construction of light weight concrete block masonry
IS: 8042	Specification for white Portland cement
IS: 8112	Specification for 43 grade Ordinary Portland Cement
IS: 12269	Specification for 53 grade Ordinary Portland Cement
Legend	
IS	Indian Standards

1.3 Quality Assurance and Quality Control

1.3.1 The work shall conform to high standards of design and workmanship, shall be structurally sound and aesthetically pleasing. Quality standards prescribed shall form the backbone for the Quality Assurance and Quality Control system.

1.3.2 At the site level the Contractor shall arrange the materials, their stacking/ storage in appropriate manner to ensure the quality. Contractor shall provide equipment and manpower to test continuously the quality of materials, assemblies, etc., as directed by the Engineer. The tests

shall be conducted continuously, and the results of tests maintained. In addition, the Contractor shall keep appropriate tools and equipment for checking alignments, levels, slopes and evenness of the surface.

1.3.3 The Engineer shall be free to carry out such tests as may be decided by him at his sole discretion, from time to time, in addition to those specified in this document. The Contractor shall provide the samples and labour for collecting the samples. Nothing extra shall be payable to the Contractor for samples or for the collection of the samples.The test shall be conducted at the Site laboratory that may be established by the Contractor or at any other Standard Laboratory selected by the Engineer.

1.3.4 The Contractor shall transport the samples to the laboratory for which nothing extra shall be payable. In the event of Contractor failing to arrange transportation of the samples in proper time Engineer shall have them transported and recover two times the actual cost from the Contractor's bills.

1.3.5 The testing charges shall be borne by the Contractor.

1.3.6 Testing may be witnessed by the Contractor or his authorized representative. Whether witnessed by the Contractor or not, the test results shall be binding on the Contractor.

1.4 General Requirements

Preamble

These specifications cover the items of works in structural and nonstructural parts of the works coming under purview of this document on Design build contract basis. All work shall be carried out in conformation with this specification. In general, provisions of Indian Standards, and other National Standards shall be followed. These specifications are not intended to cover the minute details. The work shall be executed in accordance with the best modern industry practices. All Codes and Standards referred to in these specifications shall be the latest published ones.

The work to be performed under this specification consists of design, engineering, preparation of detailed specifications, general arrangement, construction, fabrication and erection drawings including supply of all labour, materials, consumables, equipment, temporary works, temporary labour and staff colony, constructional plant, fuel supply, transportation and all incidental works not shown or specified but reasonably implied or necessary for the completion and proper functioning of the campus, all in strict accordance with the specifications, including revisions and amendments thereto as may be required during the execution of the work.

The Contractor to submit all the loading calculation & design files of all structural elements. Also, the other data and files as demanded by the approving Engineer/ Engineer's Representative for all buildings and structures, etc.

The work shall be carried out according to the detailed design, drawings and specifications to be developed by the Contractor and approved by the Engineer/ Engineer's Representative. For all buildings, structures, etc., necessary details are to be developed by the Contractor keeping in view the statutory & functional requirements of the campus and facilities and providing enough space and access for operation, use and maintenance. Certain minimum requirements are indicated in this specification for guidance purposes only. However, the bidder's offer shall cover the complete requirements as per the best prevailing practices and to the complete satisfaction of the Engineer.

The scope shall also include setting up a complete testing laboratory in the field by the Contractor to carry out all relevant tests required for the works.

1.5 Detailed Design by Contractor

1.5.1 The Contractor's detailed design shall comply with the Engineer's requirements as outlined in the Master Plan, Design Specifications and Drawings, which are made part of this specification. All other materials and components shall be accommodated within the locations, space and dimensions indicated on the layout drawings.

1.5.2 The detailed design of buildings and structures shall be evolved considering the strength and serviceability requirements as per the relevant standards and specifications, functional, technological, operation & maintenance of MEP services and other requirements for efficient operation, ensuring comfortable working environment for personnel, satisfying the aesthetic requirements. Special care shall be taken to provide elegance and aesthetics, with effective use of appropriate treatment, materials, fittings and finishes.

1.5.3 The Contractor shall design and construct all buildings and structures to meet the stipulated performance and quality requirements of the Contract and to the approval of the Engineer.

1.5.4 Approval by the Engineer shall not relieve the Contractor of any of his responsibilities under the Contract.

1.5.5 The bid purpose drawings are provided to enable Contractor to carry out design for the project in line with the specification requirements. These drawings are indicative only and represent the minimum construction, quality, scope, dimensional and space requirements. The drawings are issued subject to increase in quantity, quality and space requirement as recommended by the Contractor or as may be instructed by the Engineer to accommodate the actual operational requirements of the Project.

1.5.6 The Contractor shall himself make all necessary independent investigations and studies to ensure that the design of all buildings/ structures including all foundations and site development meets with the requirements of the Contract and is suitable and adequate for the purpose.

1.5.7 Contractor shall inspect the site, examine and obtain all information required and satisfy himself for site conditions such as access to site, communications, transport, right of way, the type and number of equipment and facilities required for the work, availability of local Labour, materials and their rates, local working conditions, weather, tidal / flood levels, subsoil conditions, natural drainage, etc. Ignorance of the site conditions shall not be accepted by the Owner as basis for any claim for compensation or extension of time. The submission of a bid by the Contractor will be construed as evidence that such an examination was made and any later claims / disputes in regard to price quoted shall not be entertained or considered by the Owner on account of ignorance of prevailing site conditions.

1.6 Documents To Be Submitted by Bidder Along with Design and Build Bid

1.6.1 Suggested plot plan locating all buildings, structures, facilities, roads, temporary site office, etc. with their plan dimensions.

1.6.2 A study notes on proposed site grading with levels along with certified data collected from various agencies to arrive at the same. Also, the source of earth to be used as fill having quality as per specification should be indicated.

1.6.3 Concept Note or Detailed write up on the following satisfying the statutory requirements,

1.6.4 Proposed shoring system for excavation during construction where water table is higher.

1.6.5 Proposed dewatering system during construction where water table is higher.

1.6.6 Waterproofing system and detailed methodology proposed for each area.

1.6.7 A report on foundation proposed for various structures, buildings and facilities based on the data furnished by the Engineer and further data collected by the Contractor. Allowable safe bearing capacity for open foundation, depth of foundation, need for pile foundations, type, length

and capacity of piles, if piles are proposed, soil improvement if any required, special precaution against aggressive soil etc. shall also be covered in the report.

1.6.8 Detailed design criteria proposed to be adopted for each building, structures etc.

1.6.9 Details of quality control laboratory with a list of testing equipment.

2.0 EARTHWORK IN GRADING, EXCAVATION AND BACK FILLING

2.1 Scope

This specification covers the general requirements of earthwork in excavation in different materials, site grading, filling in areas as shown in drawing, filling back around foundations and in plinths, conveyance and disposal of surplus soils or stacking them properly as shown on the drawings and as directed by the ENGINEER and all operations covered within the intent and purpose of this specification.

2.2 Applicable Code

The following minimum codes and standards, unless otherwise specified herein, shall be applicable. In all cases, the latest revisions of the codes on the date of signing of contract agreement shall be referred to. The revisions in the relevant codes and standards after the date of award of contract shall be informed by the Contractor to the PMC/Employer within 30 days of the issue of such revision of the code/ standard. PMC/Employer may approve use of the earlier code/ standard if the revisions do not materially affect the statutory requirements of the project or does not impact safety practices. Any cost impact arising out of such revisions shall be mutually agreed.

1	IS: 456	Code of practice for plain and reinforced concrete
2	IS: 783	Code of practice for laying of concrete pipes
3	IS: 1200	Method of measurement of Building and Civil Engineering works
	Part 1	Part 1 Earthwork
	Part 27	Part 27 Earthwork done by mechanical appliances
4	IS: 1498	Classification and Identification of Soils for General Engineering purposes
5	IS: 3764	Excavation work - code of safety
6	IS: 2720	Methods of test for soils
	Part 1	Preparation of dry soil samples for various tests
	Part 2	Determination of water content
	Part 4	Grain size analysis

	Part 5	Determination of liquid and plastic limit
	Part 7	Determination of water content - dry density relation using light compaction
	Part 9	Determination of dry density - moisture content relation by constant weight of soil method
	Part 14	Determination of density index (relative density) of cohesionless soils
	Part 28	Determination of dry density of soils in place, by the sand replacement method.
	Part 33	Determination of the density in place by the ring and water replacement method
	Part 34	Determination of density of soil in place by rubber balloon method
	Part 38	Compaction control test (HILF Method)
7	IS: 4081	Safety Code for Blasting and related Drilling Operations

2.3 Drawings

The CONTRACTOR shall furnish good for construction drawings to the PMC/EMPLOYER for review and approval as applicable. Such drawings shall indicate areas to be excavated/ filled, grade levels, areas demarcated for stacking of excavated material etc. The contractor shall follow strictly such drawings and instruction given by the PMC/EMPLOYER.

2.4 General

2.4.1 The CONTRACTOR shall visit site to understand the site condition and make his own assessment about sub-soil strata and water level likely to be encountered during the execution.

2.4.2 The CONTRACTOR shall obtain written approval from the PMC/EMPLOYER on the execution method statement. Execution method statement prepared by contractor shall indicate the detailed sequential execution plan covering manpower & machinery, safety aspects, time duration etc. based on the project requirement. Contractor's execution methodology will include detailed calculation related to:

- Slope stability and or shoring by using parameters related to proposed site, if it is in contractor's scope otherwise the excavation drawing shall be followed.
- Dewatering.

However, the approval of construction methodology shall not in any way relieve the contractor of his responsibility for any consequent loss or damage. In case the project is expected to involve blasting, contractor will carry-out conditional survey of nearby properties to record it as a baseline prior to commencement of the excavation activities.

2.4.3 The Contractor shall at his own expense and without extra charges, take all precautions such as shoring for all depths or any other arrangement as approved by Engineer-in-charge for ensuring that there shall be no sliding / collapsing of the excavated earth. The measurement for excavation shall be regulated as per the provisions of the CPWD / MORTH specification and nothing extra shall be payable because of shoring /other arrangements.

2.4.4 The Contractor shall also not be paid for any extra working space beyond concrete dimensions during excavation of foundations of various proposed structures in the Project. Any damage done to the work due to the contractor's operation beyond the excavation lines shall be repaired at the expense of the contractor. Any and all excess excavation or over breaking performed by the contractor for any purpose or reason except as may be ordered in writing by PMC/EMPLOYER and whether or not due to the fault of the contractor shall be at the expense of the contractor. Cost of refilling for all such excavation with materials as specified by the PMC/EMPLOYER must be done by the contractor at his expense.

2.4.5 The contractor in accordance with the specification and project requirements shall mobilize all necessary tools, plants, qualified supervisory personnel, labour, instruments, materials (consumables and non-consumable) required for any temporary/permanent works etc., or any such items not specifically stated herein for completion of the job.

2.4.6 The CONTRACTOR shall carry out the detailed site survey prior to commencement of the site work and shall mark all footprints within + 10mm tolerance and record existing ground levels with respect to established reference/ grid lines at 10 m intervals or nearer or as determined by the PMC/EMPLOYER based on ground profile. Initially ground levels, finish ground level, depth of excavation etc., at every intermediate and final stages shall be confirmed with PMC/EMPLOYER and thereafter properly recorded.

2.4.7 The excavation shall be done to correct lines and levels within + 10mm tolerance. This shall also include, where required, proper shoring to protect the edges of excavation from soil collapse.

2.4.8 Temporary fences, guardrails, barricades, lights, and other protective measures around the excavation area required for the safety of personnel shall be provided and maintained in good condition.

2.4.9 The price quoted by CONTRACTOR shall also include for dumping of excavated materials in segregated manner within the areas demarcated, in regular heaps, bunds, riprap with regular slopes as directed by the PMC/EMPLOYER and levelling the same to provide natural drainage. Rock/soil excavated shall be stacked properly as directed by the PMC/EMPLOYER. As a rule, all softer material shall be laid along the centre of heaps, the harder and more weather resisting

materials forming the casing on the sides and the top. Expansive, organic soil or any unsuitable soil, if encountered shall be stacked separately and shall not be used in any case for site grading activities. The surplus excavated earth shall be disposed by the CONTRACTOR at a designated location by the local authorities or as directed by PMC/EMPLOYER.

2.4.10 Known contaminated soils and water if any, shall be managed in accordance with approved soil management plan.

2.4.11 Soil erosion /sediment control shall be implemented in accordance with local authority regulations or approved erosion/sediment control measures.

2.4.12 Drainage of cuts, excavations, fills, stockpiles, spoil areas, surcharge embankments, and borrow areas shall always be maintained to prevent ponding of surface water because of ground water or rainfall by providing temporary ditches, swales, or pumping systems as required in each respective site area. Contractor shall submit management plan for the above-mentioned work along with work method statement.

2.4.13 The CONTRACTOR may, for facility of work or similar other reasons excavate, and backfill later, if so approved by the PMC/EMPLOYER, at his own cost outside the lines shown on the drawings or directed by the PMC/EMPLOYER. 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, up to the required elevation. No extra shall be claimed by the CONTRACTOR on this account.

2.4.14 The non-serviceable material and surplus soil shall be disposed of to the designated approved dumping yard or as directed by the PMC/EMPLOYER. The contractor shall be responsible for all the statutory approvals from the statutory authority and all the concerned departments, as the case may be.

2.5 Quality Control and Submittals

2.5.1 A written Quality Control Program document that provides details of how compliance with the requirements of this specification and contract documents shall be achieved and submitted by contractor to purchaser for approval a minimum of 14 days before start of construction.

2.5.2 Certified laboratory test data for the materials and products to be used in the work shall be submitted to purchaser for approval a minimum of 14 days before shipping of materials and products.

2.5.3 Results of the quality control tests required during the performance of the work shall be submitted to PMC/EMPLOYER within 2 days of completion.

2.5.4 An independent testing/inspection firm shall provide the following submittals to purchaser and contractor:

- A statement attesting that contractor's work is in accordance with the requirements of this specification and the contract documents.
- Informal daily "pass" or "fail" reports.
- Formal weekly reports including all test logs and comments. These formal reports shall include density and moisture content test logs, indicating location of tests by coordinates and elevation and all appropriate comments.
- Upon earthwork completion, all density and moisture content test logs and comments compiled and submitted for permanent project records.
- Sources and test results of all borrow materials used for fill.

2.6 Quality Assurance

2.6.1 Unless otherwise specified in the contract documents, a qualified independent inspection and testing agency will be retained by purchaser to perform field and laboratory testing and/or evaluations in accordance with the criteria of ASTM D3740 to verify compliance of the work with the requirements of this specification and to ensure the achievement of the intents and purposes of the work.

2.6.2 The performance or lack of performance of the tests and inspections by purchaser's inspector shall not be construed as granting relief from the requirements of this specification or the other contract documents.

2.6.3 During construction, purchaser shall have access to all contractor's facilities and records for conducting performance inspection/audits.

2.6.4 During an audit by purchaser, all inspection and test reports, and/or engineering analyses and calculations associated with the scope of work shall be provided to purchaser upon request.

2.7 Clearing

The areas 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 as directed by local authorities or PMC/EMPLOYER. Where earth fill is intended, the area shall be stripped of all loose/ soft patches, topsoil containing objectionable matter/ materials before fill commences.

2.8 Precious Objects, Relics, Objects Of Antiquity, Etc.

All gold, silver, oil, minerals, archaeological and other findings of importance, trees cut or other materials of any description and all precious stones, coins, treasures, relics, antiquities and other similar things which may be found in or upon the site shall be the property of the EMPLOYER and the CONTRACTOR shall duly preserve the same to the satisfaction of the EMPLOYER and from time to time deliver the same to such person or persons as the EMPLOYER may from time to time authorize or appoint to receive the same.

2.9 Classification

All materials to be excavated shall be classified by the PMC/EMPLOYER, into one of the following classes. The decision of the PMC/EMPLOYER regarding the classification of the material shall be final and binding on the CONTRACTOR and not be a subject matter of any appeal or arbitration.

Earthwork will be classified under any of the following categories:

- **Ordinary and Hard Soils:**

These shall include all kinds of soils containing sand, silt, shingle, gravel, clay, loam, peat, ash, shale, etc., which can be easily excavated either manually or mechanically.

- **Soft and Decomposed Rock:**

This shall include completely to highly weathered/fractured rock, boulders, slag, chalk, slate, hard mica schist, laterite and all other materials, which in the opinion of PMC/EMPLOYER is soft rock, difficult to excavate manually with a pickaxe or required very light mechanical excavating machines but does not need blasting. The mere fact that the CONTRACTOR resorts to blasting without prior approval from local authorities or PMC/EMPLOYER, shall not qualify for classification under 'Hard Rock'.

This shall also include excavation in macadam & tar roads and pavements, rock boulders not longer than 1 metre in any direction and not more than 500 mm in any one of the other two directions.

- **Hard Rock:**

This shall include all rock occurring in large continuous masses, which can only be excavated by blasting or by Pneumatic hydraulic breakers. Harder varieties of rock with or without veins and secondary minerals, which in the opinion of the PMC/EMPLOYER require blasting, shall be considered as hard rock.

Where hard rock is met with and blasting operations are not permitted, the CONTRACTOR shall use other methods such as use of chemicals or Pneumatic hydraulic breakers or any other method approved by the PMC/EMPLOYER for loosening the rock mass, developing cracks, etc. The loosened material shall be thereafter removed mechanically. Boulders of rock occurring in such sizes and not classified under (a) and (b) above shall also be classified as hard rock. Buried

concrete work both reinforced and unreinforced to be dismantled will be measured under this item, unless a separate provision is made in the tender.

2.10 Excavation

2.10.1 Contractor shall obtain written permission from intra departmental heads prior to commencement of work to ensure that there is no presence of underground utilities in the proposed excavation area.

2.10.2 All the required work permits shall be obtained by CONRACTOR from the EMPLOYER / PMC/EMPLOYER / LOCAL AUTHORITIES / GOVERNMENT AGENCY, as applicable.

2.10.3 In case of existence of underground utilities, the same shall be diverted away from the excavation area in consultation with the PMC/EMPLOYER. Payment of Diversion of utilities shall be made as per the item specified in the tender and if there is no provision in the tender then the same shall be executed based on the mutually agreed terms with the PMC/EMPLOYER.

2.10.4 Excavation for permanent work shall be carried out as per the approved drawings. In area involving mass excavation, initially area shall be excavated up to a depth 150 mm above the final level. The balance depth shall be excavated with special care just prior (not more than 12 hours before) the laying of P.C.C. Soft pockets, if any, shall be removed even by excavating below the final level and extra excavation shall be filled up using Lean concrete or plum concrete or plain cement concrete as directed by the PMC/EMPLOYER. It should be ensured that the foundation shall rest on single type of strata. The strata once excavated should not be exposed to environment to avoid degradation.

2.10.5 All excavation shall be done to the minimum dimensions as required for safety and working facility. The excavation must be carried out in the most expeditious and efficient manner. Where the nature of soil or the depth of the trench and season of the year do not permit vertical sides, the CONTRACTOR shall erect 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 PMC/EMPLOYER. The scheme proposed by the CONTRACTOR shall take into consideration the presence of existing buildings/ structures/traffic movement in the vicinity, if any. All necessary precautions shall be taken to avoid slipping of loose soil / rock.

2.10.6 In case of deep excavation in rocky strata the fractured excavated rock sides shall be stabilized by using rock anchors.

2.10.7 The CONTRACTOR shall make all necessary pumping arrangements for dewatering the low-lying area or area where excavation is required to carry out below ground water table. CONTRACTOR shall keep area under execution to be workable. The low-lying areas may receive

water from any source such as rains, accumulated rainwater, floods, leakages from sewer and water mains, water ingress from near-by canals / channels, subsoil water table being high or due to any other cause whatsoever.

2.10.8 In case of deep excavation in the area of high-water table special precautions shall be taken to main water table level at least 500 mm below the layer of binding concrete (Plain Cement Concrete (PCC) level to avoid uplift/damage of building basement raft/foundation due to water pressure. The water table shall not be allowed to rise above base of raft/foundation level until the structure attains adequate height required to counterbalance the uplift pressure.

2.10.9 The CONTRACTOR shall take all necessary precautions 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 PMC/EMPLOYER for the proper identification of construction area. He shall be responsible for all damages and accidents caused due to negligence on his part.

2.11 Stripping Loose Rock

2.11.1 All loose boulders, semi-detached rocks (along with earthy stuff, which might move therewith) which is not directly in the excavation but so close to the area to be excavated, and in the opinion of the PMC/EMPLOYER liable 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 is originally sound and safe.

2.11.2 Any material not requiring removal as contemplated in the work, but which, in the opinion of the PMC/EMPLOYER, is likely to become loose or unstable later, shall also be promptly and satisfactorily removed as directed by the PMC/EMPLOYER.

2.11.3 Excavation in hard rock

2.11.4 After removal of overburden, if any, excavation is likely to continue in rock to adequate depths and area of excavation footprint shown in the drawings and if the site condition permits to excavate rock by using blasting, then as far as possible, all blasting operations shall be completed prior to commencement of other construction activities.

2.11.5 All precautions shall be taken by the contractor during the blasting operations so that no damage is caused to adjoining buildings or structures because of blasting operations. In case of

any damage to permanent or temporary structures, CONTRACTOR shall repair the same to the satisfaction of PMC/EMPLOYER at his cost.

2.11.6 Specific permission of PMC/EMPLOYER shall be taken by CONTRACTOR for blasting rock, and he shall also obtain a valid Blasting License from the authorities concerned. If permission for blasting is refused by either by PMC/EMPLOYER or by local authority, the rock shall be removed by wedging, pick, barring, heating and quenching, pneumatic hydraulic breakers etc., or other approved methods including chemicals required if any. All loose or loosened rock in the sides shall be removed by barring, wedging, etc. and if any unstable wedges of rock mass from sides of excavated surface shall be stabilized by providing temporary rock bolts. The price quoted by contractor for excavation in hard rock shall include the cost of all these operations. Safety net shall be used to arrest the movement of fractured rocks as a safety precaution for the workers working inside the pit.

2.11.7 In no case shall blasting be allowed closer than 30 meters from any structure or at locations where concrete has just been placed. In the latter case, the concrete must be at least 7 days old.

2.12 Fill Material For Back Filling And Site Grading

2.12.1 General

All fill material will be subject to the PMC/EMPLOYER's approval. If any material is rejected by the PMC/EMPLOYER, the CONTRACTOR shall remove the same forth with from the site at no extra cost to the EMPLOYER. Surplus fill material shall be deposited/ disposed as directed by the PMC/EMPLOYER after the fill work is completed. No earth fill shall commence until surface water discharges and streams have been properly intercepted or otherwise dealt with as directed by the PMC/EMPLOYER.

2.12.2 Excavated soil

To the extent available, selected surplus soils from excavated materials shall be used as backfill subject to the approval based on the below test results. Contractor shall categorise the surplus excavated material and stack separately. Fill material shall be free from clods, salts, sulphates, organic or other foreign material and non-expansive in nature. The CONTACTOR shall arrange at his cost to carry out the minimum following tests on selected soil samples from excavated material in an accredited geotechnical laboratory

a) Grain size analysis
b) Moisture content
c) In-situ density
d) Specific gravity

e) Liquid limit and plastic limit
f) Standard/Modified proctor density (based on project requirement) or relative density (in case of sandy strata)
g) Free swell Index and Swelling pressure.
h) Tri- axial test / direct shear test under undrained and unconsolidated condition.

2.12.3 Borrowed material:

If any selected fill material is required to be borrowed, it shall be CONTRACTOR'S responsibility to locate suitable borrow areas for borrowing fill material, the CONTRACTOR shall decide for bringing such material from outside borrow pits. The material and source shall be subject to prior approval of the PMC/EMPLOYER. The approved borrow pit area shall be cleared of all bushes, roots of trees, plants, rubbish, etc. Top loose soil containing salts/ sulphates and other foreign material shall be removed and disposed to an approved designated location as instructed by the PMC/EMPLOYER. The CONTRACTOR shall arrange to have trial pits of specified dimensions and numbers dug at locations specified, for the PMC/EMPLOYER to examine the nature and type of material to be obtained from the borrow area. Any material rejected by the PMC/EMPLOYER shall be removed from the site immediately. The CONTRACTOR shall make necessary access road to the borrow areas and maintain the same, if such access road does not exist, CONTRACTOR shall obtain all necessary permits from local authorities.

The properties of borrow material shall meet following requirements:

Sr No.	Properties	Range of Values
1	**Field Characteristics**	
1.1	Bulk Density (γ_{bulk})	1.8 to 2.1 gm/cc
1.2	Dry density (γ_{dry})	1.3 to 1.6 gm/cc
1.3	Moisture content	34 to 36 %
1.4	Modified Proctor Density	More than 1.8 gm/cc
2	**Physical Properties**	
2.1	Specific gravity	2.65 to 2.85
3	**Index properties**	
3.1	Liquid limit (%)	40 to 65%
3.2	Plastic Limit (%)	20 to 25 %
3.3	Shrinkage limit (%)	15 to 35 %
3.4	Free swelling index	Less than 50%
4	**Mechanical analysis**	
4.1	Gravel (above 2.0 mm)	0 to 10%
4.2	Sand (2.0 to 0.06 mm)	30 to 40%

Sr No.	Properties	Range of Values
4.3	Silt (0.06 to 0.002 mm)	0 to 45 %
4.4	Clay (Below 0.002 mm)	15 to 25 %
5.0	**Chemical properties**	
5.1	Loss on ignition	3.5-4.5
5.2	Chloride (Cl)	Less than 500 mg/litre
5.3	Sulphate (SO_3)	Less than 400 mg/litre
6	**Engineering properties**	
6.1	C (kg/cm^2)	0.2-0.3
6.2	Φ	10 to 25 degree
6.3	Permeability K (cm/sec)	10^{-4} to 10^{-5}
6.4	CBR (%)	3 -6

Filling with excavated earth shall be done in regular horizontal layers each not exceeding 150 mm in depth, well rammed, watered and consolidated. All lumps and clods exceeding 125 mm in any direction shall be broken. 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.

2.12.4 Filling in pits and trenches around foundations of structures, walls, etc

As soon as the work in foundations has been accepted (after attaining 28 days strength) and measured, the spaces around the foundations, structures, pits, trenches, etc. shall be cleared of all debris, and filled with earth in layers as specified above., each layer being watered, rammed and properly compacted, before the succeeding one is laid. Each layer shall be compacted to the satisfaction of the PMC/EMPLOYER. The final backfill surface shall be trimmed and levelled to proper profile as directed by the PMC/EMPLOYER or indicated on the drawings. Backfilling for the retaining wall shall be done after the construction of upper-level slabs and curing and de-shuttering is done.

2.13 Plinth filling

Plinth filling shall be carried out with approved material and shall be filled in layers as specified above, watered and compacted with mechanical compaction machines. When filling reaches the finished level, the surface shall be flooded with water, unless otherwise directed, for at least 24 hours, allowed to dry and then the surface again compacted as specified above to avoid settlements at a later stage. The finished level of the filling shall be trimmed to the level/ slope specified.

At some locations/ areas it may not be possible to use rollers because of space restrictions, etc. The CONTRACTOR, if permitted by a PMC/EMPLOYER, shall use pneumatic tampers, rammers, etc. to ensure proper compaction.

2.14 Filling in trenches

Filling in trenches for pipes and drains shall be commenced as soon as the joints of pipes and drains have been tested and passed. The backfilling material shall be properly compacted by watering and ramming, taking due care that no damage is caused to the pipes.

Where the trenches are excavated in soil, the filling from the bottom of the trench to the level of the centre line of the pipe shall be done with selected approved earth in layers; backfilling above the level of the centre line of the pipe shall be done with selected earth in layers with proper compaction of each layer. For Piping, trenches shall be backfilled with approved selected excavated material only after the successful testing of the pipeline. The tamping around the pipe shall be done by hand or other hand-operated mechanical means. Backfilling should be placed in layers not exceeding 15 cm thickness per layer and should be compacted to a minimum of 95% maximum dry density.

In case of excavation of trenches in rock, the filling up to a level 300 mm above the top of the pipe shall be done with fine materials. The filling from a level 300mm above the top of the pipe to the top of the trench shall be done using broken rock filling of size not exceeding 150mm mixed with fine material as available to fill up the voids.

Filling of the trenches shall be carried simultaneously on both sides of the pipe to avoid unequal pressure on the pipe.

The Contractor is requested to provide the method of Backfilling compaction test and evaluation value and obtain the approval from the PMC/EMPLOYER

It is very important that the pipe zone backfill material does not wash away or migrate into the native soil. Likewise, potential migration of the native soil into the pipe zone backfill must also be prevented.

2.15 General site grading

Site grading shall be carried out as indicated in the drawings and as directed by the PMC/EMPLOYER. Excavation shall be carried out as specified under relevant clauses.

To ensure that the fill has been compacted as specified, field and laboratory tests shall be carried out by the CONTRACTOR.

Field compaction test shall be carried out as per relevant standard at different stages of filling and also after the fill to the entire height has been completed.

The CONTRACTOR shall protect the earth-fill from being eroded or washed away by rain or damaged in any other way. Should any slip occur, the CONTRACTOR shall remove the affected material and make good the slip at his cost.

The fill shall be carried out to such dimensions and levels as indicated on the drawings after the stipulated compaction. The fill shall be considered as incomplete if the desired compaction has not been achieved.

Access 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 must be deposited shall be constructed by the CONTRACTOR. Such access roads shall be maintained in good condition during all seasons to ensure completion of work according to time schedule.

2.16 Measurement and payment for item rate contract

2.16.1 All excavation shall be measured net. Dimensions for purpose of payment shall be reckoned on the horizontal area of the excavation at the base for foundations of the walls, columns, footings, tanks, rafts or other foundations/ structures to be built, multiplied by the mean depth from the surface of the ground in accordance with the foundation drawings. Excavation inside slopes will not be paid for. The CONTRACTOR may make such allowance in his rates to provide for excavation inside slopes keeping in mind the nature of the soil and safety or excavation. However, if the concreting is proposed against the excavated sides, no such over excavation will be permitted. In such cases, over excavation shall be made good by the CONTRACTOR with concrete of the same class as in the foundations at his cost.

2.16.2 Unless otherwise specified, the unit rates quoted for excavation in different types of material shall also account for a basic lead as mentioned in BOQ for disposal as specified or directed. Only leads beyond the basic lead will be considered as extra lead and paid for at the rates quoted in the schedules.

2.16.3 Backfilling, as per specification, the sides of foundations of columns, footings, structures, walls, tanks, rafts, trenches, etc. with excavated material will not be paid for separately. It shall be clearly understood that the rate quoted for excavation including backfilling shall include stacking of excavated material as directed, excavation/ packing of selected stacked material, conveying it to the place of final backfill, compaction, etc. as specified. As a rule, material to be backfilled shall be stacked temporarily within the basic lead unless otherwise directed by the PMC/EMPLOYER. If the PMC/EMPLOYER directs/ permits a lead for such material, the conveyance of the material for the extra distance over the basic lead for backfilling will be paid for.

2.16.4 Payment for fill inside trenches, plinth or similar filling with selected excavated material will be made for only compacted soil volume as specified/ directed. Cost of all other operations shall be deemed to have been covered in the rate quoted for filling. Payment for this work will be

made based on measurement of plinth/ trench dimensions filled. The plinth ground levels shall be surveyed before for this purpose. If no compaction is specified/ desired, such filling will not be separately paid for. In such an event the fill shall be levelled/ finished to the profile as directed at no extra cost.

2.16.5 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 shall be measured and paid for in cubic metres. The lead, lift, etc. shall be as indicated in the Schedule of Quantities.

2.16.6 Actual quantity of consolidated sand filling shall be measured and paid in cubic metres

2.16.7 Volume of rock excavated shall be calculated based on length, breadth and depth of excavation dimension as per the foundation drawings.

2.16.8 No payment will be made for excavations/ over-break beyond payment line specified. Where such measurement is not possible as in the case of strata intermixed with soil, excavated rock shall be properly stacked as directed by PMC/EMPLOYER and the volume of rock calculated based on stack measurements after making appropriate allowance for voids. The allowance to be made for voids shall be decided by PMC/EMPLOYER and this will not be a subject matter of dispute or appeal.

2.16.9 Measurement for Site Filling will be made based on this specification.

3.0 DEWATERING

3.1 Scope

This specification covers the general requirements of dewatering excavations in general.

3.2 General

3.2.1 All excavations shall be kept free of water. Grading and surface water drainage scheme 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 PMC/EMPLOYER 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 excavation/ trench areas required for further work of foundation construction. Method of pumping shall be approved by PMC/EMPLOYER; but in any case, the pumping arrangement shall be such that there shall be no movement of subsoil or blowing in or excavation wall collapse due to differential head of water during pumping. Pumping arrangements shall be adequate to ensure no delays in construction.

3.2.2 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.

3.2.3 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 PMC/EMPLOYER may direct the CONTRACTOR to make changes in his scheme if the adopted scheme fails to achieve the desired results.

3.2.4 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 or shall not be a cause for environmental pollution of natural water bodies.

3.2.5 When there is a continuous inflow of water and quantum of water to be handled is considered in the opinion of PMC/EMPLOYER as large, well point system - Single stage or multistage, shall be adopted. CONTRACTOR shall submit to PMC/EMPLOYER 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. Normal dewatering using bailing arrangement, submersible pumps shall be included in the item rate for excavation. Special dewatering system using well point system shall be considered as separate item.

3.2.6 In case well point dewatering is required, the Indian Standard IS 9759: 1981 (Reaffirmed 2016) - Guidelines for De-Watering During Construction shall be used for design of the dewatering system.

4.0 REINFORCED CONCRETE AND ALLIED WORKS

4.1 Scope

This Specification covers the general requirements for ready mixed concrete and for concrete using on-site production facilities including requirements with regard to the quality, handling, storage of ingredients, proportioning, batching, mixing, transporting, placing, curing, protecting, repairing, finishing and testing of concrete; formwork; requirements with regard to the quality, storage, bending and fixing of reinforcement; grouting as well as mode of measurement and payment for completed works.

It shall be very clearly understood that the specifications given herein 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 practices or in their absence in accordance with the best accepted current Engineering practices or as directed by PMC/EMPLOYER from time to time. The decision of PMC/EMPLOYER about the specification to be adopted and their interpretation and the mode of execution of work shall be final and binding on CONTRACTOR and no claim whatsoever will be entertained on this account.

4.2 Applicable codes and specifications

The following specifications, standards and codes, including all official amendments/ revisions and other specifications and codes referred to therein, should be considered a part of this specification. In all cases the latest issue/ edition/ revision shall apply. In case of discrepancy between this specification and those referred to herein below or other specifications forming a part of this bid document, this specification shall govern.

4.3 MATERIALS:

IS 455	Specification for Portland Slag Cement.
IS 1489: PART 1	Portland pozzolana cement - specification part 1 fly ash based
IS 1489: PART 2	Portland pozzolana cement - specification part 2 calcined clay based (fourth revision)
IS 12330	Specification for Sulphate Resisting Portland Cement
IS 383	Coarse and fine aggregate for concrete - specification (third revision)
IS 432	Specification for Mild Steel and Medium Tensile Steel Bars and Hand Drawn Steel Wire for Concrete Reinforcement – Part 1 and 2
IS 1786	High strength deformed steel bars and wires for concrete reinforcement – specification
IS 1566	Specification for hard-drawn steel wire fabric for concrete reinforcement
IS 9103	Concrete admixtures – specification
IS 2645	Integral waterproofing compounds for cement mortar and concrete – specification
IS 4990	Plywood for concrete shuttering work – specification
IS 4926	Ready-mixed concrete - code of practice
IS 8041	Specification for rapid hardening cement.
IS 12600	Specification for Low Heat Portland Cement
IS 6909	Specification for super-sulphated cement
IS 12089	Specification for granulated slag for manufacture of portland slag cement

4.4 MATERIAL TESTING

IS 4031 (Part 1 to 15	Methods of physical tests for hydraulic cement
IS 4032	Method of chemical analysis of hydraulic cement.
IS 650	Specification for standard sand for testing of cement.
IS 2430	Methods for sampling of aggregates for concrete.
DIN EN 12620	Aggregates for concrete (Refer Note).
IS 2386	Methods of test for aggregates for concrete (Parts 1 to 8)
IS 3025 (Part 1 to 51	Methods of sampling and test (physical and chemical) for water and wastewater
ISS 6925	Methods of test for determination of water-soluble chlorides in concrete admixtures

NOTE: These tests are optional and shall be carried out by the contractor at his cost, if directed by PMC/EMPLOYER.

4.5 MATERIAL STORAGE

IS 4082	Recommendations on stacking and storage of construction materials and components at site.

4.6 CONCRETE MIX DESIGN

IS 10262	Concrete mix proportioning-guidelines

4.7 CONCRETE TESTING

IS 1199	Method of sampling and analysis of concrete.
IS 516	Method of test for strength of concrete.
IS 9013	Method of making, curing and determining compressive strength of accelerated cured concrete test specimens.
IS 8142	Method of test for determining setting time of concrete by penetration resistance.
IS 9284	Method of test for abrasion resistance of concrete.
IS 2770 (Part 1)	Methods of testing bond in reinforced concrete: Part 1 Pull-out test

4.8 EQUIPMENT

IS 4925	Specification for concrete batching and mixing plant.
IS 7251	Specification for concrete finishers.
IS 2750	Specifications for steel scaffoldings.

4.9 CODES OF PRACTICE

IS: 456	Plain and reinforced concrete - code of practice.

IS: 457	Code of practice for general construction of plain and reinforced concrete for dams and other massive structures.
IS 3370 (Part 1)	Concrete structures for storage of liquids - code of practice - part 1 : general requirements
IS 3370 (Part 2)	Concrete structures for storage of liquids - code of practice - part 2 : reinforced concrete structures
IS 3370 (Part 3)	Code of practice for concrete structures for the storage of liquids: part 3 prestressed concrete structures
IS 3370 (Part 4)	Code of practice for concrete structures for the storage of liquids: part 4 design tables
IS 3935	Code of practice for composite construction.
IS 2204	Code of practice for construction of reinforced concrete shell roof.
IS 2210	Criteria for the design of reinforced concrete shell structures and folded plates.
IS 2502	Code of practice for bending and fixing of bars for concrete reinforcement.
IS 5525	Recommendation for detailing of reinforcement in reinforced concrete works.
IS 2751	Code of practice for welding of mild steel plain and deformed bars used for reinforced concrete construction.
IS 9417	Welding of high strength steel bars for reinforced concrete construction-recommendations
IS 3558	Code of practice for use of immersion vibrators for consolidating concrete.
IS 3414	Code of practice for design and installation of joints in buildings.
IS 4326	Earthquake resistant design and construction of buildings - code of practice
IS 4014 (Part 1)	Code of practice for steel tubular scaffolding Part 1 Definitions and materials
IS 4014 (Part 2)	Code of practice for steel tubular scaffolding: Part 2 Safety regulations for scaffolding (first revision)
IS 2571	Code of practice for laying in situ cement concrete flooring
IS 7861 (Part 1)	Code of practice for extreme weather concreting: Part 1Recommended practice for hot weather concreting
IS 7861 (Part 2)	Code of practice for extreme weather concreting: Part 2Recommended practice for cold weather concreting
IS 3812 (Part 1)	Pulverized fuel ash – Part 1 – For use as pozzolana in cement, cement mortar and concrete
IS 15388: 2003	Specification for Silica Fume

4.10 CONSTRUCTION SAFETY

IS 3696 (Part 1)	Safety code of scaffolds and ladders: Part 1 Scaffolds (first revision)
IS 3696 (Part 2)	Safety code of scaffolds and ladders: Part 2 Ladders (first revision)
IS 7969	Safety code for handling and storage of building materials.
IS 8989	Safety code for erection of concrete framed structures.

4.11 MEASUREMENT

IS 1200 (Part 2)	Method of measurement of building and Engineering works (Part 2 and 5) Methods of measurement of building and civil engineering works: Part 2 Concrete works (third revision)
IS 1200 (Part 5)	Methods of measurement of building and civil engineering works: part 5 Form work (fourth revision)

4.12 General

PMC/EMPLOYER shall always have the right to inspect all operations including the sources of materials, procurement, layout and storage of materials, the concrete batching and mixing equipment, and the quality control system. Such an inspection shall be arranged, and PMC/EMPLOYER's approval obtained, prior to starting of concrete work. This shall, however, not relieve CONTRACTOR of any of his responsibilities. All materials, which do not conform to this specification, shall be rejected.

Materials should be selected so that they can satisfy the design requirements of strength, serviceability, safety, durability and finish with due regards to the functional requirements and the environmental conditions to which the structure will be subjected. Materials complying with codes/ standards shall only be used. Other materials may be used after approval of the PMC/EMPLOYER and after establishing their performance suitability based on previous data, experience or tests.

4.13 MATERIALS

4.13.1 CEMENT

i. The Portland Pozzolana Cement shall conform to IS: 1489 & Portland Slag Cement conforming to IS: 455 shall be used as directed by PMC/EMPLOYER.
ii. Sulphate Resisting Portland Cement conforming to IS: 12330 may be used for mass concrete construction and generally complying with IS: 12330, but with Tricalcium Aluminate (C3A) content not more than 5% by mass (as manufactured by an approved manufacturer) may be used for reinforced concrete construction.
iii. Fly Ash Blended Cements conforming to IS: 1489 (Part I) or GGBS blended cements conforming to IS 16715 may be used in RCC structures as per the guidelines given below:

- IS: 456 - Code of Practice for Plain and Reinforced Concrete shall be followed about Concrete Mix Proportion and its production.
- The concrete mix design shall be done as “Design Mix Concrete” as prescribed in clause 9 of IS: 456.
- Concrete shall be manufactured in accordance with Clause 10 of IS 456 covering Quality Assurance measures.
- Minimum M25 grade of concrete shall be used in all structural elements made with RCC both in load bearing and framed structure.
- The mechanical properties such as modulus of elasticity, tensile strength, creep and shrinkage of fly ash mixed concrete or concrete using fly ash blended cements (PPCs) are not likely to be significantly different and their values are to be taken same as those used for concrete made with OPC.
- If necessitated due to low water/ binder ratio, required workability shall be achieved by use of chloride free chemical admixtures conforming to IS: 9103. The compatibility of chemical admixtures and super plasticisers with each set OPC, fly ash and/ or PPC received from different sources shall be ensured by trials.
- In cases, where structural concrete is exposed to excessive magnesium sulphate, fly ash substitution/ content shall be limited to 18% by weight. Special type of cement with low C3A content may also be alternatively used. Durability criteria like minimum binder content and maximum water/ binder ratio also need to be given due consideration in such environment.
- Wet curing period shall be enhanced to a minimum of 10 days or its equivalent. In hot and arid regions, the minimum curing period shall be 14 days or its equivalent.

iv. Use of Fly Ash Admixed Cement Concrete (FACC) in RCC Structures

There shall be no bar on use of FACC in RCC structures subject to following additional conditions.

- Fly ash shall have its chemical characteristics and physical requirements, etc. conforming to IS: 3812 (Parts I) and shall be duly certified.
- To ensure uniform blending of fly ash with cement in conformity with IS: 456, a specific facility needs to be created at site with complete computerized automated process control to achieve design quality or with similar facility from Ready Mix Concrete (RMC) plants.
- As per IS: 1489 (Part-I) maximum 35% of mass of total cementitious material is permitted to be substituted with fly ash conforming to IS: 3812 (Part-I).
- Separate storage for dry fly ash shall be provided. Storage bins or silos shall be weatherproof and permit a free flow and efficient discharge of fly ash. The filter or dust

control system provided in the bins or silos shall be of sufficient size to allow delivery of fly ash maintained at specified pressure to prevent undue emission of fly ash dust, which may interfere with weighing accuracy.

v. Use of Silica Fume Admixed Cement Concrete in RCC Structures

Silica fume conforming to IS 15388 may be used to the extent of 5 – 10% of the cement content as stipulated in IS 456 as a part replacement of cement.

vi. Use of Fly Ash Blended Cements in Cement Concrete (PPCC) in RCC Structures

- Subject to General Guidelines detailed out as above, PPC manufactured conforming to IS: 1489 (Part-I) shall be treated at par with OPC for manufacture of Design Mix concrete for structural use in RCC.
- Till the time, Bureau of Indian Standards (BIS) makes it mandatory to print the percentage of fly ash on each bag of cement, the certificate from the PPC manufacture indicating the same shall be insisted upon before allowing use of such cements in works.
- While using PPC for structural concrete work, no further admixing of fly ash shall be permitted.
- Only one type of cement shall be used in any one mix unless specifically approved by PMC/EMPLOYER. The source of supply, type or brand of cement within the same structure or portion thereof shall not be changed without prior approval from PMC/EMPLOYER.

Cement, which is not used within 90 days from its date of manufacture, shall be tested at a laboratory approved by PMC/EMPLOYER and until the results of such tests are found satisfactory, it shall not be used in any work.

4.13.2 AGGREGATES

Aggregates shall consist of naturally occurring stones and gravel (crushed or uncrushed) and sand. They shall be chemically inert, strong, hard, clean, durable against weathering, of limited porosity, free from dust/ silt/ organic impurities/ deleterious materials and conform to IS: 383. Aggregates such as slag, crushed over burnt bricks, bloated clay ash, sintered fly ash and tiles shall not be used.

Aggregates shall be washed and screened before use where necessary or if directed by the PMC/EMPLOYER.

Aggregates containing reactive materials shall be used only after tests conclusively prove that there will be no adverse effect on strength, durability and finish, including long term effects, on the concrete.

The fineness modulus of sand shall neither be less than 2.2 nor more than 3.2. If use of sand having fineness modulus more than 3.2 is unavoidable then it shall be suitable blended with crusher stone dust.

Plums 160 mm and above of a reasonable size may be used where directed. Plums shall not constitute more than 20% by volume of concrete unless specified by PMC/EMPLOYER.

4.13.3 WATER

Water used for both mixing and curing shall conform to IS: 456. Potable water is generally satisfactory. Water containing any excess of acid, alkali, sugar or salt shall not be used. The pH value of water shall not be less than 6.Seawater shall not be used for concrete mixing and curing.

4.13.4 REINFORCEMENT

Reinforcement bars shall conform to IS: 432 and/ or IS: 1786 and welded wire fabric to IS: 1566 as shown on the drawing.

All reinforcement shall be clean, free from pitting, oil, grease, paint, loose mill scales, rust, dirt, dust or any other substance that will destroy or reduce bond.

Special precaution like coating of reinforcement may be provided with the prior approval of PMC/EMPLOYER.

Reinforcement bars produced by rerolling may be used subject to the approval of the PMC/EMPLOYER. CONTRACTOR shall furnish the manufacturer's certificate stating the process of manufacture to the satisfaction of the PMC/EMPLOYER and the test sheet signed by the manufacturer giving the result of each mechanical test applicable for each lot of the material supplied including result of chemical composition. At-least one Sample from each lot received at site shall be tested in the laboratory approved by the PMC/EMPLOYER and the cost of testing shall be borne by the CONTRACTOR. It shall be ensured that all the test results conform to IS: 432 or IS: 1786 as applicable.

4.13.5 ADMIXTURES AND ADDITIVES

4.13.5.1 Approval of Admixtures

Admixture from approved manufacturer shall be used in concrete mix along with aggregates, cement and water without the written instruction or approval of the PMC/EMPLOYER in each case. If more than one admixture is proposed for use in the same concrete mix, their interaction shall be checked by trial mixes to ensure their compatibility.

The CONTRACTOR shall note that the description of any proposed admixture by trade or brand name will not be enough for the approval of the PMC/EMPLOYER.

The CONTRACTOR shall submit manufacturer's test certificates and technical literature of the admixture proposed to be used. If directed by the PMC/EMPLOYER, the admixture shall be got tested at an approved laboratory at no extra cost.

The PMC/EMPLOYER will, wherever appropriate, call for trial batches of concrete to be prepared to demonstrate the effect of the proposed admixtures both on the fresh concrete and on the hardened concrete before giving his approval. He may also lay down additional requirements for the control of the use of such admixtures.

Notwithstanding any previously given approval, the PMC/EMPLOYER may withdraw such approval at any time with respect to any mix containing admixtures if, in his opinion, the performance of the admixture under actual Site conditions is not completely satisfactory.

4.13.5.2 Supply and Storage of Admixtures

Accelerating, retarding, water-reducing, super plasticizing and air entraining admixtures shall conform to IS: 9103, integral cement water proofing admixture to IS: 2645, any other admixture to BS: 5075, if it is applicable, unless otherwise specified or agreed. Admixtures shall be stored strictly in accordance with manufacturers' recommendations and precautions shall be taken during delivery and storage to prevent damage to or adulteration of admixtures.

4.13.5.3 Use of Admixtures

Any admixture used in any concrete mix shall only be used at the rate of dosage or in the proportions previously approved by the PMC/EMPLOYER, method of mixing, etc. all in accordance with the manufacturer's instructions and within the manufacturer's recommended ambient temperature range.

Any batch of concrete, which has received an incorrect dose of an admixture, or which shall show deterioration after placing because of incorrect use of admixtures, shall be broken out or otherwise replaced at no additional cost to the EMPLOYER.

The relative density of liquid admixtures shall be checked for each drum containing the admixture and compared with the stated/ specified value before acceptance. Liquid admixtures or powder admixtures that are to be used as solutions shall be dispensed by an appliance fixed to the mixer, which measures weight, volume or dosing time and is provided with a recorder. This appliance shall be accurately calibrated, and the calibration and dosage shall be checked at regular intervals or as directed by the PMC/EMPLOYER. All such admixtures shall be dispensed with the mixing water.

All admixture dispensers shall be thoroughly cleaned before commencing each day's work and at every interruption to the work.

Where admixtures are to be used in bulk form, these shall be weigh-batched as is provided in this Specification for the batching of cement.

Powder admixtures to be used in dose form shall only be allowed if premixed and used as solutions and then only if the premixing procedure has been previously approved by the PMC/EMPLOYER.

4.13.5.4 Corrosion Inhibitor

The use of proprietary corrosion inhibitors, whether specified or not, shall be subject to the written agreement of the PMC/EMPLOYER. Their prime function shall be to form a protective film on the reinforcing steel.

Proprietary corrosion inhibitors shall be added to the concrete in accordance with the recommendations of the manufacturer. The dosage and rate of application shall be established by the CONTRACTOR following consultation with the admixture manufacturer and shall be confirmed to the PMC/EMPLOYER in writing.

4.13.5.5 Chlorides

Under no circumstances shall calcium chloride or chloride-based admixtures be used in any concrete mix, grout or mortar. The chloride content of admixtures shall be independently tested in an approved laboratory for each batch of admixture before acceptance. Calcium chloride shall not be used for accelerating set of the cement for any concrete containing reinforcement or embedded steel parts. When calcium chloride is permitted such as in mass concrete works, it shall be dissolved in water and added to the mixing water by an amount not exceeding 1.5% of the weight of the cement in each batch of concrete. The designed concrete mix shall be corrected accordingly.

4.14 SAMPLES AND TESTS

All materials used for the works shall be tested before use. The frequency of such confirmatory tests shall be decided by PMC/EMPLOYER.

Manufacturer's test certificate shall be furnished for each batch of cement/ reinforcing steel and when directed by PMC/EMPLOYER samples shall also be got tested by the CONTRACTOR in a laboratory approved by PMC/EMPLOYER at no extra cost to EMPLOYER. However, where material is supplied by EMPLOYER, all testing charges shall be borne by EMPLOYER, but transportation and preparation of material samples for the laboratory shall be done by CONTRACTOR at no extra cost.

Sampling and testing of aggregates shall be as per IS: 2386 under the supervision of PMC/EMPLOYER. The cost of all tests, sampling, etc. shall be borne by CONTRACTOR.

Water to be used shall be tested to comply with Clause 5.4 of IS: 456.

CONTRACTOR shall furnish manufacturer's test certificates and technical literature for the admixture proposed to be used. If directed, the admixture shall be got tested at an approved laboratory at no extra cost.

4.15 STORING OF MATERIALS

All material shall be stored in a manner to prevent its deterioration and contamination, which would preclude its use in the works. Requirements of IS: 4082 shall be complied with.

CONTRACTOR shall make his own arrangements for the storage of adequate quantity of cement even if cement is supplied by PMC/EMPLOYER. If such cement is not stored properly and has deteriorated, the material shall be rejected. Cost of such rejected cement, where cement is supplied by PMC/EMPLOYER, shall be recovered at issue rate or open market rate whichever is higher. Cement bags shall be stored in dry weatherproof shed with a raised floor, well away from the outer walls and insulated from the floor to avoid moisture from ground. Not more than 15 bags shall be stacked in any tier. Storage arrangement shall be approved by PMC/EMPLOYER. Storage under tarpaulins shall not be permitted. Each consignment of cement shall be stored separately and consumed in its order of receipt. CONTRACTOR shall maintain record of receipt and consumption of cement.

Each size of course and fine aggregates shall be stacked separately and shall be protected from dropping leaves and contamination with foreign material. The stacks shall be on hard, clean, free draining bases, draining away from the concrete mixing area.

CONTRACTOR shall make his own arrangements for storing water at site in tanks of approved capacity. The tanks shall be cleaned at least once a week to prevent contamination.

The reinforcement shall be stacked on top of timber sleepers to avoid contact with ground/ water. Each type and size shall be stacked separately.

4.16 CONCRETE

4.16.1 General

Concrete grade shall be as designated on drawings. Concrete in the works shall be “DESIGN MIX CONCRETE” or “NOMINAL MIX CONCRETE”. All concrete works of up to grade M15 shall be NOMINAL MIX CONCRETE whereas all other grades, M20 and above, shall be DESIGN MIX CONCRETE.

4.16.2 Design mix concrete

For this specification, Design Mix Concrete is classified as "Normal Concrete". It shall be identified by a prefix and two numbers. Prefix "M" would denote Normal Concrete. The two numbers e.g. 25 - 40 would denote the crushing strength of cube at 28 days in N/mm2 and maximum size of the coarse aggregates in millimeters respectively. Normal concrete shall have a net dry unit weight of not less than 25 kN/m3, for the finished structure after curing.

4.16.3 Mix design and testing

For Design Mix Concrete, the mix shall be designed as per IS 10262 to provide the grade of concrete having the required workability and characteristic strength not less than appropriate values given in IS: 456. The design mix shall in addition be such that it is cohesive and does not segregate during placement and should result in a dense and durable concrete capable of giving the specified finish. For liquid retaining structures, the mix shall also result in watertight concrete. The CONTRACTOR shall exercise great care while designing the concrete mix and executing the works to achieve the desired result.

The minimum grade of concrete shall be as per Table 5 of IS: 456 for various exposure conditions of concrete. For various environmental conditions, refer to Table 3 of IS: 456.

The minimum cement content for Design Mix Concrete shall be as mentioned in the Schedule of Quantities.

The quantity of maximum mixing water per unit volume of concrete may be determined from Table 2 of IS 10262.The water content in Table 2 is for angular coarse aggregate and for 25 to 50 mm slump range. The water estimate in Table 2 can be reduced by approximately 10 kg for sub- angular aggregates,20 kg for gravel with some crushed particles and 25 kg for rounded gravel to produce same workability. For the desired workability (other than 25 to 50 mm slump range),the required water content may be established by trial or an increase by about 3 percent for every additional 25 mm slump or alternatively by use of chemical admixtures conforming to IS 9103.Water reducing admixtures or super plasticizing admixtures usually decrease water content by 5 to 10 percent and 20 percent and above respectively at appropriate dosages.

It shall be CONTRACTOR's sole responsibility to carry out the mix designs at his own cost. He shall furnish to PMC/EMPLOYER for approval at least 30 days before concreting operations, a statement of proportions proposed to be used for the various concrete mixes and the strength results obtained. The strength requirements of the concrete mixes ascertained on 150 mm cubes as per IS: 516 shall comply with the requirements of Table – 2 of IS: 456.

A random sampling procedure shall be adopted to ensure that each concrete batch shall have a reasonable chance of being tested i.e., the sampling should be spread over the entire period of concreting and cover all mixing units. The minimum frequency of sampling of concrete of each grade shall be in accordance with the cl. 15.2 of IS 456.:

3 test specimens (cubes) shall be made for each sample for testing at 28 days. The test results of the sample shall be the average of the strength of 3 specimens.

In the 'very low' category of workability where strict control is necessary, for example pavement quality concrete, measurement of workability by determination of compacting factor will be more appropriate than slump (refer to IS: 1199) and a value of compacting factor of 0.75 to 0.80 is suggested.

In the 'very high' category of workability, measurement of workability by determination of flow will be appropriate (refer to IS: 9103).

Where single size graded coarse aggregate is not available, aggregates of different sizes shall be properly combined. The CONTRACTOR's mix design shall show that combined grading of coarse aggregate meets the requirements of Table 2 of IS: 383 for graded aggregates.

4.16.4 Batching and mixing of concrete

Proportions of aggregates and cement, as per approved concrete mix design, shall be by weight. These proportions shall be maintained during subsequent concrete batching by means of weigh batchers capable of controlling the weights within ±2% for cement and ±3% for aggregate. The batching equipment shall be calibrated at the frequency decided by PMC/EMPLOYER.

Amount of water added shall be such as to produce dense concrete of required consistency, specified strength and satisfactory workability and shall be so adjusted to account for moisture content in the aggregates. Each time the work stops, the mixer shall be cleaned out, and while recommencing, the first batch shall have 10% additional sand and cement to allow for sticking in the drum.

Arrangement should be made by CONTRACTOR to have the cubes tested at his own expense in an approved laboratory or in field with prior consent of PMC/EMPLOYER. Sampling and testing of strength and workability of concrete shall be as per IS: 1199, IS: 516 and IS: 456. It is preferable to cast additional cubes (minimum 3 specimens) for testing at 7 days and 14 days.

4.16.5 Ready mixed concrete

All specification as per IS: 4926 – "Specification for Ready Mixed Concrete" shall be applicable.

The design mix prepared by the RMC supplier shall be the responsibility of the CONTRACTOR.

The testing of concrete as per Codal provisions and the specifications shall be done by the CONTRACTOR same as the normal concreting works.

4.17 PRECAST CONCRETE

4.17.1 General

Precast concrete shall comply with the preceding Sections relating to Concrete as far as they are applicable.

CONTRACTOR shall submit a method statement to PMC/EMPLOYER for approval, before any work is commenced on the manufacture, furnishing details of each stage of operation. The method statement shall inter alia include full details of the plant and equipment to be used and method and location of precast concrete manufacture, striking of shutters, curing, lifting, handling, storage, transportation and installation in the Works.

4.17.2 Formwork

The formwork shall be either steel or lined with steel, waterproof/ laminated board or such other material as directed and approved by the PMC/EMPLOYER. Forms shall be strongly constructed, closely jointed and smooth and shall be such as to ensure true sharp arises and a perfect surface. Forms shall be so designed that they can be taken apart and reassembled readily.

4.17.3 Surface finish

Surface Finish of precast units shall comply with requirements of this specification. The class of Finish shall generally be of F2 type unless detailed differently on the drawings or as directed by the PMC/EMPLOYER. No construction joints will be permitted within any precast work.

4.17.4 Casting tolerance

The casting tolerance, unless otherwise ordered or directed, shall be within +3 mm of true dimensions.

4.17.5 Striking forms

The method and time of striking the side shutters after casting the units will normally be left to the discretion of the CONTRACTOR, but the PMC/EMPLOYER may specify minimum time in which case the CONTRACTOR must comply with the PMC/EMPLOYER's directions. In the event of any damage resulting from premature removal of shutters, or from any other cause, the unit will be liable to rejection and replacement by the CONTRACTOR at his own cost, whether the PMC/EMPLOYER has specified a minimum striking time or not.

4.17.6 Lifting, stacking and removal

Precast units shall not be lifted, transported or used in the Works until they are sufficiently mature. The crushing tests on the test cubes, which are to be kept along with the relevant precast units, will be used to assess the maturity of the units.

Lifting, stacking and removal of precast units shall be undertaken without causing shock, vibration or undue stress to or in the units. The CONTRACTOR shall satisfy the PMC/EMPLOYER that the methods he proposes for lifting, transporting and setting precast units will not overstress or damage the units in any way. In the event of overstress or damage due to whatever cause, the unit or units concerned will be liable to rejection. Rejected units shall be immediately broken up and removed from the site. The CONTRACTOR shall replace such rejected units at his own cost.

4.17.7 Curing

The top and sides of all precast units shall be kept covered constantly and in a damp condition with clean, potable fresh water for at least seven days after casting or for such further period as the PMC/EMPLOYER may direct. It is preferable to have a curing pond for this purpose.

4.17.8 Precasting records:

The CONTRACTOR shall maintain records for each unit, which shall include the following:

- Type and reference number.
- Date of manufacture/ casting.
- Bed/ mould number.
- Curing method and duration.
- Date of removal from bed/ mould.
- Test Cube reference number and results.
- Date of placing in the Works.
- Location in the Works.

These records shall be in a format agreed by the PMC/EMPLOYER and shall always be available for inspection. Copies of these records shall be supplied to the PMC/EMPLOYER on completion.

4.18 FORMWORK

Formwork shall be all inclusive and shall consist of but not limited to shores, bracings, sides of footings, walls, beams and columns, bottom of slabs, etc. including ties, anchors, hangers, inserts, falsework, wedges, etc.

The Design and Engineering of the formwork as well as its construction shall be the responsibility of CONTRACTOR. However, if so, directed by PMC/EMPLOYER, the drawings and calculations for the design of the formwork shall be submitted to PMC/EMPLOYER for approval.

Formwork shall be designed to fulfil the following requirements:

Sufficiently rigid and tight to prevent loss of grout or mortar from the concrete at all stages and appropriate to the methods of placing and compacting.

Capable of providing concrete of the correct shape and surface finish within the specified tolerance limits as given in clause 11.1 of IS 456.

The formwork may be of lined timber, waterproof/ plastic coated plywood, steel, plastic depending upon the type of finish specified. Sliding forms and slip form may be used with the approval of PMC/EMPLOYER. Timber for formwork shall be well seasoned, free from sap, shakes, loose knots, worm holes, warps and other surface defects. Joints between formwork and formwork and between formwork and structure shall be sufficiently tight to prevent loss of slurry from concrete using foam and rubber seals.

The faces of formwork meeting concrete shall be cleaned, and two coats of approved mould oil applied before fixing reinforcement. All rubbish, particularly chippings, shavings, sawdust, wire pieces, dust, etc. shall be removed from the interior of the forms before the concrete is placed. Where directed, cleaning of forms shall be done by blasting with a jet of compressed air at no extra cost.

Forms intended for reuse shall be approved by the PMC/EMPLOYER. CONTRACTOR shall equip himself with enough quantity of shuttering to allow for wastage to complete the job in time. Permanent formwork shall be checked for its durability and compatibility with adjoining concrete before it is used in the structure. It shall be properly anchored to the concrete.

For liquid retaining structures sleeves shall not be provided for through bolts nor shall through bolts be removed if provided. The bolts, in the latter case, shall be cut at 25 mm depth from the surface and the hole made good by cement mortar of the same proportion as the concrete just after striking the formwork.

Forms for substructure may be omitted when, in the opinion of PMC/EMPLOYER, the open excavation is firm enough (in hard non-porous soils) to act as a form. Such excavation shall be slightly larger, as directed by PMC/EMPLOYER, than that required as per drawing to compensate for irregularities in excavation.

Formwork showing excessive distortion, during any stage of construction, shall be removed. Placed concrete affected by faulty formwork, shall be entirely removed and formwork corrected prior to placement of new concrete at CONTRACTOR's cost.

The striking time for formwork shall be determined based on the following requirements:

- Development of adequate concrete strength.
- Permissible deflection at time of striking formwork.
- Curing procedure employed - its efficiency and effectiveness.
- Subsequent surface treatment to be done.
- Prevention of thermal cracking at re-entrant angles.
- Ambient temperatures and aggressiveness of the environment (unless immediate adequate steps are taken to prevent damage to the concrete).
- Before removing formwork of soffit of slabs/ beams compressive strength at 7/ 14/ 21 days shall be checked.

Under normal circumstances (generally where temperatures are above 200 Celsius) forms may be struck after expiry of the period given in IS: 456 unless directed otherwise by PMC/EMPLOYER. It is the CONTRACTOR's responsibility to ensure that forms are not struck until the concrete has developed sufficient strength to support itself, does not undergo excessive deformation and resists surface damage and any stresses arising during the construction period.

4.19 REINFORCEMENT FABRICATION AND PLACEMENT

- Reinforcing bars shall be bent and fixed in accordance with the procedure specified in IS 2502.
- All bars shall be bent by Bar bending machines.

- Re-bending or straightening incorrectly bent bars shall not be done without approval of PMC/EMPLOYER.
- Reinforcement shall be accurately fixed and maintained firmly in the correct position using blocks, spacers, chairs, binding wire, etc. to prevent displacement during placing and compaction of concrete in accordance with clause 12.3 to 12.6 of IS 456. The tied in-place reinforcement shall be approved by PMC/EMPLOYER prior to concrete placement. PVC or concrete spacers of appropriate size shall be used with the approval of PMC/EMPLOYER.
- Binding wire shall be 18-gauge soft annealed wire. Ends of the binding wire shall be bent away from the concrete surface and in no case encroach into the concrete cover.
- Substitution of reinforcement, laps/ splices not shown on drawing shall be proposed by CONTRACTOR at his own cost and approved by PMC/EMPLOYER.
- If permitted by PMC/EMPLOYER, welding of reinforcement shall be done in accordance with IS: 2751, IS: 9417 and SP: 34 as applicable.
- Tolerance on placement of reinforcement shall be as per Cl. 12.3 of IS: 456.

4.20 ANTI-CORROSIVE TREATMENT

Applying one coat of anticorrosive treatment on steel reinforcement rods (20 ltrs. Of anticorrosive chemical for one metric tonne of steel reinforcement rods) at site including a cost of required quantity of anticorrosive chemicals, (best approved quality) cement, consumables such as brushes, gloves and labour for anticorrosive coating etc. complete and as directed by the PMC/Employers. The Quantity and brand of anticorrosive chemical should be got approved by the departmental office.

4.21 TOLERANCES

Tolerance for formed and concrete dimensions shall be as per IS: 456 unless specified otherwise. Tolerance is a specified permissible variation from lines, grade or dimensions given in drawings. No tolerance specified for horizontal or vertical building lines or footings shall be construed to permit encroachment beyond the legal boundaries. Unless otherwise specified, the following tolerances will be permitted.

4.22 TOLERANCES FOR RC BUILDINGS

4.22.1 Variation from the Plumb

In the lines and surfaces of columns, piers, walls and in arises 5 mm per 2.5 m or 25 mm, whichever is less.
For exposed corner columns and other conspicuous lines.

In any bay or 5 m maximum	-	5 mm
In 10 m or more	-	10 mm

4.22.2 Variation from the level or from the grades indicated on the drawings

In slab soffits, ceilings, beam soffits and in arises		
In 2.5 m	-	5 mm
In any bay or 5 m maximum	-	10 mm
In 10 m or more	-	15 mm
For exposed lintels, sills, parapets, horizontal grooves and other conspicuous lines		
In any bay or 5 m maximum	-	5 mm
In 10 m or more	-	15 mm

4.22.3 Variation of the linear building lines from established position in plan and related position of columns, wall and partitions

In any bay or 5 m maximum	-	10 mm
In 10 m or more	-	20 mm

4.22.4 Variation in the sizes and locations of sleeves, openings in walls and floors - 5 mm except in the case of and for anchor bolts.

4.22.5 Variation in cross-sectional dimensions of columns and beams and in the thickness of slabs and walls

Minus	-	5 mm
Plus	-	10 mm

4.22.6 Footings

Variation in dimension in plan		
Minus	-	5 mm
Plus	-	50 mm
Misplacement or eccentricity		
2% of footing width in the direction of misplacement but not more than 50 mm		
Reduction in thickness		
Minus	-	5% of specified thickness subject to a maximum of 50 mm

4.22.7 Variation in steps

In a flight of stairs

Rise	-	3 mm
Tread	-	5 mm
In consecutive steps		
Rise	-	1.5 mm
Tread	-	3 mm

4.22.8 TOLERANCES IN OTHER STRUCTURES

4.21.8.1 All structures

Variation of the construction linear outline from established position in plan.		
In 5 m	-	10 mm
In 10 m or more	-	15 mm
Variation of dimensions to individual structure features from established positions.		
In 20 m or more	-	25 mm
In buried construction	-	50 mm
Variations from plumb, from specified batter or from curved surfaces of all structures.		
In 2.5 m	-	10 mm
In 5 m	-	15 mm
In 10 m or more	-	25 mm
In buried construction	-	Twice the above values
Variations from level or grade indicated on drawings in slabs, beams, soffits, horizontal grooves and visible arises.		
In 2.5 m	-	5 mm
In 7.5 m or more	-	10 mm
In buried construction	-	Twice the above values
Variation in cross-sectional dimensions of columns, beams, buttresses, piers and similar members.		
Minus	-	5 mm
Plus	-	10 mm
Variation in the thickness of slabs, walls, arch sections and similar members.		
Minus	-	5 mm
Plus	-	50 mm

4.21.8.2 Footing for Columns, Piers, Walls, Buttresses and Similar Members

Variation of dimension in Plan		
Minus	-	10 mm
Plus	-	50 mm
Misplacement or eccentricity		

2% footing width in the direction of misplacement but not more than 50 mm
Reduction in thickness
5% of specified thickness subject to a maximum of 50 mm

4.21.8.3 TOLERANCE IN FIXING ANCHOR BOLTS

	Anchor bolts without sleeves	:	1.5 mm in plan
	Anchor bolts with sleeves	:	5.0 mm in elevation
	for bolts up to and including 28 mm dia.	:	5 mm in all directions
	for bolts up to 32 mm dia.	:	3 mm in all directions
	Embedded parts	:	5 mm in all directions

4.21.8.4 TOLERANCES IN FORMWORK

The formwork shall be designed and constructed to the shapes, lines and dimensions shown on the drawings within the tolerances given below:

1.	Deviation from specified dimensions of cross section of columns and beams	-6 mm
2.	Deviations from dimensions of footings (tolerances apply to concrete dimensions only, not to positioning of vertical reinforcing steel or dowels)	+12 mm
a)	Dimension in Plan	-12 mm +50 mm
b)	Eccentricity	0.02 times the width of the footing in the direction of deviation, but not more than 50 mm
c)	Thickness	± 0.05 times the specified thickness

4.22.9 Tolerance for top of concrete of equipment and structural steel foundations shall be as under unless more stringent requirements are specified by equipment manufacturer:

- Where grout thickness is less than or equal to 25 mm: ±5 mm.
- Where grout thickness is more than 25 mm: ±5 mm.

4.23 EXECUTION AND REMOVAL OF FORMS

Before placing concrete, the surface of all forms shall be coated with suitable non-staining form releasing agents such as raw linseed oil to prevent adhesion of concrete and to facilitate removal of forms.

The form releasing agent shall cover the forms fully and evenly without excess over drip. Care shall be taken to prevent form releasing agents from getting on the surface of the construction

joints and on reinforcement bars. Special care shall be taken to thoroughly cover form strips for narrow grooves, to prevent swelling of the forms and the consequent damage to concrete prior to or during removal of forms.

Immediately before concrete is placed care shall be taken to see that all forms are in proper alignment and the supports and fixtures are properly secured and tightened.

Where forms for continuous surfaces are placed in successive units, the forms shall lap and fit tightly over the completed surface to prevent leakage of cement slurry from the fresh concrete and to maintain accurate alignment of the surface.

Forms shall be left in place until their removal is authorized and shall then be removed with care to avoid injury to concrete.

Removal of forms shall be started when the concrete has achieved strength of at least twice the stress to which the concrete may be subjected at the time of removal of formwork.

In normal circumstances and where ordinary Portland cement is used forms can be allowed to be struck asper the guideline given in clause 11.3 of IS 456.

Note: Time shall be measured from last batch concreted in respect to the structural member under consideration. For other cement stripping time as recommended above may be suitably decided by PMC/EMPLOYER.

Re-propping shall be done to the below floor to carry the construction load transferred through props/ equipment, etc. during construction of upper floor and props left under till the period of removal of props supported to or any other load due to construction load on the upper floor. Re-propping shall be part of shuttering/ formwork for concrete without any claim for extra cost.

4.24 SETTLEMENT OF FORMWORK AND CAMBER

Due to various reasons such as closure of form joints, shrinkage of timber, dead load deflections, elastic shortening of form members or formwork, deflections, settlement may occur. The CONTRACTOR shall take precautions, including using adequately rigid formwork, to prevent excessive settlement/ deflection; the usual acceptable limit being 1/500 of the spans of the formwork.

In the absence of any specified camber on the drawings, soffit of all beams more than 5 m in span and other than pre-stressed concrete beams shall be laid to a camber, the amount of which at mid span shall not be less than 1/500 of the span of the structure. The profile of soffit shall be parabolic.

4.25 Preparation prior to concrete placement

The faces of formwork coming in contact with concrete shall be cleaned and two coats of approved mould oil applied before fixing reinforcement. All rubbish, particularly chippings, shavings, sawdust, wire pieces, dust, etc. shall be removed from the interior of the forms before the concrete is placed. Where directed, cleaning of forms shall be done by blasting with a jet of compressed air at no extra cost.

All arrangements - formwork, equipment and proposed procedure, shall be approved by PMC/EMPLOYER. CONTRACTOR shall maintain separate Pour Card for each pour.

4.26 Transporting, placing and compacting concrete

Concrete shall be transported from the mixing plant to the formwork with minimum time lapse by methods that shall maintain the required workability and will prevent segregation, loss of any ingredients or ingress of foreign matter or water.

In all cases concrete shall be deposited as nearly as practicable directly in its final position. For locations where, direct placement is not possible and in narrow forms, CONTRACTOR shall provide suitable drops and “Elephant Trunks”. Concrete shall not be dropped from a height of more than 1.5 m.

Concrete shall not be placed in flowing water. Under water concrete shall be placed in position by tremie or by pipeline from the mixer and shall never be allowed to fall freely through the water.

- While placing concrete the CONTRACTOR shall proceed as specified below and ensure the following:
- Continuously between construction joints and predetermined abutments.
- Without disturbance to forms or reinforcement.
- Without disturbance to embedment.
- Without dropping in a manner that could cause segregation or shock.
- In deep pours only when the concrete and formwork is designed for this purpose and by using suitable chutes or pipes.
- Do not place if the workability is such that full compaction cannot be achieved.
- Without disturbing the unsupported sides of excavations, prevent contamination of concrete with earth. Provide sheeting, if necessary. In supported excavations, withdraw the linings progressively as concrete is placed.
- If placed directly onto hardcore or any other porous material, dampen the surface to reduce loss of water from the concrete.

- Ensure that there is no damage or displacement to sheet membranes.
- Record the time and location of placing structural concrete.
- When concrete is brought from batching plant to site in millers, the time of mixing and the time of pour shall be checked to ensure that setting has not started.

Concrete shall normally be poured & compacted in its final position within initial setting time. Concrete shall be compacted during placing with approved vibrating equipment without causing segregation until it forms a solid mass free from voids, thoroughly worked around reinforcement and embedded fixtures and into all corners of the formwork. When placing concrete in layers advancing horizontally, care shall be taken to ensure adequate vibration, blending and melding of the concrete between successive layers. Vibrators shall not be allowed to come in contact with reinforcement, formwork and finished surfaces after start of initial set. Over-vibration leads to segregation and shall be avoided.

Concrete may be conveyed and placed by mechanically operated equipment after getting the complete procedure approved by PMC/EMPLOYER. The slump shall be held to the minimum necessary for conveying concrete by this method. When concrete is to be pumped, the concrete mix shall be specially designed to suit pumping. Care shall be taken to avoid stoppages in work once pumping has started.

CONTRACTOR shall submit a method statement to PMC/EMPLOYER for approval, furnishing details of pour sequence, thickness of each layer, mixing and conveying equipment proposed, etc. preferably with a sketch.

Except when placing with slip forms, each placement of concrete in multiple lift work, shall be allowed to set for at least 24 hours after the final set of concrete before the start of subsequent placement. Placing shall stop when concrete reaches the top of the opening in walls or bottom surface of slab, in slab and beam construction, and it shall be resumed before concrete takes initial set but not until it has had time to settle as determined by PMC/EMPLOYER. Concrete shall be protected against damage until final acceptance.

4.27 Placing of concrete by pumping methods

4.27.1 General

Placing of concrete by pumping will be as specified or authorized by PMC/EMPLOYER to achieve the required speediness of construction and maintain targeted schedules.

Pumping of concrete shall be done only after conducting pumpability trials to ascertain the performance of fresh concrete on pumping in presence of the PMC/EMPLOYER as per approved procedure. During pumping, concrete shall be conveyed either through rigid pipe or through

flexible hose and discharged directly into the desired area. A steady supply of pumpable concrete is necessary for satisfactory pumping. Pumpable concrete requires properly graded aggregates, material uniformity, consistent batching and thorough mixing. They shall be used for concreting densely reinforced structures, internal structural elements of buildings and for large pours of concrete. Concrete pumps used shall be able to deliver concrete over a horizontal and vertical distance as per the directives of the PMC/EMPLOYER.

Placement of normal concrete by pumping will be permitted as specified or authorized by the PMC/EMPLOYER. The decision, whether to pump any mix shall rest entirely with the PMC/EMPLOYER and no extra claims for payment on this account will be entertained. The pumping equipment, pipelines and accessories as well as proportioning of pumpable concrete shall generally conform to the recommendations of ACI-304.2R (latest revision) – Placing of concrete by pumping method - Proportioning of pumpable mixes gives certain guidelines on concrete mix. However, final selection of mix shall be as instructed by the PMC/EMPLOYER.

4.27.2 Pumping equipment

Requisite number of modern dependable concrete pumps capable of pumping concrete of specified quality at a rate required to meet the construction schedules, together with a balanced complement of pipelines, accessories, spare parts, power-controlled placing booms, and experienced pump operators and maintenance staff shall be provided at locations and in a manner approved by the PMC/EMPLOYER.

The pumping plant shall be completely installed on each occasion, with preliminary mock operation for a sufficient length of time prior to scheduled placement of a concrete pour, to enable the PMC/EMPLOYER to conduct pumpability tests and necessary adjustments for the concrete mix, prior to use of the pumping for placement of concrete.

4.27.3 Proportioning pumpable concrete

Basic Consideration

Although the ingredients of concrete to be placed both by pumping and by other means are the same, more emphasis shall be laid on the quality control and proportioning of a dependable pumpable mix. Dependability is ensured by the equipment and the operator, with the control of all the ingredients in the mixture, the batching and mixing operations, and the knowledge and experience of all the personnel from beginning to end.

Concrete mixes for pumping shall always be “plastic”. Stiff mixes shall not be used for pumping as they do not pump well. Attention shall be given to the mortar (cement, sand and water) and the amounts and sizes of coarse aggregates.

4.27.4 Testing for pumpability

No mix shall be accepted for use on a pumping job until an actual test under field condition has been completed. Testing a mix for pumpability involves duplication of the anticipated job condition from beginning to end. The batching and conveying by truck mixers shall be the same as will be used, the same pump and operator shall be present. The pipe and hose layouts shall simulate the actual condition as far as practicable. Prior use of a mix on another job may furnish evidence of pumpability, but only if conditions are duplicated. Before commencing a new concreting job, the CONTRACTOR shall carry out pumpability tests in consultation with the PMC/EMPLOYER. Concrete used in such tests shall not be used in the actual construction, unless specifically permitted by the PMC/EMPLOYER.

Following parameters shall be established by pumpability trials:

- In-situ compressive and split tensile strength of concrete.
- Curing the sample at Site by sprinkling water.
- Curing the sample at Laboratory in curing tanks.
- Wet sieve analysis of concrete to ensure that proportions of ingredients before and after pumping are same.

4.27.5 Field practices

Proper planning of concrete supply, pump location, line layout, placing sequence and the entire pumping operation shall be done by the CONTRACTOR and got approved by the PMC/EMPLOYER on every occasion before commencement of concreting job. The pump shall be as near the placing area as practicable, and the entire surrounding area must have adequate bearing strength to support the concrete delivery trucks, thus assuring a continuous supply of concrete. For important concrete placements and large jobs, adequate standby power and pumping equipment shall be provided as replacement, should break down occur.

Direct communication shall be maintained between the pump operator, concrete placing crew and batching plant. The placing rate shall be estimated so that concrete can be operated at an appropriate delivery rate. As a final check, the pump shall be started and operated without concrete to ascertain that, all moving parts are operating properly. As stated previously, the grout mortar shall be pumped into the line to provide initial lubrication for the concrete. As soon as concrete is received, the pump shall be run slowly until the lines are completely full and the

concrete is slowly moving. Once the pumping is started, the operator shall ensure that the hopper of the pump is not emptied beyond a certain level, as air may enter the pipeline and cause choking. Continuous pumping should be ensured. If a delay occurs because of concrete delivery, form repairs, or other factors, the pump shall be slowed down to maintain some movement of the concrete till normal supply is resumed. For longer delays, the concrete in the receiving hopper shall be made to last as long as possible by moving the concrete in the lines occasionally with one stroke of the pump. In confined areas, attempt shall be made by the CONTRACTOR to run a return line back to the pump, so that concrete can be re-circulated during delays.

The CONTRACTOR shall ensure that obstructions are not found in the pipe due to interruption in the feed of the concrete by more than 30 to 45 minutes.

Minor blockages shall be cleared by operating a few strokes of the pump in reverse momentarily and then by returning to normal forward pumping. If this fails, a succession of reverse and forward strokes shall be carried out to remove the blockage. Should this fail also, the blockage may be due to air-lock and the entrapped air must be removed.

Attempt to push through the obstructions by repeatedly starting the pump will result in compaction of the concrete and complicate the removal of the concrete in the pipe. Blockages in the pipe are usually discovered by the sound when the pipe is struck. To remove the obstruction, the concrete pipe shall be taken apart at the assured position and cleaned. Then the pumping process shall be started all over again.

This method of checking the blockage and setting it right shall be done with great speed as excessive delay will cause setting of concrete in the pipeline downstream of the choke and will lead to further blockage. When the blockage is being found out and remedied, the pump shall periodically be given one or two strokes forward to keep the concrete in motion. If blockage occurs in the placer boom, a pipe joint near the base of the placer boom shall be opened and the boom made vertical to drain the pipeline by gravity.

Cleaning blockages are time consuming and as such major blockages shall best be avoided by ensuring a pumpable mix. Concrete that is either under or over sanded, short of fines, gap graded, has an excess of a size, or excessively wet or dry will be rejected by the pump either by blockage or by hard pumping involving excessive pressures.

The termination of pumping operations shall be carefully planned to utilize the concrete dormant in the pipeline and the hopper when the pump is stopped and to avoid wastage.

When the form is nearly full, and there is enough concrete in the line to complete the placement, the pump shall be stopped, and a go-devil be inserted and forced through the line to clear it out. Water under pressure shall be used to push the go-devil. The go-devil shall be stopped about one metre from the end of the line, so that the water in the line will not spill over into the placement area. After flushing, water in the pipe shall be removed by drain cock which shall be located for this purpose in the lowest part of the line. After all concrete has been removed from the lines, all lines and equipment shall be immediately cleaned thoroughly.

4.27.6 Quality control

CONTRACTOR shall ensure that workmanship and plant shall be maintained at peak efficiency. Degree of control on all the concrete operation from selection of the ingredients to the final testing of specimen shall be in line with the assumptions made in mix design with respect to the standard deviation and co-efficient of variation.

The CONTRACTOR shall ensure that any compromise in quality is not done for the pumped concrete. To be pumpable, a high level of quality control for the assurance of uniformity must be maintained. Sampling at both the truck discharges and point of final placement shall be done by the CONTRACTOR and the PMC/EMPLOYER jointly, as frequently as the PMC/EMPLOYER desires to determine, if any change in the slump air content, and other significant mix characteristics occur take necessary corrective actions.

The CONTRACTOR shall engage experienced supervision at all levels. The placing crew shall be experienced and qualified and each operation shall be well planned and properly scheduled.

All the crew engaged in each of the concrete activities shall demonstrate in the presence of the PMC/EMPLOYER, their skills and capabilities to produce the final product as specified.

4.28 Mass concrete works

Sequence of pouring for mass concrete works shall be as approved by PMC/EMPLOYER. CONTRACTOR shall exercise great care to prevent shrinkage cracks and shall monitor the temperature of the placed concrete if directed.

4.29 Placing temperature of concrete

Placing temperature of concrete should be maintained as specified in Schedule of Quantities or as directed by PMC/EMPLOYER, to avoid shrinkage cracking.

Mixing water shall be kept cool by storing it under cover. Chilled water or crushed ice as part of the mixing water to achieve the specified placing temperature shall be used. For chilled water, it is recommended that the CONTRACTOR install and maintain refrigeration facility of required capacity. The CONTRACTOR shall also build and maintain well insulated adequate capacity storage tank for cold water with insulated connected piping. To supplement this refrigeration facility, the CONTRACTOR will have to have ice plant or use commercial ice subject to approval of the PMC/EMPLOYER. The full quantity of crushed ice shall be stored in cold storage 24 hours in advance of the start of concreting. The temperature in cold storage shall not be more than -20 C. The CONTRACTOR should study the placing temperature condition and work out plant capacity commensurate with the construction schedule requirements and submit his scheme along with the tender.

Ice when used as replacement for a portion or all the mixing water shall be produced from water, which meets the requirements of clause 4.13.3. Ice when used shall be in flakes of size 3 mm or below or crushed condition and the crushed ice shall be such as to pass completely, 10 mm sieve.

4.30 Curing

Curing and protection shall start immediately after the compaction of the concrete to protect it from:

- Premature drying out, particularly by solar radiation and wind.
- Leaching out by rain and flowing water.
- Rapid cooling during the first few days after placing.
- High internal thermal gradients.
- Low temperature or frost.
- Vibration and impact, which may disrupt the concrete and interfere with its bond to the reinforcement.

All concrete, unless directed otherwise by PMC/EMPLOYER, shall be cured as specified in clause 13.5 of IS 456. The quality of curing water shall be the same as that used for mixing.

Where a curing membrane is directed to be used by the PMC/EMPLOYER, the same shall be of a non-wax base and shall not impair the concrete finish in any manner. The curing compound to be used shall be got approved from the PMC/EMPLOYER before use and shall be applied with spraying equipment capable of a smooth, even textured coat.

Curing may also be done by covering the surface with an impermeable material such as polyethylene, which shall be well sealed and fastened.

Extra precautions shall be exercised in curing concrete during cold and hot weather as per clause no. 8.3 of IS: 7861 (Part II) and clause no. 8.2 of IS: 7861 (Part I) respectively.

Curing arrangement shall be subjected to PMC/EMPLOYER's approval.

4.31 Construction joints and keys

Construction joints (location and type) shall be as shown on the drawing or as approved by PMC/EMPLOYER. Concrete shall be placed without interruption until completion of work between construction joints. If stopping of concreting becomes unavoidable anywhere, a properly formed construction joint shall be made with the approval of PMC/EMPLOYER.

Dowels for concrete work, not likely to be taken up soon, shall be coated with cement slurry and encased in lean concrete as indicated on the drawings or as directed by PMC/EMPLOYER.

Before resuming concreting on a surface, which has hardened all laitance and loose aggregates shall be thoroughly removed by wire brushing and/ or hacking, the surface washed with high pressure water jet and treated with thin layer of cement slurry for vertical joints and a 15 mm thick layer of cement sand mortar for horizontal joints, the ratio of cement and sand being the same as in the concrete mix.

4.32 CONSTRUCTION JOINT TREATMENT

Methodology stated herein under must be followed by CONTRACTOR wherever instructed by the PMC/EMPLOYER at no additional cost to the EMPLOYER.

The entire construction joint shall be treated by green cutting using air/ water jet at suitable pressure to remove the laitance from the green concrete surface to receive subsequent pour over it. Suitable, approved brand of surface retarder shall be used to retard the setting time of green concrete to a depth of 5 to 8 mm. green cutting shall be done only after the final setting of concrete, so that the additional water available from the air water jet used for green cutting on the surface does not harm the quality of the concrete.

4.33 APPLICATION OF SURFACE RETARDER AND GREEN CUTTING AT CONSTRUCTION JOINT OF CONCRETE

4.33.1 Scope

Work under this procedure covers application of surface retarder over the green concrete and green cutting the exposed surface of concrete after final setting time to expose the aggregate, for proper bonding with fresh concrete of successive pours.

4.33.2 Material Qualification

The surface retarder shall be qualified for use based on number of site trials/ mock-ups for achieving the desired surface after green cutting during different ambient conditions.

4.33.3 Application

Surface retarder shall be applied uniformly with the help of agricultural spray machine at the rate of 5 to 6 sqm/liter. Form panel at construction joint: Wherever the side of a pour is to receive concrete later, a bulkhead of such sides will be coated with surface retarder at least one hour before the receipt of concrete.

For horizontal construction joints: Wherever the concrete is to be placed above a pour, surface retarder shall be applied on the finished top surface of the said pour within half an hour of finishing.

4.33.4 Green Cutting

Green cutting shall be started after final setting time of concrete to expose the aggregate, for proper bonding with fresh concrete of successive pours. The surface of concrete shall be green cut using air-water jet. Bunds shall be made using cement mortar at convenient locations and cut out shall be made in the side shutter to drain off excess water. All the laitance and green cut material shall be removed from the green cut surface simultaneously.

The time of green cutting shall be displayed on Tags, which will be placed at appropriate locations so that said activity can be controlled in the proper way.

When concreting is to be resumed on a surface, which has not fully hardened, all laitance shall be removed by wire brushing, the surface wetted, free water removed, and a coat of cement slurry applied. On this a layer of concrete not exceeding 150 mm thickness shall be placed and well rammed against the old work. Thereafter work shall proceed in the normal way.

Approved epoxy Bonding agent, for bond between old (say 28 days or more) and new concrete may also be used as per manufacturer’s specifications.

4.34 FOUNDATION BEDDING

All earth surfaces upon which or against which concrete is to be placed, shall be well compacted and free from standing water, mud or debris. Soft or spongy area shall be cleaned out and back filled with either soil-cement mixture, lean concrete or clean sand compacted as directed by PMC/EMPLOYER. The surfaces of absorptive soils shall be moistened.

Concrete shall not be deposited on large sloping rock surfaces. The rock shall be cut to form rough steps or benches by picking, barring or wedging. The rock surface shall be kept wet for 2 to 4 hours before concreting.

4.35 REPAIR AND REPLACEMENT OF UNSATISFACTORY CONCRETE

Immediately after the shuttering is removed, all the defective areas such as honeycombed surfaces, rough patches, etc. shall be brought to the notice of PMC/EMPLOYER who may permit patching of the defective areas or reject the concrete work. PMC/EMPLOYER's decision on rejection of concrete work shall be final.

All through holes for shuttering shall be filled with cement mortar for full depth and neatly plugged flush with surface.

Rejected concrete shall be removed and replaced by CONTRACTOR at no additional cost to PMC/EMPLOYER's

For patching of defective areas all loose materials shall be removed, and the surface shall be prepared by cleaning by compressed air or water jetting.

Bonding between hardened and fresh concrete shall be done either by placing cement mortar or by applying epoxy. The decision of the PMC/EMPLOYER as to be the method of repairs to be adopted shall be final and binding on the CONTRACTOR and no extra claim shall be entertained on this account. The surface shall be saturated with water for 24 hours before patching is done with 1:5 cement sand mortar. The use of epoxy for bonding fresh concrete shall be carried out as directed by PMC/EMPLOYER.

CONTRACTOR shall submit a method statement for such repairs to PMC/EMPLOYER for approval.

4.36 HOT WEATHER REQUIREMENT

Concreting during hot weather shall be carried out as per IS: 7861 (Part I).

Adequate provisions shall be made to lower concrete temperatures, which shall not exceed 400 C at the time of placement of fresh concrete.

Where directed by PMC/EMPLOYER, CONTRACTOR shall spray non-wax based curing compound on unformed concrete surface at no extra costs.

4.37 COLD WEATHER REQUIREMENTS

Concreting during cold weather shall be carried out as per IS: 7861 (Part 2).

The ambient temperature during placement and up to final set shall not fall below 50 C. Approved anti-freeze/ accelerating additive shall be used where directed.

For major and large-scale concreting works the temperature of concrete at times of mixing and placing, the thermal conductivity of the formwork and its insulation and stripping period shall be closely monitored.

4.38 LIQUID RETAINING STRUCTURES

The CONTRACTOR shall take special care for concrete of liquid retaining structures, underground structures and those other specifically called for to guarantee the finish and water tightness.

The minimum level of surface finish for liquid retaining structures shall be of smooth type. All such structures shall be hydrotested.

The CONTRACTOR shall include in his price hydro-testing of structure, all arrangements for testing such as temporary bulk heads, pressure gauges, pumps, pipelines, etc.

Any temporary arrangements that may have to be made to ensure stability of the structures shall also be considered to have been considered while quoting the rates.

Any leakage/ sweating that may occur during the hydro-test or subsequently during the defect liability period or the period for which the structure is guaranteed shall be effectively stopped either by cement/ epoxy pressure grouting, geniting or such other method as may be approved by the PMC/EMPLOYER. All such rectification shall be done by the CONTRACTOR to the entire satisfaction of the PMC/EMPLOYER at no extra cost to the EMPLOYER.

4.39 HYDRO TESTING CONCRETE STRUCTURES

Hydrostatic test for water tightness shall be done at full storage level or soffit of cover slab, as may be directed by PMC/EMPLOYER, as described below:

In case of structures whose external faces are exposed, such as elevated tanks, the requirements of the test shall be deemed to be satisfied if the external faces show no sign of leakage or sweating and remain completely dry during the period of observation of seven days after allowing a seven-day period for absorption after filling with water.In the case of structures whose external faces are submerged and are not accessible for inspection, such as underground tanks, the structures shall be filled with water and after the expiry of seven days after the filling, the level of the surface of the water shall be recorded. The level of water shall be recorded again at subsequent intervals of 24 hours over period of seven days. Backfilling shall be withheld till the tanks are tested. The total drop in surface level over a period for seven days shall be taken as an indication of the water tightness of the structure. The PMC/EMPLOYER shall decide on the actual permissible nature of this drop in the surface level, considering whether the structures are open or closed and the corresponding effect it has on evaporation losses. Unless specified otherwise, a structure whose top is covered shall be deemed to be watertight if the total drop in the surface level over a period of seven days does not exceed 40 mm.

Each compartment/ segment of the structure shall be tested individually and then all together.

For structures such as pipes, tunnels, etc. the hydrostatic test shall be carried out by filling with water, after curing as specified, and subjecting to the specified test pressure for specified period. If during this period the loss of water does not exceed the equivalent of the specified rate, the structure shall be considered to have successfully passed the test.

4.40 OPTIONAL TESTS

If PMC/EMPLOYER feels that the materials i.e. cement, sand, coarse aggregates, reinforcement and water are not in accordance with the specifications or if specified concrete strengths are not obtained, he may order tests to be carried out on these materials in laboratory, to be approved by the PROJECT OFFICER, as per relevant IS Codes. EMPLOYER shall pay only for the testing of material supplied by the EMPLOYER, otherwise CONTRACTOR shall have to pay for the tests. Transporting of all material to the laboratory shall however be done by the CONTRACTOR at no extra cost to EMPLOYER.

In the event of any work being suspected of faulty material or workmanship requiring its removal or if the works cubes do not give the stipulated strength, PMC/EMPLOYER reserves the right to order the CONTRACTOR to take out cores and conduct tests on them or do ultrasonic testing or load testing of structure, as per relevant IS specifications. All these tests shall be carried out by CONTRACTOR at no extra cost to the EMPLOYER. Alternately PMC/EMPLOYER also reserves the right to ask the CONTRACTOR to dismantle and re-do such unacceptable work at the cost of CONTRACTOR.

If the structure is certified by PROJECT OFFICER/ PMC as having failed, the cost of the test and subsequent dismantling/ reconstruction shall be borne by CONTRACTOR.

The quoted unit rates/ prices of concrete shall deem to provide for all tests mentioned above.

In case of doubt regarding the grade of concrete used, either due to poor workmanship or based on cube strength results, Non-Destructive Tests (NDT) shall be carried out to ascertain the strength of the concrete as per the technical specification attached in the tender document.

4.41 QUALITY CONTROL

CONTRACTOR shall adopt the Quality Control format provided by the PMC/EMPLOYER. A copy of formats shall be furnished to CONTRACTOR by PMC/EMPLOYER/ EMPLOYER after the contract is awarded.

Alternatively, if CONTRACTOR has his own QC formats, he may adopt them subjected to such modifications considered necessary by PMC/EMPLOYER.
In either case CONTRACTOR shall submit his detailed Quality Assurance Plan along with the bid. This would be reviewed, appropriately modified and approved by CONSULTANT/ PMC/EMPLOYER after the award of contract.

4.42 INSPECTION

All materials, workmanship and finished construction shall be subject to continuous inspection and approval of PMC/EMPLOYER. Materials rejected by PMC/EMPLOYER shall be expressly removed from site within 3 working days and shall be replaced by CONTRACTOR immediately at no extra cost to EMPLOYER.

4.43 CLEAN-UP

Upon the completion of concrete work, all forms, equipment, construction tools, protective coverings and any debris, scraps of wood, etc. resulting from the work shall be removed and the premises left clean.

4.44 ACCEPTANCE CRITERIA DURING CONSTRUCTION STAGE AND HARDENED STATE

Any concrete work shall satisfy the requirements given below individually and collectively for it to be acceptable.

- Properties of constituent materials.
- Characteristic compressive strength.
- Specified mix proportions.
- Minimum cement content.
- Maximum free water/cement ratio.
- Workability.
- Temperature of fresh concrete, if specified.
- Density of fully compacted concrete, if specified.
- Cover to embedded steel.
- Curing.
- Tolerances in dimensions.
- Tolerances in levels.
- Surface finishes.

PMC/EMPLOYER's decision as to the acceptability or otherwise of any concrete work shall be final and binding on the CONTRACTOR.

For work not accepted, PMC/EMPLOYER may review and decide whether remedial measures are feasible to render the work acceptable. PMC/EMPLOYER shall in that case direct the CONTRACTOR to undertake the remedial measures. These shall be expeditiously and effectively implemented by CONTRACTOR. Nothing extra shall become payable to CONTRACTOR by EMPLOYER for executing remedial measures.

4.45 MODE OF MEASUREMENT AND PAYMENT

The unit rate for concrete work under various categories shall be all inclusive and no claims for extra payment because of such items and leaving holes, embedding inserts, etc. shall be entertained unless separately provided for in the Schedule of Quantities. No extra claim shall also be entertained due to change in the number, position and/ or dimensions of holes, slots or openings, sleeves, inserts or on account of any increased lift, lead of scaffolding, etc. All these factors shall be taken into consideration while quoting the unit rates. Unless provided for in the Schedule of Quantities the rates shall also include fixing inserts in all concrete work, whenever required.

Payments for concrete will be made based on unit rates quoted for the respective items in the Schedule of Quantities.

Payment for beams will be made for the quantity based on the depth being reckoned from the underside of the slabs and length measured as the clear distance between supports. Payment for columns shall be made for the quantity based on height reckoned up to the underside of slabs.

The unit rate for precast concrete members shall include formwork, mouldings, finishing, hoisting and setting in position including setting mortar, provision of lifting arrangement, etc. complete. Reinforcement and inserts shall be measured and paid for separately under respective item rates.

Only the actual quantity of steel embedded in concrete including laps as shown on drawings or as approved by PMC/EMPLOYER shall be measured and paid for, irrespective of the level or height at which the work is done. The unit rate for reinforcement shall include all wastage, binding wires, chairs, spacer bars, etc. for which no separate payment shall be made.

Where the formwork is paid for separately, it shall be very clearly understood that payment for formwork is inclusive of formwork, shuttering, shoring, propping, scaffolding, de-shuttering, etc. complete. Only the net area of concrete formed (shuttered) shall be measured for payment.

Where reinforcement is supplied by EMPLOYER, the quantity of chairs and spacer bars shall be measured for accounting wastage only.

Cost of Admixtures shall be deemed to be included in the rates and no separate payment shall be made.

5.0 TERMITE PRECONSTRUCTIONAL CHEMICAL TREATMENT IN BUILDINGS

5.1 SCOPE

This specification covers the general requirements for Anti-termite Constructional Measures, chemical treatment of soils for the protection of buildings from attack by subterranean termites, chemicals to be used with their minimum rates of application and procedure to be followed while the building is under construction.

5.2 APPLICABLE CODES AND SPECIFICATIONS

The following codes, standards and specifications are made a part of this specification. In case of discrepancy between this specification and those referred to herein, this specification shall govern.

The codes and standards mentioned below shall be latest as on the day of award of contract of the works unless otherwise specified. Contractor shall be responsible to inform to the

PMC/EMPLOYER in case of any revisions/re-affirm/amendment in the relevant codes and standards after the date of award of contract within 30 days of the issue of such revision/re-affirm/amendment of the code/ standard. PMC/EMPLOYER may approve use of the earlier code/ standard if the revisions do not materially affect the statutory requirements of the project or does not impact safety practices. Any cost impact arising out of such revisions shall be mutually agreed.

1	IS 6313 Part 1: 1981 (R2015)	Code of practice for anti-termite measures in buildings: Part 1 Constructional measures
2	IS 6313 Part 2: 2013 (R2018)	Code of Practice for Anti-Termite Measures in Buildings - Part 2: Pre-Constructional Chemical Treatment Measures
3	IS 6313 Part 3: 2013 (R2018)	Code of Practice for Anti-termite Measures in Buildings - Part 3: Treatment for Existing Buildings
~~3~~	IS:8944-2005	Specification for Chlorpyrifos Emulsifiable Concentrates
4	IS:16131-2015	Specification for imidacloprid suspension concentrate
5	IS:4015-1998	Guide for Handling cases of Pesticide Poisoning

5.3 GENERAL

Contractor shall furnish all tools, plants, instruments, qualified supervisory personnel, labour, materials, any temporary works, consumables, any and everything necessary whether such items are specifically stated herein for completion of the job in accordance with specification requirements or not.

All work shall be done in the order of progress required by PMC/EMPLOYER’s construction program. Contractor shall take all necessary precautions to prevent any accident in connection with the performance of the work.

On completion of all work, Contractor shall leave the entire premises within the site of his operation clean and free from all rubbish resulting from his operation.

PMC/EMPLOYER reserves the right to inspect, check and direct any or all operations at any stage of the work and to require unsatisfactory work to be remedied at Contractor's expense.

No work shall be carried out under unsuitable weather conditions viz. when raining or when the soil is wet due to rain or sub-soil water.

Chemicals shall be brought to site of work in sealed original containers. The materials shall be brought in, at a time, in adequate quantity to suffice for the work. The material shall be kept in cool and locked stores. The empties shall not be removed from the work site till the relevant item of work has been completed and permission granted by PMC/EMPLOYER.

Chemicals available in concentrated forms with concentration indicated on the sealed containers only shall be used. Chemicals shall be diluted with water in required quantity before use, using graduated containers to achieve the desired percentage of concentration:

5.4 PRE-CONSTRUCTIONAL CHEMICAL TREATMENT

5.4.1 APPLICATION

Hand operated pressure pump with graduated containers shall be used to ensure uniform spraying of the chemical. Continuous check shall be kept ensuring that the specified quantity of chemical is used for the required area during the operation. On large projects, a power sprayer may be used to save time and labour.

5.4.2 TIME OF APPLICATION

Soil treatment shall start when the foundation trenches and pits are ready to receive mass concrete in foundations. Laying of mass concrete shall start when the chemical emulsion has been absorbed by the soil and the surface is quite dry. Treatment shall not be carried out when it is raining, or soil is wet with rain or sub-soil water. The foregoing also applies in the case of treatment to the filled earth surface within the plinth before laying the subgrade for the floor.

5.4.3 DISTURBANCE

The treated soil barriers shall not be disturbed after they are formed. If by chance, treated soil barriers are disturbed, immediate steps shall be taken to restore the continuity and completeness of the barrier system.

5.4.4 SOIL TREATMENT

Any chemicals conforming to Indian Standards, in water emulsion shall be applied uniformly over the area to be treated. The treated area shall be immediately covered by polythene sheet. It can be uncovered 2 hours before concrete casting.

5.4.5 TREATMENT OF COLUMN-PITS, WALL-TRENCHES AND BASEMENT EXCAVATIONS

The bottom surface and the sides (up to a height of about 300 mm) of the excavations made for column pits, wall trenches and basements shall be treated with the chemical at the rate of 5 liters per sqm of the surface area.

After the column foundations and the retaining walls of the basement come up, the backfill in immediate contact with the foundation structure shall be treated at the rate of 7.5 litres per sqm of the vertical surface of the sub-structure for each side. If water is used for ramming the earth-fill, the chemical treatment shall be carried out after the ramming operation is done by rodding the earth at 150 mm centers close to the wall surface and spraying the chemical with the above dose. The earth shall be returned in layers and the treatment shall be carried out in similar stages. The chemical emulsion shall be directed towards the concrete or masonry surfaces of the columns and walls so that the earth in contact with these surfaces is well treated with the chemical.

In the case of R.C.C. framed structures with columns and plinth beams and R.C.C. basements, with concrete mix 1:2:4 or richer, the treatment shall start at the depth of 500 mm below ground level for columns and plinth beams. From this depth the back-fill around the columns, beams and R.C.C basement walls shall be treated at the rate of 7.5 liters/sq.m of vertical surface.

5.4.6 TREATMENT OF TOP SURFACE OF PLINTH FILLING

The top surface of the filled earth within plinth beams/walls shall be treated with chemical emulsion at the rate of 5 liters per sq.m of the surface before the sand bed/subgrade is laid. Holes up to 50 to 70 mm deep at 150 mm centres both ways shall be made with 12 mm dia. crowbar on the surface to facilitate saturation of the soil with chemical emulsion.

5.4.7 TREATMENT OF JUNCTION OF WALL AND FLOOR

To achieve continuity of vertical chemical barrier to inner wall surfaces from the ground level, small channel 30 x 30 mm shall be made at all the junctions of wall and columns with the floor (before laying the subgrade) and rod holes made in the channel up to ground level 150 mm apart and the chemical emulsion poured along the channel at the rate of 7.5 litres/ sqm of the vertical wall or column surface so as to soak the soil right to the bottom. The soil shall be tamped back into place after this operation.

5.4.8 TREATMENT OF SOIL UNDER APRON ALONG EXTERNAL PERIMETER OF BUILDING

The top surface of the consolidated earth over which the apron is to be laid shall be treated with chemical emulsion at the rate of 5 liters/ sqm of the surface before the apron is laid. If consolidated earth does not allow emulsion to seep through, holes up to 50 to 75mm deep at 150

mm centers both ways may be made with12 mm diameter mild steel rod on the surface to facilitate saturation of the soil with the chemical emulsion.

5.4.9 TREATMENT OF SOIL ALONG EXTERNAL PERIMETER OF BUILDING

After the building is complete, holes shall be made in the soil with iron rods along the external perimeter of the building at interval of about 150 mm and depth 300 mm and these holes filled with chemical emulsion at the rate of 7.5 liters/meter of perimeter of the external wall. If the earth outside the building is graded on completion of building, this treatment shall be carried out on completion of such grading. If the filling is more than 300 mm the external perimeter treatment shall extend to the full depth of filling up to the original ground level so as to ensure continuity of chemical barrier.

5.4.10 TREATMENT FOR EXPANSION JOINTS

Anti-termite treatment shall be supplemented by treating through the expansion joint after the sub-grade has been laid at the rate of 2 liters per linear meter of expansion joint.

5.4.11 TREATMENT OF SOIL SURROUNDING PIPES AND CONDUITS

When pipes and conduits enter the soil inside the area of the foundations, the soil surrounding the points of entry shall be loosened around each such pipe or conduit for a distance of 150 mm and to a depth of 75 mm before treatment is commenced. When they enter the soil external to the foundations, they shall be similarly treated for a distance of over 300 mm unless they stand clear of the walls of the building by about 75 mm.

5.4.12 Safety precautions

All chemicals used for anti-termite treatment are poisonous and hazardous to health. These chemicals can have an adverse effect upon health when absorbed through the skin, inhaled as vapours or spray mists or swallowed. Person using or handling these chemicals should be warned of these dangers and advised that absorption through the skin is most likely source of accident poisoning. They should be cautioned to observe carefully the safety precautions given below.

These chemicals are usually brought to site in the form of emulsifiable concentrates. The containers should be clearly labelled and should be stored carefully so that children and pet cannot get at them. They shall be kept securely closed.

Particular care shall be taken to prevent skin contact with concentrates. Prolonged exposure to dilute emulsions shall also be avoided. Workers shall wear clean clothing and wash thoroughly with soap and water, especially before eating and smoking. In the event of severe contamination, clothing shall be removed at once and the skin washed with soap and water. If chemicals splash

into eyes they shall be flushed with plenty of soap and water and immediate medical attention shall be sought.

The concentrates are oil solutions and present a fire hazard owing to the use of petroleum solvents. Flames shall not be allowed during mixing.

Care shall be taken in the application of chemicals to see that they are not allowed to contaminate wells or springs which serve as source of drinking water.

In case of poisoning suitable measure shall be taken for protection in accordance with IS 4015.

5.4.13 Measurements

The measurements shall be made in sq.m on the basis of plinth area of the building at ground floor only for all operations described above. Nothing extra shall be measured.

5.4.14 Rate

The rate shall include the cost of all materials and labour involved in all the operations described above including making holes and refilling and making good the same.

6.0 WATERPROOFING WORKS

6.1 TERRACE WATERPROOFING

6.1.1 MATERIAL

The specified waterproofing system is meant for the water tightness and protection of roof/slab exposed to rain, from water penetration. Waterproofing shall be seamless waterproofing membrane. The waterproofing membrane has high elasticity having elongation > 500%, excellent, tensile strength of >4 MPa, Shore A hardness of 60-65 (±5).

6.2 WORKMANSHIP

6.2.1 Cleaning and Surface preparation

The cleaning and preparation of the substrate on which the waterproofing coating is applied as follow. Cleaning the surface, removing laitance ensuring substrate shall be free from dust by mechanical. Grinding of the substrate, ensuring substrate shall be free from any coating, oil or other contaminants that interferes to the bond or membrane with concrete. Treatment of Honey combing/ loose concrete, cracks, termination points in wall to slab joints using geotextile fabric.

6.2.2 Coving

Providing and applying 100 x 100mm thick fillet using cement concrete M15 grade mixed with polymer @ 10kgs per 50 kg bag of cement.

6.2.3 Primer Application

Directly above prepared mother concrete, parapet walls, upstands pedestals etc. apply moisture insensitive epoxy primer followed by sand broadcasting. Consumption of primer shall be between 0.2-0.25kgs per sqm.

6.2.4 Waterproofing Application

Apply PU membrane in two coats. Check the application shall reach to every corner, covering pipe penetrations, up stands, pedestals seamlessly.

6.2.5 Termination of Waterproofing

Waterproofing is to be terminated at parapet walls by taking waterproofing vertically upto 300mm above finished floor level. Vertical to horizontal joints shall be treated using geotextile mat to be sandwiched using PU waterproofing.

6.2.6 Testing

48 Hours water ponding to check leakage (if any).

6.2.7 Vertical UV Protection of waterproofing

All areas where waterproofing is exposed to sun such as parapet walls, upstands, terminations etc. shall be protected using UV topcoat.

6.2.8 Horizontal Protection

Providing and laying 300 GSM geotextile above waterproofing.

6.2.9 Screed Laid to slope:

Screed shall be minimum M15 grade shall be laid with reinforcement as per design. Screed shall be minimum 65mm thick at khurra/drain point complying with BS 8204. Pipe penetrations and RCC top level shall match.

Total water proofing system shall be applied by approved applicator of approved manufacturer's only with 10 years composite guarantee against leakages of total water proofing system to be provided by the contractor/ applicator.

The rate includes cost of all materials and labour required to carry the works as per the above specifications. The rate also includes cleaning surface and treating the cracks, joints, providing vata, vertical and horizontal protection shall not be paid separately, and only sloping screed shall be paid separately.

Only Plan area of terrace slab, balcony etc shall be measured and paid in sqm.

6.3 UG TANK - INNER WALL AND SLAB

6.3.1 MATERIAL

An integral crystalline slurry, hydrophilic in nature, shall be applied for waterproofing treatment to the RCC structures like inner and slab of UG water tanks. The material shall meet the requirements as specified in ACI-212-3R-2010 i.e. by reducing permeability of concrete by more than 90% compared with control concrete as per DIN 1048 and resistant to 16 bar hydrostatic pressure on negative side. The crystalline slurry shall be capable of self-healing of cracks up to a width of 0.50mm. The product performance shall carry guarantee for 10 years against any leakage.

6.3.2 WORKMANSHIP

The total system of water proofing as follows:

6.3.3 Surface Preparation

Surfaces should be prepared by acceptable preparation equipment to an open texture to achieve the required adhesion value for the waterproofing system. All connections between the substrate

and pipe entries must be sealed and made watertight before applying the water proofing material. Any joints which are present in the structure must also be sealed and made watertight. Any visible cracks exceeding 0.5 mm wide must be sealed using appropriate methods. Area of honeycomb concrete and other surface imperfections must be repaired with polymer modified mortars.

6.3.4 Curing Treatment

Protect fresh mortar immediately from premature drying using an appropriate curing method, e.g. water spray, moist geotextile membrane, moist hessian cloth, moist gunny bags, polyethylene sheet, etc. Cure at least for 5 days after application. For full cure approx. 28 days is recommended.

6.4 BELOW TANKS, ON TOP OF PCC

6.4.1 MATERIAL

The waterproofing treatment for Raft shall be using 1.2mm thick, pre-applied, fully bonded pure HDPE membrane over PCC. The system should be fully bonded to the RCC and consists of highly resilient HDPE film, self-adhesive polymer layer and a trafficable granular layer.

The membrane shall have minimum of 75mm side and end laps which shall be sealed with double sided adhesive tape. The size of the membrane should not be less than 1.2 Mtr. x 20 Mtr. to minimise the joints. This membrane shall be continued over the vertical surface upto minimum 300mm height above the Raft bottom.

The membrane shall have HDPE film of ≈0.9mm, Tensile Strength > 25 MPa ASTM D412, Elongation at Break ≥ 500 % ASTM D412, Peel Adhesion to Concrete ≥ 1500 N/m ASTM D903, Puncture Resistance ≥ 1000 N ASTM E 154, Resistance to Hydrostatic Head > 70m ASTM D 5385, Lap Peel Adhesion ≥ 1500 N/m ASTM D1876, Lateral Water Migration Resistance > 70m ASTM D5385.

6.4.2 WORKMANSHIP

The total system of water proofing as follows:

6.4.2.1 Surface Preparation

The concrete surface should be thoroughly abraded to remove all laitance. Any trace of loose plaster, oil grease and any other material that might affect adhesion is to be removed by wire brushing the surface. The entire surface shall then be washed thoroughly with plenty of water and then allowed to dry.

6.4.2.2 Treatment of construction joints

All the construction joints, tie rod holes, honeycomb's locations etc., shall be sealed using polymer modified non-shrink waterproof cementitious mortar and carrying out injection grouting to the RCC surface at honeycombs, voids, cracks, leaking spots etc., in the raft etc., wherever required using hydro grout non-shrink cementitious grouting compound. They shall also include sealing around the base junction between the membrane and any other pipe / sleeve etc. using liquid applied polyurethane flashing system.

6.4.2.3 Installation of pressure release pipes

Pressure release pipes of required dia and sizes as per site requirement and approved by PMC/Employer shall be installed. Provide & install aluminium termination bar of minimum 200mm above finished floor level & fix with non-corrosive fastener @ 4 no's per Rmt. Sealing the termination bar with Sealant shall be a part of CONTRACTOR's scope of work at his own cost.

6.4.2.4 Application

As per the manufacturers technical data sheet and specification.

6.4.2.5 Mode of measurement:

Actual area of wall surface covered with chemical shall be considered for payment. The rate includes cost of all materials and labour required to carry complete works as per the above specifications. The rate shall be for a unit of one sqm.

7.0 STRUCTURAL STEEL WORKS

7.1 SCOPE

This specification covers the general requirements for supply of all steel items where specified, fabrication, inspection, testing and delivery at site of all fabricated structural steel items. This specification also covers design of all connections and substituted members, preparation of all shop fabrication drawings, inspection of fabricated items. The scope of work also includes but is not limited to proper stacking and storage of fabricated materials, transport from place of storage to place of erection, wherever required. All the works shall be carried as per approved QA procedures.

7.2 APPLICABLE CODES STANDARDS AND SPECIFICATIONS

The pertinent clauses of the following Indian Codes, Standards and Specification (latest editions including all applicable official amendments, reaffirmations and revisions) shall apply to the material and workmanship covered by this specification. In the event of the conflict of certain

requirements between this specification and the codes referred herein, this specification shall govern.

It is not the intent to specify herein all the codes and standards required for the satisfactory completion of work. The list of codes and standards indicates certain primary codes and standards and not all the codes required for the work under the contract. It is understood that all the pertinent codes and standards shall form the part of this specification whether explicitly indicated or not.

IS 800	General Construction in Steel –Code of Practice
IS 803	Code Of Practice For Design, Fabrication And Erection Of Vertical Mild Steel Cylindrical Welded Oil Storage Tanks.
IS 806	Code Of Practice For Use Of Steel Tubes In General Building Construction
IS 808	Dimensions for Hot Rolled Steel Beam, Column, Channel and Angle Sections
IS 813	Scheme of symbols for welding
IS 814	Covered Electrodes for Manual Metal Arc Welding of Carbon and Carbon Manganese Steel-Specification
IS 816	Code of Practice for use of Metal Arc Welding for General construction in Mild Steel
IS 822	Code of Procedure for Inspection of Welds
IS 1024	Code of practice for use of welding in bridges and structures subjected to dynamic loading
IS 1161	Steel Tubes for structural purposes-Specification
IS 1182	Recommended Practice for Radiographic examination of Fusion Welded Butt Joints in Steel Plates.
IS 1239	Steel Tubes, Tubular and Other Wrought Steel Fittings-Specification-Part 1: Steel Tubes
IS 1239	Mild steel tubes, tubular and other wrought steel fittings-Part 2:Mild steel tubular and other wrought steel pipe fittings
IS 1363	Hexagon Head Bolts, Screws and Nuts of Product Grade ‘C’ Part 1: Hexagon Head Bolts (Size range M5 to M64) Part 2: Hexagon Head Screws (Size range M5 to M64) Part 3: Hexagon Nuts (Size range M5 to M64)
IS 1367	Technical Supply Conditions for Threaded Fasteners (All Parts)

IS 1395	Low and medium alloy steel covered electrodes for manual metal arc welding
IS1852	Rolling and Cutting Tolerances for Hot Rolled Steel Products (4th Rev)
IS 2062	Hot Rolled low, medium and High tensile structural steel
IS 2595	Code of Practice for Radiographic Testing
IS 3502	Steel Chequered Plates-Specification.
IS 3600:	Method of testing fusion welded joints and weld metal in steel (All parts)
IS 3658	Code of Practice for Liquid Penetrate Flaw Detection
IS 3757	Specification for High Strength Structural Bolts
IS 4000	Code of Practice High strength bolts in Steel Structures
IS 4260	Recommended practice for ultrasonic testing of butt welds in ferritic steel.
IS 4353	Submerged arc welding of mild steel and low alloy steels – Recommendations
IS 5334	Magnetic Particle Flaw Detection of Welds-Code of Practice
IS 6639	Specification for Hexagon Bolts for Steel structures
IS 7215	Tolerances for Fabrication of Steel Structures.
IS 9595	Metal Arc Welding of Carbon and Carbon Manganese Steels-Recommendations
IS 12778	Hot rolled parallel flanged section for beams, columns
SP:6(1)	Structural Steel Sections.
AWS D1.1	Structural Welding Code: Steel

7.3 STEEL SUPPLY

All steel and other material shall be procured and supplied by the CONTRACTOR, from the reputed manufacturers as mentioned in tender document. Steel proposed to be procured from other manufacturers shall have prior approval from the OWNER before placement of procurement order. However, OWNER reserves the right to accept or reject material from other manufacturers. Materials from re-rollers will not be accepted. Steel procured shall conform to the applicable codes & standards mentioned in clause 2.0.

CONTRACTOR shall use materials for fabrication as specified in the approved drawings. All materials supplied by the CONTRACTOR shall be in sound condition, of recent manufacture, free from defects such as mill scales, slag intrusions, laminations, pitting, flaky, rust etc. and be of full weight and thickness as specified.

CONTRACTOR shall furnish the mill / manufacturer's test reports, along with the materials and satisfactorily demonstrates the specific grade and quality. Material test certificate shall be original.

All materials required for the work shall be correlated with manufactures test certificates. In the absence of test certificates, CONTRACTOR shall test materials through reputed laboratory approved by PMC/EMPLOYER for establishing quality, at CONTRACTOR's cost and as directed by the PMC/EMPLOYER.

Material supplied against this Test Certificates (TC) should have identification stamped or stencilled on them. All such identification markings shall be authenticated by the inspection agency, which has inspected and approved the material.

The CONTRACTOR shall furnish to the PMC/EMPLOYER duplicate copies of all purchase order copies covering the material ordered by him for the project under reference and test reports.

The PMC/EMPLOYER shall have the right to test random samples to prove authenticity of the test certificates produced by the CONTRACTOR at the CONTRACTOR's cost. Any material found not meeting the required specification would be rejected.

Whenever the CONTRACTOR desires to substitute structural members / shapes, plates for the sizes shown on the drawings, for want of availability of requisite materials, such substitutions shall be made only after authorization in writing by the PMC/EMPLOYER. PMC/EMPLOYER may also direct that substitution be made, when he considers such substitution to be necessary.

7.4 CONTRACTOR'S DRAWINGS (FABRICATION DRAWINGS)

Fabrication drawings shall be prepared by the CONTRACTOR or through an agency approved by PMC/EMPLOYER at his own cost based on the PMC/EMPLOYER's Design drawing "Released for Construction" and their subsequent revisions. All the drawings for the entire work shall be prepared in metric units. The drawings shall preferably be of one standard size and the details shown there in shall be clear and legible. Drawings shall be prepared in computer tools and the details shall be drawn to the minimum scale as specified under.

a) Marking Plan : 1:75

b) Joint Details : 1:5; 1:10; 1:1

c) Elevations: : 1:20

CONTRACTOR shall not commence detailing unless PMC/EMPLOYER's design drawings are officially released for preparation of shop drawings. The CONTRACTOR shall be responsible for the correctness of all fabrication drawings. Fabrication drawings shall be revised by the CONTRACTOR to reflect all revisions in design drawings as and when such revisions are made by the PMC/EMPLOYER.

Key plan prepared by the CONTRACTOR shall indicate the fabrication / erection marking of each member and a table showing the corresponding fabrication drawing number where these members are detailed. Also, each drawing prepared by CONTRACTOR shall indicate corresponding PMC/EMPLOYER's design drawing number with revisions.

Each member shall be detailed separately unless members are identical in all respects with no deviation whatsoever. Shop detail drawings shall show all shearing, punching, drilling, bevel cutting, bending, and all welding in complete detail. All connections and splices shall be designed and detailed by the CONTRACTOR and clearly shown on the drawings. Bill of material shall show number, size, length, weight and assembly work of each erection piece. Bill of material for each drawing shall include fasteners/bolts, nuts, washers and other accessories complete with specification, size, length, numbers, etc for each erection mark and proper identification for each joint. Bill of material shall be prepared erection mark wise, showing weight of each component part and total weight of each erection mark. All revisions after initial issue of a drawing shall be clearly indicated with issue number and date of revision.

Each drawing prepared by the CONTRACTOR shall clearly indicate Names of OWNER, PMC/EMPLOYER, CONTRACTOR, Project Title, Title of drawing, Scale, Notes, Details of revisions carried out etc; All titles, noting, markings and writings on the drawing shall be in English and all dimensions shall be in metric units. Before the commencement of preparation of fabrication drawings, CONTRACTOR shall discuss with the PMC/EMPLOYER any specific requirement to be followed for fabrication drawing preparation.

No detailed shop drawings will be accepted by the PMC/EMPLOYER unless they are complete and checked and approved by CONTRACTOR's qualified Structural PMC/EMPLOYER and accompanied by an erection plan showing the location of all pieces detailed.

CONTRACTOR should check for erection clearance and ensure that detailing of connections is carefully planned to obtain ease in erection of structures including field-welded connection and bolting. Field connections/splices may be welded, or bolted type as specified in design drawings.

CONTRACTOR shall submit design calculations for each connection detail proposed by him and for any substitution for members, desired by him and approved by the PMC/EMPLOYER. Fabrication drawings not accompanied by calculation for connection details are liable for rejection.

Each lot of drawings sent by CONTRACTOR for approval shall contain a limited number of drawings and shall be in an order and manner which follows erection sequence or as required by PMC/EMPLOYER based on priorities allocated. PMC/EMPLOYER will return one copy of CONTRACTOR's drawing marked with PMC/EMPLOYER’s approval/comments. CONTRACTOR shall furnish the PMC/EMPLOYER the required number of prints of all approved drawings for field use and record purpose.

Site splicing may be by welding or by means of high tensile bolts. In the case of welded connection, efficiency of field butt weld shall be considered as 50% and cover plate shall be designed for 50% of the tensile strength of the plates spliced.

In the case of framing beams, the weld between flange and web shall be calculated based on standard formula considering the shear force as the full shear capacity of the web. Continuous weld shall be provided keeping size of weld uniform for the full length of girder. However, is no case the size of weld shall be less than half the web thickness.

Weld between flanges and web both for column as well as beams, shall be made using automatic welding machines, with proper sequence of welds to avoid warping.

Connection of bracings /tie beams to column shall follow the details given in the design drawings. Where such details are not given, the connection shall be designed for 50% of the tensile strength of the member unless design drawings indicate a higher load in the member. The maximum size of the weld shall be less than or equal to the thickness of the rolled section at the location of connection.

Weld between flanges and web both for column as well as beams, shall be made using automatic welding machines, with proper sequence of welds to avoid warping.

Thickness of gusset plates shall be at least equal to the thickness of member connected and shall have adequate cross section to transfer the force at the point. If the members are connected

on either side of gusset, thickness of gusset shall be more than sum of thickness of fillet weld on either side of gusset.

PMC/EMPLOYER may review / approve the fabrication drawing at his option some, all or none of the fabrication drawings. Wherever such review is carried out the same shall be restricted to the following.

Review/ approval of the size of members, dimensions and general arrangement but shall not constitute approval of the connections between members and other details.

Correctness of overall dimensions, centre to centre distance, elevations. Important / typical connection details (adequacy of number of bolts / weld length for few connections only will be checked), working points for bracing members and orientation and sizes / sections of members.

It shall be clearly noted by the CONTRACTOR that even where review is done by the PMC/EMPLOYER, the following shall be the sole responsibility of the CONTRACTOR.

- Provision for erection.
- Marking of members.
- Cutting Lengths of members
- Matching of Joints and holes
- Provision kept in the member for all other interconnected members
- Bill of materials.
- Gusset sizes.
- Connections

Approval by PMC/EMPLOYER of any of the fabrication drawings shall not relieve the CONTRACTOR from the responsibility for correctness of engineering, design of connections, workmanship, and fit of parts, details, material, errors or omissions of all work shown thereon. PMC/EMPLOYER's approval shall not invalidate any claim for damages of any kind for incorrectly detailed / fabricated steel, notwithstanding any approval of such drawings by PMC/EMPLOYER.

On completion of fabrication and erection, the CONTRACTOR shall update his fabrication drawings, incorporating all site changes and substitutions and shall submit two (2) sets of hard copies of such "as built "drawings to PMC/Employers for record purpose. The CONTRACTOR shall also furnish two sets of soft copies of all final approved Contractors' drawings in the form of CDs.

Time consumed by the CONTRACTOR in securing approval of drawings should not be added to the time allowed for completion of contract. A period of two (2) weeks from the dates of receipt

of drawings by the PMC/EMPLOYER should be anticipated for this item of procedure in the schedule.

7.5 FABRICATION

7.5.1 GENERAL

Fabrication shall not be started until CONTRACTOR has received copies of such drawings upon which PMC/EMPLOYER has endorsed his approval. Any work done prior to approval of CONTRACTOR's fabrication drawings will be at the CONTRACTOR's risk. The CONTRACTOR shall make such changes in the design when so directed, which are considered necessary to make the structures conform to the provisions and intent of the specifications, without any additional cost to the OWNER.

All workmanship and finish shall be of the best quality and shall conform to good engineering practice and the best-approved method of fabrication. All materials shall be finished straight and shall be machined / ground smooth, true and square where so specified.

Materials at the shop shall be kept clean and protected from weather. Cutting, punching, drilling, welding and fabrication tolerances shall be generally as per relevant Codes and Standards. In addition, the CONTRACTOR shall strictly adhere to the following.

- All care should be taken to avoid undue welding distortions.
- Complete layout shall be prepared and got approved by the PMC/EMPLOYER before actual fabrications are started. If needed mock-ups may also be prepared.

All fit ups shall be got approved from the PMC/EMPLOYER.

7.5.2 Connections

All shop connections shall be welded unless otherwise specified in PMC/EMPLOYER's design drawing. Field connections can be either welded or bolted and as shown in design drawings. Bolts used for erection shall conform to IS-6639 and as specified in the design drawings. Bolts used for permanent connections shall be high strength tensile bolts and shall conform to grade 'C' as per IS:1363 and property class 8.8 (minimum) as per IS:1367 or as indicated in design drawings.

All connections shall be designed for forces indicated on the design drawings or as specified elsewhere in the specification/standard drawing if not given in the design drawings. The CONTRACTOR shall be responsible for selection of standard connections from AISC Manual of Steel Construction or any other standards approved by PMC/EMPLOYER.

All connections shall be designed and detailed as per guidelines given in IS800 code.

In case of bolted connections, taper washers or flat washers or spring washers shall be used with bolts as necessary. In case of high strength friction grip bolts, hardened washers are used under the nuts or the bolt heads whichever are turned to tighten the bolts. The length of the bolt shall be such that at least one thread of the bolt projects beyond the nut, except in case of high strength friction grip bolts where this projection shall be at least three times the pitch of the thread.

In all cases where bearing is critical, the unthreaded portion of bolt shall bear on the members assembled. A washer of adequate thickness may be provided to exclude the threads from the bearing thickness, if a longer grip bolt must be used for this purpose.

Not more than one shop splice shall be provided to make up the full length of a member. Shop splices to make the full member lengths shall be of full penetration butt welded type and radiographically tested.

Transportation or the CONTRACTOR's erection methods may require additional splices not shown on the drawings. The CONTRACTOR shall be responsible for the design and detailing of such splices or joints and shall submit these for the PMC/EMPLOYER's approval.

All bolts, nuts, screws, washers, electrodes, etc. shall be supplied / brought to site 10% more than the requirement in each category and size. Rates shall cover the cost of this extra quantity and no additional payment will be made for this extra quantity supplied.

All members likely to collect rain water shall have drain holes provided.

7.5.3 Straightening

Rolled material, before being worked, shall be straightened, unless otherwise specified. If straightening or flattening is necessary, it shall be done by methods that will not injure the material. Long plates shall be straightened by passing through a mandrel or levelling rolls and structural shapes by the use of mechanical or hydraulic bar/section straightening machines. Heating or forging shall not be resorted to without the prior approval of the PMC/EMPLOYER in writing. In case of site fabrication, CONTRACTOR shall obtain PMC/EMPLOYER's approval in writing on the straightening method proposed to be adopted before commencing the work.

Checking of the straightness of the structural members like angles, channels, beams etc. shall be done by using the thread. For checking of the straightness of the column sections piano wire shall be used. The sections, which are twisted beyond repairs, shall not be used for fabrication. Heating or hammering shall not be permitted. After removal of bends structural members shall be submitted for inspection and approval of PMC/EMPLOYER.

7.5.4 Cutting

Cutting may be done by shearing, cropping, sawing or machine flame cutting. All re-entrant corners shall be shaped notch free to a radius of at least 12-mm. Sheared or cropped edges shall be dressed to a neat workmanlike finish and shall be free from distortion and burrs.

Hand flame cutting shall be undertaken, only if so permitted by the PMC/EMPLOYER and shall only be carried out by an expert in such work. Hand flame cut edges shall be ground smooth and straight.

Edges of flange cover plates and plates used to form any sections shall be ground smooth.

7.5.5 Punching and drilling

Holes in secondary members such as Purlins, grits, lacing bars etc. may be punched full size through material not over 12 mm thick. Holes should be clean cut, without burr or ragged edges. Holes for all other connections shall be drilled accurately and the burrs removed effectively. Where several parts are to be connected to very close tolerances such parts shall be first assembled, tightly clamped together and drilled through.

Sub-punching may be permitted before assembly, provided the holes are punched 3 mm smaller in diameter than the required size and reamed after assembly to the full diameter. The thickness of material punched shall not in such cases exceed 16 mm.

When match drilling is carried out in one operation through two or more separate parts, these parts shall be separated after drilling and the burrs removed.

Holes for turned and fitted bolts shall be drilled to a slightly smaller diameter and reamed to a diameter equal to the nominal diameter of the shank or barrel subject to tolerance specified in IS: 919.

Where reamed members are taken apart for transporting or handling, the respective pieces reamed together shall be so marked that they may be reassembled in the same position in the final setting up. No interchange of reamed parts will be permitted. Poor matching, over drilling and ovality in holes shall be a cause for rejection. Burning holes with gas is strictly prohibited.

Holes may be required to be drilled by the CONTRACTOR at no extra cost at site for installing equipment or steel furnished by other agencies. The information for this will be supplied to the CONTRACTOR by the PMC/EMPLOYER before or after erection of the steel. Holes should be by drilling or other machining process and not by gas cutting sets.

7.5.6 Rolling and forming

Plates, Channels, Rolled Steel joists etc., for circular bins, bunkers, hoppers, gantry girders, etc., shall be accurately laid off and rolled or formed to required profile/ shape as called for on the drawings. Adjacent sections shall be match-marked to facilitate accurate assembly, welding and erection in the field.

7.5.7 Grinding

Column ends bearing on each other, resting on base plates, compression joints designed for bearing, base plates coming in contact with column end and cap plate shall be ground smooth to ensure 90% contact with local gap not exceeding 0.10 mm (filler gauge shall be used to check this gap). Bottom edge of knife edge support (bearing stiffener) for crane girder and top of cap plates where the knife edge supports rest shall also be accurately ground as above. All ground surfaces shall be protected from dirt and mechanical damages till the assembly is completed. However, the underside of base plate bearing on grout need not be machined.

7.5.8 Welding

Before the start of the work, welding procedure shall be submitted to PMC/EMPLOYER for approval. Welding shall be entrusted to only qualified and experienced welders who shall be periodically tested and graded as per relevant standards.

Welding procedure specification (WPS) shall be established, and Qualification of weld procedure (QWP) shall be done as per approved standards. Welders employed shall also be qualified as per above standards prior to taking up fabrication. CONTRACTOR shall obtain approval from PMC/EMPLOYER before the start of the work.

Following pre-qualified welding process shall be employed for fabrication, erection and repair and the same shall have the approval of PMC/EMPLOYER before adopting the welding process on the job.

- Submerged Arc Welding (SAW).
- Shield Metal Arc Welding (SMAW).
- Gas Metal Arc Welding (GMAW).
- Gas Tungsten Arc Welding (GTAW)

All welds shall be free from defects like blowholes, lack of penetration, undercutting, cracks etc. All welds shall be cleaned of slag or flux and show sections, smoothness of weld metal, featheredges without overlap and freedom from porosity.

50mm on either side of the surfaces on which weld metal is to be deposited shall be smooth, uniform, free from fins, tears, burrs, cracks and absolutely free from grease, paint, loose scale, moisture or any other substance which would adversely affect quality and strength of weld.

Machining, thermal cutting or grinding may be employed for joint preparation or removal of unacceptable work or metal. The weld edges shall be smooth & regular surface, free from cracks & notches. Flame cut material above 50mm thick shall be pre-heated as per relevant standards prior to flame cutting and shall be subjected to PMC/EMPLOYER's approval.

All welds fit-up shall comply with tolerances specified in the relevant standards. The parts to be joined by fillet welds shall be brought into close contact as practicable and within the tolerable limits as per relevant codes & standards.

All tack welds shall be made using qualified procedure and qualified welders. Any preheat requirement specified in the welding procedure shall also apply to tack welds. All tack welds shall be examined visually for defects and if found defective, shall be removed and re-welded. Throat thickness, leg length and length of tack weld shall be as per IS:9595.

Welding of temporary attachment/fixtures to retain fit up is permitted in case the parts have a nominal thickness of at least 10 mm. Temporary attachments are welded at the minimum distance of at least 50 mm from the weld seam. Welding of temporary attachments/fixtures into the joint slot is not allowed. All temporary fixtures shall be removed after welding, by grinding them to weaken the welded portion and hammering thereafter followed by grinding the portion of any weld remaining on the base metal. A dye check at the discretion of the quality surveyor shall be done to detect any crack/defect at the point of fixture temporary weld.

It is not allowed to turn over and carry over heavy assemblies in tacking condition to control the geometric dimensions to the requirements of the drawings. The work shall be positioned for flat welding wherever practicable and overhead weld shall be avoided as far as possible.

In the joints of the parts with dissimilar thickness smooth transition of one part to the other must be provided by way of the gradual decreasing of the thickness of the thicker part with the slope of the surface not exceeding 15 degrees.

Welding shall not be done when the surface of the members are wet or exposed to rain or high wind velocities unless the welding operator and the work are properly protected.

In joints connected only by fillet welds, the minimum size of fillet weld to be used shall be as per IS 9595-1996.

Welds shall be defect free and surfaces shall be thoroughly cleaned to remove all visible weld defects and extra material.

For all built up sections such as Columns, Crane Girders etc welding between web and flange plates shall be carried out by SAW process. Especially for butt welds of Crane girders full penetration of weld between top of web plate and top flange shall be ensured. Welding shall be continuous and shall be on both sides of the connecting member. One side fillet weld is not acceptable.

7.5.9 Welding consumables

Electrodes, filler wires and flux used for welding shall be from approved manufacturers/Suppliers. CONTRACTOR shall submit the list of Electrode manufacturers proposed to be procured to the PMC/EMPLOYER for approval. The CONTRACTOR shall furnish certification that electrode or electrode flux combination will meet the requirements of classification. The classification and size of electrode, arc length, voltage & amperage shall be suited to type and thickness of material, type of groove, welding positions and other circumstances attending work.

Only low hydrogen electrodes shall be used for welding. All electrodes having low hydrogen covering shall conform to relevant acceptable standards. These electrodes shall be purchased in hermetically sealed containers or baked by the user as recommended by electrode manufacturer. Electrode flux coating shall be sound and unbroken. Broken or damaged coating shall cause the electrodes to be discarded. Before welding, the electrodes shall de dried in a holding oven at 120OC at least for one (1) hour or as per manufacturer’s recommendations. Only limited quantity shall be issued to the welders. The electrodes shall be kept in “carry ovens” and shall not be exposed to the atmosphere.

Welding plants and accessories shall have capacity adequate for welding procedure laid down and shall satisfy appropriate standards and be of approved make and quality. CONTRACTOR shall furnish and obtain approval from PMC/EMPLOYER the details of equipment he proposes to deploy for the works. All the electrical plant in connection with the welding operation shall be properly and adequately earthed and adequate means of measuring the current shall be provided. Proper safety rules shall be strictly followed.

7.6 TESTING, INSPECTION, AND REPORTS

7.6.1 GENERAL

On award of work, the CONTRACTOR shall submit to PMC/EMPLOYER, his Field Quality Plan (FQP), outlining the types, details and extent of inspection he proposes to execute, covered in the rates quoted for various items of work.

CONTRACTOR shall give due notice to PMC/EMPLOYER in advance of the materials or workmanship getting ready for inspection. All rejected material shall be promptly removed from the shop and replaced with new material for PMC/EMPLOYER's approval / inspection. The fact that certain material has been accepted at CONTRACTOR's shop shall not invalidate final rejection at site by PMC/EMPLOYER if it fails to conform to the requirements of these specifications, be in proper condition or has fabrication inaccuracies which prevent proper assembly.

No material shall be painted or dispatched to site without the inspection and approval by PMC/EMPLOYER unless such inspection is waived in writing by the PMC/EMPLOYER.

Shop inspection by PMC/EMPLOYER or submission of test certificates and acceptance thereof by PMC/EMPLOYER shall not relieve CONTRACTOR from the responsibility of furnishing material conforming to the requirements of these specifications, nor shall it invalidate any claim which the PMC/EMPLOYER may make because of defective or unsatisfactory material or workmanship

CONTRACTOR shall provide all the testing and inspection services and facilities for shop work except where otherwise specified. CONTRACTOR's inspection work shall be under the control of competent Chief Inspector whose primary responsibility is inspection (reporting to Management) and not to production department.

For fabrication work carried out in the field, the same standard of supervision and quality control shall be maintained as in shop fabricated work. The inspection and testing shall be conducted in a manner satisfactory to PMC/EMPLOYER. The inspection and testing on structural steel members shall be as set forth below:

7.6.2 MATERIAL TESTING

All materials conforming to a particular Indian or any other standard as called for shall be tested as required by such standard. Proof in the form of certified test reports or mill certificates indicating that the required tests have been carried out as per specification at the source is acceptable.

If mill test reports are not available for any steel materials, the same shall be got tested by CONTRACTOR to PMC/EMPLOYER's satisfaction to demonstrate conformity with the relevant specification at his own cost.

Raw material with cracks, seams, laps, lamination and heavy pitting are not acceptable. Ultrasonic testing of plates above 50 mm thick shall be carried out for the soundness of material.

PMC/EMPLOYER has option to specify additional inspection or testing as he deems necessary, and the additional cost of such testing shall be borne by the CONTRACTOR.

The CONTRACTOR shall maintain records of all inspection and tests, which shall be made freely available to the PMC/EMPLOYER and shall be submitted to the PMC/EMPLOYER on completion of each stage of work.

7.6.3 TESTS ON WELDS

All welds shall be tested for flaws by any of the methods described under. The choice of the method adopted shall be determined by the PMC/EMPLOYER. Following methods are generally recommended for the quality control of welded joints:

7.6.3.1 Magnetic Particle Test (MPT)

All fillet welds in general structural steel work shall have their final passes fully tested by MPT. However, for fillet welds of size 10mm and above and /or critical areas, the root and final passes shall be tested using MPT. The PMC/EMPLOYER shall however decide the requirements of this additional testing. For Complete penetration butt welds, the root and final passes shall be tested using MPT. All MPT shall be as per relevant acceptable standards. Defects if found, shall be repaired and retested. MPT shall be carried out using alternating current only. Direct current may be used with the permission of the PMC/EMPLOYER. The cost of demagnetizing after testing is deemed to be included in the quoted rates of the CONTRACTOR.

7.6.3.2 Dye Penetrant Test (DPT):

MPT may be substituted by Dye Penetrant Inspection where the former is not feasible due to configuration. The testing should be in accordance with relevant acceptable standards.

7.6.3.3 Radio-graphic Inspection (RT):

All completed full penetration butt welds to a length of about 10% shall be radio-graphed as per PMC/EMPLOYER’s directive in accordance with the relevant acceptable standards. In case of crane girders 100 percent of the splicing shall be inspected by RT. In the case of hoppers of coal bunkers at least 10% of the circumferential as well as seam welds shall be inspected by RT.

7.6.3.4 Ultrasonic Testing (UT):

Wherever built-up sections for crane runway girders are fabricated, the T-joints of the sections shall be subjected to ultrasonic testing. 100 percent length of the seam as well as circumferential welds of hoppers of coal bunkers shall be inspected by UT.

7.6.3.5 Acceptance Standard

The acceptable standards for various weld tests shall be as per ASME Sec VIII- Div I or relevant acceptable standards.

7.6.3.6 INSPECTION OF WELDS

Welding shall be carried out as per approved WPS and QWS by qualified welders.

All welds shall be inspected for flaws by any of the standard methods described under the choice of the method adopted shall be determined by the PMC/EMPLOYER.

The correction of defective welds shall be carried out as directed by the PMC/EMPLOYER without damaging the parent metal. When a crack in the weld is removed, magnetic particle inspection or any other equally positive means as prescribed by the PMC/EMPLOYER shall be used to ensure that the whole of the crack and material up to 25 mm beyond each end of the crack has been removed. Cost of all such tests and operations incidental to correction shall be to the CONTRACTOR's account.

CONTRACTOR shall perform the following minimum tests on welds with no cost implication to the PMC/EMPLOYER. CONTRACTOR's quoted rate is deemed to have included the cost of such tests.

Sl No	**Location & Type of weld**	**Type of Test**	**Extent of test**	**Remarks**
1.	All fillet welds in general other than those covered under the Sl no 2 ,3,5,7 & 8	DPT	1% of fillet weld with minimum of one test on each member / joint	
2.	Fillet welds for plate thickness greater than 25 mm and fillet size more than 10 mm	MPT/ DPT	10%	
3.	Flame cut edges of plates more than 38 mm for fillet weld	MPT / DPT	100%	

4.	Flame cut edges of plates greater than 25 mm for butt welds,	MPT / DPT	100%	
5.	Fillet welds between tension flanges and webs	MPT / DPT	100%	
6.	Full penetration butt welds	DPT	100 %	DPT shall be carried out after back gouging before second side welding
7.	Fillet Weld greater than 12 mm on flame cut edges of low alloy steel	MPT	100%	
8.	Fillet Welds for built up girders, columns and other heavy structures for penetration.	Macro etch test	One (1) test per structure for penetration	
9.	Butt welds of thickness greater than 25 mm and less than 32 mm	MPT / DPT	100 %	
10.	Butt welds of thickness greater than 32 mm	RT	100%	
11.	Butt welds of rolled sections having depth greater than 600 mm	RT	100%	

In addition to the minimum tests to be conducted by the CONTRACTOR, PMC/EMPLOYER reserves his right to direct the CONTRACTOR to conduct additional tests. The extent, type and location of test shall be decided by the PMC/EMPLOYER. These additional tests shall be conducted by the CONTRACTOR or through an approved agency in presence of the PMC/EMPLOYER. If the test fails, the cost of that test shall not be payable to the CONTRACTOR. The tests which when successful will be paid for at the rates specified in the schedule.

7.6.4 WELD DEFECTS AND ACCEPTABLE CRITERIA

Type of defect	**Acceptance criteria**	**Remarks**
Cracks	Not acceptable	
Incomplete or lack of Fusion	Not acceptable	
Mis-alignment of butt welds	0.25 x T (maximum of 3 mm)	T: Thickness of thinner plate
Reinforcement	Max reinforcement of 2 mm for t < 10 mm 3 mm for t > 10mm < 15 mm. 4 mm for 15 mm and greater	
Undercut	0.25 mm deep max	
Sharp edges	Min radius of 2 mm	

7.6.5 WELD REPAIRS

Whenever weld repair is required, CONTRACTOR shall give prior intimation to the PMC/EMPLOYER and obtain permission before the repair is taken up. When a defect is detected in a weld, it shall be removed by cutting / grinding and smooth blending of the area with parent metal without sharp edges, corners. If welding is required, the same shall be done using the qualified procedure / welder and stage inspection as per the original weld. Correction of defect in the same portion of the weld shall not be allowed more than two (2) times. Portion of the welding seams, which have been subjected to repair, must be indicated in the weld inspection reports.

7.6.6 INSPECTION AND TESTS ON STRUCTURAL STEEL FABRICATED MEMBERS

Inspection and tests on Structural Steel Fabricated Members shall be as set forth below:

- All the fabricated parts of Structural Steel members shall be inspected at all stages of fabrication and assembly to verify that dimensions, tolerances, alignment, and surface finish are in accordance with the requirements shown on the approved CONTRACTOR's shop drawings and/or PMC/EMPLOYER’s drawings.

- Fit ups shall be examined by the quality surveyor as per the approved QA plan prior to welding the joint. All welds shall be inspected for flaws by the method described under the Clause 7.4 (Inspection Of welds).
- The dimensions of the fit ups shall be maintained as specified in the fabrication drawings.
- Dimensions of all the assemblies and sub-assemblies shall be as per fabrication drawings within the tolerances specified in IS 7215.

7.6.7 TOLERANCES

The dimensional and weight tolerance for rolled shapes shall be in accordance with IS:1852 for indigenous steel and equivalent applicable codes for imported steel. The tolerances for fabrication of structural steel shall be as per IS:7215.

7.6.8 TEST FAILURE

In the event of any failure of welding, structural steel members to meet inspection or test requirements, the CONTRACTOR shall notify the PMC/EMPLOYER or his authorised representative. A design concession request must be made and got approved from the PMC/EMPLOYER or his representative before repair is undertaken. The quality control procedures to be followed to ensure satisfactory repair shall be subject to approval by PMC/EMPLOYER.

CONTRACTOR shall maintain records of all inspection and testing which shall be made available to the PMC/EMPLOYER or his authorized representative, for three years from the date of completion of the contract.

The PMC/EMPLOYER has the right to specify additional testing as he deems necessary, and the additional cost of such testing shall be borne by the PMC/EMPLOYER only in case of successful testing.

7.6.9 DRILLING HOLES FOR OTHER WORKS

As a part of this Contract, holes in members required for installing equipment or steel furnished by other manufacturers or other CONTRACTORs shall be drilled by the CONTRACTOR at no extra cost to the PMC/EMPLOYER The information for such extra holes will be supplied by the PMC/EMPLOYER.

7.6.10 MARKING OF MEMBERS

After checking and inspection, all members shall be marked for identification during erection. This mark shall correspond to distinguishing marks on approved erection drawings and shall be

legibly painted and stamped on it. The erection mark shall be stamped with a metal dye with figures at least 20 mm high and to such optimum depth as to be clearly visible.

All erection marks shall be on the outer surface of all sections and near one end, but clear of bolt holes. The marking shall be so stamped that they are easily discernible when sorting out members. The stamped marking shall be encircled boldly by a distinguishable paint to facilitate easy location.

Erection marks on like pieces shall be in identical locations. Members having lengths of 7.0 m or more shall have the erection mark at both ends.

7.6.11 ERRORS

Any error in shop fabrication which prevents proper assembling and fitting up of parts in the field by moderate use of drift pins or moderate amount of reaming will be classified by the PMC/EMPLOYER as defective workmanship. In case PMC/EMPLOYER rejects such material or defective workmanship, the same shall be replaced by the materials and workmanship conforming to the PMC/EMPLOYER's requirements by CONTRACTOR free of cost at site.

7.7 QUALITY SURVEILLANCE

7.7.1 GENERAL

The PMC/EMPLOYER shall subject all works and materials covered by this specification to Inspection.

The CONTRACTOR shall provide free access in his shop during working hours for the inspection staff, designated by the PMC/EMPLOYER, at all phases of the work and assist them where necessary in conducting the inspection. The CONTRACTOR shall expeditiously furnish all gauges, instruments and other necessary measuring equipment required for inspection of the work in the shop. The shop inspection by the inspector is intended to ensure that the material and workmanship are in accordance with this specification, but it will not relieve the CONTRACTOR of any of his responsibilities for the product. The inspector's inspection will include, but not be limited to, the following:

7.7.2 MATERIAL

The inspector will ascertain that only materials conforming to the requirements of this specification are used.

7.7.3 DIMENSION AND TOLERANCES

The PMC/EMPLOYER will ensure and check that the structural members conform to the dimensions and tolerances as set out on the drawings and as required by the specification.

7.7.4 WELDING PROCEDURE

The PMC/EMPLOYER will witness the welding and testing of any procedure qualification tests that are required by this specification. The PMC/EMPLOYER will also check that welding procedure (including the electrode, flux, current, arc voltage, speed of travel) used are in accordance with the approved welding procedures.

7.7.5 WELDING EQUIPMENT

The PMC/EMPLOYER will check the welding equipment to be used for the work to ensure that it is in such condition as to enable qualified welders to follow the procedures.

7.7.6 WELDER AND WELDING OPERATOR QUALIFICATIONS

The PMC/EMPLOYER will permit welding to be performed only by welders and welding operators who are qualified by tests in accordance with relevant standards

When the quality of a welder or welding operators' work, appears to be below the requirements, the PMC/EMPLOYER may require testing of his qualifications by necessary tests.

7.7.7 WELDS

The PMC/EMPLOYER will ascertain that the sizes, length and the location of all welds conform to the requirements of this specification and the approved fabrication drawings. Temporary welds used for the works shall be removed and ground flush with the original surface.

The PMC/EMPLOYER will identify with a distinguishing mark of all parts of the joints that he has inspected and accepted.

The CONTRACTOR shall comply with all the demands of the PMC/EMPLOYER to correct improper workmanship and to remove and replace, or correct as instructed, all welds found defective or deficient.

In the event of faulty welding or its removal for rewelding results in damage to the base metal in the judgment of the PMC/EMPLOYER, or its retention is not in accordance with the intent of the plans and specification, the CONTRACTOR shall remove and replace the damaged materials at his own cost.

7.8 Method of measurement

For the purpose of payment, the weight of the actual completed structures shall be calculated from the approved drawings for different items of work. The CONTRACTOR shall submit to the OWNER relevant material list containing weight of each item.

No allowances will be permitted for bolts, nuts, washers, studs, screws etc, galvanizing, welding or for rolling margins. One tonne for the purpose of payment shall mean ONE METRIC TONNE i.e. 1000 Kg. Permanent bolts, however, will be considered for payment against the relevant item under schedule of items.

The weight of a member made from standard rolled section such as beams, channels, angles, etc. shall be based on the standard IS:808 without deductions for holes, notches, bevel cuts, etc. Where a component consists of a cut rolled sections, the full weight of the rolled section shall be considered only if more than half the depth of the original section is used. Otherwise, only half the section unit weight shall be considered for calculation of the weight of the components. Deductions shall be made in the weight of gussets/plates for cuts and notches of 900 sq. cm. or larger.

For gussets/plates used in trusses, bracings, columns, beams, etc, the area shall be that of the minimum circumscribing rectangle except as stated in 16.3 above.

The weight of any built-up members shall be based on the weight of each component.

7.9 PROTECTIVE COATING FOR STRUCTURAL STEEL

7.9.1 Scope

This specification covers the general requirement of hot dipped galvanizing of steelwork. It covers the supply of all materials, labour, tools, plant, equipment, necessary to galvanize the structures in accordance with specifications.

7.9.2 Applicable codes and specifications

The following Specifications and Codes of Practice are made a part of this specification. All Specifications and Codes of Practice referred to herein shall be the latest editions including all applicable official amendments and revisions. In case of discrepancy between this specification and those referred to herein, this Specification shall govern.

IS: 1367	Hot-dip Galvanised Coatings on Threaded Fasteners. (Part-13)
IS: 2629	Recommended Practice for Hot-dip Galvanising on Iron and Steel.

IS: 2633	Methods of Testing Uniformity of Coating on Zinc Coated Articles
IS: 4736	Hot-dip Zinc Coatings on Mild Steel Tubes.
IS: 4759	Hot-dip Zinc Coatings on Structural Steel and Other Allied Products.
IS: 5905	Sprayed Aluminium and Zinc Coatings on Iron and Steel.
IS: 6158	Recommended Practice for Safeguarding Against Embrittlement of Hot-dipped Galvanised Iron and Steel Products.
IS: 6159	Recommended Practice for Design and Fabrication of Material Prior to Galvanizing.
IS: 6745	Method for Determination of Mass of Zinc Coating on Zinc Coated Iron and Steel Articles.
IS: 13229	Zinc for galvanizing

7.9.3 Material

Zinc used for galvanising shall conform to grade Zn 98.5 as per IS: 13229. Chemical composition of the metal shall be as per Table 1 of the above code with minimum zinc content of 98.5%.

The mass of Zinc coating per square meter of exposed surface shall be as specified in the Schedule of Quantities and Prices.

Surfaces of steel work exposed to rural and non-polluted environment shall normally be protected with a minimum of 610 gms/m2 of Zinc for an expected coating life of 10 years.

Surfaces of steel work exposed to industrial and un-polluted marine environments shall normally be protected with a minimum of 910 gms/m2 of Zinc, for an expected coating life of 20 years.

7.9.4 Galvanising plant

The CONTRACTOR shall indicate in his bid about the location of galvanising plant where galvanising work will be carried out. Prior approval shall be obtained from PMC/EMPLOYER if galvanising is proposed to be carried out outside Contractor’s plant.

7.9.5 Surface preparation

If the steel work to be galvanised is contaminated by oil, grease or paint, pre-treatment with special solvents will be necessary for their removal. Generally, a Sodium Hydroxide solution obtained by dissolving 10-15 kg of Sodium Hydroxide in100 litres of water is used. The temperature of the solution shall be kept at about 85-900C and immersion time shall vary from 10-20 minutes depending on the degree of contamination. The work shall be so handled in a degreasing bath, as to allow free circulation of the solution over all surfaces of the steel work taking due care to clean all the scum collected. Several proprietary reagents are also available, which, if approved by Owner, may be used for degreasing the works, as per the instructions of the manufacturers.

Immediately after degreasing, the steel work shall be rinsed in hot water having a temperature of about 60 0 C, followed by a final rinse in cold running water.

The degreased rinsed steel work will now be subjected to pickling to remove all the scales etc and to expose the base metal surface. Both Hydrochloric Acid and Sulphuric Acid may be used for pickling. Hydrochloric Acid will be used at room temperature whereas, in the case of Sulphuric Acid better results are obtained with acid temperature at 60-80 0 C. Pickling shall be carried out as per clauses 4.3.1 to 4.3.5 of IS: 2629. Special care shall be taken to avoid Over Pickling.

After pickling, the steel work shall be rinsed clean in running water.

Flux is a chemical compound which helps maintaining surface of ‘works’ free from oxides. In the ‘wet process’ (hot dip galvanizing), the flux is spread as a molten blanket over the galvanizing bath. Primary purpose of the flux is to help in keeping the surfaces of both the ‘work’ and the molten Zinc from oxide at the time of reaction. Fluxing shall be generally carried out as per clause 4.6 of IS: 2629.

7.9.6 Workmanship

After all shop work is complete, all structural material shall be punched with the erection mark to be hot dip galvanized. Before galvanizing, the steel shall be thoroughly cleaned of any paint, grease, rust, scale, acid or alkali or such other foreign matters as are likely to interfere with the galvanizing process or with the quality and durability of the zinc coating as specified in clause 4 of IS: 2629. Pickling followed by Rinsing shall be carefully and properly done as specified in IS: 2629.

The control of bath temperature is essential if the quality of the product is to be consistent and Zinc is to be used economically. 'Works' should be galvanized at the lowest possible temperature, which will allow free drainage of Zinc from the work piece during withdrawal. The bath temperature may vary from 440 0 C to 460 0C and a working temperature of 450 0 C is normally used.

The galvanized surface shall consist of continuous & uniformly thick coating of zinc, firmly adhering to the surface of steel. The finished surface shall be reasonably smooth and free from imperfections as flux, ash and bare patches, black spots, pimples, lumpiness, runs, rust stains, bulky white deposits and blisters. The presence of any of these defects noticed on visual or microscopic inspection shall render the material liable for rejection. Sampling and nos. of test for coating characteristics shall be as specified in IS: 4759. Mass of zinc coating may be determined in accordance with IS: 6745.

All galvanized members shall be treated with Sodium Dichromate solution or an approved equivalent after galvanizing, so as to prevent white storage stains.

Dross shall be allowed to settle at the bottom of the Zinc bath and should not be disturbed unnecessarily during dipping operation. As far as possible the 'work' shall not be sunk to the bottom of the bath during galvanizing.

The 'work' should be immersed as rapidly as possible as the amount of dross increases with the time of contact with the flux blanket in the Wet Process. The speed of immersion also influences the uniformity of coating.

The time of immersion for a 'work' depends on several factors such as its chemistry, size, thickness, etc. In most cases the 'work' shall be left in the bath until it reaches the temperature of the bath which is usually indicated by the stopping of its boiling action. It is then withdrawn without much delay. Galvanizing of each member shall be carried out in one complete immersion. Double dipping will not be permitted

The rate of withdrawal which determines the thickness of the unalloyed zinc layer left on the 'work' varies according to the process being operated, and the shape of the 'work'. Special jigs and carriers may be used for dipping and withdrawing the 'works'in batches. The rate of withdrawal shall be controlled so that Zinc drains freely from the surface. 'Works' are withdrawn through a bath of clear Zinc to avoid contamination by flux. Where the 'works are withdrawn through a flux blanket. it is recommended to quench the 'works to remove flux residues

Small ‘works. Such as bolts nuts and washers, handled in baskets should be centrifuged to remove excess zinc immediately while the coating is still in molten condition. The quality of finish depends on the rapidity with which the work is transferred from the galvanizing bath to the centrifuge. After centrifuging, the ‘works should be immediately tipped into water to allow the coating to set and to prevent the works from sticking to each other. Threads on the ‘works’ which are unsuited for centrifuging shall be cleaned with a rotating wire brush immediately after galvanizing and before the coating sets. It should be confined only to the threaded portion of the’ works’

The Zinc coating on freshly galvanized surfaces when exposed to humid and poorly ventilated conditions during storage and /or transport react with the moisture, carbon dioxide oxygen etc in the atmosphere forming a mixture of salts which are white in colour known as ‘white rust’ or ‘wet storage stain’. To prevent this white colour formation, a post treatment like chromating is recommended. The chromating solution contains one percent sodium dichromate and half percent sulphuric acid and the solution shall be kept to room temperature. The galvanized ‘works are dipped into the chromating solution after galvanizing and water quenching operations.

Galvanized ‘works shall not be stacked immediately after quenching to avoid flaking of coating. The ‘works shall be allowed to dry before any handling operation is taken up

Regarding working condition and safety measures for the galvanizing shop the provisions stipulated in Appendix –B of IS: 2629 shall be strictly adhered to.

7.9.7 Inspection and testing

The Zinc coating shall be adherent, smooth, reasonably bright, continuous and free from imperfections, such as but not limited to flux, ash & dross inclusions, bare & black spots, pimples, lumpiness rust stains, bulky white deposits and blisters. The presence of any of these defects noticed on visual or microscopic inspection shall render the work liable for rejection. Sampling and numbers of tests for acceptance of coating characteristics shall be as specified in IS; 4759

Uniformity of thickness of Zinc coating on the works shall be tested in accordance with Preece test described in IS: 2633.

Mass of Zinc coating shall be determined in accordance with IS: 6745

Adherence of the Zinc coating on fabricated steel Works shall be tested by pivoted hammer test as described in IS: 2629.

Adherence of the Zinc coating on hardware shall be tested using Knife Test as described in IS: 2629.

Enough care should be exercised while storing, packing and handling of galvanized works. Contractor shall ensure that galvanizing is not damaged in transit. While storing and transporting, adequate ventilation should be provided as otherwise 'White rust' or 'Wet storage stain' may result with humidity and atmospheric gases It is sometimes necessary to store galvanized 'works' with spacers in between. They are also sometimes kept at an inclination to facilitate drainage of water if collected on the 'works' In areas where there is substantial variation in day and night temperature and hence possibility of condensation the storage area may have to be kept warm by providing heaters. In the event of occurrence of any damage, Contractor shall at its own cost adopt scrapping & re-galvanizing the member to satisfy the specific requirements.

7.9.8 Method of measurement

Galvanizing work shall not be measured separately if galvanizing is already included in the scope of item of work of fabrication/erection of steel.

In case the galvanizing is to be carried out on already fabricated steel work, a separate rate for galvanizing shall be quoted as called for in the Schedule of Quantity. The weight of the actual completed structures including weight of bolts, nuts and washers shall be calculated from the approved drawings for different items of work and NO ALLOWANCE in weight will be made for weight of zinc added due to galvanizing.

8.0 MORTARS

8.1 LIST OF BUREAUS OF INDIAN STANDARD CODES

S. No.	I.S. No.	Subject
1	IS 269	Specification for 33 grade ordinary Portland cement
2	IS 383	Specification for coarse and fine aggregate from natural source for concrete.
3	IS 455	Specification for Portland slag cement.
4	IS 460 (Part I)	Specification for test sieves: wire cloth test sieves.
5	IS 650	Specification for standard sand for testing of cement
6	IS 1269	Specification for 53 grade ordinary Portland cement
7	IS 1344	Specification for calcined clay Pozzolana.
8	IS 1489	Specification for Portland pozzolana cement

9	IS 1542	Specification for sand for plaster
10	IS 1727	Methods of Test for Pozzolana materials
11	IS 2116	Specification for sand for masonry mortar.
12	IS 2250	Code of practice for preparation and use of masonry Mortar.
13	IS 2386 (Pt-I)	Method of test for aggregate for concrete (Particle size and shape)
14	IS 2386 (Pt-II)	-Do- Estimation of deleterious materials and organic impurities.
15	IS 2386 (Pt-III)	-Do- Specific gravity, density, voids, absorption and bulking.
16	IS 3025	Method of sampling and test for water
17	IS 3406	Specification for masonry cement.
18	IS 3812 (Part I)	Specification for fly ash for use as pozzolana in cement mortar and concrete
19	IS 3812 (Part II)	Specification for fly ash for use as admixture in cement mortar and concrete
20	IS 4031 (Part I) to (Part XIII)	Method of Physical test for hydraulic cement
21	IS 4032	Method of chemical analysis of Hydraulic cement.
22	IS 8041	Rapid hardening Portland cement.
23	IS 8042	Specification for white cement
24	IS 8043	Hydrophobic Portland cement
25	IS 8112	Specification for 43 grade ordinary Portland cement
26	IS 11652	Woven HDPE sacks for packing cement
27	IS 11653	Woven polypropylene sacks for packing cement
28	IS 12174	Jute synthetic union bags for packing cement

8.2 GENERAL

Desirable properties of mortars for use in masonry are:

a. Workability
b. Water retentivity

c. Rate of stiffing
d. Strength
e. Resistance to rain penetration
f. Durability

8.3 MATERIALS

8.3.1 WATER

8.3.1.1 Water used for mixing and curing shall be clean and free from injurious quantities of alkalis, acids, oils, salts, sugar, organic materials, vegetable growth or other substance that may be deleterious to bricks, stone, concrete or steel. Potable water is generally considered satisfactory for mixing. The Ph value of water shall be not less than 6. The following concentrations represent the maximum permissible values: (of deleterious materials in water).

a. Limits of Acidity: To neutralize 100ml sample of water, using phenolphthalein as an indicator, it should not require more than 5ml of 0.02 normal NaOH. The details of test shall be as given in IS 3025 (part 22).
b. Limits of Alkalinity: To neutralize 100ml sample of water, using mixed indicator, it should not require more than 25ml of 0.02 normal H2SO4. The details of tests shall be as given in IS 3025 (part 23).
c. Percentage of Solids: Maximum permissible limits of solids when tested in accordance with IS 3025 shall be as under:
   Organic 200mg/ litre
   Inorganic 3000 mg/ litre
   Sulphates 400 mg/ litre
   Chlorides 2000 mg/ litre.-For concrete not containing embedded steel and
   500 mg./litre. -For reinforced concrete work.
   Suspended matter 2000 mg/ litre

Water found satisfactory for mixing is also suitable for curing. However, water used for curing shall not produce any objectionable stain or unsightly deposit on the surface.

8.3.1.2 Sea water shall not be used for mixing or curing

8.3.1.3 Water from each source shall be tested before the commencement of the work and thereafter once in every three months till the completion of the work. In case of ground water, testing shall also be done for different points of drawdown. Water from each source shall be got tested during the dry season before monsoon and again after monsoon.

8.3.2 CEMENT

Shall be as per 4.13.1

8.3.3 FINE AGGREGATE

8.3.1.4 Aggregate most of which passes through 4.75 mm IS sieve is known as fine aggregate. Fine aggregate shall consist of natural sand, crushed stone sand, crushed gravel sand stone dust or marble dust, fly ash and broken brick (Burnt clay). It shall be hard, durable, chemically inert, clean and free from adherent coatings, organic matter etc. and shall not contain any appreciable amount of clay balls or pellets and harmful impurities e.g. iron pyrites, alkalis, salts, coal, mica, shale or similar laminated materials in such form or in such quantities as to cause corrosion of metal or affect adversely the hardening, the strength, the durability or the appearance of mortar, plaster or concrete. The sum of the percentages of all deleterious material shall not exceed 5%. Fine aggregate must be checked for organic impurities such as decayed vegetation humps, coal dust etc. in accordance with the procedure prescribed in Appendix 'A' as given under.

APPENDIX A DETERMINATION OF PARTICLE SIZE

In order that the sieves shall not be overloaded, care must be taken to ensure that the maximum sieve loads shown in Table are not exceeded at the completion of sieving.

I.S. Sieve Designation	**Maximum weight for**	
	45 cm dia sieve kg	**30 cm dia sieve kg**
45 mm	10	4.5
40 mm	8	3.5
31.5 mm or 22.1 mm	6	2.5
20 mm	4	2.0
16 mm or 12.5 mm	3	1.5
10 mm	2	1.0
5.6 mm	1.5	0.75
4.75 mm	1.0	0.50
3.35 mm	-	0.30

The sample weight taken will thus normally require several operations on each sieve. Each sieve should be taken separately over a clean tray or receiver until no more than a trace passes, but in any case, for not less than two minutes. Materials should not be forced through the apertures, but hand placing is permitted. A light brush should be used with fine sieves. The cumulative

weight passing each sieve should be calculated as percentage of the total sample weight to the nearest whole number.

8.3.1.5 Silt Content: The maximum quantity of silt in sand as determined by the method prescribed shall not exceed 8%. Fine aggregate containing more than allowable percentage of silt shall be washed as many times as directed by PMC/Employer so as to bring the silt content within allowable limits for which nothing extra shall be paid.

8.3.1.6 Grading : On the basis of particle size, fine aggregate is graded in to four zones. The grading when determined shall be within the limits given in Table 3.1 below. Where the grading falls outside the limits of any particular grading zone of sieves, other than 600 micron IS sieve, by a total amount not exceeding 5 per cent, it shall be regarded as falling within that grading zone.

IS Sieve	Percentage passing for			
	Grading Zone I	**Grading Zone II**	**Grading Zone III**	**Grading Zone IV**
10 mm	100	100	100	100
4.75 mm	90-100	90-100	90-100	95-100
2.36 mm	60-95	75-100	85-100	95-100
1.18 mm	30-70	55-90	75-100	90-100
600 microns	15-34	35-59	60-79	80-100
300 microns	5-20	8-30	12-40	15-50
150 microns	0-10	0-10	0-10	0-15

Note 1: For crushed stone sands, the permissible limit on 150-micron sieve is increased to 20 per cent. This does not affect the 5 per cent allowance permitted in 3.1.3.4 (e) (1) applying to other sieves.

Note 2: Allowance of 5% permitted in 3.1.3.4 (e) (1) can be split up, for example it could be 1% on each of three sieves and 2% on another or 4% on one sieve and 1% on another.

Note 3: Fine aggregate conforming to Grading Zone IV shall not be used in reinforced cement concrete unless tests have been made to ascertain the suitability of proposed mix proportions.

Note 4: Sand requiring use for mortar for plaster work shall conform to IS 1542 and for masonry work shall conform to IS 2116.

8.3.1.7 Type and grading of fine aggregate to be used shall be specified. It shall be coarse sand, fine sand, stone dust or marble dust, fly ash and surkhi. Use of sea sand shall not be allowed, unless otherwise specified.

a. Coarse and fine sand shall be river sand. Its grading shall fall within the limits of grading
b. Zone I, II, III, IV of Table. Grading of sand shall conform to IS 2116 for use in Masonry work.
c. Stone dust shall be obtained by crushing hard stones or gravel. Its grading shall fall within the limits of grading Zone, I, II, or III of Table.
d. Marble dust shall be obtained by crushing marble. Its grading shall fall within the limits of Grading Zone IV of Table below. Grading of Marble dust for use in Mortar shall be as per following table.

IS Sieve	**Percentage Passing**
10 mm	100
4.75 mm	95-100
2.36 mm	95-100
1.18 mm	90-100
600 microns	80-100
300 microns	15-50
150 microns	0-15

8.3.1.8 Sand for Masonry Mortar and for Plaster- Sand shall consist of natural sand, crushed stone sand or crushed gravel sand or a combination of any of these. Sand shall be hard durable, clean and free from adherent coating and organic matter and shall not contain the amount of clay, silt and fine dust more than specified as under. Deleterious Material: Sand shall not contain any harmful impurities such as iron, pyrites, alkalis, salts, coal or other organic impurities, mica, shale or similar laminated materials, soft fragments, sea shale in such form or in such quantities as to affect adversely the hardening, strength or durability of the mortar.

The maximum quantities of clay, fine silt, fine dust and organic impurities in the sand / Marble dust shall not exceed the following limits:

Clay, fine silt and fine dust when determined in accordance with IS 2386 (Part II). In natural sand or crushed gravel sand and crushed stone sand - Not more than 5% by mass

Organic impurities when determined in accordance with IS 2386 (Part II) - Colour of the liquid shall be lighter than that indicated by the standard specified in IS 2386 (Part II).

Grading of sand for use in masonry mortar shall be conforming to IS 216 (Table below).

Grading of sand for use in masonry mortar		Grading of sand for use in plaster	
IS Sieve Designation	Percentage passing by mass	IS Sieve Designation	Percentage passing by mass
10 mm	100	10 mm	100
4.75 mm	100	4.75 mm	95 to 100
2.36 mm	90 to 100	2.36 mm	95 to 100
1.18 mm	70 to 100	1.18 mm	90 to 100
600 microns	40 to 100	600 microns	80 to 100
300 microns	5 to 70	300 microns	20 to 65
150 microns	0 to 15	150 microns	0 to 50

Note: For crushed stone sands, the permissible limit on 150 micron IS Sieve is increased to 20%, this does not affect the 5% allowance as per IS 2386 (Part 1).

8.3.1.9 Bulking: Fine aggregate, when dry or saturated, has almost the same Volume but dampness causes increase in volume. In case fine aggregate is damp at the time of proportioning the ingredients for mortar or concrete, its quantity shall be increased suitably to allow for bulkage, which shall be determined by the method prescribed in Appendix 'D' of Chapter 3.0 Table 3.3 gives the relation between moisture content and percentage of bulking for guidance only.

8.3.1.10 Bulking of fine aggregates/sand (field methods)

Two methods are suggested for determining the bulking of sand/fine aggregate. The procedure may be suitably varied, if necessary. Both depend on the fact that the volume of inundated sand/fine aggregate is the same if the sand/fine aggregate were dry.

Method -1: Put sufficient quantity of sand loosely into a container until it is about two-third full. Level off the top of the sand and push a steel rule vertically down through the sand at the middle to bottom, measure the height. Suppose this is 'X' cm.

Empty the sand out of the container into another container where none of it is lost. Half fill the first container with water. Put back about half the sand and rod it with a steel rod, about 6 mm in

diameter, so that its volume is reduced to a minimum. Then add the remainder and level the top surface of the inundated sand. Measure its depth at the middle with the steel rule. Suppose this is 'Y' cm.

The percentage of bulking of the sand due to moisture shall be calculated from the formula:

Percentage bulking = (X/Y -1) X 100

Method-2: In a 250 ml measuring cylinder, pour the damp sand, consolidate it by staking until it reached the 200 ml mark.

Then fill the cylinder with the water and stir the sand well (the water shall be sufficient to submerge the sand completely). It will be seen that the sand surface is now below its original level. Suppose the surface is at the mark of Yml, the percentage of bulking of sand due to moisture shall be calculated from the formula.

Percentage bulking= (200/Y – 1) x 100

Moisture content %	Bulking % age (by volume)
2	15
3	20
4	25
5	30

8.3.1.11 Stacking: Fine aggregate shall be so stacked as to prevent dust and foreign matter getting mixed up with it as far as practically possible. Marble dust in dry condition shall be collected in bags and properly staked so as not to form lumps, suitable arrangements shall be made to protect it from moisture similar to those adopted for stacking of cement bags.

8.3.1.12 Measurements: As the fine aggregate bulks to a substantial extent when partially wet, measurements shall be taken when the stacks are dry or appropriate allowance made for bulking.

8.3.4 BROKEN BRICK (BURNT CLAY) FINE AGGREGATE

8.3.4.1 Broken Brick (Burnt Clay) Fine Aggregate, also known as Surkhi, shall be made by grinding well burnt (but not under or over burnt) broken bricks as specified in IS 3068-1986. It shall not contain any harmful impurities, such as iron pyrites, salts, coal, mica, shale or similar laminated or other materials in such form of quantity as to adversely affect hardening, strength, durability or appearance of the mortar.

8.3.4.2 The maximum quantities of clay, fine silt, fine dust and organic impurities in surkhi (all taken together) shall not exceed five per cent by weight. The particle size grading of surkhi for use in lime mortars shall be within the limits specified in Table below

IS Sieve Designation	Percentage passing (by wt)
4.75 mm	100
2.36 mm	90-100
1.18 mm	70-100
600 microns	40-100
300 microns	5-70
150 microns	0-15

8.3.4.3 Stacking: Surkhi shall be stacked on a hard surface or platform so as to prevent the admixture of clay, dust, vegetation, and other foreign matter. It shall be also protected from rain and dampness and kept under adequate coverings.

8.3.4.4 Measurements: Surkhi shall be measured in regular stacks in cubic metres. Alternatively, it may be measured by weight when supplied in bags.

8.3.5 FLY ASH

Fly ash is finely divided residue resulting from the combustion of pulverized coal in boilers. Fly ash is the pulverized fuel ash extracted from the flue gases by any suitable process such as cyclone separation or electrostatic precipitation. The ash collected from the bottom of boilers is termed as bottom ash. Fly ash is finer than bottom ash. Siliceous fly ash (ASTM Class F) containing calcium oxide less than 10% by mass is normally produced from burning anthracite or bituminous coal and possesses pozzolanic properties. Calcareous fly ash (ASTM Class C) is produced by burning lignite or sub-bituminous coal and contains calcium oxide more than 10% by mass; the content could be as high as 25%. This fly ash has both hydraulic and pozzolanic properties. It shall be clean and free from any contamination of bottom ash, grit or small pieces of pebbles. It is obligatory on the part of supplier/ manufacture that the fly ash conforms to the requirements if mutually agreed upon and shall furnish a certificate to this effect to the purchaser

or his representative.

8.3.5.1 Characteristics: The physical requirements of fly-ash shall be as specified in Annexure 'E' as given below. The chemical properties of fly ash shall be as per IS 3812 (part 1 and 2) depending on the usage.

APPENDIX 'E': PHYSICAL REQUIREMENTS OF FLY ASH

(Clause 3.1.5 and 3.1.5.1)

Sr. No	**Characteristics Requirement of Fly Ash**	**For use as Pozzolana**	**For use as admixture in**
1	**2**	**3**	**4**
(i)	Fineness- Specific surface in m^2/kg by Blaine's permeability method, min	320	200
(ii)	Lime reactivity – average compressive strength in $\underline{N/mm^2}$ Min	4.5	-
(iii)	Compressive strength at 28 days in N/mm^2	Not less than 80 per cent of the strength of corresponding mortar	-
(iv)	Soundness of autoclave test expansion of specimens, per cent,	0.8	0.8
(v)	Particles retained on 45 micron IS sieve (wet sieving) in percent maximum	34	50

8.3.5.2 Stacking: Fly ash shall be protected from dirt collecting on it.

8.3.5.3 Measurements: Fly ash shall be measured in regular stacks in cubic meters. Alternatively, it may be measured by weight when supplied in bags.

8.4 GROUND GRANULATED BLAST FURNACE SLAG FOR USE IN CEMENT

Blast furnace slag is a non-metallic product consisting essentially of glass containing silicates and alumino-silicates of lime and other bases, which is developed simultaneously with iron in blast furnace. Granulated blast furnace slag is obtained by further processing the molten slag by rapidly chilling or quenching with water or steam. It is granulated blast furnace slag duly ground so as to meet the requirements of this standard.

The properties and specifications shall be conformed with IS 16714:2018.

Chemical Properties Reference IS 16714: 2018 Ground Granulated Blast Furnace Slag for Use in Cement, Mortar and Concrete – Specifications Table 1 Chemical Requirements of GGBS (Clause 5.1)			
i)	Manganese oxide (MnO), Max	5.5	IS 4032
ii)	Magnesium oxide (MgO), Max	17	IS 4032
iii)	Sulphide sulphur (S), Max	2	IS 4032
iv)	Sulphate (as SO3), Max	3	IS 4032
v)	Insoluble residue, Max	3	IS 4032
vi)	Chloride content, Max	0.1	IS 4032
vii)	Loss on ignition, Max	3	IS 4032
viii)	(CaO+MgO+1/3AlO3) / (SiO2 +2/3 AlO3) Min	1	IS 4032
ix)	(CaO+MgO + Al2 O3) / SiO2 Min	1	IS 4032
x)	(CaO+CaS+1/2MgO+Al2 O3) /SiO2 Min	1.5	IS 4032
Physical Properties Reference IS 16714: 2018 Ground Granulated Blast Furnace Slag for Use in Cement, Mortar and Concrete – Specifications Table 2 Chemical Requirements of GGBS (Clause 5.1)			
Sl No.	**Constituent**	**Requirement**	**Method of Test, Ref to**
i)	i) Fineness, m2 /kg, Min	320	See Note 1 in reference code
ii)	Slag activity index		See Note 2 in reference code
	a) 7 days	Not less than 60 percent of control OPC 43 Grade cement mortar cubes	

	b) 28 days	Not less than 75 percent of control OPC 43 Grade cement mortar cubes
Please refer to relevant codes for more clarity		

8.5 PREPARATION OF MORTARS AND ITS GRADE

8.5.1 GRADE OF MASONRY MORTAR

The grade of masonry mortar will be defined by its compressive strength in N/mm2 at the age of 28 days as determined by the standard procedure detailed in IS 2250.

For proportioning the ingredients by volume, the conversion of weight into volume shall be made on the following basis:

a. Burnt Clay Pozzolana 860 Kg/cum
b. Coarse Sand (dry) 1280 kg/cum
c. Fine sand (dry) 1600 kg/ cum
d. Fly Ash 590 kg/ cum
e. GGBS

For details of grades and criteria for selection of Masonry mortars see Appendix 'F'.

APPENDIX F - CRITERIA FOR SELECTION OF MASONRY MORTARS
(Clauses 3.2.0, 3.2.0.1, 3.2.1.1)

8.5.1.1 The selection of masonry mortars from durability consideration will have to cover both the loading and exposure condition of the masonry.

8.5.1.2 In case of masonry exposed frequent to rain and where there is further protection by way of plastering or rendering or other finishes, the grade of mortar shall not be less than 0.7 MM but shall preferably be of grade MM2. Where no protection is provided, the grade of mortar for external wall shall not be less than MM2.

In case of load bearing internal walls, the grade of mortar shall preferably be MM 0.702 or more for high durability but in no case less than MM 0.5.

In the case of masonry work in foundations laid below damp proof course, the grade of mortar for use in masonry shall be as specified below.

a) Where soil has little moisture, masonry mortar of grade not less than MM 0.7 shall be used.

b) Where soil is very damp, masonry mortar of grade preferably MM 2 or more shall be used. But

in no case shall the grade of mortar be less than MM 2.

8.5.1.3 For masonry in building subject to vibration of machinery, the grade of mortar shall not be less than MM 3.

8.5.1.4 For parapets, where the height is greater than thrice the thickness, the grade of masonry mortar shall not be less than MM3. In case of low parapets the grade of mortar shall be the same as used in the wall masonry.

8.5.1.5 The grade of mortar for bedding joints in masonry with large concrete blocks shall not be less than MM 3.

8.5.1.6 The compressive strength shall be determined in accordance with the procedure given in IS 2250.

(i) While mixing the pozzolanic material like fly ash/GGBS in mortars Ordinary Portland cement only shall be used.

Grade of Masonry Mortar (IS 2250) (Clause 3.2.0)

Sl. No.	**Grade**	**Compressive strength at 28 days in N/mm^2**	**Cement**	**Pozzolana (Fly Ash)**	**Sand**
1	MM 0.7	0.7 to 1.5	1	--	8
2			1	0.4*	10
3	MM 1.5	1.5 to 2.0	1	--	7
4			1	0.4*	8.75
5	MM 3	3.0 to 5.0	1	--	6
6			1**	0.21	4.2
7			1	0.4*	7.5
8	MM 5	5.0 to 7.5	1	--	5
9			1	0.4	6.25
10			1	0.4	5

11	MM 7.5	7.5 & above	1		4
12			1**	0.2	2.1
13			1	0.4	3
14			1		3.75

Note:

* Pozzolana of minimum lime reactivity of 4 N/MM2

** This ratio by volume correspondence approximately to cement pozzolana ratio of 0.8:0.2 by

weight. In this case, only ordinary Portland cement is to be used (see IS 269). Specifications for

ordinary rapid hardening and low heat Portland Cement (Third revision)

8.5.2 CEMENT MORTAR

8.5.2.1 This shall be prepared by mixing cement and sand with or without the addition of pozzolana in specified proportions as per Appendix 'F'.

8.5.2.2 Proportioning: Proportioning on weight basis shall be preferred considering specific gravity of sand and moisture content. Boxes of suitable size shall be prepared to facilitate proportioning on weight basis. Cement bag weighting 50 kg shall be taken as 0.035 cubic metres. Other ingredients in specified proportion shall be measured using boxes of size 40 x 35 x 25 cm. Sand shall be measured on the basis of its dry volume in the case of volumetric proportioning.

8.5.2.3 Mixing: The mixing of mortar shall be done in mechanical mixers operated manually or by power as decided by PMC/Employer. The PMC/Employer may, however, permit hand mixing at his discretion considering the nature, magnitude and location of the work and practicability of the use of mechanical mixers or where item involving small quantities are to be done or if in his opinion the use of mechanical mixer is not feasible. In cases where mechanical mixers are not to be used, the contractor shall take permission of the PMC/Employer in writing before the commencement of the work.

(a) Mechanical Mixing: Cement and sand in the specified proportions shall be mixed dry thoroughly in a mixer. Water shall then be added gradually, and wet mixing continues for at least three minutes. only the required quantity of water shall be added which will produce mortar of workable consistency but not stiff paste. Only the quantity of mortar, which can be used within 30 minutes of its mixing shall be prepared at a time. Mixer shall be cleaned with water each time before suspending the work.

(b) Hand Mixing: The measured quantity of sand shall be levelled on a clean masonry platform and cement bags emptied on top. The cement and sand shall be thoroughly mixed dry by being turned over and over, backwards and forwards, several times till the mixture is of a uniform colour. The quantity of dry mix which can be used within 30 minutes shall then be mixed in a masonry

trough with just sufficient quantity of water to bring the mortar to a stiff paste of necessary working consistency.

8.5.2.4 Precautions: mortar shall be used as soon as possible after mixing and before it begins to set, and in any case within half hour, after the water is added to the dry mixture.

8.5.3 CEMENT FLY ASH SAND MORTAR

8.5.3.1 This shall be prepared by mixing cement, fly ash and sand in specified proportions. Mixing shall be done in a mechanical mixer (operated manually or by power) unless otherwise permitted by the PMC/Employer in writing. The PMC/Employer may, however, permit hand mixing at his discretion, considering the nature, magnitude and location of the work and practicability of the use of mechanical mixer or where items involving small quantities are to be done or if in his opinion the use of mechanical mixer is not feasible. In case, where mechanical mixer is not to be used, the contractor shall take permission of the PMC/Employer in writing before the commencement of the work.

8.5.3.2 Proportioning: Proportioning on weight basis shall be preferred considering specific gravity of Fly Ash, sand and moisture content. Boxes of suitable size shall be prepared to facilitate proportioning on weight basis. Cement bag weighting 50 kg shall be taken as 0.035 cubic metres. Other ingredients in the specified proportions shall be measured using boxes of suitable sizes. Sand and fly ash shall be measured on the basis of their dry volume in the case of volumetric proportioning.

8.5.3.3 Mixing

(a) Mechanical Mixing: Sand and fly ash in the specified proportions shall be mixed dry in a mixer and then the specified quantity of cement shall be added and mixed dry thoroughly. Water shall then be added gradually and wet mixing continued for at least one minute. Water shall be just sufficient to bring the mortar to the consistency of a workable paste. Only the quantity of mortar which can be used within 30 minutes of its mixing shall be prepared at a time.

(b) Hand Mixing: The measured quantity of sand and fly ash shall be mixed dry on a clean masonry platform before adding specified quantity of cement to it. The resulting mixture of cement, sand and fly ash shall then be mixed thoroughly being turned over and over, backward several times till the mixture is of a uniform colour. The quantity of dry mix which can be used within 30 minutes shall then be mixed in a clean watertight masonry trough with just sufficient quantity of water, to bring the mortar to a stiff paste of necessary working consistency.

8.5.3.4 Precautions: Shall be same as specified in 5.4.12

9.0 BLOCK MASONRY WORKS

9.1 SOLID CONCRETE BLOCK WORK

9.1.1 SCOPE

These specifications cover the use of Concrete Block Masonry for the structural / non-structural purposes.

9.1.2 GENERAL

The provision of the latest Indian Standards listed below form part of these specifications:

All relevant Standards as specified elsewhere in this Volume are also applicable.

1.	IS 269	Specification for ordinary and low heat Portland cement
2.	IS 383	Specification for coarse and fine aggregates from natural sources for concrete.
3.	IS 455	Specification for Portland slag cement
4.	IS 456	Code of Practice for plain and reinforced concrete.
5.	IS 2185	(Part I) Solid cement concrete blocks.
6.	IS 2572	Code of practice for construction of hollow concrete block masonry.
7.	IS 2645	Specification for integral waterproofing compound.
8.	IS 9103	Specification for admixtures for concrete.

9.1.3 MATERIAL

9.1.3.1 Cement

Shall be as per 4.13.1

9.1.3.2 Aggregates

Aggregates shall conform to IS 383. Grading shall be as indicated in IS 383.The aggregates used in the manufacture of block shall be clean and free from all deleterious matter and shall conform to the requirements of IS:383-1970. All the properties and specifications shall be as per 3.3 IS.

9.1.3.3 Water

Water conforming to IS 456 and as approved by the EIC shall be used.

9.1.3.4 Admixtures

Additives or admixtures may be added to the cement or concrete mix conforming to the IS specifications. Admixtures shall be chloride free and melamine polymer based.

Other additives or admixtures not being governed by Indian Standards shall be tested and checked that the same are not detrimental to durability. However, any addition shall only be after approval of the EIC.

9.1.3.5 Fly Ash

Fly Ash conforming to IS: 3812-1981 may be used for part replacement of fine Aggregate up to a limit of 20% or as directed by the Structural Consultant

9.1.3.6 GGBS

GGBS conforming to IS:16715-2018 may be used for replacement of fine aggregate as directed by PMC/Employer.

9.1.4 MANUFACTURE

9.1.4.1 Concrete blocks may be hollow (open or closed cavity) or solid and shall be referred to by its nominal dimension. The term nominal dimension includes the thickness of the mortar joint. All specifications of solid concrete blocks including specifications for actual dimensions, tolerances, sizes, shapes and webs, grades of blocks etc. shall conform to IS : 2185. Blocks may be manufactured either at construction site or in factory on a central casting platform using steel moulds with or without surface vibration for compaction of cement concrete.

9.1.4.2 Mould: - Moulds shall be fabricated using mild steel plates and mild steel angles for stiffening the plates. The mould shall pc either fixed type (box with four side walls fixed at corners, and top and bottom open) or split type. Split type may be either individual or gang mould. Where the compaction of the concrete is done manually, the mould may be either fixed type or split type. When the compaction of the blocks is done with surface vibrator, the mould shall be only split type (individual• or gang mould).

9.1.4.3 Concreting: Concrete mix used for blocks shall be pre-designed to give a minimum crushing strength Concrete shall be mixed in the mechanical mixer. Blocks shall be moulded, laid and compacted with automatic machines table vibrator. Care shall be taken to see that the mix mould is properly filled up. Block shall be protected until they are sufficiently hardened to permit handling without damage. The cement concrete mix for concrete masonry blocks shall not be richer than one part by volume of cement to 9 parts by volume of combined fine and coarse aggregates and shall not be leaner than one part by volume of cement to 13 parts by volume of combined fine and coarse aggregates.

In case of blocks where compaction is done manually, concrete mix of medium Consistency (10-12 mm slump) shall be used in order to enable proper compaction and de-moulding. The consistency of the mix should be such that it may cohere when compressed in the hand without free water being visible.

In case of blocks where compaction is done by external vibrator, concrete mix of very low consistency (zero slumps) shall be used in order to vibrate and compact the concrete under pressure.

9.1.4.4 Mixing: - Concrete shall normally be mixed in a mechanical mixer unless otherwise permitted by PMC/Employer. In case of hand mixing 10% extra cement shall be used without any extra payment. Mixing shall be continued until there is a uniform distribution of the materials, and the mass is uniform in color and consistency.

9.1.4.5 De-moulding shall be done 5 to 10 minutes after compaction. In case of fixed type mould it shall be pulled up with side handles while pressing down the block with the plate at top with

thumb., In case of split type mould, the sides shall be removed first, and the partition plates (gang mould) shall be pulled up subsequently.

After de-moulding, the blocks shall be protected until they are sufficiently hardened to permit handling without damage.

9.1.4.6 Curing and Drying

Blocks shall be cured in the curing yard by keeping them continuously moist for at least 14 days. Steam-cured blocks shall be preferred. Cured blocks shall be allowed to dry for a period of 4 weeks before being used. The blocks shall be allowed to complete their initial shrinkage before they are laid in the wall.

9.2 PHYSICAL REQUIREMENTS

All blocks shall be sound and free of cracks or other defects. For exposed construction face or faces shall be free of chips, or other imperfections, and the overall dimensions of the blocks shall be in accordance to tolerance as specified. Minimum compressive strength shall be as per table 2 below, maximum permissible water absorption shall not exceed the limit specified in I.S.:2185, dimensional variations shall conform to I.S. 2185.

The minimum compressive strength at 28 day being the average of eight blocks, and the minimum compressive strength at 28 days of individual blocks, when tested in the manner described in Appendix B, of IS:12440-1988, shall be as prescribed in Table.

COMPRESSIVE STRENGTH OF CONCRETE STONE MASONRY BLOCKS

Class Designation	**Minimum average Compressive Strength of blocks (N/mm2)**	**Minimum strength of individual blocks N/mm2**
5	5.0	3.5
6	6.0	4.2
7	7.0	5.0
9	9.0	6.3
10	10.0	7.5

For 100 mm wide blocks (for 100 mm thick walls), the minimum strength may be 3.5 N/mm2

9.3 TESTING

Tests as indicated in Appendices A to F of IS 2185 shall be conducted on samples of units selected according to the sampling procedure given here under to ensure conformity with the physical requirements as specified.

9.4 SAMPLING

A sample of 20 blocks shall be taken from every consignment of 5000 blocks or part thereof of the same size and same batch of manufacture. From these samples, the blocks shall be taken at random for conducting the test.

The blocks shall be taken at regular intervals during the course of work, preferably while being loaded or unloaded. In case samples are to be taken from the stacks, blocks shall be taken at random from across the top of the stacks, the sides accessible and from the interior of the stacks. The blocks shall be kept under cover and protected from extreme conditions of temperature, relative humidity, and wind until they are required for test. The test shall be conducted as soon as the sample has been taken.

9.5 NUMBER OF TESTS

All the 20 blocks shall be checked for dimensions and inspected for visual defects. Out of the 20 blocks, 3 blocks shall be subjected to the test for block density, 8 blocks to the test for compressive strength, 3 blocks to the test for water absorption and 3 blocks to the test for drying shrinkage and later to the test for moisture movement. The remaining 3 blocks shall be reserved for retest for drying shrinkage and moisture movement if a need arises.

Blocks shall be approved if requirements of conditions mentioned in 11.2 to 11.5 (as given below) of IS 2185 (Part I) are satisfied.

- The number of blocks with dimensions outside the tolerance limit and / or with visual defects, among those inspected shall not be more than two.
- For Block density and compressive strength, the mean value determined shall be greater than of equal to the minimum limit specified in Table 2 of IS 2185 (Part I) and reproduced as Table 27 of Annexure.
- For drying shrinkage and moisture movement, all the test specimens shall satisfy the requirements of the test. If one of more specimens fails to satisfy the requirements, the remaining 3 blocks shall be subjected to these tests. All blocks shall satisfy the requirements. Drying shrinkage shall not exceed 0.1 percent.
- For water absorption, the mean value determined shall not be more than 10 percent by mass.

9.6 HOLLOW AND SOLID CONCRETE BLOCK MASONRY

Hollow and solid concrete blocks- Shall conform to the requirements of IS: 2185--1979.
Specification for hollow and solid concrete blocks except with regard to the mix of cement concrete and sizes of aggregates shall be as indicated. Hollow blocks shall be sound, free from cracks, broken edges, honey combing and other defects that would interfere with the proper placing of block or impair the strength or performance of construction.
Concrete Block-hollow (open or closed cavity) or solid shall be referred to by its nominal dimensions. The nominal dimensions of concrete block shall be, as follows:
Length 400,500 or 600 mm
Height 200 or 100 mm
Width 50,75,100, 150, 200, 250 or 300mm.
In addition, block shall be manufactured in half lengths of 200, 250 or 300 mm to correspond to the full lengths. The maximum variation in the length of the units shall be not more than ±5mm and maximum variation in height and width of unit, not more than ±3mm.

9.6.1 WORKMANSHIP

9.6.1.1 In total dry climate top and sides may be slightly moistened to avoid absorption of water from mortar.

9.6.1.2 Joints shall not be bigger than 10mm and will be perfectly horizontal and vertical. Joints shall be raked 10mm deep while mortar is wet.

9.6.1.3 Cut blocks shall not be used. Special solid pre-cast blocks at site shall be cast well in advance to be used as spacers and to adjust breaking of vertical joints.

9.6.1.4 Cracks in block masonry are due to shrinkage or expansion of blocks or due to settlement, thermal expansion or changes in moisture content in the structural members enclosing the block walls. The following measures are recommended to prevent formation of cracks.

a) While curing, the block masonry should be lightly sprinkled with water and not made excessively wet.
b) Expansion joints shall be provided in walls exceeding 30m in length.
c) Reinforcement should be provided in the bed joints in block work, one course above and course below windows and above doors in order to distribute the shrinkage/ temperature stresses occurring at the corners of openings, more uniformly throughout the walls.
d) R.C.C, Post and Transoms shall be provided and per the detail drgs in all Masonry and as mentioned in BOQ. The gap between the top most layer of block and the soffit of the beam shall be packed by lightly hammering flat pieces of Shahabad / Kota tiles and then the gaps will be covered by weld mesh before closing them by cement plaster. The PVC mesh will be extended at least 150 mm on the R.C.C. beam and 150 mm on block masonry and nailed to them with strong nails.
e) Provisions for door and window frames: - A course of solid concrete block masonry shall be provided under door and window openings (or a 10cm thick pre-cast concrete sill block under windows). The solid course shall extend for at least 30cm beyond the opening on either side. For jambs of very large doors and windows either solid units are used, or the hollows shall be filled in with concrete of mix 1:3:6.
f) Provisions for Roof / ceiling: - The course immediately below the roof slab shall be built with solid blocks: The top of the roof course shall be finished smooth with a layer of cement and coarse sand mortar 1:3, 10mm thick and covered with a thick coat of white wash or crude oil, to ensure free movement of slab.

g) Intersecting walls: - When two walls meet or intersect and the courses are to be laid up at me same time, a true masonry bond between at least 50% of the units at the intersection is necessary. When such intersecting walls are laid up separately, pockets with 20mm maximum vertical spacing shall be left in the first wall laid. The corresponding course of the second wall shall be built into these pockets. Fixtures, fittings, etc. shall be built into the masonry in cement and coarse sand mortar 1:3 while laying the blocks where possible. Hold fasts shall be built into the joints of the masonry during laying. Holes, chases, sleeves, openings, etc of the required size and shape shall be formed in the masonry with special blocks while laying, for fixing pipes, service lines, passage of water etc. After service lines, pipes etc are fixed, voids left, if any, shall be filled up with cement concrete 1:3:6(1 cement 3 coarse sand: 6 stone aggregate 20mm nominal size) and neatly finished.

9.7 SCAFFOLDING

Scaffolding shall be double and shall be erected with steel sections or pipes of adequate strength so as to be safe for construction operations. The contractor shall take all measures to ensure the safety of the work and working people. Any instructions of the PMC/Employer in this respect shall also be complied with. The contractor shall be entirely responsible for any damage to properly or injury to persons resulting from ill erected scaffolding, defective ladders and materials or otherwise arising out of his default in this respect. Proper scaffolding shall be provided to allow easy approach to every part of the work. Overhead work shall not be allowed. Block work shall be carried out with double scaffolding only. Making holes of any kind for the purpose of supporting the scaffolding shall not be permitted. Railing Must be provided for safety purposes at all heights & levels. Contractor to ensure safety measures are followed as instructed.

9.8 MEASUREMENT

Hollow or solid cement concrete block work shall be measured in Sqm for the specified width.

9.9 RATES

Rates for concrete block masonry item shall include the following:

a) Material and labour, for the completion of items as specified including any centring, shuttering, curing etc.
b) Raking out of joints.
c) Preparation of the tops and sides.
d) Forming and preparing expansion, contraction or construction joints as detailed above or specified in the BOQ or drawings.
e) Making holes, openings, etc. for outlets, embedding down take pipes, etc. wherever

necessary during construction and finishing exposed surfaces as per instruction of the EIC.

f) Curing and protection as specified.
g) Making holes, openings, outlets, etc. embedding pipes, ends of beams, joints, slabs, trusses, sills, etc. whatever required during construction and neatly finishing the exposed surfaces and opening as per instructions of the EIC.
h) RCC Post and Transoms as per BOQ

9.10 AUTOCLAVED AERATED BLOCKS / LIGHT WEIGHT BLOCK MASONRY

9.10.1 MATERIAL:

The lightweight block shall be of Siporex (India) manufacture or equivalent. The blocks shall have thickness of 200 mm, 150 mm, 100 mm for load bearing walls, partitions, and cladding work, etc. The blocks shall have a maximum density of 640 kg / cu.m. or less.

9.10.1.1 Structural Strength requirement:

a) Compressive Strength: The lightweight concrete block shall have a minimum compressive strength of 35 kg / sq.cm.
b) Bending Compression: 15 kg / sq.cm.

9.10.1.2 The mortar used for light weight concrete block shall be as specified in the Schedule of Items; Cement and water used in mortar shall conform to the quality as described in 'Concrete', whereas sand used for mortar shall be fine screened only. The light weight concrete block masonry should not be used below ground or in plinth. The block masonry work shall be built in stretcher course only.

9.10.1.3 The light weight concrete block wall or required thickness as described in Schedule of Items, shall be constructed with R.C.C. vertical and horizontal stiffeners, of required size at suitable intervals, as directed by the PMC/Employer, or as per drawing. R.C.C. and steel reinforcement shall be included in the rate and will not be paid separately. The masonry work shall be raised truly in plumb. All courses shall be laid truly horizontal and all vertical joints shall be truly vertical. The vertical joints should be not more than 12mm thick and shall be fully filled from the top with cement mortar without any void in masonry. All face joints shall be raked out to a minimum depth of 15 mm. by raking tool, during the progress of the work, when the mortar is still green, so as to provide proper key for the plaster or pointing. All fixtures, pipes, outlets of water, holdfasts, of doors, windows, which are required to be built into the block masonry, shall be embedded in mortar or cement concrete, as specified, in correct position, as the work

proceeds and as directed by the PMC/Employer. After masonry work is over, the masonry shall be marked with date of construction, visible for inspection and curing.

9.10.2 CURING

All joints of block masonry shall be kept constantly moist by sprinkling water on all joints for a minimum period of seven days.

9.10.3 SCAFFOLDING

Same as described in 9.7.

9.10.4 MEASUREMENT

Light weight block masonry wall shall be measured in sq. Metres for a width of less than 200mm. For 200mm blocks the mode of measurement to be in cubic meters. All measurements to be correct to two places of decimal. All opening in masonry works for doors, windows, ventilators and any other opening shall be deducted to get net quantity of actual light weight concrete block masonry. No deduction is to be made for opening up to 0.1 m2. No separate payment shall be made for extra work involved in making openings, chases in wall for electrical inserts, conduits, etc.

9.10.5 RATE

The rate quoted for block masonry shall include the cost of material, wastage, labour involved in all operations described above, including transportation, overheads, profits, cutting, tools, equipment, necessary scaffolding, raking out joints to receive plaster, opening, cutting and chases in masonry for fixing doors, windows, ventilators, switch boxes, conduit, etc. and making good. Rate is also inclusive of making pillars, copings, ledges, projections, if any, and also to be inclusive of all operations for masonry work to be done at all levels.

9.11 PLASTERING

9.11.1 SCOPE

These specifications cover the use of plastering for masonry and RCC work, pointing for brick and stone masonry work.

9.11.2 IS CODES

The provision of the latest revisions of the following IS codes shall form a part of this specification to the extent they are relevant.

IS: 269	Specification for ordinary rapid hardening and low heat Portland cement
IS: 712	Building Lines
IS: 1200 (Part XII)	Method of measurement of building and Civil Engg. Works - Plastering and Pointing
IS: 1542	Specification for sand for plaster
IS: 1630	Mason's Tools for Plaster work and pointing work.
IS: 1661	Code of practice for application of cement lime plaster finishes
IS: 10067	Material Constants for Building Works

Other I. S. Codes, not specifically mentioned here, but pertaining to plastering work, form part of these specifications.

9.11.3 GENERAL

9.11.3.1 CEMENT MORTAR

Cement mortar shall have the proportion of cement to sand as specified and shall comply with relevant clauses of Cement Mortar specifications.

9.11.3.2 Cement

Shall be as per 4.13.1

9.11.3.3 Water

Shall be as per 4.13.3

9.11.3.4 Fine Aggregate

Shall be as per 8.3.3

9.11.3.5 SCAFFOLDING

Shall be as per 9.7.

9.11.4 TOOLS AND ACCESSORIES

Tools and accessories used in plaster work shall conform to IS: 1630. All tools shall be cleaned by scrapping and washing at the end of each day's work or after use. Metal tools shall be cleaned after each operation. All tools shall be examined to see that they are thoroughly cleaned before plastering is begun.

9.11.5 PROGRAMME OF WORK IN RELATION TO PLASTERING

The program of other building operations before, during and after plastering shall be according to the instructions contained in clause 9 of IS: 1661.

9.11.6 GENERAL PRECAUTION IN PLASTERING

All general precautions as specified in IS. 1661, Clause 9, shall be taken and preparation of the background shall be done as laid down in IS: 1661, Clause 13. Care shall be taken to see that other parts of the work or adjacent works are not damaged while plastering.

9.11.7 PREPARATORY WORK

All joints in the face work that is to be plastered shall be raked out to depth equal to not less than the width of the joints or as directed by the PMC/Employer. The raking shall be done taking care not to allow by chipping of masonry. In new work the raking out shall be done when the mortar in the joints is still green. Smooth surfaces of concrete, old plaster, etc. must be suitably roughened to provide necessary bond for the plaster. All dirt, soot, oil paint or any other material that might interfere with satisfactory bond shall be removed. In the case of stone masonry, scrubbing on the walls to receive the plaster shall not be more than 12 mm (1 ½"). The surface to be plastered shall be cleaned and scrubbed with fresh water and kept wet for 6 hours prior to plastering. It shall be kept damp during the progress of the work. The plastering shall not be commenced unless the preparatory work is passed in writing by the PMC/Employer.

In hand mixed mortar, cement and sand in the special proportions shall be thoroughly mixed dry on a clean impervious platform. Fresh and clean water as specified above shall be added gradually and thoroughly mixed to form a stiff plastic mass of uniform colour so that, each particle of sand shall be completely covered with a film of wet cement. The water cement ratio may be as under or as directed by the PMC/Employer.

Cement Ratio per 50 kg of cement	**Sand**	**Water-Cement**	**Qty of Water (Litres)**
1	1	0.25	12.5
1	1-1/2	0.28	19
1	2	0.3	15
1	2-1/2	0.35	17.5
1	3	0.4	20
1	4	0.53	26.5
1	5	0.6	30
1	6	0.7	35
1	8	0.9	45

Machine mixed mortar shall be prepared in an approved mixer. Water cement ratio shall be as per hand mixed mortar. The mortar so prepared shall be within 30 minutes of adding water should be used in the work. The mortar remaining unused after that period mortar which has partially hardened or is otherwise damaged shall not be re-tempered or remixed. It shall be destroyed or thrown away.

9.11.8 GAUGES

Patches of plaster 15cm x 15cm shall be put on about 3 m apart as gauges to ensure even plastering in one plane.

9.11.9 WORKMANSHIP

9.11.9.1 Plastering

In all plaster work the mortar shall be firmly applied with somewhat more than the required thickness and well pressed into the joints and on the surface and rubbed and levelled with a flat wooden rule to give required thickness. Long straight edges shall be freely used to give perfectly plane and even surface. All corners must be finished to their true angles or rounded as directed by the PMC/Employer. The surface shall be finished to plane or curved surface as shown on the plan or directed by the PMC/Employer and shall present a neat appearance. The mortar shall adhere to the masonry surface intimately when set and there should be no hollow sound when struck. Cement plastering should be done in squares or strips as directed. Plastering shall be done from top downward.

9.11.9.2 First or Backing Coat

The first coat of the specified thickness shall be applied as described above. The subsequent coat shall be applied after this coat has been allowed to set for 3 to 5 days depending upon weather conditions. The surface shall not be allowed to dry during this period.

9.11.10 PLASTERING TO CEILING

Projecting burrs of mortar formed due to the gaps at joints in shuttering shall be removed. The surface shall be scrubbed clean with wire brushes. In addition, concrete surface shall be poke marked with a pointed tool at spacing of not more than 50 mm centres, the pokes being made not less than 3 mm deep, to ensure a proper key for the plaster. The mortar shall be washed off and surface cleaned of all oil, grease etc., and well wetted before the plaster is applied.

Cement plaster to ceiling shall be 6 mm thick finished / not finished with a floating coat of neat cement and thick coat of lime wash on top of walls for bearing of slabs.
The plaster shall be applied over the cleaned and wetted surface of the wall. When the plaster has been brought to a true surface with the wooden straight edge it shall be uniformly treated over its entire area with a paste of neat cement and rubbed smooth, so that the whole surface is covered with neat cement coating. The quantity of cement applied for floating coat shall be 1 kg per Sqm. Smooth finishing shall be completed with trowel immediately and in no case later than half an hour of adding water to the plaster mix. The rest of the specifications described above shall apply.

9.12 SAND FACED PLASTER IN CEMENT MORTAR

9.12.1 BASE COAT

The base coat plaster shall be of cement mortar 1:4 or as specified in the BOQ. Waterproofing compound of approved make shall be added according to the makers' instructions to make the mortar waterproof.
The plaster with this mortar shall be laid as specified above with a thickness of not more than 12 mm for brick work and concrete surfaces, and 15 mm for rubble stone masonry. Keys shall be formed on the surface by thoroughly combing it with wavy horizontal lines about 12 mm apart and about 3 mm deep when the mortar is still plastic. The base coat shall be cured for not less than 2 days.

9.13 SAND. FACED TREATMENT

The cement mortar for sand faced plaster shall have washed Kharasalis or similar type of approved sand with slightly larger proportion of coarse material. The proportion of cement to sand shall be 1:4 or as specified in the BOQ. The water is added gradually to make the mixture homogeneous. The thickness of finishing coat shall not exceed 7 mm. After application, the surface should be finished with a wooden flat, lined with cork and tapped gently to retain a coarse surface texture. When the finishing coat has hardened, the surface shall be kept moist continuously for 14 days.

9.14 GROOVES IN SAND FACE PLASTER

The grooves are to be to the required depth and width. They should be neatly finished with extreme care. All horizontal and vertical grooves should be in perfect line and level.

9.15 SCAFFOLDING

Shall be as per 9.7

9.16 ROUGH COAT CEMENT PLASTER WITH CEMENT MORTAR

9.16.1 BASE COAT

The first coat of plaster shall be of cement mortar of 1:4 mix and applied according to the relevant provisions of IS: 1661 Clause 14. 1. The finished thickness of the first coat shall be 12 mm for brick masonry or concrete surface and 1 5 mm for rubble stone masonry. The plaster shall be laid by throwing the mortar (by using a strong whipping motion) on the prepared surface with a trowel in a uniform layer and pressed to form a good bond. The surface shall be roughened.

9.17 SECOND COAT

The second coat shall be the rough coat mixture consisting of aggregate, which may vary in size from 5 to 8 mm and may consist of specially graded mixture mixed with fine sand and cement. The proportion of cement to sand and aggregate shall be 1:11/2:3. It shall be flung upon the first coat with large trowels to form an even protective coat. The second coat must be applied while the first coat is still soft and plastic. The work shall generally conform to clause 16.5 of IS: 166. The thickness of the coat shall be about 12 mm.

9.18 SCAFFOLDING

Shall be as per 9.7

9.19 MESH TO WALLS

9.19.1 PVC PLASTER MESH

PVC Plaster mesh should be made from Polypropylene products and should possess good chemical and heat resistance. They should be semi rigid with good impact strength, appearance and are easily welded. The thickness of mesh to be 0.9mm.

9.19.2 100% VIRGIN POLYPROPYLENE FIBRES

The following are the general properties of the 100% Virgin Polypropylene fibres:

a) Should provide inherence micro-reinforcement against shrinkage and intrinsic cracking.
b) Should reduce rebound losses in plasters to 60-70%.
c) Should improve impact resistance 3-4 times and should improve abrasion resistance by 30-40%.
d) Should reduce permeability and thus protects interior paint in plasters.

Dosage for plasters: 100-125 g / 50 kg cement bag or as recommended by designer.

Mixing process: Mix directly in the concrete mixer @ 125 g /50 kg bag of cement or 0.9 kg/m3.

For plastering applications dry mix with sand cement mortar before adding water.

9.20 GYPSUM PLASTER TO WALLS

GYPSUM UNIVERSAL PLASTER (Base coat), a gypsum-based material in a handy application can be applied over any normal background in not more than one coat, depending on evenness or the background. Smooth finish and good impact strength are its virtue.

Gyplaster base coat plaster is a calcium sulphate hemihydrate plaster with additives including light weight aggregate to improve plasters handling workability and application. It attains early strength and is free from shrinkage cracks. The thickness of the plaster should be a maximum of 13 mm on uneven background but should not exceed 10 mm or less than 5 mm on a level and even background.

The setting time of plaster is approximately 30 minutes after the application, depending upon suction of background. The setting progresses evenly and gradually until the surface is hard enough to receive a final stroke of a trowel, at approximately 45 to 60 minutes.

The coverage is approximately 65 to 75 sq.m. per 1000 kg at 13 mm thickness.

For application of gyplaster, the wall is first marked vertically at 1220 mm centres, then checked with straight edge, or line (preferably aluminium square tube) centres to find the high spots which are used as guide for level to be set.

The background should be suitably wetted with a brush 5-10 minutes before plastering to displace the trapped air and for a good plaster contact with the surface. Four points (by putting plaster with flat surface) are fixed in level and plumb to each corner of the wall to determine the thickness of the plaster required to be done.

40 mm wide strips of plaster are fixed. Then the points are applied vertically, in level and plumb of both ends of the wall.

These vertical strips are then made with plaster at even 1220 (or 1550 mm) centres on the entire area of the wall, to ensure level and plumb of the strips, to be in line.

The plaster is applied to surface of the wall with a trowel to required thickness and finish the surface by setting straight edge (sq. tube) horizontally by them placing on the vertical strips already fixed above, with firm pressure.

A tight coat is applied then turned back with the same batch material to fill out to required thickness.

A featheredge should be used to straighten the plaster to a reasonable plane, whilst at the same time filling in any slacks or hollows when the plaster has stiffened sufficiently, further ruling out the feather edge is necessary to achieve a flat surface.

As the plaster stiffens progressively, further flattening and paring should be carried out with a spatula.

When the plaster is sufficiently formed, the surface should be soaked lightly with a sponge float and light application of water if necessary to raise the flat and bring the surface to a suitable condition for finishing.

Closing in with the trowel should commence as soon as plaster starts to set, followed by a final trowel at the appropriate time.

Over polishing should not be done at any cost.

Decoration and final finish should be delayed until the plaster work has dried out thoroughly.

Precautions:

a. Tools and water used in mixing must be clean and free from set plaster and other impurities.

b. Set plaster shorten the setting time and thus reduces the strength of plaster which sets.

c. Surfaces should be protected from weather and should be reasonably wetted 5-10 minutes before plastering so that the plaster holds on the background satisfactorily.

d. Fittings and plugging of all kinds should be done before proceeding to plaster.

e. Openings, chases or other apertures for cable conduits and other's should be cut before plastering.

f. Background to be plastered should be thoroughly brushed with broom to remove dust and loose mortar.

g. Once a mix has started to set, it should not be retempered neither should be a fresh gauging be mixed with an old one.

Background surface should be reasonably dry and protected from the weather. The suitability of a particular background for plastering should be considered in relation to its length, suction, bonding properties, shrinkage or thermal movement characteristics, water and soluble salt content. The high suction of certain backgrounds (like concrete block masonry) should be adjusted by sprinkling water.

Plaster is not supposed to isolate dampness, and this is not suitable for use in continuously damp or humid conditions. During application of Gyplaster in hot or dry conditions, care should be taken to ensure that rapid loss of water is avoided. The reason is that Gyplaster requires a proportion of the mixing water in order to set and achieve full strength. If the water is dried off too rapidly then the strength of the plaster will be impaired. Once set and fully dry, it is suitable for use in situation where the inside temperature is 50 de. C maximum.

Universal plaster attains early strength during the drying process and the plaster work does not suffer from inherent shrinkage cracks. Whilst the finished surface can be intended by impact, the natural resilience of set plaster prevents more serious damage.

Tubular service conduits should be chased into the background wherever possible. The following precautions should be taken in order to minimise any risk of subsequent plaster cracking or rust staining over service runs.

a) Conduit of minimum permissible dimensions should be used.
b) High spots in the background should be chiselled if possible.
c) The undercoat plaster thickness specified should be sufficient to cover the extreme protrusions of the conduit by at least 5 mm.
d) Service routes should avoid door frames, ground, etc.
e) Service piping, conduits, fixing clips and other metallic objects should be adequately protected by galvanizing, painting or applying a thicker layer of lacquer in order to protect if from rusting.
f) At junctions of different materials (like concrete blocks and RCC columns/ beams) a fibre mesh shall be applied prior to the application of the plaster to avoid cracks at a later date.

Gyplaster universal shall be mixed in a clean mixing bucket using clean water. Plastic buckets can be used to avoid rust staining from metal containers

9.21 MEASUREMENTS

9.21.1 Length and breadth shall be measured correct to a cm and its area shall be calculated in square meters correct to two places of decimal.

Thickness of the plaster shall be exclusive of the thickness of the key i.e. grooves, or open joints in brick work.

The measurement of wall plaster shall be taken between the walls or partitions (the dimensions before the plaster shall be taken) for the length and from the top of the floor or skirting to the ceiling for the height. Depth of coves or cornices if any shall be deducted.

The following shall be measured separately from wall plaster.

- Plaster bands 30 cm wide and under
- Cornice beadings and architraves or architraves moulded wholly in plaster.
- Circular work not exceeding 6 m in radius.

Plaster over masonry pilasters will be measured and paid for as plaster only.

Exterior plastering at all heights shall be measured together. Patch plastering (in repairs) shall be measured as plastering new work, where the patch exceeds 2.5 Sqm. extra payment being made for preparing old wall, such as dismantling old plaster, raking out the joints and cleaning

the surface. Where the patch does not exceed 2.5 Sqm in area it shall be measured under the appropriate item under sub head 'Repairs to Buildings.

9.22 Deductions in measurements, for opening etc. will be regulated as follows:

No deduction will be made for openings or ends of joists, beams, posts, girders, steps etc. up to 0.5 Sqm in area and no additions shall be made either, for the jambs, soffits and sills of such openings. The above procedure will apply to both faces of wall.

Deduction for opening exceeding 0.5 Sqm but not exceeding 3 Sqm each shall be made for reveals, jambs, soffits sills, sills, etc. of these openings.

a) When both faces of walls are plastered with same plaster, deductions shall be made for one face only.
b) When two faces of walls are plastered with different types of plaster or if one face is plastered and other is pointed or one face is plastered and other is unplastered, deduction shall be made from the plaster or pointing on the side of the frame for the doors, windows etc. on which width of reveals is less than that on the other side but no deduction shall be made on the other side. Where width of reveals on both faces of wall are equal, deduction of 50% of area of opening on each face shall be made from area of plaster and/or pointing as the case may be.
c) For opening having door frame equal to or projecting beyond thickness of wall, full deduction for opening shall be made from each plastered face of wall.

For opening exceeding 3 Sqm in area, deduction will be made in the measurements for the full opening of the wall treatment on both faces, while at the same time, jambs, sills and soffits will be measured for payment. In measuring jambs, sills and soffits, deduction shall not be made for the area in contact with the frame of doors, windows etc.

9.23 RATE

The rate shall include the cost of all labour and materials involved in all the operations described above.

9.23.1 Providing GI Chicken mesh 20 gauge or PVC mesh (whichever is mentioned in the BOQ), over lapping to a width of 150 mm at the junctions of masonry and concrete works on either side and including tying in position by using suitable nails / clamps / screws and as directed etc. complete at all levels

9.23.2 Forming of drip mould/ bands, grooves of sizes as required etc,. wherever grooves are to be provided horizontally/ vertically for in accordance with the drawings.

9.23.3 Cost of All material and labour

9.23.4 Hacking concrete surfaces to be plastered or rendered

9.23.5 Preparation of surfaces by raking out joints, wetting the surface etc.,

9.23.6 Work at all heights, levels and situations.

9.23.7 Washing floors, cleaning glass and leaving premises clean and tidy after the plastering is done. Disposing off the debris outside the site

9.23.8 Curing the same.

9.23.9 Providing necessary scaffolding, ladder, platform for any height and depth and removing the same after the work is completed

9.23.10 Neat finishing of junctions of plaster and skirting

9.23.11 Screening and washing approved fine aggregates

9.24 PAINTING

9.24.1 SCOPE

These specifications cover the use of paints for the plastered and concrete surfaces. It also includes the painting of wood and metal surfaces. The paint to be low VOC. Conventional paints contain Volatile Organic Compounds (VOC), which are petroleum-based solvents that evaporate from paint films while the paint is drying. These compounds are the unpleasant solvent fumes that may trigger respiratory reactions including asthma and breathing discomfort, when using conventional paints. They also contribute to greenhouse gas emissions.

Traditional oil based paints (also known as alkyd enamels) have a solvent level of approximately 50% or more. This means that for every four-litre can of enamel, two litres go straight into the atmosphere, compounding the “Greenhouse Effect”. Conventional water-borne paints have a solvent level of around 7%, so obviously using water-borne paints is a far more environmentally responsible option.

Additives classified as VOC’s are included to achieve some of the positive attributes of paint, such as good coverage, easy application and wash ability. The challenge for manufacturers, is delivering the quality of paint finish customers have come to expect, whilst reducing the overall environmental impact of each tin.

Low VOC paints, stains and varnishes use water as a carrier instead of petroleum-based solvents. As such, the levels of harmful emissions are lower than solvent-borne surface coatings. These certified coatings also contain no, or very low levels, of heavy metals and formaldehyde. The amount of VOC's varies among different "low-VOC" products and is listed on the paint can or MSDS. Paints and stains, to meet EPA standards. must not contain VOCs in excess of 200 grams per litre. Varnishes must not contain VOCs in excess of 300 grams per litre.

As a general rule, low VOC paints marketed by reputable paint manufacturers usually meet the 50 g/L VOC threshold. Paints with the Green Seal Standard (GS-11) mark are certified lower than 50 g/L.

Low VOC paints will still emit an odour until dry. If you are particularly sensitive, make sure the paint you buy contains fewer than 25 grams/litre of VOC's.

9.24.2 GENERAL

The provision of the latest revisions of the following IS: Codes shall form a part of this specification.

IS: 63	Whiting for Paints Ready mixed paint, brushing, grey filler, for Enamels, for use over primers.
IS: 426	Specification for paste filler for colour coats.
IS: 428	Specification for Distemper, Oil Emulsion, and colour as required.
IS: 710	Marine Plywood
IS: 1200 (Part XIII)	Method of Measurement of Building and Civil Engg Works - White Washing, colour washing, distempering and other finishes.
IS: 1477 (Part 1)	Code of practice for painting of ferrous metals in buildings Pre-treatment
IS: 1477 (Part 11)	Code of practice for finishing of ferrous metals in buildings. Painting
IS: 2338 (Part 1)	Code of practice for finishing of wood and wood based materials Operations and workmanship for finishing.
IS: 2338 (Part 11) :	Code of practice for finishing of wood and wood based materials, Schedule
IS: 2395 (Part 1) :	Code of practice for painting concrete masonry and plaster surfaces. Operation and workmanship
IS: 2395 (Part 11)	Code of practice for painting concrete, masonry and plaster surfaces. Schedule.
IS: 159	Specification for ready mixed paint, brushing, acid resistant.
IS: 2524 (Part 1)	Code of practice for painting of non-ferrous metal in buildings Pre-treatment
IS: 2524 (Part ll)	Code of practice for painting of non-ferrous metal in buildings Painting
IS: 3140	Code of practice for painting asbestos cement buildings:
IS: 5410	Specification for cement paints, colour as required.

Other IS Codes not specifically mentioned here but pertaining to painting form part of these specifications.

9.24.3 MATERIALS

Materials shall strictly conform to the relevant IS: Specifications.

9.24.4 PLASTERED OR CONCRETE SURFACES

Wherever scaffolding is necessary, it shall be erected in such a way that as far as possible no part of scaffolding shall rest against the surface to be painted. Properly secured and well tied suspended platforms (JHOOLA) may be used for painting. Where ladders are used, pieces of old gunny bags shall be tied at top and cotton to prevent scratches to the walls and floors. For painting of ceilings, proper stage scaffolding shall be erected, where necessary.

Please note that the figures below are a guide only, as the actual VOC rating will depend on gloss level selected. All figures exclude tinting.

-Note that the exact VOC rating will vary depending on the sheen level, so the range is given to cover all.

-All measurements are in grams per liter for untainted product

The surface shall be thoroughly cleaned off all dirt, dust, mortar dropping and other foreign matter, before paint is to be applied. New plaster surfaces shall be allowed to dry for at least 2 months, before applying paint. All unnecessary nails shall be removed.

Pitting in plaster shall be made good with putty. The surface shall then be rubbed down again with a fine grade sandpaper and made smooth.

The surface shall be allowed to dry thoroughly before the regular cost of paint is allowed.

The surface affected by moulds moss, fungi, algae, linens, efflorescence shall be treated in accordance with IS 2395 (Part 1) before applying paint.

9.25 OIL-BOUND DISTEMPERING

9.25.1 Materials

Oil emulsion (Oil Bound) washable distemper (IS 428) of approved brand and manufacture shall be used. The primer wherever used for new work shall be cement primer or distemper primer as described in the item. These shall be of the same manufacture as distemper. The distemper shall be diluted with water or any other prescribed thinner in a manner recommended by the manufacturer. Only sufficient quantity of distemper required for day's work shall be prepared. The distemper and primer shall be brought by the contractor in sealed tins in sufficient quantities at a time to suffice

for a fortnight's work, and the same shall be kept in the joint custody of the contractor and the PMC/Employer. The empty tins shall not be removed from the site of work, till this item of work has been completed and passed by the PMC/Employer

9.26 Preparation of Surfaces

For new work the surface shall be thoroughly cleaned of dust, old white or colour wash by washing and scrubbing. The surface shall then be allowed to dry for at least 48 hours. It shall then be sand papered to give a smooth and even surface. Any unevenness shall be made good by applying putty, made of plaster of Paris mixed with water on the entire surface including filling up the undulation and then sand papering the same after it is dry. In the case of old work, all loose pieces and scales shall be removed by sand papering. The surface shall be cleaned of all grease, dirt etc. Pitting in plaster shall be made good with plaster of Paris mixed with the colour to be used. The surface shall then be rubbed down again with a fine grade sand paper and made smooth. A coat of the distemper shall be applied over the patches. The patched surface shall be allowed to dry thoroughly before the regular coat of distemper is applied.

9.27 Primer Coat

The primer where used as on undercoated surfaces shall be alkali resistance primer or distemper primer as specified in the item. These shall be of the same manufacture as of oil bound distemper. If the wall surface plaster has not dried completely alkali resistance primer shall be applied before distempering the walls. But if the distempering is done after the wall surface is dried completely, distemper primer shall be applied.

9.28 Application

Primer shall be applied with a brush on the clean dry and smooth surface. Horizontal strokes shall be given first and vertical strokes shall be applied immediately afterwards. This entire operation will constitute one coat. The surface shall be finished as uniformly as possible leaving no brush marks. It shall be allowed to dry for at least 48 hours, before oil bound distemper or paint is applied.

9.29 Preparation of oil bound distemper

The distemper shall be diluted with water or any other prescribed thinner in a manner recommended by the manufacturer. Only sufficient quantity of distemper required for days work shall be prepared.

9.30 Application of distemper coat

After the primer coat has dried for at least 48 hours, the surface shall be lightly sand papered to make it smooth for receiving the distemper, taking care not to rub out the printing coat. All loose particles shall be dusted off after rubbing. Minimum two coats of distemper shall be applied with brushes in horizontal strokes followed to immediately by vertical which together shall constitute one coat. The subsequent coats shall be applied after a time interval of at least 24 hours between consecutive coats to permit the proper drying of the preceding coat.

The finished surface shall be even and uniform without patches, brush marks, distemper, drops, etc.

Sufficient quantity of distemper shall be mixed to finish one room at a time. The application of a coat in each room shall be finished in one operation and no work shall be started in any room, which cannot be completed the same day.

15 cm. double bristled distemper brushes shall be used. After each day's work, brushes shall be thoroughly washed in hot water with soap solution and hung down to dry. Old brushes which are dirty and caked with distemper shall not be used on the work.

9.31 Scaffolding:

Wherever scaffolding is necessary, it shall be erected on double supports tied together by horizontal pieces, over which scaffolding planks shall be fixed. No ballies, bamboos or planks shall rest on or touch the surface which is being white washed. For all exposed brick work or tile work, double scaffolding having two sets of vertical supports shall be provided. The supports shall be sound and strong, tied together with horizontal pieces over which scaffolding planks shall be fixed.

Note: In case of special type of brick work, scaffolding shall be got approved from PMC/Employer in advance. Wherever ladders are used, pieces of old gunny bags shall be tied on their tops to avoid damage or scratches to walls. For white washing / painting the ceiling, proper stage scaffolding shall be erected

9.32 Precautions/protective measures

Doors, windows, floors, articles of furniture etc. and such other parts of the building not to be white washed/ painted, shall be protected from being splashed upon. Splashing and droppings, if any shall be removed by the contractor at his own cost and the surfaces cleaned. Damages if any to furniture or fittings and fixtures shall be recoverable from the contractor

9.33 Measurement:

The Mode of measurement shall be as per IS 1200

9.34 Rate:

The rate shall include all material and labour involved in all the operations described above.

9.35 WATERPROOF CEMENT PAINT:

9.35.1 Materials

The cement Paint shall be (conforming to IS 5410) of approved brand and manufacture. The cement Paint shall be brought to the site of work by the contractor in its original containers is sealed condition. The material shall be brought in at a time in adequate quantities to suffice for the whole work or at least a fortnight's work. The materials shall be kept in the joint custody of the Contractor and the PMC/Employer. The empty containers shall not be removed from the site of work till the relevant item of the work has been completed and permission obtained from the PMC/Employer

9.35.2 Preparation of Surfaces

For New Work, the surface shall be thoroughly cleaned of all mortar dropping, dirt dust, algae, grease and other foreign matter by brushing and washing. Pitting in plaster shall be made good and a coat of water proof cement Paint shall be applied over patches after wetting them thoroughly. The surfaces shall be thoroughly wetted with clean water before the water proof cement paint is applied.

9.35.3 Preparation of Paint

Portland cement paints are made readily by adding paint power to water and stirring to obtain a thick paste which shall then be diluted to a brush able consistency. Generally equal volumes of paint powder and water make a satisfactory paint. In all cases the manufacturer's instructions shall be followed. The paint shall be mixed in such quantities as can be used up within an hour of mixing as otherwise the mixture will set and thicken, affecting flow and finish.

The lids of cement paint drums shall be kept tightly closed when not in use, as by exposure to atmosphere the cement paint rapidly becomes air set due to its hydroscopic qualities.

9.35.4 Application of Paint

No painting shall be done when the paint is likely to be exposed to a temperature of below 7 degree within 48 hours after application.

When weather conditions are such as to cause the paint to dry rapidly, work shall be carried out in the shed as far as possible. This helps the proper hardening of the paint film by keeping the surface moist for a longer period.

To maintain a uniform mixture and to prevent segregation the paint shall be stirred frequently in the bucket.

For undecorated surfaces, the surface shall be treated with minimum two coats of water-proof cement paint. Not less than 24 hours shall be allowed between two coats and the second or subsequent coat shall not be started until the preceding coat has become sufficiently hard to resist marking by the brush being used. In hot dry weather the preceding coat shall be slightly moistened before applying the subsequent coat.

The finished surface shall be even and uniform in shade without patches, brush marks, paint drops, etc.

Cement paints shall be applied with a brush with relatively short stiff hog or fibre bristles. The paint shall be brushed in uniform thickness and shall be free of excessively heavy brush marks. The laps shall be well brushed out. For unflustered surfaces the contractor to apply suitable putty before application of paint. This is to be included in the rate for cement paint

9.35.5 Curing

Painted surfaces shall be sprinkled with water two or three times a day. This shall do between coats and for at least two days following the final coat. The curing shall be started as soon as the paint has hardened so as not to be damaged by the sprinkling of water say about 12 hours after its application.

9.35.6 Scaffolding

Scaffolding shall be as mentioned under the head of Oil Bound Distemper

9.35.7 Precautions/protective measures:

Precautions / protective measures shall be as mentioned under the head of Oil Bound Distemper

9.35.8 Measurement

The Mode of measurement shall be as per IS 1200

9.35.9 Rate

The rate shall include all material and labour involved in all the operations described above

9.36 PAINTING WOOD AND METAL SURFACES

9.36.1 General Requirement

The materials required for the execution of painting work shall be obtained directly from approved manufacturers and brought to the site in maker's drums, with seals unbroken. All paints shall conform to relevant Indian Standards as mentioned under sub-head "Material".

All materials not in actual use shall be kept properly protected. Lids of containers shall be kept closed and surface of paint in open or partially open containers covered with a thin layer of turpentine to prevent formation of skin. Materials which have become stale or fat due to improper and long storage shall not be used. The paint shall be stirred thoroughly in its container before pouring into small containers. While applying also, the paint shall be continuously stirred in the smaller container. No left-over paint shall be put back into stock tins. When not in use, the containers shall be kept properly closed.

If for any reason thinning is necessary, in case of ready mixed paint, the brand of thinner recommended by manufacturer shall be used.

Painting except the priming coat shall generally be taken in hand after all other builder's work is practically finished. The rooms shall be thoroughly swept out and the entire building cleaned up at least one day in advance of the paint work being started. The surface to be painted shall be thoroughly cleaned and dusted. All rust, dirt scales, smoke and grease shall be thoroughly removed before painting is started.

No painting on exterior or other exposed parts of the work shall be carried out in wet, humid, or otherwise unfavorable weather and all the surfaces must be thoroughly dry before painting work is started.

9.36.2 Brushing of Paint:

The brushing operations are to be adjusted to the spreading capacity advised by the manufacturers of the particular paint. The painting shall be applied evenly and smoothly by means of crossing and laying off, the later in the direction of the grain of wood. The crossing and laying off consists of covering the area over with paint, brushing the surface hard for the first time over and then brushing alternatively in the opposite directions two or three times and then finally brushing lightly in a direction at right angles to the same. In this process, no brush marks shall be left after the laying off is finished. The full process of crossing and laying off will constitute one coat.

During painting, every time after the paint has been worked out of the brush bristles or after the brush has been unloaded, the bristles of the brush. (Which are drawn together due to the high surface tension) shall be opened up by striking the brush against a portion of the unpainted surface with the end of the bristles held at right angles to the surface, so that bristles thereafter will collect the correct amount of paint when dipped again into the paint container.

9.36.3 Spraying

Where so stipulated, the painting shall be done with spray. Spray machine used may be (a) high pressure (small air aperture) type or (b) a low pressure (large air gap) type, depending on the nature and location of work to be carried out. Skilled and experienced workmen shall be employed for this class of work. Paints used shall be brought to the requisite consistency by adding a suitable thinner.

Spraying should be done only when dry conditions prevail. During spraying the spray gun shall be held perpendicular to the surface to be coated and shall be passed over the surface in a uniform sweeping motion. Different air pressures and fan adjustment shall be tried so as to obtain the best application with the minimum wastage of paint. The air pressure shall not be kept too high as otherwise the paint will clog up and will be wasted.

Spots that are inaccessible to the spray pattern shall be touched up by brush after spraying.

At the end of the job, the spray-gun shall be cleaned thoroughly so as to be free from dirt. Incorrect adjustments shall be set right, as otherwise they will result in variable spray patterns, runs, sags and uneven coats.

Each coat shall be allowed to dry completely and lightly rubbed with very fine grade of sand paper and loose particles brushed off before next coat is applied. Each coat shall vary slightly in shade and shall be got approved `from the PMC/Employer before next coat is started.

Each coat except the last coat shall be lightly rubbed down with sand paper or fine pumice stone and cleaned off dust before the next coat is applied.

No hair marks from the brush or clogging of paint puddles in the corner panels, angles of moulding, etc. shall be left on the works. In painting doors and windows, the putty round the glass panes shall also be painted but care shall be taken to see that no paint stains etc. are left on the glass. Tops of shutters and surfaces in similar hidden locations shall not be left out in painting.

In painting steel work, special care shall be taken while painting over bolts, nuts, rivets, overlaps etc.

The additional specifications for primer and other coats of paints shall be according to the detailed specifications under the respective headings.

9.36.4 Brushes and containers:

After work, the brushes shall be completely cleaned off paint and linseed oil by rinsing with turpentine. After cleaning, the brushes are wrapped in heavy paper or waterproof paper for storage. It is to be used the next day; it shall be hung in a thinner or linseed oil in a container. On no account shall brushes to be made to stand on bristles. A brush in which paint has dried up is ruined and shall on no account be used for painting work. The containers, when not in use, shall be kept closed and free from air so that paint does not thicken and also shall be kept guarded

from dust. When the paint has been used, the containers shall be washed with turpentine and wiped dry with soft, clean cloth, before they can be used again.

9.36.5 Scaffolding:

Scaffolding shall be as mentioned under the head of Oil Bound Distemper

9.36.6 Precautions/protective measures

Precautions / protective measures shall be as mentioned under the head of Oil Bound Distemper

9.36.7 Measurement

The Mode of measurement shall be as per IS 1200

9.36.8 Rate

The rate shall include all material and labour involved in all the operations described above

9.37 PAINTING TO STEEL AND OTHER METAL SURFACES

9.37.1 Preparation of Surfaces

The surface before painting shall be cleaned of all rust, scale, dirt and other foreign matter sticking to it with wire brushes, steel wool, scrappers, sand papers etc. The surfaces shall then be wiped finely with mineral turpentine which shall also remove grease and perspiration of hand marks. The surface shall then be allowed to dry.

9.37.2 Application of primers and paints

After preparation of the surface, the priming coat shall be applied immediately. The specifications for application shall conform to Para on painting wood surfaces above.

9.37.3 Scaffolding

Scaffolding shall be as mentioned under the head of Oil Bound Distemper

9.37.4 Precautions/protective measures

Precautions / protective measures shall be as mentioned under the head of Oil Bound Distemper

9.37.5 Measurement

The Mode of measurement shall be as per IS 1200

9.37.6 Rate

The rate shall include all material and labour involved in all the operations described above.

9.38 PAINTING TO WOOD AND WOOD BASED MATERIALS:

9.38.1 Preparation of Surface

All woodwork shall be dry and free from any foreign matter, incidental to building operation. Nails shall be punched well below the surface to provide a firm key for stopping. Moulding shall be carefully smoothened with abrasive paper and projecting fibres shall be removed. Flat portions shall be smoothened off with abrasive paper used across the grain prior to painting. Any knots, resinous, streaks or bluish sap wood that are large not enough to justify cutting out shall be treated with two coats of pure shellac knotting, applied thinly, and extended about 25 mm beyond the actual area requiring treatment.

9.38.2 Plywood and Block Board

This shall be treated as for solid wood, described above.

9.38.3 Hard Boards

The surface shall be dusted off and painted with a coat of plastic emulsion paint thinner with water or with a coat of shellac varnish as specified. The surface shall then be rubbed down with fine grade abrasive paper and followed with required under coating and finishing coat as for soiled wood.

9.38.4 Particle Board

The surface shall be filled with thin brush able filler and finished as for solid wood.

9.38.5 Insulation Boards

Two thin coats of water-based paints shall be applied by spraying.

9.38.6 Priming Coat

The dirt or any other extraneous material shall be removed from the surface to be painted. In case the surface is already finished with printer coat but unsatisfactory, it shall be rubbed down to bare wood and surface re-primed. Primer shall be applied by brushing.

9.38.7 Application for transparent wood filler

The filler shall be applied with brush or rag in such a way that it fills up all the pores and indentations and levels up the surface. It shall be allowed to dry for 24 hours and it shall then be cut and rubbed with emery paper so that the surface of the wood is laid bare, with, the filler only in the pores and crevices of the wood.

9.38.8 Stopping

All holes, cracks, crevices, etc. shall be stopped carefully to true and level surface with putty before the main undercoat is applied and after the application of the priming coat, stopping shall be prepared as below:

Bees wax, resin, and lac (orange in colour) in the proportion of 1: 1: 16 by weight shall be melted down together in a suitable pot using slow heat, the mix being kept well stirred. Colouring materials to produce the required shade shall be added into molten mixture and stirred. Stopping shall on cooling be rolled into stick forms for use.

9.38.9 Application of Paints

The specifications for application shall conform to Para on painting wood surfaces above

9.38.10 Applying wood preservatives

The preservatives of specified quality shall be applied in two coats. On new wood work, it shall be applied liberally with a stout brush and not doubled with rags or cotton waste, the first coat shall be allowed at least 24 hours to soak in before the second coat is applied. The excess of preservative which does not soak into the wood shall be wiped off with a clean dry piece of cloth.

9.38.11 Scaffolding

Scaffolding shall be as mentioned under the head of Oil Bound Distemper

9.38.12 Precautions/protective measures:

Precautions / protective measures shall be as mentioned under the head of Oil Bound Distemper

9.38.13 Measurement:

The Mode of measurement shall be as per IS 1200.

9.38.14 Rate

The rate shall include all material and labour involved in all the operations described above

9.39 WHITEWASHING

9.39.1 General

The item refers to whitewashing over old and new concrete, stone masonry brick plastered surfaces and asbestos cement sheets.

Whitewash shall be prepared from fresh burnt white stone lime or shell lime. This lime shall be of class C type as per IS: 712. Surkhi lime or lime of equivalent quality may be used. The lime shall be dissolved in a tub with sufficient quality of water (about 4.5 liters/Kg. of lime) and the whole

shall be thoroughly mixed and stirred until it attains the consistency of thin cream. The whitewash shall be taken out in small quantities and strained through a clear course cloth. Alternatively, with IS: 63 may also be used. Clean gum dissolved in hot water shall then be added in suitable proportion of 2 gm of gum Arabic to a litre of lime or whiting to prevent the white- wash coming off easily when rubbed. Rice may be used instead of gum.

9.39.2 Scaffolding

This may be double or single according to requirements. If ladders are used, pieces of old gunny bags or cloth rags shall be tied on their tops to avoid damage or scratches to the wall. Proper stage scaffolding shall be created when white-washing ceiling. The contractor shall be responsible for accidents if any taken place.

9.39.3 Preparation of Surface

The surface shall be prepared by removing all mortar dropping and foreign matter and thoroughly cleaned with wire or fiber brush or other means as may be ordered by the PMC/Employer to produce an approved clean and even surface. All loose pieces and the scales shall be scraped off and holes stopped with mortar. In case where the surface has been previously colored-washed, the old colour wash must be entirely removed before the white-wash is applied. In the case of surface which has once been white-washed, the old loose white-wash shall be broomed down. In case, the loose whitewash cannot be removed by brooming, the PMC/Employer may order scraping of the surface.

After cleaning the surface as specified above, the unwanted nails shall be removed and all nail holes, cracks and crevices stopped with mortar similar in composition to the surface to be stopped. The mortar should be cured.

9.39.4 Application of whitewash

On the surface so prepared, the whitewash shall he laid. Each coat shall be laid on with a brush. The first stroke of the brush shall be from the top downwards, another from bottom upwards over the first stroke, and similarly, one stroke from the right and another from the left over the first brush before it dries. This will form one coat. Each coat must be allowed to dry and shall be subject to inspection before the next coat is applied. When dry, the surface shall show no signs of cracking. It shall present a smooth and uniform finish free from brush marks and it should not come off easily when rubbed with a finger.

No portion in the surface shall be left out initially, to be patched up later on.

For new work, the whitewashed surface shall present a smooth and uniform finish.

For old work, patches and repairs shall be whitewashed first. Thereafter, the whole surface shall be whitewashed with the required number of coats.

Doors, windows, floors and other articles of furniture, etc., shall be protected from being splashed upon. Splashing and droppings, if any, shall be removed and the surfaces cleaned.

Preparing the surface for whitewash including the scaffolding

Applying the whitewash in required number of coats as specified above and prior whitewashing of repaired patched.

9.39.5 Precautions/protective measures

Precautions / protective measures shall be as mentioned under the head of Oil Bound Distemper

9.39.6 Measurement

The Mode of measurement shall be as per IS 1200

9.39.7 Rate.

The rate shall include all material and labour involved in all the operations described above

9.40 PLASTIC EMULSION PAINTING ON WALL AND CEILING

9.40.1 General

Plastic emulsion paints are not suitable for application on external wood and iron surfaces and surfaces which are liable to heavy condensation and are to be used generally on masonry or plastered surfaces. Suitable primer as per manufacturer shall be provided.

9.40.2 Paint

Plastic emulsion paint of approved brand and manufacture and of the required shade shall be used.

9.40.3 Preparation of Surface

The surface shall be thoroughly cleaned of dust, old white or colour wash by washing and scrubbing. The surface shall then be allowed to dry for at least 48 hours. It shall then be sand papered to give a smooth and even surface. Any unevenness shall be made good by applying putty, made of plaster of Paris mixed with water on the entire surface including filling up the undulation and then sand papering the same after it is dry.

9.40.4 Application

The number of coats shall be as stipulated in the item. The paint will be applied in the usual manner with brush or roller. The paint dries by evaporation of the water content and as soon as the water has evaporated the film gets hard and the next coat can be applied. The time of drying varies from one hour on absorbent surfaces to 2 to 3 hours on non-absorbent surfaces.

The thinning of emulsion is to be done with water and not with turpentine. Thinning with water will be particularly required for the undercoat which is applied on the absorbent surface. The quantity of thinner to be added shall be as per manufacturer's instructions. The surface on finishing shall present a flat velvety smooth finish. If necessary, more coats will be applied till the surface presents a uniform appearance.

9.40.5 Precautions

Old brushes if they are to be used with emulsion paints, should be completely dried of turpentine or oil paints by washing in warm soap water. Brushes should be quickly washed in water immediately after use and kept immersed in water during break periods to prevent the paint from hardening on the brush.

In the preparation of walls for plastic emulsion painting, no oil base putties shall be used in filling cracks, holes etc.

Splashes on floors etc. shall be cleaned out without delay as they will be difficult to remove after hardening.

Washing of surfaces treated with emulsion paints shall not be done within 3 to 4 weeks of application.

9.40.6 Other Detail

These shall be as per specification for "Painting" as far as they are applicable.

9.41 ACRYLIC PAINTING TO EXTERNAL SURFACES:

Acrylic weather shield paint of approved brand shall be applied over plastered surfaces as directed by the PMC.

Other specifications including preparation of surfaces, application of paint etc. shall conform to paint above and as directed by PMC. The priming coat, anti-fungal treatment, preparation of paint etc. shall be carried out as per manufacturer's specification / as directed by PMC.

9.42 EXTERNAL TEXTURE PAINTING

Painting work to be carried out by authorized applicator only as recommended by approved paint manufactures,

Method Statement to be submitted for approvals by the contractors as submitted by the authorized applicator.

9.42.1 Sealer Coat

Allow new surface to dry out completely. It is recommended to allow at least 12 weeks as the curing time for new masonry surfaces. Please ensure pH level between 7 & 9 before painting. Ensure that the surface is clean and free from grime, dust, flakes, grease etc. For old surfaces, remove all loosely adhering particles, powdery materials or defective paints by thorough brushing, scraping and water jetting, if required. For algae & fungus-affected area, application of Pre-Treatment Coat is recommended. Note: It is recommended not to apply any kind of putty. Do not apply Exterior Sealer during wet weather. On horizontal surfaces, it is recommended to do 3 coats of topcoat material. For best results and for surfaces that remain powdery, friable or chalky even after thorough preparation, application of topcoat material as primer with 1:1 dilution in water as an extra coat, is recommended. Fill up all minor cracks and defects with cement and sand mixture in the ratio 1:3. Avoid application of putty or filling compound. Exterior Sealer should not be applied to the surfaces or substrates which are exposed to continuous seepage or dampness. For best adhesion performance, the moisture content in the wall should not exceed 10%.

Dilute 1 part of Exterior Sealer with 1 part of clean water by volume.
Note: Excessive dilution from that recommended will result in low coverage and may impact application properties and color.

9.42.2 Application Tools: By roller, brush or conventional /airless spray (nozzle size 0.5mm to 0.7mm)

9.42.3 Texture Application

9.42.3.1 Surface preparation

Ensure surface is thoroughly clean, dry and free from all loose dirt, chalk, grease, fungi, algae and flaking paint. This can be achieved by brushing with a wire/stiff coir brush followed by water jetting if required. Fill up all minor cracks and defects with cement and sand mixture in the ratio 1:3. Avoid application of putty or filling compounds while painting an exterior surface. Application of one coat of Pre-Treatment coat is recommended for better performance of the paint.

9.42.3.2 Application Tools:

By roller, brush, or conventional /airless spray (0.5mm to 3mm) / trowel (hand or machine as per paint supplier recommendation) in one or two coats as per the approved pattern of texture selected.

9.42.3.3 Dilution

No thinning of the material is recommended for the final coat. But for ease of application a little water can be sprinkled.

9.42.3.4 Final Coat of Paint

As mentioned in Acrylic Emulsion Exterior Grade Paint

9.43 QUALITY CONTROL FOR ALL TYPES OF PAINT

Only the paints which have been tested for the following qualities as per the specification given in the relevant IS codes should be used:

- drying time
- flexibility and adhesion
- consistency
- dry thickness and rate of consumption

Unless otherwise specified all painting and protective coating work shall be done in accordance with IS: 1477.

Test certificates shall be furnished by the CONTRACTOR for PMC/Employer approval and acceptance.

9.44 CONSUMPTION OF PAINT FOR DIFFERENT PAINTING ITEMS

Sl no.	**Brief description of painting work**	**Consumption per 10 Sqm. Of net**
A	**Oil bound distemper on plastered surfaces:**	
1	Cement primer (one coat)	0.91 litres
2	Two finishing coats	1.60 kg
3	Three finishing coats	2.4 kg
B	**Flat oil paint to plastered surfaces:**	
1	Cement primer (one coat)	0.91 litres
2	Cement primer (two coats)	1.82 litres
3	Two finish coats	1.72 litres
C	**Acrylic emulsion paint:**	

Sl no.	Brief description of painting work	Consumption per 10 Sqm. Of net
1	Cement primer (one coat)	0.91 litres
2	Two finishing coats (two coats)	0.87 litres
3	Three finish coats	1.30 litres
D	**Cement paint (old surface):**	
1	Two coats on sand faced plastered surface	4.10 kg
2	Two coats on rough cast plastered surface	7.70 kg
E	**Cement paint (old surface):**	
1	Two coats on sand faced plastered surface	4.50 kg
2	Two coats on rough cast plastered surface	8.50 kg
F	**Enamel paint to wood / steel:**	
1	Wood primer (one coat)	0.90 litres
2	Steel primer (one coat)	0.75 litres
3	Two finishing coats on wood	1.40 litres
4	Two finishing coats on steel	1.35 litres
G	**Flat oil paint to wood /steel work:**	
1	Wood primer (one coat)	0.90 litres
2	Steel primer (one coat)	0.75 litres
3	Two finishing coats on wood	1.70 litres
4	Two finishing coats on steel	1.70 litres
H	**External painting with flat oil paint:**	
1	Cement primer (one coat)	1.00 litres
2	Two finishing coats	1.74 litres
I	**Re-painting old painted surfaces:**	
1	Two coats of emulsion paint	0.86 litres
2	Two coats of flat oil paint	1.59 litres
3	Two coats of enamel paint	1.35 litres

(The consumption give is indicative only. Please check the respective vendors for more details and accurate figure. No escalation will be paid on account of increase in the consumption of paint)

9.45 MEASUREMENT

Painting on plastered or concrete surface shall be measured as for plastering. Painting on wooden or metal surfaces shall not be measured separately and is deemed to be included in the respective item for wood and MS respectively.

IS 1200 shall be followed for measuring all painting.

10.0 FLOOR FINISHES

10.1 SCOPE

These Specifications covers flooring, skirting, dado, or cladding works using different types of stone/ slabs/ tiles as detailed hereunder:

10.2 GENERAL

The provision of the latest revisions of the following IS Codes shall form a part of this specification to the extent they are relevant:

IS: 269	Specification for ordinary, rapid hardening and low beat Portland cement.
IS: 383	Specification for coarse and fine aggregate from natural sources for concrete
IS: 777	Specification for glazed earthenware tiles.
IS: 1200 Part XI	Method of measurements for Building and Civil Engg. Works, paving, floor finishes, dado and skirting.
IS: 1237	Specification for cement concrete flooring tiles.
IS: 1443	Code of practice for laying and finishing of cement concrete flooring tiles.
IS-. 2541	Code of practice for use of lime concrete' in buildings.
IS: 2571	Code of practice for laying in situ cement concrete flooring
IS: 10067	Material Constants in Building Work

Other I.S Codes not specifically mentioned here but pertaining to Floor Finishes form part of these specifications. NBC 2005, 2016 Vol-I & Vol II for Fire Safety & mandate requirements for Differently abled individuals.

10.3 INDIAN PATENT STONE FLOORING

10.3.1 MATERIALS

10.3.1.1 Cement concrete

The cement concrete shall generally conform to specifications for ordinary concrete. The coarse aggregates shall be carefully selected, sufficiently tough and hard stone pieces broken in a manner that will provide particles of approximately cubical shape affording good interlocking. The fine aggregate shall consist of properly graded particles. The proportion of mix shall be M15 or as mentioned in the BOQ. The least amount of mixing water that will produce a workable mix and will allow finishing without excessive travelling shall be used.

10.3.1.2 Workmanship

The sub-grade in all cases shall be formed to proper levels and slopes, well compacted and cured. The top surface shall be kept slightly rough.

The surface of the sub-grade shall be cleaned off all loose materials and moistened immediately before laying the concrete floor. The concrete flooring shall be laid in alternate bays not exceeding 6.25 Sqm (about 64 sf.ft) each. The edge of each panel into which the floor is divided should be supported by flat bars of steel or wood duly oiled to prevent sticking. Their depth shall be the same as that proposed for the finished floor as mentioned in the item. The bars should be removed before filling in the adjoining panels. At least 48 hours shall elapse before the concreting in the adjacent bays is commenced.

The concrete shall be laid immediately after mixing. While being placed the concrete shall be vigorously sliced and spaded with suitable tools to prevent formation of voids or honeycomb pockets. The concrete shall be brought to the specified levels by means of a heavy straight edge resting on the side forms and drawn ahead with a sawing motion in combination with a series of lifts and drops alternating with small lateral shifts. While concreting the adjacent bays care shall be taken to ensure that the edges of previously laid bays are not broken by careless or hard 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. After striking off the surfaces to the required grade concrete shall be compacted with a wooden float. The blows shall be fairly heavy in the beginning but as consolidation takes place, light rapid strokes shall be given to

complete the ramming. The floating shall be followed by steel travelling after the concrete has hardened sufficiently to prevent excess of fine material from working to the surface, The finish shall be brought to a 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 on the surface of the concrete to absorb moisture or to stiffen the mix. After the concrete has been thoroughly rammed and has dried sufficiently to allow rendering to be worked up, surface shall be rendered with a thin coat of 1:1 cement mortar with fine sand and uniformly floated. If so directed by the PMC/Employer approved mineral colour pigment conforming to appendix-B of IS 657 shall be added to the cement mortar to give the required colour and shade to the flooring. When the cement mortar rendering is sufficiently stiff, lines shall be marked on it with strings or by any other device to give the appearance of tiles 30 x 30 cm or of any other size laid diagonally or square as directed by the PMC/Employer. The junctions of floor and walls shall be rounded off if so directed, without any extra payment.

After the concrete in the bays has set, the joints of the panels shall be filled with cement cream or with suitable bitumastic compound as shown on the drawings or directed by the PMC/Employer. Vertical edge of the bays shall be neatly marked on the surface of the concrete with a pointed trowel after filling the joints.

10.3.1.3 Finishing:

When the rendering is somewhat stiff, neat cement may be sprinkled on sparingly through a paper pot on the surface and rubbed lightly to give smooth polished ordinary cement colored surface. If coloured flooring is required by the PMC/Employer, the approved colored cement shall be used. Surface shall be protected after completion of work till handover.

10.3.1.4 Curing:

Curing shall start on the next day after finishing and shall be continued for 14 days.

10.3.2 MODE OF MEASUREMENT

Mode of measurement shall be planning Area in Sqm.

10.4 IPS WITH NON-METAL HARDNERS

Cement concrete flooring of specified thickness and mix as per ‘Itemized Schedule of Quantities’ shall be laid as specified under the specification of cement concrete flooring. The top surface shall be roughened with brushes while the concrete is still green, and the forms shall be kept projecting up 12mm. Over the concrete surface to receive the metallic hardening compound topping.

The nonmetal hardeners shall be as per the manufacturer's specifications. All installation procedure, mixing, laying procedure shall be as per manufacturer's specifications.

10.4.1 MODE OF MEASUREMENT

Mode of measurement shall be planning Area in Sqm.

10.5 KOTA FLOORING

10.5.1 KOTA STONE SLABS

The slabs shall be of selected quality, hard, sound, dense and homogeneous in texture free from cracks, decay, weathering, and flaws. They shall be hand or machine cut to the requisite thickness. They shall be of the colour indicated in the drawings or as instructed by the PMC/Employer.

The slabs shall have the top (exposed) face polished before being brought to site, unless otherwise specified. The slabs shall conform to the size required. Before starting the work the contractor shall get the samples of slabs approved by the PMC/Employer.

10.5.2 DRESSING

Every slab shall be cut to the required size and shape and fine chisel dressed on the sides to the full depth so that a straight edge laid along the side of the stone shall be in full contact with it. The sides (edges) shall be table rubbed with coarse sand or machine rubbed before paving. All angles and edges of the slabs shall be true, square and free from chippings and the surface shall be true and plane.

The thickness of the slab after it is dressed shall be 20, 25, 30 or 40 mm as specified in the description of the item. Tolerance of ±2 mm shall be allowed for the thickness. In respect of length and breadth of slabs Tolerance of ± 5 mm for hand cut slabs and ± 2 mm for machine cut slabs shall be allowed.

10.5.3 PREPARATION OF SURFACE AND LAYING

Base concrete or the RCC slab on which the slabs are to be laid shall be cleaned, wetted and mopped. The bedding for the slabs shall be with cement mortar 1:4 (1 cement: 4 coarse sand) or as given in the description of the item.

The average thickness of the bedding mortar under the slab shall be 25 mm and the thickness at any place under the slab shall be not less than 12 mm.

The slabs shall be laid in the following manner:

Mortar of the specified mix shall be spread under the area of each slab, roughly to the average thickness specified in the item. The slab shall be washed clean before laying. It shall be laid on top, pressed, tapped with wooden mallet and brought to level with the adjoining slabs. It shall be lifted

and laid aside. The top surface of the mortar shall then be corrected by adding fresh mortar at hollows. The mortar is allowed to harden a bit and cement slurry of honey like consistency shall be spread over the same at the rate of 4.4 kg of cement per Sqm. The edges of the slab already paved shall be buttered with grey cement with or without admixture of pigment to match the shade of the Kota slabs as given in the description of the item.

The slab to be paved shall then be lowered gently back in position and tapped with wooden mallet till it is properly bedded in level with and close to the adjoining slabs with as fine a joint as possible. Subsequent slabs shall be laid in the same manner. After each slab has been laid, surplus cement on the surface of the slabs shall be cleaned off. The flooring shall be cured for a minimum period of seven days. The surface of the flooring as laid shall be true to levels, and slopes as instructed by the PMC/Employer. Joint thickness shall not be more than 1 mm.

10.5.4 POLISHING AND FINISHING

The day after the tiles is laid all joints shall be cleaned of the grey cement grout with a wire brush or trowel to a depth of 5 mm and all dust and loose mortar removed and cleaned. Joints shall then be grouted with grey or white cement mixed with or without pigment to match the shape of the topping of the wearing layer of the tiles. The same cement slurry shall be applied to the entire surface of the tiles in a thin coat with a view to protect the surface from abrasive damage and fill the pin holes that may exist on the surface.

The floor shall then be kept wet for a minimum period of 7 days. The surface shall thereafter be grounded evenly with machine fitted with coarse grade grit block (No. 60). Water shall be used profusely during grinding. After grinding the surface shall be thoroughly washed to remove all grinding mud, cleaned and mopped. It shall then be covered with a thin coat of grey or white cement, mixed with or without pigment to match the colour of the topping of the wearing surface in order to fill any pin hole that appear. The surface shall be again cured. The second grinding shall then be carried out with machine fitted with fine grade grit block (No. 120).

The final grinding with machine fitted with the finest grade grit blocks (No. 320) shall be carried out the day after the second grinding described in the preceding Para or before handing over the floor, as ordered by the PMC/Employer.

For small areas or where circumstances so require, hand grinding/polishing with hand grinder may be permitted in lieu of machine polishing after laying. For hand polishing the following carborundum stones, shall be used:

1st grinding — coarse grade stone (No. 60)
Second grinding — medium grade (No. 80)
Final grinding — fine grade (No. 120)

In all other respects, the process shall be similar as for machine polishing.

After the final polish, oxalic acid shall be dusted over the surface at the rate of 33 gm per square metre sprinkled with water and rubbed hard with a 'namdah' block (pad of woollen rags). The following day the floor shall be wiped with a moist rag and dried with a soft cloth and finished clean. If any tile is disturbed or damaged, it shall be refitted or replaced, properly jointed and polished. The finished floor shall not sound hollow when tapped with a wooden mallet.

10.6 EPOXY COATING

Epoxy coating should be based on carefully selected solvent less Epoxy resin composition. It should be a 3-component system consisting of base, hardener and hard-wearing quartz fillers. It should be self-levelling composition and forms a very smooth, attractive hygienic, hard wearing, and chemical resistant floor topping.

It should provide a joint less flooring making it dust free and is easy to clean because of smooth surface.

Chemical Resistant – It should have excellent chemical resistance to most chemicals

Wear Resistant – It should provide a tough floor topping to withstand foot and light vehicular traffic.

10.6.1 SURFACE PREPARATION

The long-term durability of the applied Epoxy topping is dependent upon the adhesive bond achieved between the flooring material and substrate. It is most important therefore, that substrate surface is correctly prepared prior to application.

Substrate must be of sufficient strength to support loads applied through the topping. New concrete or Cementitious substrates should have been placed for at least 28 days and have a moisture content of less than 5% before topping. Before application, the surface to be coated should be free from loose particles, rust, oils,

grease or earlier coatings and should be thoroughly dry. After surface is dry, all repair work like sealing of joints, cracks filling of cavities and crevices should be carried out. 5. The self-levelling action is very localized and does not eradicate irregularities of level present in the original substrate. It is most important, therefore, that adequate surface preparation and repair is undertaken prior to application of flooring systems.

10.6.2 PRIMING

This is to be as per manufacturer's specifications.

10.6.3 MIXING

This is to be as per manufacturer's specifications.

10.6.4 LAYING

Spread the mixture on the floor immediately to the required thickness by means of rollers and serrated trowels. The floor should be rolled by a spike roller to remove trapped air. The floor shall self-level to uniform color and smoothness.

10.7 CERAMIC TILES /VITRIFIED TILES FLOOR AND DADO

10.7.1 Ceramic tiles shall be 300mm x 300mm x 7mm thick in size or as mentioned in the BOQ, Vitrified tiles to be 600x600x10mm thick/900 x 900 x 12mm / 1000 x 1000 x 12mm or as specified in the Item and of best quality, Indian make obtained from approved manufacturer. The tiles shall be sound, hard, well and evenly treated, free from twist, with fine and sharp edges. Sample of the tiles shall be first got approved by the PMC/Employer in case of the Contractor's supply and all the tiles which shall be used in the work shall strictly conform to the approved sample otherwise all the tiles will be rejected. The surface to be laid for the flooring or dado shall be thoroughly hacked, joints of masonry racked, cleaned of all mortar scales, concrete" lumps, loose materials, etc. and washed to remove mud, dirt, etc. from the surface. Unless and until the surface is approved by the PMC/Employer, the flooring and dado shall not be started. The prepared surface shall be thoroughly drenched with water.

10.7.2 Flooring

A bedding 20 mm thick (unless otherwise specified) of cement mortar 1:3 shall be laid evenly to levels or slope as directed; The tiles shall then be laid on the bedding with a backing of thin cement paste. All tiles shall be truly and evenly set and pressed in position to obtain a uniform plane surface. The tiles shall be closed jointed and ail joints shall be uniform and run in perfect straight lines. Joints shall be filled with matching cement paste. Entire finished surface shall be thoroughly cleaned to remove all cement stains, etc. The joints shall be kept wet for 7 days. Epoxy joints can also be used as a substitute for cement paste.

When tile flooring is to be laid over the existing flooring without dismantling old flooring it can be laid with adhesive. The old flooring shall be thoroughly cleaned and checked for undulations, if any shall be rectified with cement mortar 1:3 (1 cement: 3 coarse sand). Old cement concrete surface shall be hacked and cleaned off to have proper bond with the old surface. High polymer modified quick set tile adhesive (conforming to IS 15477) shall be thoroughly mixed with water and a paste of zero slump shall be prepared so that it can be used with in 1.5 to 2 hours. It shall be spread over an area not more than one Sqm at one time. Average thickness of adhesive shall

be 3 mm The adhesive so spread shall be combed using suitable trowel. Tiles shall be pressed firmly in to the position with slight twisting action checking it simultaneously to ensure good contact gently being tapped with wooden mallet till it is properly backed with adjoining tiles. The tiles shall be fixed within 20 minutes of application of adhesive. The surplus adhesive from the joints, surface of the tiles shall be immediately cleaned. The surface of the flooring shall be frequently checked during laying with straight edge of above 2m long so as to attain a true surface with required slope. Where spacer lugs tiles are provided these shall be filled with grout with lugs remaining exposed. Where full size tile cannot be fixed these shall be cut (sawn) to the required size and edges rubbed smooth to ensure straight and true joints. Tiles which are fixed in floor adjoining to wall shall enter not less than 10 mm under plaster, skirting or dado.

10.7.3 Dado

The prepared surface shall be plastered with cement mortar 1:3 to get a bedding of 12mm thick. The plastered surface shall be even, uniform and true to plumb. The tiles shall be fixed in position with a backing of cement paste or water proof adhesive of approved manufacturer as specified in the item. All tiles shall be evenly set and pressed in position to a true plane surface. The specifications for workmanship shall be exactly similar to tile flooring. The joints shall be filled with matching cement paste or with joint filler material of approved manufacturer as specified in the item. If the tile manufacturer specifies the use of adhesives for dado, the Contractor to use the same at no extra cost to the Client

10.8 TWIN GRANITE/MARBLE STONE FRAMES

10.8.1 Bedding shall be of grey cement-paste with minimum cement consumption of 0.21 bags per Sqm. Of applied area, unless specified otherwise in the BOQ/drawings. The base of cement shall be compacted to a reasonably true plain surface and to the required and level. The amount of water added shall be the minimum necessary to give just sufficient plasticity for laying and satisfactory bedding. Before spreading paste, the sub- base shall be cleaned off all dirt, scum or laitance and of loose material and then well wetted without forming any pools of water on the surface. The paste shall then be evenly and smoothly spread over so much area as will be covered with slabs within half an hour. The thickness of the paste shall not be less than 6 mm and not more than 12 mm.

The joints shall be cleaned and properly grouted with a neat paste of white cement with minimum cement consumption of 0.55 kg per Sqm

The proportion of mortar bedding shall be 1:4 , unless and otherwise prescribed any other proportion and shall be as per IS 2116-1965 , as applicable to non-reinforced masonry work.

The adhesion of two slab frames overlay shall be ensured with araldite or approved Ardex endure / Latecrete adhesive.

10.8.2 Laying:

Laying of marble /granite stone slab frame shall be as follows :-

Before laying, the stone slab shall be thoroughly wetted with clean water. 20mm thick marble slab / tiles shall be fixed with polymer modified cement adhesive or cement paste (as per BOQ) Each stone slab then shall be gently tapped with a wooden mallet till it is firmly and properly bedded. If there is a hollow sound on gentle tapping of the slabs such slabs shall be removed and reset properly. The joints shall be as thin as possible and limited to 2mm at the maximum. Unless and until detailed in the BOQ or Drg, exposed edges of window sills/door frames, the edges shall be neatly rounded off.

Laying shall start after due consideration is given to following points and approved by the PMC/Employer.

The vertical surface for frame cladding work should be rough, fairly in plumb and in right angles with each other, Concealed plumbing and electric conducting shall be complete before the execution of frame cladding work.

Check all the right angles of the corners of bath/W.C. /toilet or pantry area. Please ensure that the plaster is in plumb.

Check the level of the wooden Patti with spirit level before commencing the cladding work.

After the frames are laid, surplus cement slurry from the joints shall be cleaned. The following day the joints shall again be cleaned, washed and wire brushed.

In case not specified in the Drawing or BOQ, and if the projection is not recommended, 6mm groove to be provided at the junction of the wall and stone frame.

Polishing and grinding shall be completed on the surfaces and edges before the laying of the stone frames. At first the grinding shall be with rough stone of grade 48 to 60. All chips shall be visible and grinding shall be uniform. It shall be cleaned with water. All pin-holes and opened out joints shall be grouted with matching coloured cement grouts supplied by the tile manufacturer. It shall be cured for a period of 7 days by keeping it moist.

Second coat cutting/grinding shall be done with carborandum stone of grade 120. The same procedure as for the first coat shall be repeated till curing is completed.

The final cutting/grinding shall be with a fine stone of 220-320 grade and shall be done with ample water.

Oxalic acid powder shall be spread 33 gm/Sqm. and polished by machine fitted with Hessian bobs. The floor shall then be washed, cleaned and dried with a soft cloth or linen. They should be hand polished by using rubbing stone.

In case of wax polishing, wax polish shall be applied to the surface. It shall be rubbed with machine. Then clean saw-dust shall be spread over the slab and rubbed with polishing machine. This will remove wax, leaving a glossy surface underneath.

10.8.3 Rates:

Apart from other factors mentioned elsewhere in this contract , the rate shall include for the following:

- All labour, materials(except for Client supplied ones), equipments, cleaning of the sub-base, laying mortar bed and adhesives, grout, fixing marble slabs as specified above and making up the joints.
- Transportation of material / equipment
- Any cutting and wasting if required
- Mouldings and edge polishing
- All adhesives, grouts and mastic sealants etc.
- Curing
- Cleaning the floor and surrounding areas all stains, etc.

10.9 PANTRY / HAND WASH COUNTER

Necessary chases to be made in the wall for supporting the backing materials

Machine cut Cudappa stone slabs used shall be of 25 mm thickness, colour shall be uniform and the slabs free from all defects. Or 19mm marine ply wood to be used instead of Cudappa (as specified in the BOQ)

Slabs shall be either machine cut at factory in required sizes or cut by machine at site. In all cases no damaged stone shall be used in the work.

Vertical stones and stones of shelf shall be machine polished on both sides while the top slab shall be polished on one side i.e. underside, while top surface shall be kept rough for better adhesion with granite top.

All edges shall be sharp, perfectly rectangular and the exposed edges shall be pencil rounded and machine polished.

Assembly of toilet counter shall be done as per detail given by Architect or Engineer complete to all details and dimensions.

Vertical pieces shall be in perfect plumb on all sides while horizontal slab shall be in perfect level.

All joints and in fill layer shall be filled with cement sand mortar of mix 1:4 (1 cement : 4 sand) and properly cured.

Granite top used shall be of approved quality and shade. Thickness shall be about 20 mm and all slabs shall be machine cut.

All slabs preferable shall be from same mines and granite blocks / rocks to ensure uniformity of colour and quality.

Cutting and polishing shall be by machine only at factory. No damaged piece shall be used.

All edges shall be sharp, perfectly rectangular and the exposed edges shall be pencil rounded and polished.

Granite top shall be laid over cement mortar bed of about 20 mm thickness of mix cement mortar 1:4 (1 cement : 4 sand). Prior to laying of mortar bed the top of Cudappa stone base shall be scrapped clean and washed thoroughly. In case Granite is to be laid on ply backing, the same to be done by means of approved Adhesive from Roff or Ardex Endura or Latecrete as per the manufacturer's specifications

Mortar bed shall be laid and neat cement slurry with cement paste shall be spread over the mortar bed and clear granite slab shall be laid and fixed to perfect level over it.

Joints shall be as thin as possible and limited to 1-2 mm maximum. The joints shall be wiped off for excess cement slurry and cleaned prior to grouting with matching coloured cement grout.

Granite facia Patti shall be fixed by using anchor fasteners and epoxy based adhesives of approved type by the Engineer.

Work shall be protected and cured for at least 7 days. The timber props on braces shall be left in place as per instruction / recommendations of adhesive manufacturer.

The sink / wash basin of specified size and make shall be fixed by cutting of Cudappa stone base and the joints on top with granite shall be filled with silicon sealant of approved make and colour.

Measurements shall be in running meters or as mentioned in BOQ.

Rate shall include all materials, wastage, labour, grout, sealant, adhesives, anchors, protection, curing etc. complete. Sink/ wash basin shall be paid separately

The cost to include storage below the counter if mentioned in the BOQ.

11.0 SHUTTERS AND DOORS

11.1 SCOPE

The specifications refer to wood work in general including carpentry and joinery work in the building.

11.2 GENERAL

The provision of the latest revisions of the following I.S. codes shall form a part of these specifications.

IS 205	Specifications for non-ferrous metal butt hinges
IS 287	Recommendation for maximum permissible moisture content of timber used for different purposes.

IS 303	Specification for plywood for general purpose.
IS 362	Specification for parliamentary hinges
IS 419	Specification for putty for the use on window frames
IS 883	Code of practice for design of structural timber in building.
IS 1003	Specification for Timber paneled and glazed shutters Part II - Window and ventilator shutters.
IS1200	Method of measurement of building and Civil Part XXI Engineering Works - Wood Work and Joinery.
IS:1341	Specification for steel butt hinges
IS:1658	Specification for Fibre Hard Boards
IS: 1761	Specification for transparent sheet glass for glazing and framing purposes.
IS: 3087	Specification for wood particle boards (medium density for structural timber in building)

Other I.S. codes not specifically mentioned here but pertaining to woodwork and joinery form part of these specifications.

11.3 MATERIALS

11.3.1 SAWN TIMBER

The timber shall be free from decay, fungal growth, boxed heart, pitch pockets or streaks on the exposed edges, splits, and cracks. The timber shall be graded as first grade and second grade on the basis of the permissible defects in the timber. For both the grades, knots should be avoided over a specified limit. Timber is classified as under :

(i) Teak wood
(ii) Deodar wood
(iii) Non-coniferous timbers other than teak
(iv) Coniferous timber other than deodar.

11.3.2 Teak Wood (Tectona Grandis)

It is of outstanding merit in retention of shape and durability. The heart wood is one of the most naturally durable woods of the world. It usually remains immune to white ant attack and insect attack for very long periods. It is, however, not always immune from fungus attack (rot). Taken as a whole, good quality teak is very durable, it is relatively easy to saw and work. It can be

furnished to a fare surface and takes polish well. It is generally used for making furniture and all important timber construction.

11.3.3 Superior Class Teak Wood such as Balarsha, Malabar and Dandeli

Individual hard and sound knot shall not be more than 12 mm in diameter and the aggregate area of all the knots shall not exceed one half per cent of the area of the piece. It shall be close grained.

11.3.2.1 Deodar Wood (Cedrus Deodars)

It is the strongest of the Indian conifers. Its weight and strength is 20% per cent less than teak. It is easy to saw and works to a smooth finish. It is not, however, a suitable wood for polish or paint work as the oil in the wood and especially near knots, always seeps through such finishes and discolours them. It is used for house building, furniture and other construction work. It is also suitable for beams, floors, boards, posts, window frames and light furniture etc.

11.3.2.2 Sal Wood (Shoera Robusta)

Sal is about 30 per cent heavier than teak, 50 per cent harder, and about 20 to 30 per cent stronger. In shock resistance it is about 45 per cent above teak. Its heart wood is a naturally durable wood, and usually remains immune to attack by white ants and fungi for a long period, while its sapwood is very perishable and should not be used. Well dried sal is not a really easy wood to saw and work. It is a rough constructional wood than a carpentry timber. No individual hard and sound knot shall exceed 25 mm in diameter and the aggregate area of all the knots shall not exceed 1% of the area of the piece. It can be used for a variety of purposes, such as for beams, rafters, flooring, piles, bridging, tool handles, picker arms and tent pegs, etc.

11.3.2.3 Kail Wood (Pinus Roxburghie)

Kail Wood is not a very durable wood. But it is easy to saw and work and usually very popular in workshops. It can be brought to a fine smooth surface, but is more suitable for paint and enamel finishes than for polish work. It is useful for joinery works, constructional work, light furniture and house fitments

All wood to be FSC (Forest Stewardship Council) certified Forests certified to be in compliance with the standards endorsed by the Forest Stewardship Council (FSC).

Products milled or otherwise altered by manufacturers certified to be in compliance with the standards endorsed by the Forest Stewardship Council (FSC).

11.3.4 GLAZING MATERIALS

11.3.3.1 Glass Panels

Unless otherwise specified, glass panes used in glazed or panelled and glazed shutters, shall be of good quality glass of thickness not less than 2 mm for panes up to 0.1 Sqm in area not less than 3 mm for glass panes of area larger than 0.1 Sqm with a tolerance of 0.2 mm in both cases. The glass shall be free from flaws such as specks, bubbles, smoke waves, air holes, etc. and shall conform to the relevant IS : 1761.

Unless otherwise specified, glass panes used in shutters of bath room and lavatories shall be frosted and of thickness as mentioned above and shall be free from any flaws.

Where so specified, special quality glass such as plate glass, pin heads glass, wired glass, float glass etc. shall be used. They shall conform to relevant IS standards as regards quality.

11.3.3.2 Putty for glazing in wooden frames of doors and windows

Putty shall be prepared by mixing one part of white lead with three parts of finely powdered chalk and then adding boiled linseed oil and mixing the whole thing into a homogeneous stiff paste. It shall be free from impurities like dust, grit, etc. and shall conform to IS: 416.

11.4 FITTINGS

The item of woodwork of joinery generally includes fittings such as hinges and screws for fixing of door shutters and is explicitly so mentioned in the item.

Hinges - Hinges shall be of iron, brass, aluminum or any other material as specified. They shall present a neat appearance and shall operate smoothly. All hinges shall be of steel and their riveted heads shall be well formed and smooth. Hinges shall be of the type specified and shall conform to the relevant Indian Standard Specifications.

11.5 FRAMING

Framed woodwork includes all sawing, cutting, planning, jointing framing, supply and use of straps, bolts holdfasts, nails treenails, spikes, screws etc. necessary for framing and fixing. Framing and trussing are to be done in the best possible manner. Holes of correct size shall be drilled before inserting screws. Driving in or starting the screws with hammer is prohibited. All screws shall be dipped in oil before being inserted in the wood. The kind of nails and screws shall be subject to the approval of the PMC/Employer.

11.6 SCAFFOLDING

The Contractor shall provide all labor, scaffolding ladders and tackle necessary for hoisting and fixing woodwork in position and afford facilities for its inspection during construction. The Contractor shall be responsible for the safety of the work, workmen and for any action or compensation that may arise in this connection.

11.7 IRON WORK

All iron work connected with woodwork which is going to be embedded in masonry shall before erection, receive two coats of hot coal tar. If it is to be painted, it shall be given the first two coats on the ground before being fixed in position and the third coat after erection in position.

11.8 PRECAUTIONS AGAINST FIRE

During the progress of work all shavings, cutting and other rubbish shall be cleared away as the work progresses and all precautions shall be taken against fire.

11.9 INSPECTION

All woodwork shall be inspected and passed by PMC/Employer before being put into actual position. In no case the woodwork shall be painted or otherwise treated before it is inspected and approved by the PMC/Employer. After approval it shall have the primary coat of paint put on or otherwise treated before being fitted in position. The subsequent coats of paint or other finish shall be applied after the woodwork is fixed in position.

11.10 DEFECTIVE WORK

If within three months after the work is completed any undue shrinkage or bad workmanship is discovered the Contractor shall forthwith replace or refix the same to the satisfaction of the PMC/Employer, without extra charge.

11.11 MOISTURE CONTENT

Control on moisture content of timber is necessary to ensure its proper utility in various climatic conditions. For specifying the permissible limit of moisture content in the timber the country has been divided into four climatic zones. In each of the zones, maximum permissible limit of moisture content of timber for different uses, when determined in accordance with the shall be as per Table.

Maximum Permissible Moisture Content of Timber

Sr.No.	Use		Max Moisture Content Percent		
		Zone	Zone	Zone	Zone
		I	II	III	IV
1.	Beams, Rafters, and Posts	12	14	17	20
2.	Doors and windows				
	(a) 50 mm and above thickness	10	12	14	16

	(b) Thinner than 50 mm	8	10	12	14
3.	Flooring strips	8	10	10	12
4.	Furniture and Cabinet making	10	12	14	15

TOLERANCE ON MOISTURE CONTENT

Average Moisture content of all the samples from a lot shall be within + 3 per cent and moisture content of individual samples within + 5 per cent of maximum permissible moisture content specified in Table This tolerance are the absolute values over the percentage moisture content for Sl. No. 1 and 2 of Table No tolerance on moisture content is permitted for Sl. No. 3 and 4 of Table.

11.12 SEASONING OF TIMBER

The process of drying timber under controlled conditions is called seasoning of timber. Timber shall be either air seasoned or kiln seasoned and in both cases moisture content of the seasoned timber shall be as specified in Table 9. 2 above unless otherwise specified, air seasoned timber shall be used. Kiln seasoning of timber, where specified, shall be done as per IS 1141 in a plant approved by PMC/Employer.

11.13 PRESERVATION OF TIMBER

Preservative treatment does not improve basic properties of timber but gives varying degree of protection against deterioration due to attacks by fungi, termites, borers and marine organisms. Preservative treatment, where specified, shall be done using Oil type, Organic solvent type or Water-soluble type preservative. Oil type preservatives shall be used if the timber is not required to be polished or painted. Before preservative treatment, the timber shall be sawn and seasoned. All surfaces exposed after treatment, except due to planning, shall be thoroughly brushed with the preservation before jointing. Preservative treatment of timber shall be done as per IS 401 in a plant approved by the PMC/Employer.

11.14 WORKMANSHIP

11.14.1 WOODWORK, WROUGHT, FRAMED AND FIXED

11.14.1.1 General

The work shall be carried out as per detailed drawings and/or as directed by the PMC/Employer. The wooden members of the frame shall be planed smooth and accurate to the full dimensions.

Rebates, rounding, moldings, etc. as shown in the drawing shall be done before the members are joined into frames. Where woodwork is not exposed to view as in the case of frames for false ceiling, however, no planning is required to be done unless specified expressly as rough timber work.

Note: The work wrought shall mean 'planed'.

11.14.1.2 Jointing in timber frames must be made carefully and accurately. They shall be strong, neat and shall fit without edging or filling. The joints shall be pinned with hard wood or bamboo pins of 10 to 15 - dia after the members of the frame are pressed together in a suitable vice-mechanism

11.14.1.3 The door and window frame shall have rebate to house the shutters, and the depth of such rebate shall be 1.25 cm. Timber for door, window and ventilators frames shall be as specified. Timber shall be sawn in the direction of the grains. All members of a frame shall be of the same species of timber and shall be straight without any warp or bow. Frames shall have smooth, well-planed (wrought) surfaces except the surfaces touching the walls, lintels, sill etc., which may be left clean sawn. Rebates, rounding or moulding shall be done before the members are jointed into frames. The depth of the rebate for housing the shutters shall be 15 mm, and the width of the rebates shall be equal to the thickness of the shutters. A tolerance of ± 2 mm shall be permitted in the specified finished dimensions of timber sections in frames.

11.14.1.4 Woodwork shall be painted, oiled, polished, or otherwise treated as specified. All portions of timber abutting against masonry or concrete portion of building shall be coated with boiling coal tar or other type of approved wood preservatives primer, before placing them in final position. Before any surface treatment is applied in the woodwork shall be got approved by the PMC/Employer. The Jamb posts shall be through tenoned into the mortise of the transoms to the full thickness of the transoms and the thickness of the tenon shall be not less than 2.5 cm. The tenons shall closely fit into the mortise without any wedging or filling. The contact surface of tenon and mortise before putting together shall be glued with polyvinyl acetate dispersion based adhesive conforming to IS 4835 or adhesive conforming IS 851 and pinned with 10 mm dia hard wood dowels, or bamboo pins or star shaped metal pins. The joints shall be at right angles when checked from the inside surfaces of the respective members. The joints shall be pressed in position. Each assembled door frame shall be fitted with a temporary stretcher and a temporary diagonal brace on the rebated faces.

11.14.1.5 Fixing in Position

11.14.1.6 The frames shall be fixed only after acceptance by the PMC/Employer. In case of door frames without sills, the vertical members shall be buried in floor for the full thickness of the floor and the door frame shall be temporarily braced at the sill level so as to prevent warping or distortion of frame during construction. The frames shall be got approved by the PMC/Employer before being painted, oiled or otherwise treated and before fixing in position. The surface of the frames abutting masonry or concrete and the portions of the frames embedded in floors shall be given a coating of coal tar. Frames shall be fixed to the abutting masonry or concrete with holdfasts or metallic fasteners as specified Hilti or equivalent make. After fixing, the jamb posts of the frames shall be plugged suitably and finished neat. Vertical members of the door frames shall be embedded in the floor for the full thickness of the floor finish and shall be suitably strutted and wedged to prevent warping during construction. A minimum of three hold fasts shall be fixed on each side of door and window frames one at center point and other two at 30 cm from the top and bottom of the frames. In case of window and ventilator frames of less than 1 m in height two hold fasts shall be fixed on each side at quarter point of the frames. Hold fasts and metallic fasteners shall not be measured and paid for separately.

11.14.2 PANELLED, GLAZED OR PANELLED AND GLAZED SHUTTERS

11.14.2.1 General

The work shall be carried out as per detailed drawing. The wooden members shall be planed smooth and accurate. They shall be cut to the exact shape and sizes without patching or plugging of any kind. Mouldings, rebates, rounding, etc. shall be done, as shown in the drawing, before the pieces are assembled into the shutter.

11.14.2.2 Joinery work

The thickness of the styles and rails shall be as specified in the item of work. The minimum thickness of panels shall normally be 15 mm where the clear width of panel is not more than 300 mm and 20 mm where the clear width of the panel is more than 300 mm. However, where the PMC/Employer so considers lesser thickness up to 12 mm and 15 mm respectively may be allowed by him instead of 15 mm and 20 mm specified above. Solid wood panel for door and window shutters shall be made out of one or more strips of timber planks of not less than 125 mm width. it is preferable to use strips of not more than 200 mm width to reduce chances of warping, splitting or other defects. The timber strips shall be joined together with continuous

tongued and grooved joints, glued together and reinforced with metal dowels. The grooving of the solid panel shall normally run along the longer dimensions of the panel unless otherwise directed. The corners and edges of panels shall be finished as shown in the drawing and these shall be feather tongued into styles and rails. Sash bars shall have mitres joints with the styles.

Styles and rails of shutters shall be made out of single piece. Lock and intermediate rails exceeding 200 mm in width if permitted by the PMC/Employer may be made out of one or more pieces of timber but the width of each pieces shall not be less than 125 mm. Where more than one piece of timber is used, they shall be joined with a continuous tongued and grooved joint glued together and reinforced with metal dowels (rust proof) at regular intervals of 20 cm or pinned with not less than three 40 mm rust proof pins of the lost head type.

The tendons shall pass clear through styles. The styles and rails shall have a 12 mm groove to receive the panel.

In case the double shutters the rebate at the closing junction of the two shutters shall be of depth not less than 2 cm.

Shutters shall not be painted or otherwise treated before these are passed by the PMC/Employer and fixed in position.

11.14.2.3 Glazing

The glazing work shall be done in accordance with the specification given separately elsewhere.

11.14.2.4 Hold Fasts

Hold fasts used for fixing doors and window frames shall be made of 40 x 3 mm flat iron and 40 cm long. It shall have two holes on one end for fixing to frame with long screws, and at the other end, the flat iron shall be split and bent at right angles in the opposite direction. The hold fast shall be tightly fixed to the frame by means of bolts, the bolt hole in frame being plugged suitably and finished neat. The hold fast shall be embedded into masonry by concrete block of 200 x 250 x 400 mm size.

11.14.2.5 Measurements

Unless otherwise specified in the BOQ, Woodwork and joinery work shall be measured in cubic meters. Length and width of unfinished opening shall be measured to the nearest 0.01 m.

Volume shall be worked out correct up to 3rd place of decimal of a Cum. All work shall be measured net as fixed, that is, no extra allowance in measurement shall be made for shape, joints, etc. However, where the dimensions as fixed exceeds the specified dimension (as per drawing, etc.) only the specified dimensions(s) shall be measured and where one or more dimension of the piece as fixed is less than the fixed dimension the actual dimension shall be measured, without prejudice to the right of the PMC/Employer to reject the piece and order replacement of such pieces.

It shall include:

- Supply of specified species of timber sawn to requisite sizes without any defect, wrought, framed and fixed in position with the required standard of workmanship including supply-and-fixing of fixtures, straps, bolts, hold-fasts, spikes, nails, screws, etc. applying contractors glue or other jointing materials, coal tarring embedded parts, glazing and supplying and fixing of all specified fittings.
- All material, labour, scaffolding, use of equipment etc. for framing, fixing and completing the item as specified.

11.14.3 FLUSH DOOR SHUTTER

11.14.3.1 General

The door shall be of flush type solid core with single or double shutter.

11.14.3.2 Shutters

Flush door shutters shall have a solid core and may be of the decorative or non-decorative (Paintable type as per IS 2202 (Part I). Nominal thickness of shutters may be 25, 30 or 35 mm. Thickness and type of shutters shall be as specified.

Width and height of the shutters shall be as shown in the drawings or as indicated by the PMC/Employer. All four edges of the shutters shall be square. The shutter shall be free from twist or warp in its plane. The moisture content in timbers used in the manufacture of flush door shutters shall be not more than 12 per cent when tested according to IS 1708.

11.14.3.3 Core

The core of the flush door shutters shall be a block board having wooden strips held in a frame constructed of stiles and rails. Each stile and rail shall be a single piece without any joint. The

width of the stiles and rails including lipping, where provided shall not be less than 45 mm and not more than 75 mm. The width of each wooden strip shall not exceed 30 mm. Stiles, rails and wooden strips forming the core of a shutter shall be of equal and uniform thickness. Wooden strips shall be parallel to the stiles.

11.14.3.4 End joints of the pieces of wooden strips of small lengths shall be staggered. In a shutter, stiles and rails shall be of one species of timber. Wooden strips shall also be of one species only but it may or may not be of the same species as that of the stiles and rails. Any species of timber may be used for core of flush door. However, any non-coniferous (Hard wood) timber shall be used for stiles, rails and lipping.

11.14.3.5 Face Panel

The face panel shall be formed by gluing, by the hot-press process on both faces of the core, either plywood or cross-bands and face veneers. The thickness of the cross bands as such or in the plywood shall be between 1.0 mm and 3.0 mm. The thickness of the face veneers as such or in the plywood shall be between 0.5 mm and 1.5 mm for commercial veneers and between 0.4 mm and 1.0 mm for decorative veneers, provided that the combined thickness of both is not less than 2.2 mm. The direction of the veneers adjacent to the core shall be at right angles to the direction of the wooden strips. Finished faces shall be sanded to smooth even texture. Commercial face veneers shall conform to marine grade plywood and decorative face veneers shall conform to type I decorative plywood in IS 1328.

11.14.3.6 Lipping

Lipping, where specified, shall be provided internally on all edges of the shutters. Lipping shall be done with battens of first class hardwood or as specified of depth not less than 25 mm. For double leaved shutters, depth of the lipping at meeting of stiles shall be not less than 35 mm. Joints shall not be permitted in the lipping.

11.14.3.7 Rebating

In the case of double leaves shutters the meeting of stiles shall be rebated by 8 mm to 10 mm. The rebating shall be either splayed or square type as shown in drawing where lipping is provided. The depth of lipping at the meeting of stiles shall not be less than 30 mm.

11.14.3.8 Opening for Glazing

When required by the purchaser opening for glazing shall be provided and unless otherwise specified the opening for glazing shall be as per drawings. The bottom of the opening shall be at

a height as shown in the drawings. Opening for glazing shall be lipped internally with wooden batten of width not less than 25 mm. Opening for glazing shall be provided where specified or shown in the drawing.

11.14.3.9 Tolerance

Tolerance on width and height shall be + 3 mm and tolerance on nominal thickness shall be ± 1.2 mm. The thickness of the door shutter shall be uniform throughout with a permissible variation of not more than 0.8 mm when measured at any two points.

11.14.3.10 Adhesive

Adhesive used for bonding various components of flush door shutters namely, core, core frame, lipping, cross-bands, face veneers, plywood etc. and for bonding plywood shall conform to BWP type, phenol formaldehyde synthetic resin adhesive conforming to IS 848.

11.14.3.11 Tests

Samples of flush door shutters shall be subjected to the following tests:

- End Immersion Test
- Knife Test
- Glue Adhesion Test

11.14.3.12 Fixing

For side hung shutters of height up to 1.2 m, each leaf shall be hung on two hinges at quarter points and for shutter of height more than 1.2 m, each leaf shall be hung on three hinges one at the center and the other two at 200 mm from the top and bottom of the shutters. Top hung and bottom hung shutters shall be hung on two hinges fixed at quarter points of top rail or bottom rail. Centre hung shutter shall be suspended on a suitable pivot in the center of the frame. Size and type of hinges and pivots shall be as specified. Flap of hinges shall be neatly counter sunk into the recesses cut to the exact dimensions of flap. Screws for fixing the hinges shall be screwed in with screwdriver and not hammered in. Unless otherwise specified, shutters of height more than 1.2 mm shall be hung on butt hinges of size 100 mm and for all other shutters of lesser height butt hinges of size 75 mm shall be used. For shutter of more than 40 mm thickness butt hinges of size 125 × 90 × 4 mm shall be used. Continuous (piano) hinges shall be used for fixing cup-board shutters where specified. Fittings shall be provided as per schedule of fittings decided by Architect Cost of providing and fixing shutter shall include cost of hinges, door closer, handle, lock and necessary screws for fixing the same. The fittings shall conform to specifications laid

down under the hardware list which is coming up in the document later. Where the fittings are stipulated to be supplied by the Client free of cost, screws for fixing these fittings shall be provided by contractor and nothing extra shall be paid for the same.

11.14.3.13 Measurements

Length and width of the shutters shall be measured to the nearest cm in closed position covering the rebates of the frames but excluding the gap between the shutter and the frame. Overlap of two shutters shall not be measured. The overall openings to be measured in case the doors are paid in Nos.

11.14.4 FIRE RATED / GENERAL PURPOSE STEEL DOOR

11.14.4.1 Scope

This specification covers the design, supply of materials, manufacture and installation of factory made type fire rated steel doors with 1 (one) Hour or 2 (two) Hours fire rating / General purpose Steel Door of approved make with different rating as per the requirements with all accessories, hard wares, iron Mongery, fastening materials and including installation of door with hard wares in position.

11.14.4.2 General requirements

The Nominated sub Contractor shall furnish all materials, labour, operations, equipment, tools and plant, scaffolding and incidentals necessary and required for the completion of metal work in connection with steel doors, as called for in the drawings, specifications and bill of quantities which cover the major requirements only. Anything called for in the tender documents shall be considered as applicable to the items of work concerned. The supply and installation of additional fastenings (Metal expansion Shields), accessory features and other items not specifically mentioned, but which are necessary to make a complete functioning installation shall form a part of this contract.

All metal work shall be free from defects, impairing strength, durability and appearance and shall be of the best quality for purposes specified made with structural properties to withstand safety strains, stresses to which they shall normally be subjected to. All Hardware fittings and Accessories shall be of high quality and as specified and as approved by the Employer / OE and PMC.

The Nominated subcontractor shall strictly follow, at all stages of work, the stipulations contained

in the Indian Standard Safety Code and the provisions of the safety code and the provision of the safety rules as specified in the General Conditions of the Contract for ensuring safety of men and materials.

Any approval, instructions, permission, checking, review, etc. whatsoever by the Employer / OE and PMC, shall not Relieve the Nominated subcontractor of his responsibility and obligation regarding adequacy, correctness, completeness, Safety, strength, quality, workmanship, etc.

The Nominated sub-Contractor shall submit the Shop drawing for all works including all details, and after check by his own Engineer. The Nominated subcontractor shall not commence the work before obtaining prior and final approval for shop drawings incorporating the changes, if any, instructed by the Employer / OE and PMC. Such prior approval shall not relieve the Nominated subcontractor from his responsibility of correctness of design, workmanship and material errors and omissions, if any.

11.14.4.3 CODES AND STANDARDS

All standards, specifications, acts, and codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions.

List of certain important Indian Standards, Acts and Codes applicable to this work is given below. However, the applicable standards and codes shall be as per this but not limited to the list given below:

IS : 277	Galvanized steel sheet (plain and corrugated) of GPL Grade Z 120 coating.
IS: 3614 Part 1 and 2/ BS 476 Part 20 and 22	Metallic and non-metallic fire check doors - Resistance test and Performance criteria.
BS 7352 /BS EN 1935	Specification of Hinges

11.14.5 HOLLOW METAL FIRE DOOR / GENERAL PURPOSE DOOR WITHIN FILL MATERIAL AS PER MANUFACTURER'S SPECIFICATION.

Fire door shall be 1 Hour / 2-hour fire rated and door quality shall be approved by CBRI, and the door should be tested to conform the Performance Criteria as per IS: 3614 and should meet the

requirements of CBRI. General purpose Door shall be as per Manufacturer's specification. Unless otherwise specified, the door shall be provided to the height of 2100 mm. If the height specified as above 2100 mm and up to 3000 mm height, the options would be:

a) A man operation door up to 2100 mm high shall be provided with a removable / fixed panel on top as below: (i.e. above 2100 mm level as below).
b) Fire Door: Fully flush double skin steel panel construction to a total thickness of 46 mm.
c) General purpose Door: Fully flush double skin steel panel construction to a total thickness of 46 mm or fixed Glazing Panel on the top with Single / Double glass panel.

The construction and finish of panel above 2100 mm level shall be designed like that of a shutter in case of flush panel in order to match the exterior finish.

11.14.5.1 Door frame Material

Frame shall be manufactured by using Galvanized steel sheets complying with latest IS 277. Galvanized coating shall be GPL grade Z 120 coating.

Profile:

Fire Door and General Purpose door frame profile shall be as given below:

Fire Door - 2 Hour rating: Double rebate profile of size 143 x 57 mm (+/- 0.3) with bending radius of 1.4 mm.

Fire Door - 1 Hour rating: Single rebate profile of size 100 x 57 mm (+/- 0.3) with bending radius of 1.4 mm.

General Purpose Door: Single rebate profile of size 100 x 57 mm (+/- 0.3) with bending radius of 1.4 mm.

Manufacture: Frame shall be fabricated from galvanized steel sheet to the thickness specified below and to the specified profile and dimensions:

- Fire Door - 2 Hour rating : 16 Gauge or 1.6 mm thick.
- Fire Door - 1 Hour rating : 18 Gauge or 1.25 mm thick.
- General Purpose Door : 18 Gauge or 1.25 mm thick.

Frames fabricated at factory shall be in knock down form with butt joints for bolted assembly at site or as per manufacturer's Specification.

Preparation:

Frames shall be provided with 3 mm thick back plates on all jambs with provision for anchor bolt fixing to wall openings.

Frames shall be provided with hinge plates 3 mm thick pre-drilled to receive approved type and make of hinges for screw mounted fixing.

Frames shall have factory finish-pre-punched cut outs to receive specified type and make of hardware and iron Mongery. All cut outs including hinge plates, strike plates to have mortar guard covers from inside to prevent cement, dust ingress into cut outs at the time of grouting of the frame.

Frames shall have reinforcement pads for fixing of door closer, locks and handles at appropriate location as per manufacturer's details.

Frames shall have plug-in type rubber silencer not less than 2 mm dia on the strike jambs for single shutter frames and on the head jambs for double shutter frames.

11.14.5.2 Door shutter

Material

a) Shutter shall be manufactured with double skins press formed by using Galvanized steel sheets complying with latest IS 277. Galvanized coating shall be GPL grade Z 120 coating.

b) Profile:

c) Shutters should be press formed with double skins in such a way to get 46 mm thick double skin hollow door with lock seam joints at stile edges.

Fire Door and General-Purpose door frame profile shall be as given below:

a) Fire Door - 2 Hour rating : 18 Gauge or 1.25 mm thick.

b) Fire Door - 1 Hour rating : 20 Gauge or 0.80 mm thick.

c) General Purpose Door : 20 Gauge or 0.80 mm thick.

Shutters shall have no visible screws or fasteners on both face and internal reinforcement shall be provided at top, bottom and stile edges for desired fire rating.

In Fill Material

Shutters shall be provided with honeycomb paper core as infill material and to be bounded to the inner faces of the shutter or as per Manufacturer's specification. Door should have been tested with Infill material proposed by the manufacturer and the same should have been approved by CBRI.

Preparation

Shutters shall be provided with factory prepared and with pre-punched cut-outs and reinforcement pads to receive the approved type and make of Hardware and Iron Mongery. The shutter should have an interlocking arrangement at this stile edges for flat surface on either side.

Shutters shall have pre-drilled hinge plates with hinge guard covers.

Shutters with locks to have concealed lock box with lock fixing brackets with pre-tapped holes and screws.

Shutter shall have reinforcement pad at appropriate location to receive the locks, Door closer, Panic Bar, etc as per the approved type and make of Hardware and all as per manufacturer's design and conforming to Standards.

Necessary provision / fixing arrangements shall be provided in the shutter as well as in the frame to receive / fix the Electromagnetic latch, Electromagnetic contact for hooters with reinforcement pads and in such a way to connect the same to the card access control system / IBMS. Fixing Details of the above latches shall be provided in coordination with IBMS agency.

Vision panel shall be provided as given below

a) Fire rated Door (1 Hour / 2 Hour) - Provide Borosilicate single clear toughened glass of approved equivalent make to the thickness of 6 mm to with stand two hours fire rating.

b) General purpose Door - Provide Single / Double clear toughened glass of approved equivalent make to the thickness of 5 mm to the specified size and as per Manufacturer specification. Glass to be fixed with clip on frames for square and rectangular vision panels and with spin turned rings for circular vision panels. One side adhesive Glazing tape shall be provided in the frame to fix the vision panel glass in position and ensuring the stability of the fixing.

c) Finish – Frame and Shutter:

d) Surface of the frame and shutter shall be cleaned suitably and thoroughly with solvents and as per manufacturer's specification.

e) Apply Zinc etch primer coating as shop coat to receive additional coat of primer and top coats.

f) Apply stove zinc phosphate primer (35 microns DFT) as additional coat.

g) Apply as finish coat and finish the surface neatly with thermo setting polyurethane paint (35 microns DFT) of approved colour and make.

h) PACKING

i. Individual frames members and individual shutters to be wrapped and protected with self-adhesive Peel-off Polythene sheets or Co extruded PE film to a minimum thickness of 60 Microns, with low tack adhesive and with abrasion resistant for a minimum period of 6 months and UV resistant capability.

ii. Individual frames members and individual shutters to be packed in an individual card board boxes and to be sealed with Identification numbers.

iii. All frames and shutters shall be marked with identification number in such a way install the door according to the door schedule.

i) STORAGE

Frames shall be stacked flat and shutters shall be stacked vertically on wooden runners and suitably covered as per the manufacturer's instructions to prevent rust and damage.

j) INSTALLATION

k) FRAME:

i. Door frames should be assembled adjacent to the place of installation as per the Manufacturer's specification. Frames are not allowed for transporting in an assembled condition. If the manufacturer is desired to transport the frames in an assembled condition, the frames should be designed suitably and adequate packing to be given prior to transport in order to avoid any damage, bending etc during transport. If any defects found during the installation, such frames will be summarily rejected and will not be allowed to use.

ii. After assembly it is to be ensured that all threaded preparations / joints are covered by using 15 x 10 self adhesive sponge strips at the back of the frame to prevent penetration of grouting mortar into screw threads. The head member of assembled frame shall be positioned against jambs ensuring correct alignment and secured using M 8 x 20 mm long plated Stainless steel bolts together with nuts spring and flat washers. Frames to be assembled at site with aid of roofing bolts and the protective film shall not be removed during installation.

iii. Assembled frame shall be kept in position within the opening by means of bracing. In order to correctly position the frame against finished floor level or equalize on adjustable floor anchors where specified, suitable strength PVC nylon shim shall be used under jambs. The frame shall be checked for square ness, alignment, twist etc. with carpenters bevel and plumb.

iv. A tie rod shall be fixed to the frame during installation to ensure the correct dimensions between the frame rebates and the same may be removed after installation.

v. Where fixing the frame is necessitated, the required gap between frame and jambs shall be created to accommodate the PVC nylon shims in such a way to maintain the uniform frame level.

vi. Methodology to be followed during the installation of the frames:

vii. Site survey shall be conducted to ensure the opening size and reveal the correct opening size prior to installation of the frames.

viii. Place the frame in position, brace, level etc.

ix. Mark all positions of fixings anchors on the wall / lintel.

x. Remove frame and drill wall to appropriate fastener or anchor bolts size.

xi. Place and fit rod anchor shells metal expansion bolts into the wall.

xii. Place and fit jamb spacer bracket into back of frame profile.

xiii. Reposition the frame back into opening and realign.

xiv. Lightly tighten the CSK HD machine screws into shells.

xv. Check the position of the nylon shims placed behind frame to ensure the uniform gap between the frame and jamb.

xvi. Slowly fasten the screws continually by checking the plumb, square ness etc. and finally ensure that the frames are not deformed while tightened.

xvii. After fixing the frame in position, the frame shall be pressure grouted with cement slurry 1:3 ratio or filling the pre- cast solid block core to the frame profile as approved. The surface after grouting shall be neatly cleaned and to be ensured that there is no scratch in the door frames after grouting.

xviii. Back fill the frame through holes provided and insert plug in type nylon plugs after cleaning the surface. Nylon plugs shall be provided to suit the frame finish and colour.

xix. Gap between the frame and masonry surface shall be grouted with cement slurry and sealed with Intumescent sealant of approved make, if called for in the Bills of quantities.

l) SHUTTER:

i. Fix all the hardware to the door shutter like hinges, flush bolts, bolts, Mortise locks, Dead lock, handle, Push plate, Door closer, Door stoppers, etc. with the appropriate SS screws and bolts supplied.

ii. The shutter is to be then fixed in to the installed frame and align the shutter to match the hardware to the cut-outs in the frame. Tighten the hinge screws.

iii. Clean the door jamb rebate surfaces of all dust, oil etc.

iv. Affix self-adhesive 'FLAT' seal on the door frame rebates, on hinge jambs, strike jambs, head member, sill etc and affix 'FLAT' seal in the shutter by using self-adhesive EPDM smoke seal 'FLAT' type (Polyethylene cross linked foam of size 2 mm thick and 12.5 mm width) of Monarch Make and as indicated by the manufacturer and if specifically called for in the bills of quantities.

HARDWARE SCHEDULE:

Refer the Hardware Schedule enclosed along with BOQ.

a) TESTING / INSPECTION and GURANTEE:

During the process of manufacturing the Door by the agency, successful vendor shall arrange an inspection of the factory by the representative of Employer/OE and PMC/LA within the quoted rate. After installing the door, the Nominated sub Contractor shall test the performance of the Door Frame and Shutter in the presence of the Employer / OE and PMC. The doors shall be smoothly operable under all ambient conditions. All control, hardwares and locking devices shall give fault free performance.

A successful bidder shall arrange a test for one door with the specified hardware and place the door for testing in exactly the same way as fixed at site. The Employer / OE and PMC at random basis will select the door during the process or end of the manufacture and conduct the test at an approved laboratory in the presence of the representative of Employer / OE and PMC within the quoted rate and ensure that the door shall comply with the set out criteria.

Provide a guaranteed certificate and Test certificate for the tested door in an acceptable format in a stamped paper.

11.14.6 2-HOUR NON METAL FIRE RATED DOOR

2 Hours fire Non Metal fire rated doors system duly tested for integrity and Insulation as per the IS:3614 part 2 and BS:476 part 20 at FRL CBRI Roorkee with standard heating conditions as specified in IS:3809 - 1979 and BS:476 part 20 and 22 1987 to achieve the required integrity and insulation (I.e. to restrict the heat radiation, temperature rise on the non fire side to the maximum of 140 degree Celsius above the ambient temperature on the

unexposed surface of the shutter), Framework to be in Seasoned hardwood (Moisture contain limited to 18%) frame of section 150mm X 75mm with 1 nos. of approved make Intumenscent strip to take care of Hot smoke size of 20mm X 2mm cancelled in the grove of the frame with fixing arrangements of 3 nos. of G.I. hold fast 225mmX20mmX4mm with split end on either side and wall grouted with cement concrete mix 1:3;6 adjustable lugs with split end tail to each jamb alternatively approved make Anchor Fastener, including 4 nos. of stainless steel ball bearing hinges of SS 304 quality of size 102mmX102mmX3mm thick to capable of taking load up to 120 Kg of the shutter with SS pin, lock strike plate, shock absorbers as specified and 56mm thick single leaf shutter made out of perimeter railing of Seasoned Red Marenti hard wood (Moisture contain limited to 18%) of size 100mmX30mm and 2 nos. of 9mm thick Promina – 60 board duly HOT PRESSED with 4mm Commercial / Marine Ply to get the require surface for Laminate/ Veneer/ Paints with 30mm thick Non–combustible Fire Retardant compound and Fire Intumenscent Seal of size 20mm x 2mm mounted in the grooves in the shutter on all sides except bottom with 10mm thick teak wood beading on all side and Intumenscent sealant is used to seal the gaps between Promina-60 Board and shutter beading. The fire Doors with frame will be as per IS:3614 part 4 and BS:476 part 20 at FRL CBRI Roorkee with standard heating conditions as specified in IS:3809 - 1979 and BS:476 part 20 and 22 1987 all complete to the entire specification with the certified copy of the valid Test Certificates

11.14.7 TRAP DOOR

The trap Door should be of size as mentioned in the drawings. It should be made from 19mm marine grade plywood and finished in 1mm thick approved shade laminate on the exposed side and balancing laminate, 0.8mm thick on the underside. The edges to be in finished in 6mm thick teakwood lipping and finished in approved melamine polish. The framework should be as mentioned in the drawings. The cost should include hardware like a hatch using self-adjusting clasping springs, with a lock and hinge mechanism that is integrated in the frame corners and concealed. The system should be equipped with round cylinder lock / square bolt / lock, designed for profile cylinders Product / system. Item should include all accessories, fitments, man and

material, correct installation procedure, necessary cutting in False ceiling strictly with unit template and finishing, cleaning complete.

Method and workmanship

The location of the trap door to be neatly located, surrounding surface cleaned of all dust and grime. The location and outline of the trap door should be neatly marked. This should strictly be the cut-line, any opening larger or smaller than this is not technically appropriate and may lead to malfunctioning of the Trap door. The self tapping screws provided for in the unit packing and the corresponding raul-plugs to be strictly used. Only the indicated number of screw holes and their indicated positions should be followed. The trap door is a system designed to rest on false ceiling Gypsum board. Any installation damages to false ceiling can be touched up with gypsum plaster. Post installation finishing involves neat painting touch-up to the vicinity, with masking tapes on the Trap door rim.

Working Platform and Safety

A local portable ladder of sufficient stoutness and stability should be used for reaching out to the false ceiling.

Making good

Post installation inspection should follow sufficient drying of paint and removal of masking tapes & fine touch-up if need be.

Mode of Measurement and payment

Mode of measurement should be in Sqm. Architect/Consultant certified completed units to be eligible for measurement for payment.

11.15 DOOR HARDWARE

Mortise Latch

1) Shall carry manufacturer's warranty of 1 year
2) Euro Mortise Passage Latch - Inside and Outside shall be opened by handle at all times
3) Shall comply with EN12209-1 and BS 5872 Standards

4) Shall be Tested for 5,00,000 cycles
5) Shall be suitable for wooden, metal and fire doors (latch functions) with 60mm standard back set
6) Shall be suitable for doors of thickness range 30mm to 50mm
7) Latch bolt, Deadbolt, Faceplate shall be made of Stainless Steel
8) Shall have Satin Stainless Steel finish
9) As an option locks may be Fire tested to GB7633 standards, CNACL certified, AS 130.4-2005 Standard
10) Euro Mortise Lock - Outside – Shall be opened by handle when unlocked. Lever shall withdraw latch bolt. Key shall lock or unlock bolt, key shall withdraw latch bolt. Inside – Shall be opened by handle when unlocked. Lever shall withdraw latch bolt. Key shall lock or unlock bolt, key shall withdraw latch bolt.
11) Euro Mortise Deadbolt - Outside - Bolt shall be locked or unlocked by key or turn. Inside - Bolt shall be locked or unlocked by key or turn
12) Euro Mortise Night latch – Outside – Latch bolt shall be withdrawn by key or turn. Inside – Latch bolt shall be withdrawn by key or turn.
13) Euro Mortise Privacy Lock – Outside – Shall be opened by handle except when bolt is thrown by turn knob from inside. Bolt may be unlocked from outside by coin or screwdriver by operating the slotted emergency button. Inside – Shall be opened by handle except when bolt is thrown by inside turn knob.

Euro Cylinder –

1) Shall carry manufacturer’s warranty of 1 yr
2) Shall be of 5 pin Euro Double Cylinder
3) Shall be suitable to be used with Euro Profile Mortise Locks
4) Shall have C4 Key Profile, 70mm length and have 3 keys
5) Shall have Satin Chrome Finish

Euro Single Cylinder with Thumb turn –

1) Shall carry manufacturer’s warranty of 1 yr
2) Shall be of 5 pin Euro Single Cylinder with Turn
3) Shall be suitable to be used with Euro Profile Mortise Locks
4) Shall have C4 Key Profile
5) Shall be of 65mm length
6) Shall have 3 keys
7) Shall have Satin Chrome Finish

Tubular Lever Handle –

1) Shall carry manufacturer's warranty of 1 yr
2) Tubular Lever on Rose shall be with Euro Profile Escutcheon
3) Shall be made of Stainless Steel Grade 304
4) Shall have Satin Stainless Steel Finish
5) Shall be tested for corrosion resistance in accordance with AS 2331.3.1 Neutral Salt
6) Spray Test

Euro Profile Escutcheon or Rose –

1) Shall carry manufacturer's warranty of 1 yr
2) Euro Profile Rose material
3) Stainless Steel Grade 304
4) Satin Stainless Steel Finish
5) Tested for corrosion resistance in accordance with AS 2331.3.1 Neutral Salt Spray Test

Entrance Handle –

1) Shall carry manufacturer's warranty of 1 yr
2) Shall be tubular Back to Back Pull Handle
3) Shall have spigots to suit 10 – 12mm thick glass doors as well as spigots to suit aluminium and timber doors up to 50mm thick
4) Shall be made of 304 grade stainless steel construction suitable for use in external environments
5) Shall have Satin Stainless Steel Finis

Cylindrical lever –

1) Shall carry manufacturer's warranty of 1 yr
2) Shall be suitable for semi commercial applications such as apartments and offices
3) Back set shall be 60mm standard. Extension tubes shall be available for 127mm back set
4) Latch bolt shall be of Stainless Steel
5) Shall suit door thickness of 35-46mm
6) Shall have standard T Strike
7) Shall have Satin Stainless Steel finish
8) Shall have field changeable handing
9) Shall be successfully tested up to 4 hours on fire door assemblies in accordance with Australian Standards AS-1905 Part 1, fire resistant door sets

Patches –

1) Shall carry manufacturer's warranty of 1 yr
2) Shall be suitable for doors with maximum weight 80Kgs and maximum width 1100mm
3) Shall have Satin Stainless Steel Finish

Doorstop/ Security door chain/ door guard / other door accessories–

1) Shall carry manufacturer's warranty of 1 yr
2) Shall be made of 304 Grade Stainless Steel
3) Shall have Satin Stainless Steel finish

Hinges–

1) Shall carry manufacturer's warranty of 1 yr
2) Stainless Steel Ball Bearing Button Tip Hinge
3) Shall be suitable for interior / exterior doors
4) Shall be with two ball bearings
5) Shall be manufactured of 304 Stainless Steel
6) Shall be with Fixed Pins of Standard Imperial Hole pattern
7) Shall be of size as per manufacturer's specifications
8) Finish shall be Satin Stainless Steel

Kick Plates–

This shall be of brass (finished bright or chromium plated or oxidized) bronze, stainless steel, aluminum or as specified. Aluminum kicking plates shall be anodized and the anodic coating shall not be less than grade AC-10 of IS 1868. It shall be made from a plate of minimum thickness 3.0 mm & 1.5mm in case of stainless steel. Shape of the plate shall be as specified. This shall have beveled or straight edges and shall be fixed by means of counter sunk or rounded screws of the same material and finish as that of the plate. The shape and pattern shall be according to the drawings and as approved by the PMC/Employer.

12.0 MISCELLANEOUS

12.1 GROUTING

12.1.1 SCOPE

The works covered by this specification consists of supplying all materials; furnishing all equipment's, labor etc.; performing all operations; for placing grouts at locations such as under column base plates, anchor bolt pockets, under machine or equipment bases etc. The works shall be carried out in conjunction with other contractors/vendors who are responsible for erection of their structures and equipment's and maintaining the levels, alignments etc. of their bases.

12.1.2 TYPE OF GROUTS

There are three types of grouts to be used.

- Standard dry pack grouts,
- Non-shrink cementitious grouts,
- Non-shrink epoxy grouts,

The type of grout to be used shall be as specified in the drawings/ advised by engineer.

12.1.3 STANDARD DRY PACK GROUTS

Standard dry pack grouts are prepared by mixing of cement and sand. The proportions of grout shall be such as to produce a flowable mixture consistent with minimum water content and shrinkage. Quantity of water shall be such so that it is just enough for compaction and hydration and shall have the consistency of damp sand. Sand used shall meet the usual grading specification for concrete.

a) The grout proportions shall be limited as follows:

Use	Grout thickness	Mix Proportions	W/C Ratio (Max)
Fluid Mix	Under 25mm	One part Portland Cement to one part sand	0.44
b) General	25mm and over but less than 50mm	One part Portland Cement to 2 parts of sand	0.53
c) Stiff Mix	50mm and above	One part Portland Cement to 3 parts of sand	0.53

(b) Sand:

i) Sand shall be such as to produce a flowable grout without any tendency to segregate.

ii) Sand, for general grouting purposes, shall be graded within the following limits:

Passing IS 2.36 mm sieve 95 to 100%
Passing IS 1.18 mm sieve 65 to 95%
Passing IS 300-micron sieve 10 to 30%
Passing IS 150-micron sieve 3 to 10%

iii) Sand for fluid grouts shall have the fine material passing the 300 and 150-micron sieves at the upper limits specified above.

i) Sand, for stiff grouts, shall meet the usual grading specifications for concrete

12.1.4 Non-Shrink Cementitious Grouts

These shall be a pre-proportioned product, obtained from approved manufacturers, containing a mixture of aggregate, cement and admixtures, pre-blended and pre-packaged requiring only the addition of water at site. Unless mentioned otherwise, it shall be used below all structural base plates and associated anchor bolt pockets. It can also be used below all static and rotating equipment bases having no or low impact loads. It should not be used in areas where the grouts are subjected to corrosive atmosphere and chemical attacks. The material shall be chloride free and must not contain expansive cements or metallic particles such as aluminum powder or iron fillings.

12.1.5 Non-Shrink Epoxy Grouts

These are two components epoxy bonding systems mixed with oven dry aggregate and other proprietary materials. It shall be obtained from approved manufacturers. The components shall be mixed in complete units in accordance with manufacturer's recommendations. If not specifically mentioned, it shall be used in areas where the grouts are subjected to corrosive atmosphere or aggressive chemicals and/or shock or heavy impact loads below equipment bases, such as reciprocating machines, crushers, crane rails etc. Where epoxy grouts are subjected to temperature more than 50o C, manufacturer's advice shall be sought before its use, as its stiffness and strength get affected under high temperature.

12.2 GENERAL

12.2.1 The thickness of standard dry pack grouts shall be minimum 75mm. However, thickness of flowable grout can be anywhere between 20 to 50mm.

12.2.2 Generally, the type of grout selected shall have twice the strength of the base concrete on which the grout is placed.

12.2.3 The grouts shall be chloride free.

12.2.4 They shall be used following strictly the manufacturer's specification.

12.2.5 All materials shall be delivered to site in original unopened packages, clearly labelled with the manufacturer's identification and printed instructions. The contractor must submit the manufacturer's certified test data on the grout's constituents, 24 hour compressive strength and its flowability, from approved test laboratory, prior to placement of order. Manufacturers shall also give warranty saying that the nonshrink grout supplied shall never go below its initial placement volume.

12.2.6 Plain Cement Grouts:

Cement grout shall be prepared using ordinary portland cement along with an approved admixture to overcome operated shrinkage. It is recommended to use plasticised expanding grout admixture. Proportion or admixture quantity or water and type of mixing shall be as per manufacturer's instructions. Compatibility of admixture with the type of cement used shall be ascertained before use of any admixture with cement.

12.2.7 Special Grout

Ready mixed special grout shall be used wherever they are specified or called for in the drawing or as advised by the engineer. The type of grout to be used shall be as per their strength requirements and as per manufacturer's recommendation depending on the type of load they will be subjected to - light, heavy or dynamic. Generally, the type of grout selected shall have twice the strength of the base concrete. The thickness of grout shall generally vary depending on the situation and shall be in the range of 15mm to 50mm.

12.3 PREPARATION / WORKMANSHIP

12.3.1 Concrete surfaces to be grouted shall be thoroughly roughened by sand blasting or other mechanical means and cleaned of all loose materials/ foreign matter and laitanance from the surface.

12.3.2 Anchor bolts, anchor bolt holes and the bottom of equipment and column base plates shall be cleaned of all oil, grease, dirt and loose material.

12.3.3 Prior to grouting, the hardened concrete surfaces on which the cementitious grouts are to be placed shall be saturated with water. All standing water shall be removed from the concrete surface as well as from anchor bolt holes before grouting is started. However, surface shall be dry before placing epoxy grouts.

12.3.4 Water used for mixing of grout shall be clean and free from oils, acids, alkalies, organics and other deleterious materials.

12.3.5 Forms must be rigid to completely confine and withstand the pressure of grout during placement, without any deformation. It should be tight to prevent any leakage. All cracks and joints in the form works shall be caulked with an elastomeric sealant. It shall be lined with polyethylene or such material for easy removal. Air relief holes must be provided, to remove any entrapped air below the plates during grouting. Chamfer edges shall be built in with the form works, for epoxy grouts.

12.3.6 Forms around base plates shall be reasonably tight to prevent leakage of the grout. When the base is to be flow grouted, forms shall be built and securely anchored outside the base plate

so as to completely confine and withstand the pressure of liquid grout under working and rodding condition without leaking and provide a head of minimum 100 mm above the underside of the base plate to ensure the grout is in full contact with the underside of the base plate. Provisions of grout holes in base plates, rodding, arrangements shall be checked prior to commencement of grouting.

12.3.7 Adequate clearances shall be provided between forms and base plate to permit grout to be worked properly into place.

12.3.8 Grouting, once started, shall be done quickly and continuously to prevent segregation, bleeding and break down of initial set. Grout shall be worked from one side of one end to the other to prevent entrapment of air. To distribute the grout and to ensure more complete contact between base plate and foundation and to help release of entrapped air, link chains or doubled over flexible steel strapping's may be used to work the grout into place.

12.3.9 Grouting through holes in base plates shall be by pressure grouting. The pressure to be used for grouting shall be as directed by the ENGINEER.

12.4 INSTALLATION

12.4.1 Ready mixed grouts shall be mixed in the manner and in accordance with manufacturer's recommendations and shall be used in the form of liquid. Consistency of grout shall be such so that it can maintain its flowability within the gap provided below the base plates, during its entire period of placement. Grouts shall be placed from one end to the other. Grouting, once started, shall be finished quickly and continuously to prevent segregation, bleeding and starting of initial set. No water or solvent shall be added to change the consistency if the grout stiffens during placement. The stiffened grouts along with other grout, in place but not completed, shall be removed.

12.4.2 All equipments and tools shall be cleaned thoroughly before use. For cementitious grouts, the mixer shall be wetted and excess water removed, before mixing begins.

12.4.3 After the bases of structures and equipments are levelled and aligned by other vendors, by using shims, the liquid grouts shall be placed by flowing or by pumping. Standard dry pack grouts, if used, shall be placed by rodding. Extreme care shall be taken to see that alignment and levels of bases are not disturbed during grouting.

12.4.4 The grouts shall be prepared only to the extent it can be used within the specific potlife by the manufacturer. Any leftover grout or grouts not consumed within the potlife time shall not be used and shall be discarded. The shelf life of the grout shall also be checked before they are used. Grouts having expired date shall not be used under any circumstances.

12.4.5 The cementitious grouts shall be cut back at an angle of 45o or vertical, as shown in the drawing, after the grout has reached its initial set.

12.4.6 Forms and shims shall not be removed and the anchor bolts shall not be tightened for at least twenty four hours after placing the grout. After removal of forms and peripheral shims, area occupied by shims shall be filled and the area between the base and the edge of the foundation shall be finished smooth to allow drainage away from the base. Interconnecting piping and machinery shall not be attached to the machinery before anchor bolts are tightened. It is desirable to make these connections at least after a minimum of seven days from the date of grouting. During this period, the grout shall be properly cured.

12.4.7 Grout shall be cured in accordance with manufacturer's specification and recommendation.

12.5 INSPECTION

12.5.1 All materials, workmanship and finished construction shall be subject to the continuous inspection and approval of ENGINEER.

12.5.2 All materials supplied by CONTRACTOR and all works or construction performed by CONTRACTOR and rejected - as not in conformity with the specifications and drawings - shall be immediately replaced at no additional expense to the OWNER.

12.5.3 Preliminary approvals of any materials or phase of work shall in no way relieve the CONTRACTOR from the responsibility of supplying grouting materials and or producing finished grout in accordance with the specifications and drawings.

12.5.4 All grouting shall be protected against damage until final acceptance by OWNER or his representative.

12.5.5 Upon the completion of grouting work, all forms, equipment, construction tools, protective coverings and any debris shall be removed from the area as directed by the ENGINEER.

12.6 WATERSTOPS

12.6.1 MATERIAL

The material for the PVC waterstops shall be a plastic compound with the basic resin of polyvinyl chloride and additional resins, plasticizers, inhibitors, which satisfies the performance characteristics specified below as per IS:15058. Testing shall be in accordance with IS: 8543, IS 13360 and IS 9766.

(a) Tensile strength: 13.8 MPa minimum
(b) Ultimate elongation: 285% minimum
(c) Hardness (Shore A): 65, minimum
(d) Water absorption: 0.6 maximum

(e) Cold bend temp at which samples do not crack : -25Oc minimum

(f) Accelerated extraction

i) Tensile strength: 10.3 Mpa minimum

ii) Ultimate elongation: 280% minimum

(g) Effect of Alkali: 7 days

i) Weight increase: 0.25% maximum

ii) Weight decrease: 0.10% maximum

iii) Hardness change: ± 5 points

(h) Effect of Alkali: 28 days

i) Weight increase: 0.40% maximum

ii) Weight decrease: 0.30% maximum

iii) Dimension change: ± 1%

PVC water stops shall be either of the bar type, serrated with centre bulb and end grips for use within the concrete elements or of the surface (kicker) type for external use. The width, type, minimum thickness and safe hydraulic head requirements shall be as specified in the individual items of work.

PVC water stops shall be of approved manufacture. Samples and the test certificate shall be got approved by the ENGINEER before procurement for incorporation in the works.

12.7 WORKMANSHIP

12.7.1 Water stops shall be laid as per IS 12200. It should be cleaned before placing them in position. Oil or grease shall be removed thoroughly using water and suitable detergents.

12.7.2 Water stops shall be procured in long lengths as manufactured to avoid joints as far as possible. Standard L or T type of intersection pieces shall be procured for use depending on their requirement. Any non-standard junctions shall be made by cutting the pieces to profile for jointing. Lapping of water stops shall not be permitted. All jointing shall be of fusion-welded type as per manufacturer's instructions.

12.7.3 Water stops shall be placed at the correct location/level and suitably supported at intervals with the reinforcement to ensure that it does not deviate from its intended position during concreting and vibrating. Care shall also be taken to ensure that no honeycombing occurs because of the serrations/end grips, by placing concrete with smaller size aggregates in this region. Projecting portions of the water stops embedded in concrete shall be thoroughly cleaned of all mortar/ concrete coating before resuming further concreting operations. The projecting water stop shall also be suitably supported at intervals with the reinforcement to maintain its intended position during concreting so as to ensure that it does not bend leading to formation of pockets. In addition, smaller size aggregate shall be used for concreting in this region also.

12.8 PREFORMED FILLERS AND JOINT SEALING COMPOUND

12.8.1 MATERIALS

12.8.1.1 Preformed filler for expansion/isolation joints shall be non-extruding and resilient type conforming to IS: 1838 (Part II).

12.8.1.2 Bitumen coat to concrete/masonry surfaces for fixing the preformed bitumen filler strip shall conform to IS: 702. Bitumen primer shall conform to IS: 3384.

12.8.1.3 Sealing compound for filling the joints above the preformed bitumen filler shall conform to Grade 'B' as per IS: 1834.

12.8.2 WORKMANSHIP

12.8.3 The thickness of the preformed bitumen filler shall be as specified in the respective items of work. CONTRACTOR shall procure the strips of the desired thickness and width in lengths as manufactured. Assembly of small pieces/thicknesses of strips to make up the specified size shall not be permitted.

12.8.3.1 The concrete/masonry surface shall be cleaned free from dust and any loose particles. When the surface is dry, one coat of bitumen primer conforming to IS: 3384 to be applied over which one coat of industrial blown type bitumen of grade 85/25 conforming to IS: 702 shall be applied hot by brushing at the rate of 1.20 kg/sq.m. When the bitumen is still hot, the preformed bitumen filler shall be pressed and held in position till it completely adheres. The surface of the filler against which further concreting/masonry work is to be done shall similarly be applied with one coat of hot bitumen at the rate of 1.20 kg/sq.m.

12.8.3.2 Sealing compound shall be heated to a pouring consistency for enabling it to run molten in a uniform manner into the joint. Before pouring the sealing compound, the vertical faces of the concrete joint shall be applied with a coat of hot bitumen primer conforming to IS: 3384 in order to improve the adhesive quality of the sealing compound.

12.8.3.3 Expansion joints between beams/slabs shall be provided with l00mm wide x 4mm thick mild steel plate at the soffit of RCC beams/slabs to support and prevent the preformed joint filler from dislodging. This plate shall be welded to an edge angle of ISA 50 x 50 x 6mm provided at the bottom corner, adjacent to the expansion joint of one of the beams/slabs, by intermittent fillet welding. Steel surfaces shall be provided with 2 coats of red oxide zinc chrome primer and 3 coats of synthetic enamel paint finish.

12.9 INSERTS AND CUTOUTS IN CONCRETE WORK

12.9.1 Numerous inserts are required to be fixed/ embedded in concrete. These inserts comprise plates, angles, pipe sleeves, anchor bolt assemblies, etc. While some of the inserts may be supplied by the Owner, free of cost at his stores, for incorporation in the works, other inserts are required to be supplied and fabricated by the Contractor. These would be indicated clearly on the construction drawings.

12.9.2 Contractor shall accurately fix the inserts at the correct levels/alignment and shall include any temporary supports/anchors such as bars including cutting, bending, welding, etc. as required.

12.9.3 Steel templates shall be used by the CONTRACTOR to locate and very accurately position bolts, groups of bolts, inserts, embedded parts, etc. at his cost. Such templates shall be got previously approved by the Engineer. Templates shall invariably be supported such that the same is not disturbed due to vibration, movement of labourers, materials, shuttering work, reinforcement, etc. while concreting. The CONTRACTOR will have to suitably bend, cut or otherwise adjust the reinforcement in concrete at the location of inserts, as directed by the Engineer. If the Engineer so directs, the inserts will have to be welded to reinforcement to keep these in place. The Contractor shall be responsible for the accuracy of dimensions, levels, alignments and centre lines of the inserts in accordance with the drawings and for maintenance of the same until the erection of equipment/structure or final acceptance by the Owner.

12.9.4 The Contractor shall ensure proper protection of all bolts, inserts, etc. from weather by greasing or other approved means such as applying white lead putty and wrapping them with gunny bags or canvas or by other means as directed by the Engineer to avoid damage due to movement of his labourers, materials, equipment, etc. No extra claim from the Contractor on this account shall be entertained. The Contractor shall be solely responsible for all damage caused to bolts, inserts, etc. due to his negligence and in case damage does occur, they shall be rectified to the satisfaction of the Engineer at the Contractor's cost.

12.9.5 Cut outs, chamfers, pockets, etc. shall be left as indicated in the drawings and no extra cost shall be payable for providing these at their correct locations. The Contractor shall take all necessary precautions to protect the cut outs from accidentally getting filled up or the edges getting broken.

12.10 MISCELLANEOUS INSERTS, BOLTS ETC.

All the miscellaneous inserts such as bolts, pipes, plate embedments etc. either supplied FREE by the OWNER or to be furnished by the CONTRACTOR shall be accurately installed in the building works at the correct locations and levels, all as detailed in the construction drawings. CONTRACTOR shall prepare and use templates for this purpose, if so directed by the ENGINEER. In the event any of the inserts are improperly installed, CONTRACTOR shall make

necessary arrangements to remove and re-install at the correct locations/levels, all as directed by the ENGINEER without any extra cost to the OWNER.

12.11 ALUMINIUM PANELS:

12.11.1 GENERAL

- Aluminium panels shall be solid aluminium or composite panels and shall satisfy the following minimum requirements:
- External Panels – minimum thickness
- 4mm solid aluminium
- 6mm composite aluminium
- Internal Panels – minimum thickness
- 3mm solid aluminium
- 4mm composite aluminium
- Perforated Panels- minimum thickness
- 1 mm perforated corrugated aluminium

13.0 STRUCTURAL DESIGN CONSIDERATION FOR STP.

(a) Design criteria of RCC structural units shall conform to the Design requirements of latest version of IS:456

(b) The bidder shall ensure design drawings and construction is in conformity with the latest applicable Indian Standards and sound engineering practice.

(c) Soil Condition, Ground Water Table and Bearing Capacity:

The Soil investigation report for the location is available and extract of the same is attached as part of tender document for designing the foundation system. The bidder may, if required, get himself satisfied with such investigation done at his end and nothing shall be paid on this account.

Bidder shall consider SBC as follows for designing the foundation system.

1. Raft Foundation all tanks shall be given at a depth of 3.75m **with an SBC of 130kN/m^2 from N.G.L**.

2. Isolated Foundation (blower room, MCC room, Operator room, Storeroom) shall be given at depth of 3.75m **with an SBC of 130kN/m^2 from N.G.L.**

The contractors shall submit the gross bearing pressure and other related documents for the structure, obtained after structural analysis, so that the SBC and the settlement of the soil at the proposed location shall be verified by Employer/PMC.

(d) Foundations:

The foundation shall be designed as per relevant BIS codes.

(e) Design Loads:

Buildings and structures for this project will be designed for the following loads

(i) Dead Load (DL)

The dead load is calculated based on unit weight of materials given in code IS: 875 (Part 1). The dead load considered in the structural design will consist of the full weight of all known fixed structural elements.

S. No.	Material	Density(kN/m^3)
1	Reinforced Concrete	25.0
2	Plain cement concrete	24.0
3	Cement Plaster	20.4
5	Structural steel	78.5
6	Water	10.0
7	Autoclaved Aerated Concrete (AAC) blocks	7.0

(ii) Imposed Load (LL)

The imposed loads to be considered in the design of buildings shall be the greatest loads that probably will be produced by the intended use or occupancy. The imposed loads shall be considered as per IS: 875 (Part-2).

(iii) Wind Load (WL)

The wind pressure shall be calculated on the basis of data specified in IS 875 (Part 3)

(iv) Seismic Load (SL)

The earthquake forces shall be considered in accordance with IS: 1893 (Part-1) with following parameters:

(i) Importance factor : 1.2

(ii) Damping: : 5%

(iii) Seismic Zone : III As per IS 1893 (Part 1)

(iv) Surcharge Load

Minimum surcharge of 10KN/m2 will be considered for design of all underground structures to take in to account the construction load and vehicular traffic in the vicinity of structure.

(v) **Earth Pressure**

Earth pressure for walls of basement/ tanks etc. will be calculated using coefficient of earth pressure at rest. Unit weight of the soil and other soil parameters such as cohesion and angle of internal friction will be as per the Geotechnical report. Seismic considerations of earth pressure calculations will be as per code IS: 1893- Part 3.

Bulk desity of soil	1.72 to 2.21g/cc
Dry density	1.67 to 1.93 g/cc
Porosity (%)	2.5
Void ratio (%)	0.6
Specific gravity	2.63
Cohesion C	0.22kg/cm2
Angle of friction	33

(vi) Hydrostatic Pressure

The ground water pressure will be applied on the substructure as per geotechnical report in addition to the earth pressure. Uplift check will be done considering the water table level mentioned in geotechnical report.

(f) Permissible Stresses

- Whenever seismic forces are considered along with other normal design forces, the permissible stresses in material will be governed by the respective codes as per which the structure/equipment is being designed. In the absence of such code/standard, provisions of IS: 1893 will be used.

- Permissible increase in allowable bearing pressure of soil and pile Capacity provisions of IS: 1893 will be used.

- Earthquake will not be considered to act simultaneously with wind.

(g) Load combinations

The load combinations considered shall be as per IS: 456 and IS: 1893 (Part-I).

(h) Analysis Methods

This section provides certain guidelines for the methods to be used for seismic analysis of structures. An acceleration spectrum in accordance with IS: 1893, will be used. The structural analysis and design shall be carried out using validated software(s).

(i) Permissible Deflection

The permissible vertical deflection for RCC members will be as per clause 23.2 of IS 456.

(j) Structural Design

(i) All structural elements shall be designed according to the Limit state method as specified in IS 456:2000.

(ii) Environmental exposure condition will be considered as SEVERE as per clause 8.2.2, Table-3 of IS 456.

(iii) The Minimum grade of reinforced cement concrete will be M30 conforming to IS 456. For the storage of liquid, the minimum grade of concrete used will be M30 conforming to IS 3370.

(iv) Minimum of Plain cement concrete is 75 mm thickness with concrete mix grade of M10. (by weight, using 20mm and downsize grade crushed stone aggregate) will be provided under all RCC foundations.

(v) High Strength Deformed Reinforcement Steel bars of grade Fe 500D, conforming to IS: 1786 will be used.

(vi) All reinforcement will be detailed in accordance with IS 456, SP 34, IS 13920 for Plain and Reinforced Concrete structures.

(vii) Minimum member sizes to meet the 2-hr fire rating will be adopted as per IS 456

(viii) The nominal cover to the reinforcement will be based on the exposure condition as well as fire protection consideration as per IS 456

(ix) Durability of Steel structures will be ensured by painting in accordance with IS 1477 (Parts 1 and 2).

(x) For design of ties, key elements and joints etc. reference may be made to IS 15916.

(xi) The water retaining structures shall be designed by using working stress method. For this, relevant provision of IS: 3370 (Part-I to Part-IV) shall be followed.

(k) Codes, Standards and Specifications

The design will comply with the latest editions and revisions of the codes, specifications and standards listed below as noted, supplemented or modified herein:

S No.	Code Title	Code No.	Year
	Design		
1	National Building Code of India	NBC	2016

2	Code of practice for plain & reinforced concrete	IS 456	2000 (Reaffirmed 2021)
3	Code of practice for general construction in steel	IS 800	2007 (Reaffirmed 2017)
4	Code of practice for design loads (other than earthquake) for buildings and structures		
	Part 1, 2, 4, 5	IS 875	1987 (Reaffirmed 2018)
	Part 3		2015 (Reaffirmed 2020)
5	Criteria for earthquake resistant design of structures		
	Part1 - General Provisions and Buildings	IS 1893	2016 (Reaffirmed 2021)
	Part 2 – Liquid Retaining tanks		2014 (Reaffirmed 2019)
6	Code of practice for design and construction of foundations in soils: general requirements.	IS 1904	2021
7	Code of practice for concrete structures for the storage of liquids	IS 3370	2009 (Reaffirmed 2019)
8	Earthquake resistant design and construction of buildings - code of practice	IS 4326	2013 (Reaffirmed 2018)
9	Recommendations for detailing of reinforcement in reinforced concrete works	IS 5525	1969 (Reaffirmed 2018)

(l) Software used for Analysis & Design

The structural analysis and design shall be carried out using validated software(s).

(m) Approval for Design and Drawings

1. Contractor shall prepare and submit DBR for STP design and get it approved by Employer/PC before proceeding with structural design.

2. Structural design and drawings for STP:

The contractor should design STP & prepare good for construction structure concrete and reinforcement drawing and get it approved by PMC/Employer. Contractor to submit design report for STP design consists of load calculations, foundation design calculations, analysis models such as ETABS/STAAD/SAFE, structural layout drawings, reinforcement drawings etc. to PMC/Employer and get the same approved by PMC/Employer. Upon approval contractor to get the design and drawings proof checked from reputed institutions like IIT/Anna University before proceeding with execution of work.

TECHNICAL SPECIFICATIONS FOR STP-ELECTROMECHANICAL & INSTRUMENTATION WORKS

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SEWAGE TREATMENT PLANT

1.0 SEWAGE TREATMENT PLANT PHILOSOPHY

Sewage Treatment Plant (STP) will be designed to remove the contaminants from sewage as per the norms specified by guidelines and produce treated sewage deemed fit for recycling for non-potable purposes such as irrigation (landscaping), flushing, HVAC requirements. In line with sustainable infrastructure plan, 100% sewage is proposed to be treated to the required standards and recycled for the non-potable purposes.

Based on the water demand and wastewater estimates, the ultimate Sewage generation from all the plots of south parcel is about 4000 KLD. From the plots which are being developed on immediate basis (S8 and S16 & S17) about 500 KLD of sewage generation is estimated. It is likely that it may take some time for all the plots to occupy fully, and ultimate sewage generation as envisaged.

Therefore, it is suggested that STP be developed or constructed into two 0.5 MLD modules for Phase I in order to accommodate variable or minimum flow until the final sewage generation is obtained at STP. The plant will be built to run for 22 hours. One MLD for Phase I STP will be designed as 2 x 0.5 MLD modules for the modular sewage treatment plant. STP will be developed as a specialized 1 x 1 MLD module for Phase II and a dedicated 1 × 2 MLD module for Phase III. Every phase's STP must have a 50% turndown ratio, and the 2 x 0.5 MLD modules in particular must be built so that every MBR system process unit is modular.

RO system and sludge handling system shall be designed combine for Phase I and Phase II and separately for Phase III.

1.81 KLD of MBR treated water shall be used for toilet flushing and part of MBR treated water shall be subjected to RO system designed to generate 1.05 KLD RO permeate for HVAC make-up requirements.

Phase wise details for Phases I, II and III are as given below.

Description	Total Requirement	Phase I	Phase II	Phase III
Sewage Treatment Plant (Phase wise Modules)	**4000 KLD**	**2 x 500 KLD**	**1 x 1000 KLD**	**1 x 2000 KLD**
MBR Permeate	3998 KLD	999 KLD	999 KLD	1999 KLD
For Flushing	1810 KLD	453 KLD	453 KLD	905 KLD
RO Feed	1750 KLD	438 KLD	438 KLD	875 KLD

Description	Total Requirement	Phase I	Phase II	Phase III
RO Permeate for HVAC	1050 KLD	263 KLD	263 KLD	525 KLD

This tender is based on turnkey contract and civil construction to be done for Phase I, Phase II and Phase III as indicated above and Execution Electromechnical equipment to be done for Phase I at initial stage .

The tentative invert level of incoming sewer to screen chamber is 4.0 m below FGL. Considering 300 mm of free fall invert level of incoming pipe is considered as 3.70 m below FGL. The coarse screen chamber and equalisation tank shall be underground while all other units shall be above ground /partially above ground as per the best suited design.

2.0 MODULAR DEVELOPMENT OF SEWAGE TREATMENT PLANT

Sewage treatment facility designed for average ultimate flow of 4 MLD with peak factor of 2.25. The 4 MLD STP shall be constructed and commissioned in Three Phases based on Modular approach. In the initial phase the civil work to be done for ultimate phase as per details mentioned in below table, The capacities of the various units of the STP to be constructed are as follows:

Modular Development of Sewage Treatment Plant

Sr. No.	STP Unit	Scope of work for this tender (Phase I)		Scope of work for this tender (Phase II)		Scope of work for this tender (Phase III)	
		Civil Component	Electrical, Mechanical & Instrumentation Component	Civil Component	Electrical, Mechanical & Instrumentation Component	Civil Component	Electrical, Mechanical & Instrumentation Component
1	Inlet Chamber	4 MLD	4 MLD				
2	Coarse Screen Channel-manual	4 MLD @ 1 Nos	4 MLD @ 1 nos				
3	Coarse Screen Channel-mechanical	4 MLD @ 1 Nos	4 MLD @ 1 nos				
4	Pumping Station (Wet Well)	4 MLD	1.0 MLD @ 2 no.s		1.0 MLD @ 2 no.s		2 MLD @ 2 no.s

Sr. No.	STP Unit	Scope of work for this tender (Phase I)		Scope of work for this tender (Phase II)		Scope of work for this tender (Phase III)	
		Civil Component	Electrical, Mechanical & Instrumentation Component	Civil Component	Electrical, Mechanical & Instrumentation Component	Civil Component	Electrical, Mechanical & Instrumentation Component
5	Stilling Chamber	4 MLD	4 MLD				
6	Fine Screen Channel-manual	2 MLD @ 2nos	2 MLD @ 1 no.s				2 MLD @ 1 no.s
7	Fine Screen Channel-mechanical	2 MLD @ 2nos	2 MLD @ 1 no.s				2 MLD @ 1 no.s
8	Oil & Grease Chamber	2 MLD @ 2 nos	2 MLD @ 1 nos				2 MLD @ 1 no.s
9	Equalization Tank	1 MLD @ 2 nos & 2 MLD @ 1 no	1MLD @ 1 nos		1MLD @ 1 nos		2 MLD @ 1 no.s
10	Anoxic Tank	4 MLD	0.5 MLD @ 2 nos		1.0 MLD @ 1 no		2.0 MLD @ 1 no
11	Aeration Tank	4 MLD	0.5 MLD @ 2 nos		1.0 MLD @ 1 no		2.0 MLD @ 1 no
12	MBR Tank	4 MLD	0.5 MLD @ 2 nos		1.0 MLD @ 1 no		2.0 MLD @ 1 no
13	MBR Permeate Tank	2 MLD @ 2 Nos	2.0 MLD @ 1 no				2.0 MLD @ 1 no
14	Irrigation Tank	2 MLD @ 2 Nos	2.0 MLD @ 1 no				2.0 MLD @ 1 no
15	RO permeate Tank	2 MLD @ 2 Nos	2.0 MLD @ 1 no				2.0 MLD @ 1 no
16	Sludge tank	2 MLD @ 2 Nos	1.0 MLD @ 1 no		1.0 MLD @ 1 no		2.0 MLD @ 1 no
17	Odour Control system	4 MLD	2.0 MLD @ 1 no				2.0 MLD @ 1 no
18	Electrical HT Substation	4 MLD	4 MLD				

Sr. No.	STP Unit	Scope of work for this tender (Phase I)		Scope of work for this tender (Phase II)		Scope of work for this tender (Phase III)	
		Civil Component	Electrical, Mechanical & Instrumentation Component	Civil Component	Electrical, Mechanical & Instrumentation Component	Civil Component	Electrical, Mechanical & Instrumentation Component
19	DG Platform	4 MLD	0.5 MLD @ 2 nos		1.0 MLD @ 1 no		2.0 MLD @ 1 no
20	Admin cum MBR Air Blower, MCC PLC/Control room,	4 MLD	0.5 MLD @ 2 nos		1.0 MLD @ 1 no		2.0 MLD @ 1 no
21	RO Shed	2 MLD @ 2 Nos	1.0 MLD @ 1 no		1.0 MLD @ 1 no		2.0 MLD @ 1 no
22	Chlorination system	2 MLD @ 2 Nos	1.0 MLD @ 1 no		1.0 MLD @ 1 no		2.0 MLD @ 1 no
23	Centrifuge Feed Pump House	2 MLD @ 2 Nos	1.0 MLD @ 1 no		1.0 MLD @ 1 no		2.0 MLD @ 1 no
24	Centrifuge House {G(Stilt)+1 structure}	4 MLD	1.0 MLD @ 1 no		1.0 MLD @ 1 no		2.0 MLD @ 1 no
25	Operator Room	As per Design					
26	Storeroom	As per Design					
27	Compound Wall	As per Design for Entire STP lot area for 4 MLD plant.					

*** NOTE : All Civil work to be carried out during phase I as per above table and the drawings available with tender document.*

3.0 SCOPE OF WORK FOR SEWAGE TREATMENT PLANT

This tender is based on turnkey execution along with operation and maintenance period of 2 years including Defect Liability Period (DLP) from the date of successful commissioning and completion of one month trial run of plant executed.

The scope includes but not limited to the design, detailed engineering, construction, manufacture, procurement and supply of all materials and equipment, receipt, storage, conservation & preservation of all materials including all civil, structural steel works (sheds, platforms, ladders, etc.), interconnecting piping, electrical, instrumentation, fabrication, painting, inspection & testing at bidder's works, packing, forwarding, transportation, transit insurance, delivery at site, erection/installation, testing, commissioning at site and carrying out performance / acceptance guarantee test runs, operating and maintenance of the STP and handing over of STP as described hereunder and in various other referred documents including the Specifications and Data Sheets attached herein.

Scope broadly covers the following but not limited to:

- The design of the plant under this project will be based on the design criteria recommended in "Manual on Sewerage and Sewage Treatment Systems" - 2013 of Central Public Health and Environmental Engineering Organization (CPHEEO), Ministry of Housing & Urban Affairs (MoUHA), Government of India (GOI), New Delhi and internationally recognized references. In case of difference or discrepancies between CPHEEO Manual and Internationally recognized guidelines / books, the process design shall be carried out considering stringent design parameters.
- The treatment process is based on Membrane Bio Reactor (MBR) technology for treatment of sewage.
- Bidder must provide all information necessary for complete evaluation of the technology by the Employer, 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. Bidder shall include with their Bid evidence acceptable to the Employer of satisfactory past performance of same technology-based plant designs and the associated equipment and processes offered and full details of similar plant capacities called for to enable proper evaluation of design.
- The Bidders must submit following details along with his bid.
    a. Treatment methodology, detailed specifications, and process design calculation along with data sheets.
    b. List of Equipment and unit sizing calculation.

c. Process flow diagram, P&ID, Layout and Hydraulic flow diagram.
d. Power consumption statement as per tender format.
e. Statement of Chemical consumption.
f. Detailed break up of cost estimates for O&M as per tender including estimation of technological items.

- 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 Plants in this contract unless specifically indicated otherwise. The Contractor shall use this description together with other specific information for each Plant provided elsewhere in these bid documents, including but not limited to Process Unit Design Criteria given under, Process Flow Diagram (PFD), Plant Location, all of which are integral to this Process and Facilities Description and are incorporated herein for reference.
- The extra treated effluent from the plant is to be suitably disposed off in the existing sewer network. A gravity main pipeline of required size to carry design peak flow equipped with flow meter and quality online analysers for BOD, COD, TSS, pH, Ammoniacal Nitrogen (NH4-N), Total Nitrogen (N-Total) & Residual Chlorine shall be laid up to the plot boundary limit and beyond as per site condition to nearest receiving existing sewer network (up to disposal point).
- Contractor should note that the 'Major Process Units and Facilities' described are for bidders guidance purpose only. Any other process units or facilities required for successful completion and commissioning of this plant will be a part and parcel of the contract and no separate payment will be made for such account.
- The final treated sewage is to be disinfected through chlorination before its disposal.
- 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.
- All equipment shall be arranged, and buildings and structures designed to permit safe and easy access to and removal of all equipment.
- 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.

- 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.
- All units shall be interconnected by RCC overhead walkways, minimum 1.2 m wide with handrail and RCC staircase.
- 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.
- 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.
- Prepare and submit GA and structural drawings (GFC) as per documents and drawing submission & distribution schedule.
- The equipment to be supplied and erected as detailed in BOQ and these shall be in accordance with Specification and the relevant data sheets section.
- Piping inside and around STP including suction and delivery piping, delivery header, recirculation piping including all the valves.
- Supporting arrangements needed (indoor & outdoor) for the piping, valves and instrumentation.
- Proper ventilation and entry / exit staircases shall be provided to access the underground units of STP. Cut-outs, vents have to be provided in the roof slab.
- Any item which may not have been specifically mentioned herein but are needed to complete the equipment / system shall also be treated as included and the same shall also be furnished and erected, unless otherwise specifically excluded as indicated.
- Coarse Screen and Pumping station of STP shall be constructed below ground. From Pumping station, sewage shall be pumped, and rest of the civil units shall be preferably above ground / partially above ground as per the best suited design aspects.
- Emergency power backup is to be provided for Sewage Transfer Pump, Air blowers of Aeration and tanks and Return Sludge Pumps and other require process units from the existing DG set available at project site
- A discharge pipe of the Equalised sewage transfer pumps shall be provided from the Equalisation tank along with blind flange to the nearest drain manhole leading

to external sewer network. (To be used exceptionally in case of major breakdown only)

- The Location of outfall and High Flood Level (HFL is to be obtained by the Bidder/Contractor for the planning and designing of the treatment plant. The HFL the plant site will be approved by client/consultant during review of vendor drawings.
- The Bidder shall be fully responsible for including 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, a fully integrated system which can achieve 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.
- 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.
- 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.
- 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. The normal pipeline flow velocity for air shall not be more than 15.0 m/s.

- 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.
- Plant Layout: Tentative layout is given with tender document, Vendor to finalize STP plant layout in the given area, no additional area to be given from Client.
- Sewage Inlet, outlet, wash water inlet pipe shall be DI only and minimum size of 200 mm as per approved make / brand. 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 as per structural designs. 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.
- 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.
- 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
- Foam, scum, fats, oil, grease, or any other floating material removed from any location in the plant shall be completely removed from the process flow path along with waste activated sludge, thickened sludge and/or dewatered solids leaving the STP and shall under no circumstances be recycled or returned to any location in the plant. Scum removal arrangement and mechanism shall be provided for oil and Gease trap. Transport arrangement from plant to the designated place to be considered in Contractor’s scope for the same. Location to be confirmed by client with in the 10 km boundary from project area.
- All units shall be interconnected by RCC overhead walkways, minimum 1.2 m wide with MS/ SS handrail and RCC staircase with MS/ SS handrail.
- All screenings, dewatered sludge produced daily shall be transported and disposed off by the contractor suitably away from plant site, while adhering to all

environmental laws laid by pollution control board, to the place as directed by the Engineer-In-Charge.

- Other details / specification including Instrumentation and Automation work mentioned in tender shall be applicable without any deviation.
- Plant Layout: Tentative layout is given with tender document, Vendor to finalize STP plant layout in the given area, no additional area to be given from Client.
- The finished level of plant should be planned with respect to HFL of receiving water body to avoid flooding. The finished level shall be at least 0.50 m above HFL. The treated sewage pumping station shall be provided for safe disposal of treated sewage without extra cost to Employer. The bidder shall assess the treated sewage disposal (as per the Engineer-in-charge)/ and sludge disposal aspects as per site conditions carefully at bidding stage and consider in his bid.
- Compound wall (minimum 2.5 m of height) all along the STP plot boundary as specified in tender documents. Boundary wall to be designed and take prior approval from Engineer In charge before construction.
- All civil tanks except process tanks (Anoxic tanks, Aeration tanks and MBR tanks) will be closed from the top with require manholes of size 600mm x 600mm to be planned for maintenance work.
- Anoxic tanks, Aeration tanks and MBR tanks will be open from the Top and will be covered with proper PVC shed at the height of 2.0m to 2.5 m height from top of the of the tank. The cover shed to be design with proper aesthetic look and prior approval of Engineer In charge before construction.
- Covered sheet to be properly design and selection to be based on the aesthetic look as the STP plant location is in the middle of the development.

- Odour control system to be considered in design and provided for Pumping station , Screen chamber followed by O & G trap and Equalization tank including Sludge tank also.

- Demolition of Interfaces and Tie-Ins with Existing Facilities if any, 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.

4.0 SPECIFIC REQUIREMENTS / INSTRUCTION TO BIDDERS

4.1 Wastewater Quantity and Characteristics

In Phase I, the total maximum wastewater inlet at STP is 1000 KLD. The STP is being proposed to be constructed on Membrane Bio Reactor (MBR) technology.

Considering the varying population STP shall be designed on modular basis as indicated in Section 1.

The STP capacity and expected characteristics of the raw and treated sewage generated to be guaranteed by bidder are presented in Table 1.1 & Table 1.2. Bidder must give confirmation in Table 1.2 upon its agreement.

Table 1.1 Plant Capacity

Sl. No.	Description		STP
1	Raw Sewage (Normal Flow) for Phase I	:	1.0 MLD (0.5 MLD x 2 nos of modules)
2	Raw Sewage (Normal Flow) for Phase II	:	1.0 MLD (1 MLD x 1 no. of module)
3	Raw Sewage (Normal Flow) for Phase III	:	2.0 MLD (2 MLD x 1 no. of module)
4	Peak factor	:	2.25
5	Plant operating Time	:	22 Hours per day
6	Sludge dewatering system operating time	:	16 Hours per day
7	Treatment Process	:	Membrane Bioreactor (MBR) Technology
8	Project completion period for entire work including civil and electromechnical work	:	10 months from date of work order.

Table 1.2 Characteristics of Raw Sewage (Design Basis)

Sr. No.	Parameters	Typical Raw Sewage parameters for Design of plant
1.	pH	6.5 to 8.0
2.	COD (mg/L)	400 to 500
3.	BOD, 5 days @ 20^0C (mg/L)	250 to 300
4.	Suspended solids (mg/L)	300 to 400
5.	Total Nitrogen (mg/L)	50
6.	Organic Nitrogen (mg/L)	15
7.	Ammonia Nitrogen (mg/L)	35
8.	Nitrate Nitrogen (mg/L)	5
9.	Total Phosphorous (mg/L)	7-8
10.	Oil & grease (mg/L)	25 to 50

4.2 Treated Sewage Characteristics

From STP, part of treated sewage after MBR treatment will be used for landscape irrigation and flushing. Part of MBR treated sewage shall be used for toilet flushing and remaining shall be further subjected to reverse osmosis (RO) system to get the permeate quality suitable for HVAC requirements.

The reject from STP-RO shall be blended with part of the treated sewage as required in irrigation tank such that it meets the desired quality parameters deemed fit for irrigation.

The treated sewage criteria for intended uses of flushing and irrigation are specified in Table 1.3 below. The treated sewage for HVAC requirements shall meet the quality requirement as indicated in Table 1.4.

Table 1.3: Treated Sewage Quality for Flushing / Horticulture

Sr. No.	Parameters	Values
1.	pH	6.5– 8.3
2.	Oil & Grease, mg/lit	<10
3.	Total suspended solids, mg/lit	AA
4.	BOD, mg/lit	<6

5.	COD, mg/lit	<50
6.	Total nitrogen (N), mg/lit	<10
7.	Total phosphorous, mg/lit	<1
8.	Coli forms per 100mL, mg/lit	Nil
9.	Turbidity (NTU)	<2

- *Note: AA – as arising when other parameters are satisfying.*

Table 1.4: Treated Sewage Quality for HVAC makeup water

Sr. No.	Parameters	After RO Treatment
1.	pH	6.5– 8.3
2.	Hardness mg/lit	<50
3.	Total Dissolved Solids mg/lit	<250

5.0 TREATMENT SCHEME

The raw sewage shall be passed through Screen chamber in which coarse screen shall be followed by Equalisation tank and then pumped to Fine screen followed by Oil & Grease Trap and then biological treatment units employing Membrane Bioreactor (MBR).

The raw sewage shall enter in screen chamber by gravity and subjected to coarse screen to remove the floating materials, plastics, papers, etc. The screed shall be collected and safely disposed off by the Contractor. The screened sewage shall flow by gravity to Equalisation Tank. Equalisation tank which shall serve as balancing tank to store the excess flows during peak hours and to supply the composite sewage to the downstream units during the lean period so as to maintain constant average flow rate at downstream units of the plant. Air shall be supplied at the bottom of equalisation tank with the help of Air blowers and air grid to keep sewage in mixed condition in the tank and to avoid septic condition in the tank.

After Equalization tank the sewage to be pumped to Fine screen chamber followed by Oil and grease trap chamber shall be essentially provided with baffle wall with adequate detention time for the physical separation of floating oil. Separated oil shall be collected through oil skimmer and disposed off by contractor. The grit settled in the oil and grease trap shall also be removed periodically and disposed off by the Contractor.

Equalised sewage from Equalisation tank shall be pumped and transferred fine screen followed by Oil and Grease Trap and then to the biological system to degrade organic matter such as COD and BOD.

Biological Treatment - (Anoxic & MBR):

To reduce the Nitrogen level in sewage up to desired level, Nitrification- Denitrification process is adopted. Sewage from equalisation tank shall be pumped to fine screen followed by Anoxic Tank and MBR System. Anoxic Tank is introduced for Denitrification process. Anoxic Tank comprises of a slow-moving submersible mixer. Sewage from anoxic tank enters in the aeration tank followed by MBR tank.

The design shall consist of Two biological module/train, each module with an anoxic tank, an aeration tank and a membrane tank. Nitrate formed in the aeration and membrane tank, is recycled back to the anoxic tank where it is denitrified. Each Anoxic tank shall consist of one submersible mixer for mixing the sewage with recycle sludge from membrane tanks. For Denitrification, DO shall be maintained 0.1-0.2 mg/lit in Anoxic tank. Having the anoxic zone as a first zone, allows for maximum influent BOD utilization for denitrification. The sewage shall overflow from the anoxic tank to aeration tank. Fine bubble diffusers shall be provided at the bottom of aeration tank to supply oxygen for biological decomposition of organic matter and to keep the mixed liquor suspended solids (MLSS) in suspension. Air blowers shall be provided to supply oxygen to aeration tanks. Dissolved oxygen will be monitored in aeration tank. The Air blowers shall be provided with VFD.

Membrane Tank

The mixed liquor from aeration tank shall be overflowed in membrane tank consisting of submerged membrane modules. Clean water shall be withdrawn from the mixed liquor through the membranes using permeate pumps. Permeate shall be taken from the backpulse water tank/ Membrane Permeate Tank for backpulsing and cleaning the membranes. Backpulse pumps shall be used for cleaning the membranes. The sludge from the membrane tank shall be recycled to anoxic tanks using Return sludge transfer pumps. Excess sludge shall be transferred to a sludge holding tank. The permeate and backpulse pumps shall be provided with VFD. Citric Acid and NaOCl Dosing system shall be provided for cleaning.

Disinfection Unit

Sodium hypochlorite solution shall be dosed in the MBR Permeate tank to maintain residual chlorine for water reuse.

MBR Permeate Tank (Treated Water Tank)

The treated sewage from MBR Permeate tank shall be collected and used for flushing. MBR Permeate shall be transferred for flushing with the help of Flushing Water transfer Pumps. The part of treated sewage shall be transferred to the RO system for further treatment.

Service Water & Instrument Air

The treated sewage from the MBR Permeate Tank shall be used as service water for washing of screenings, flushing and chemical solution preparation.

If required, for operation of various pneumatically operated valves Instrument air shall be provided with the help air compressors. Air Compressor along with receiver tank, and air - dryer shall be provided for operating pneumatic valve actuators.

Sludge Handling

Excess sludge from MBR tanks, shall be removed periodically and collected in Sludge Holding tank. Compressed air shall be supplied to keep the sludge in suspension and to avoid anaerobic condition in the tank. The Sludge from the sludge holding tank shall be pumped to the Decanter Centrifuge for mechanical dewatering. For better flocculation, Dewatering Polyelectrolyte would be dosed. The dewatered sludge can be used as a soil conditioner. The Centrate from Decanter centrifuge will be taken by gravity into the Equalisation Tank.

Odour control system

Odour emissions from raw wastewater sump, screening areas, grit chamber, pumping station and sludge dewatering areas shall be treated with suitable odour control system.

A well-designed odour control system shall be capable of accepting a large variation in the contaminant loads and still maintain the designed odour threshold at the outlet.

Odour control systems shall be based on the following technology: -

- Chemical oxidation
- Biological oxidation
- Adsorption onto solids

Odour masking, incineration, ozone and ultraviolet scrubber systems shall not be considered.

Any odour control system shall be available for use at all times and therefore should be designed in a duty/standby mode. An allowance shall be made for 100% standby capacity in the extraction fan sets, recirculation pump sets and adsorption onto solids chambers. In the event of duty pump or fan failures, the standby set shall start automatically.

Each flow stream shall be fitted with variable control dampers, non-return valves and isolation valves. Components which may be exposed to corrosive environments shall be manufactured from austenitic stainless steel.
The inlet ducts shall be fitted with mesh screen and disposable dust filters.

To ensure sufficient mechanical strength the ductwork shall be coated with GRP (300 g/m2).
The system should be designed to avoid static electrical charges being built up.
Where polishing filters are proposed, a de-humidifier controlled by a relative humidistat shall be required to ensure that the relative humidity of the air stream is limited to 70 - 80% before delivery to the polishing filter.
The use of final effluent as a re-circulating fluid in the bio-scrubbers shall not be permitted.
The distribution nozzles shall be enclosed and dispersal of aerosols into the atmosphere shall be minimized.
The system shall be fully automated and monitored by continuous gas monitoring equipment to control the airflow and establish efficiency.
The treated air shall be exhausted through a purpose built exhaust stack. The factors to be considered when designing an exhaust stack will include: -

- capacity
- material
- noise and vibration
- shape
- visible impact of stack and plume
- temperature
- access for maintenance
- sampling
- lightning protection

The noise shall be below 65 dBA at 1.0 metre from the unit.

Apart from nuisance at the boundary, high concentrations of odorous gases may give rise to problems within the workplace and may need control. The Occupational Exposure Limit (OEL) of H2S is 10ppm. This is the level at which it is deemed not to be harmful to operators exposed for 8 hours a day, 40 hours a week, over a 40 year working life.

Advanced Tertiary Treatment – RO System:

In order to prevent scaling of RO Membranes, RO feed shall be dosed with suitable antiscalant solution and shall be dechlorinated with Sodium Meta Bi Sulphite (SMBS). pH correction shall also be carried out if required.

MCF shall be designed to trap any colloidal particles of size of 5 micron and greater. Micro filtration shall eliminate possibility of regular clogging of the RO membrane surface. Filtered sewage from MCF shall be pumped to RO unit by High Pressure Pumps.

RO High pressure pumps downstream of MCF are provided to boost the pressure of RO unit. These pumps shall be of centrifugal type, vertical, in-line design with multistage impellers. The pumps shall boost the pressure on-line, as required.

The RO unit will remove dissolved solids and other contaminants and make the quality of sewage suitable for reuse. RO essentially works on molecular level. It separates the molecular impurities from the water reducing its TDS content. RO is a cross-flow filtration, high pressure spiral-wound/hollow fibre/flat type, fouling resistant membrane process which produces permeate (product water) stream low in TDS and a reject stream high in TDS.

The RO units shall be designed such that minimum 60% volumetric recovery is obtained and consistent and continuous permeate is produced all the time as per the quality indicated in these specifications

RO membranes shall be flushed/ cleaned whenever required using chemical solutions specified by membrane manufacturers. RO Clean in Place System (CIP) shall be provided which will be used infrequently for membrane cleaning.

RO Permeate Tank will store RO Permeate. RO permeate transfer pumps shall be provided to pump RO permeate for reuse for HVAC make-up requirements.

RO reject will be collected in Irrigation tank where it shall be blended with the MBR treated sewage and shall be used for horticulture / gardening.

Irrigation Tank:

Irrigation tank will be designed as per the volume indicated in unit list and layout drawing. It shall receive RO reject which will be blended with MBR treated sewage and used for landscape irrigation.

Sludge Handling:

The sludge generated is a direct function of the BOD5 removed. In general, greater the BOD5 removed higher will be the sludge generated. The excess sludge generated from MBR will be withdrawn periodically. Excess sludge shall be transferred to sludge dewatering system consisting of Sludge holding tank, Centrifuge, Centrifuge feed pumps and Dewatering Polyelectrolyte (DWPE) dosing system. Sludge holding tank shall be equipped with aeration grid.

Centrifuge system shall be provided for reducing the sludge volume and facilitate sludge dewatering. Dewatering Poly Electrolyte (DWPE) will be provided to increase the efficiency of the dewatered sludge in terms of solid concentration.

Dewatered biological sludge can be used as landscape manure and centrate shall be re-routed back to the system.

MCC / PLC Room:

A separate room is proposed for controlling operation of STP which shall accommodate MCC / PLC for the process control of the plant.

Blower Room:

A separate suitable room is proposed for housing all air blowers.

6.0 SCOPE OF WORK

6.1 Design, detailed engineering, construction, manufacture, procurement and supply of all materials and equipment, receipt, storage, conservation & preservation of all materials including all civil, structural steel works (sheds, platforms, ladders, etc.), interconnecting piping, electrical, instrumentation, fabrication, painting, inspection & testing at bidder's works, packing, forwarding, transportation, transit insurance, delivery at site, erection/installation, testing, commissioning at site and carrying out performance / acceptance guarantee test runs, operating and maintenance of the STP and handing over of Phase I – 2 x 0.5 MLD STP, For Phase II – 1 x 1.0 MLD and For Phase III – 1 x 2.0 MLD STP as described hereunder and in various other referred documents including the Specifications and Data Sheets attached herein

For STP Capacity – 4 MLD (Design as per modules explained above)

For Phase I – 2 x 0.5 MLD,

For Phase II – 1 x 1.0 MLD and

For Phase III – 1 x 2.0 MLD

a) Coarse Screen chamber (2 No.) MOC-RCC
   - 1 No. Manual Coarse Bar screen- 10 mm opening, MOC- SS 316.
   - 1 No. Mechanical Coarse Bar screen- 10 mm opening, MOC- SS 316.
   - Average Design Flow: 4 MLD
   - Peak Factor: 2.25
   - Peak Flow: 9.0 MLD

b) Pumping Station (1 no.).
   - MOC-RCC, with level transmitter
   - Retention time- Max 30 minutes at average flow
   - Average Design Flow: 4 MLD
   - Peak Factor: 2.25
   - Peak Flow: 9.0 MLD

c) Sewage Transfer Pumps-

   For Phase I,

   No. of pumps - 2 Nos. (1W+1S), submersible cutter type pumps with accessories. For transferring equalised sewage to Anoxic tank. MOC- CI with SS Impeller and shaft. Suitable lifting arrangement for maintenance.

   For Phase II

   No. of pumps - 2 Nos. (1W+1S), submersible cutter type pumps with accessories. For transferring equalised sewage to Anoxic tank. MOC- CI with SS Impeller and shaft. Suitable lifting arrangement for maintenance.

   For Phase III

   No. of pumps - 2 Nos. (1W+1S), submersible cutter type pumps with accessories. For transferring equalised sewage to Anoxic tank. MOC- CI with SS Impeller and shaft. Suitable lifting arrangement for maintenance.

d) Fine Screen chamber (4 No.s) MOC-RCC
   - 2 No. Manual Fine Bar screen- 6 mm opening, MOC- SS 316.
   - 2 No. Mechanical Fine Bar screen- 6 mm opening, MOC- SS 316.
   - Average Design Flow: 4 MLD
   - Peak Factor: 2.25
   - Peak Flow: 9.0 MLD

e) Oil and Grease Tank (2 No.s) MOC-RCC,

- 2 No.
- Slotted pipe Oil skimmer, MOC- MSEP
- Average Design Flow: 2 MLD, each
- Peak Factor: 2.25
- Peak Flow: 4.5 MLD

- Equalisation Tank (3 No.s). - MOC-RCC, with level transmitter
  - Retention time- Minimum 6-8 hrs
  - Average Design Flow:
  - Phase I : 1 MLD
  - Phase II : 1 MLD
  - Phase III : 2 MLD
  - Air Blowers along with Acoustic enclosure –
  - Phase I : 1W + 1S
  - Phase II : 1W + 1S
  - Phase III : 1W + 1S
  - same shall be used for Sludge Holding Tank, MOC- CI
  - Coarse bubble perforated pipe air grid, MOC- UPVC

f) Equalised Sewage Transfer Pumps

Design Flow - For Phase I – 2 x 0.5 MLD,

No. of pumps - 3 Nos. (2W+1S), 1W for each module and 1 common standby, submersible cutter type pumps with accessories. For transferring equalised sewage to Anoxic tank. MOC- CI with SS Impeller and shaft. Suitable lifting arrangement for maintenance.

For Phase II – 1 x 1.0 MLD

No. of pumps - 2 Nos. (1W+1S), submersible cutter type pumps with accessories. For transferring equalised sewage to Anoxic tank. MOC- CI with SS Impeller and shaft. Suitable lifting arrangement for maintenance.

For Phase III – 1 x 2.0 MLD

No. of pumps - 2 Nos. (1W+1S), submersible cutter type pumps with accessories. For transferring equalised sewage to Anoxic tank. MOC- CI with SS Impeller and shaft. Suitable lifting arrangement for maintenance.

g) Drum screen prior to anoxic tank:

2 Nos - (1W + 1S) for each phase an each module.

2 mm punched hole, MOC- Body-CS, Drum- SS 304.

h) Anoxic Tank-

For Phase I – 2 x 0.5 MLD,(1 No. for each module)

For Phase II – 1 x 1.0 MLD and

For Phase III – 1 x 2.0 MLD

MOC-RCC, Each with Submersible Mixer

Submersible Mixer- 1 No., MOC- SS 304

Minimum HRT – 2 hrs.

i) Aeration Tank with compartment –

For Phase I – 2 x 0.5 MLD,(1 No. for each module)

For Phase II – 1 x 1.0 MLD and

For Phase III – 1 x 2.0 MLD

MOC - RCC,

Minimum HRT – 6-8 hrs.

Process Air Blowers (VFD) along with Acoustic enclosure

Fine bubble, non-clog, retrievable diffusers for diffused aeration (As per Vendor design and module wise)

Membrane MOC- EPDM

DO meter, 1 Nos. 1 No. for each aeration tank

- No. of air blowers for Phase I – 2 x 0.5 MLD,(1 No. for each module) 3 Nos. (2W+1S),
- No. of air blowers for Phase II – 2 Nos. (1W+1S),
- No. of air blowers for Phase III – 2 Nos. (1W+1S),

j) MBR tank

For Phase I – 2 x 0.5 MLD,(1 No. for each module)

For Phase II – 1 x 1.0 MLD and

For Phase III – 1 x 2.0 MLD

MOC - RCC,

Minimum HRT – 2 hrs. (As per Vendor design)

- Membrane modules (As per Vendor design and module wise), MOC-PVDF. Suitable lifting arrangement for maintenance/replacement. Lifting arrangement of membrane for maintenance / replacement if at all surfaces above ground have to be covered up by Mummty.

- Sludge Recirculation Pumps / Return sludge Pumps - 2 Nos. (1W+1S) phase wise, Nitrifying liquor Recirculation Pumps and accessories for transferring mix liquor from MBR tank to Anoxic tank. MOC-CI with SS Impeller. Same pump can be used to transfer excess sludge into Sludge Holding Tank.
- Membrane Air Blowers (VFD) along with Acoustic enclosure
- Fine bubble, non-clog, retrievable diffusers for diffused aeration (As per Vendor design and module wise)
- Membrane MOC- EPDM
- DO meter, 1 Nos. for each aeration tank
- Air Blower
    - No. of air blowers for Phase I – 2 x 0.5 MLD,(1 No. for each module) - 3 Nos. (2W+1S),
    - No. of air blowers for Phase II – 2 Nos. (1W+1S),
    - No. of air blowers for Phase III – 2 Nos. (1W+1S),
- MBR Permeate Pumps (VFD)
    - No. of permeate pump for Phase I – 2 x 0.5 MLD,(1 No. for each module) - 3 Nos. (2W+1S),
    - No. of permeate pump for Phase II – 2 Nos. (1W+1S),
    - No. of permeate pump for Phase III – 2 Nos. (1W+1S),
- Membrane Cleaning system- 3 Sets (1 set for each phase), Each set consists,
    - Sodium hypochlorite Dosing tank (1 No), MOC- HDPE, and Dosing pumps, 2 Nos. (1W+1S), MOC-PP.
    - Citric Acid Dosing tank (1 No), MOC- HDPE, Agitator, 1 No. MOC- SS 304 and Dosing pumps, 2 Nos. (1W+1S), MOC-PP.

k) MBR Permeate Tank/Treated Water Tank **(Common for Phase I & II)** - 1 No. MOC-RCC, with level transmitter

- Retention time- Minimum 4 hrs
- Design Flow – 2000 KLD
- Back pulse pumps (VFD) - 3 Nos. (2W+1S), MOC- CI with SS impeller.

MBR Permeate Tank/Treated Water Tank for **(Phase III)** - 1 No. MOC-RCC, with level transmitter

- Retention time- Minimum 4 hrs

- Design Flow – 2000 KLD
- Back pulse pumps (VFD) - 3 Nos. (2W+1S), MOC- CI with SS impeller.

l) Disinfection

For Phase I

- Sodium hypochlorite Dosing tank 2 Nos. (1W+1S), MOC- HDPE, and
- Dosing pumps, 2 Nos. (1W+1S), MOC-PP.
- Design Flow : 1000 KLD

For Phase II

- Sodium hypochlorite Dosing tank 2 Nos. (1W+1S), MOC- HDPE, and
- Dosing pumps, 2 Nos. (1W+1S), MOC-PP.
- Design Flow : 1000 KLD

For Phase III

- Sodium hypochlorite Dosing tank 2 Nos. (1W+1S), MOC- HDPE, and
- Dosing pumps, 2 Nos. (1W+1S), MOC-PP.
- Design Flow : 2000 KLD

m) Sludge Dewatering System **(Common for Phase I & Phase II)**

- Sludge Holding tank 1 No. MOC-RCC, with level switch,
  Min HRT – 12 hrs
- Coarse bubble perforated pipe air grid, MOC- UPVC, with Air blowers (Common Air blowers shall be used to supply compressed air in Equalisation tank and Sludge Holding tank), MOC-CI
- 2 Nos. (1W+1S) Centrifuge Feed Pumps, MOC- CI with SS impeller
- Decanter Centrifuge 1 No., MOC- CI, Wetted parts-SS 316
- Dewatering Polyelectrolyte dosing tank - 2 Nos. MOC-HDPE, Agitator – 2 Nos., MOC- SS 304,
- Dewatering Polyelectrolyte dosing pumps 2 Nos. (1W+1S) MOC-PP.

Sludge Dewatering System **(Phase III)**

- Sludge Holding tank 1 No. MOC-RCC, with level switch,
  Min HRT – 12 hrs

- Coarse bubble perforated pipe air grid, MOC- UPVC, with Air blowers (Common Air blowers shall be used to supply compressed air in Equalisation tank and Sludge Holding tank), MOC-CI
- 2 Nos. (1W+1S) Centrifuge Feed Pumps, MOC- CI with SS impeller
- Decanter Centrifuge, MOC- CI, Wetted parts-SS 316
- Dewatering Polyelectrolyte dosing tank - 1 No MOC-HDPE, Agitator – 1 No., MOC- SS 304,
- Dewatering Polyelectrolyte dosing pumps 2 Nos. (1W+1S) MOC-PP.

RO system combine for Phase I & II and separately for Phase III (20 hrs Operation)

n) Skid mounted RO System consisting of:

- RO Feed Pumps 2 Nos. (1W+1S), Minimum Capacity: 25 cum/hr @ 15 m Head
- RO skid MOC: SS 304
- Micron Cartridge Filter (MCF) with SS 304 housing
- Anti-scalant dosing system- Dosing Tank 1 No., MOC- HDPE, PP Dosing Pumps 2 Nos. (1W+1S)
- SMBS Dosing System- Dosing Tank 1 No.- MOC- HDPE, PP Dosing Pumps 2 Nos. (1W+1S)
- RO High Pressure Pumps 2 Nos. (1W+1S) MOC: SS 316
- RO Pressure Tubes (MOC: FRP) with RO Membranes (MOC: Polyether sulfone / Polysulfone)
- pH correction dosing system
- RO CIP (Cleaning-in-Place) System
  - 1 No. Cartridge Filter
  - CIP Tank 1 No., MOC- HDPE, Chemical Feed Pumps 2 Nos. (1W+1S).

o) RO Permeate Tank for Phase I & II - 1 no., MOC-RCC,
Minimum Retention time 4hrs
RO Permeate Tank for Phase III - 1 no., MOC-RCC,
Minimum Retention time 4hrs

p) RO permeate transfer pumps for Phase I & II - 2 Nos. (1W +1 S), MOC-CI with SS shaft and Impeller. For transferring RO permeate to HVAC water tank.

RO permeate transfer pumps for Phase III - 2 Nos. (1W +1 S), MOC-CI with SS shaft and Impeller. For transferring RO permeate to HVAC water tank.

q) Irrigation Tank for Phase I & II - 1 no., MOC-RCC,
Minimum Retention time 4hrs,

Irrigation Tank for Phase III - 1 no., MOC-RCC,
Minimum Retention time 4hrs,

r) Irrigation water transfer pumps for Phase I & II - 2 Nos. (1W +1 S), MOC-CI with SS shaft and Impeller. For transferring water to irrigation tank.
Irrigation water transfer pumps for Phase III - 2 Nos. (1W +1 S), MOC-CI with SS shaft and Impeller. For transferring water to irrigation tank.
Provision for suitable Bypass system to be kept for Irrigation water to existing Sewer/Storm water network.

s) MCC/PLC Room, 1 No along with cables and cable trays for Phase I & II
- MCC Panel- 2 Nos. Compartmentalised, 1 for each phase
- PLC Panel - 2 Nos. for Fully Automatic operations of RO, 1 for each phase

MCC/PLC Room, 1 No along with cables and cable trays for Phase III
- MCC Panel- 1 No. Compartmentalised
- PLC Panel- 1 No. for Fully Automatic operations of RO

t) RO shed (Industrial Type) of suitable size to accommodate RO system combine for phases I & II and for phase III separately. The RO shed to be design with proper aesthetic look and contractor to take prior approval of Engineer In charge before construction.

u) RO shed of suitable size to accommodate RO system combine for phases I & II and for phase III separately.

v) Centrifuge house to accommodate centrifuge for sludge dewatering system combine for phases I & II and for phase III separately.

w) If required, Instrument air compressor with an air receiver tank, air filter-dryer and air filter regulator along with instrument air piping and tubing for pneumatically operated valves.

x) Proper mechanical ventilation and entry / exit staircases shall be provided to access the underground units of STP. Cut-outs, vents have to be provided.

y) Required lighting, fans, wiring, cabling within the following rooms
   1. Operation building housing MCC Room
   2. Blower room
   3. RO shed
   4. Centrifuge Shed

6.2 Submission of Plant Layout, Process Design and Hydraulic Flow Diagram, Single Line Diagram, P&I Diagram along with preliminary calculation at the time of Tender submission to justify the allocation of plant space/ Owner's work requirement. Supporting evidence such as equipment catalogues, etc. shall be submitted to substantiate the design.

6.3 Detailed design and calculations, Detailed Plant Layout, Detailed GA and structural drawings, Detailed GFC drawings, Piping layout, Hydraulic Flow Diagram, Single Line Diagram, P&I Diagram, GA drawings with sectional drawings, Fabrication Drawings, Technical datasheets, selection of equipment, preparation of the drawings for the complete STP operation to the requirement as stipulated in this specification.

6.4 Contractor shall provide the details for equipment foundations drawings, GA and structural drawings of the civil units, opening, sleeves and cut outs in structures, etc. complete.

6.5 Removal of screened material, floating oil and its disposal. The transportation and disposal of screened material, dewatered sludge and oil is in Contractor Scope.

6.6 Provision of primer and finishing coats painting to all civil and metal pipe work and auxiliary equipment as stated in the specification.

6.7 Static testing of equipments.

6.8 Trial Run, Testing and Commissioning of the plant under normal operational conditions.

6.9 Provision of test reports from Third party NABL accredited laboratory after the commissioning of the plant. Quality of the Incoming raw sewage and outgoing treated sewage shall be included. Parameters shall be analysed as given in the specifications.

6.10 Sealing gaps between pipe sleeves and pipe work/ conduit, etc. if any.

6.11 A complete package submission to local government authority for approval and obtaining license/ consent for establishment/ consent for operation of the plant will be in the scope of the Contractor.

6.12 Preparation and submission of Operation and Maintenance Manual as detailed elsewhere in the specification.

6.13 operation and maintenance period of 2 years including Two years of Defect Liability Period (DLP) from the date of successful commissioning and one month trial run of plant.

6.14 The MBR and RO membranes shall be replaced free of cost in case of any kind of performance deterioration during the membrane warranty period. Membrane warranty shall be minimum 5 years from the date of commissioning.

7.0 CONTROL PHILOSOPHY

7.1 MBR Technology

The Overflow of the Aeration Tank comes into respective MBR Tank. To control the level of the Tanks Ultrasonic Level Transmitters shall be provided in the MBR tank. Both Level Transmitters are interlocked with MBR Suction Pumps/ MBR permeate pumps. MBR permeate Pumps will start when MBR Tank level goes high from Set Value.

Level transmitter shall be also interlocked with Equalised Sewage Transfer Pumps. The Equalised Sewage Transfer Pumps will stop when level in MBR tank level goes high from set Value.

Sludge from the bottom shall be recycle back to the Anoxic Tank & Aeration tank to maintain the desired MLSS and excess sludge shall be transfer to Sludge Holding Tank. To monitor the Turbidity of MBR Permeate, Turbidity Meter & Pressure Transmitter at each MBR Tank Permeate line or MBR Permeate pump suction line.

Flow Meter shall be provided at MBR permeate Pump suction line to monitor & Totalize the Flow of the MBR Treated Water.

Turbidity Meter, Pressure Transmitters & Flow Meters shall be interlocked with VFD of the MBR Permeate Pumps.

The Membrane Operating System is an assembly with integral membrane modules arranged in rack assemblies, inserted into the membrane tank. MOS Mixed Liquor Distribution & Recirculation Jets are designed to distribute the air scour and mixed liquor flow evenly across the membrane sub modules. This feature eliminates potential polarization (concentration) of suspended solids around the membrane fibres which could be main cause for the failure and damage of individual fibres thus sub modules. Additionally, this feature provides even distribution of mixed liquor solids to each membrane unit, critical so that all membranes see the same process conditions. The return recirculation of mixed liquor ensures influent comes in intimate contact with the concentrated biomass, offering better organism selection and added flexibility in the anoxic cycle for advanced nitrogen removal, when required. This same system also acts as an integral part of the membrane cleaning system, providing an efficient scouring of the membranes with chlorine cleaning solution. The integrated cleaning system allows the sub modules to be quickly cleaned in place. Additionally, the clean and efficient procedure eliminates the need for membrane removal from process tanks that can damage membranes and present risks to plant-operators. Relaxation, Maintenance and in site CIP are exclusive features of this MBR Process to ensure consistent water quality and complete membrane life. The entire operation is PLC controlled.

i. Filtration and Relaxation Mode

Relaxation time, in which membrane surface cleaning is conducted, must be provided between suction intervals for stable treatment using the MBR system.

ii. CIP Mode

There are three types of chemical cleaning using sodium hypochlorite and/or acid. Two type of chemical cleaning required for MBR System. Maintenance/Weekly cleaning and recovery cleaning. Cleaning procedures shall be as per MBR manufacturers guidelines.

7.2 RO System Technology

Treated sewage would be received and collected in MBR Permeate Tank. Level transmitter shall be installed in the MBR Permeate Tank. At low level, Filter Feed pump shall trip.

Antiscalant & SMBS (Antioxidant) shall be dosed at inlet of RO System prior to Micron Cartridge Filter. Antiscalant is used to control carbonate scaling, sulphate scaling and calcium fluoride scaling. Scale Inhibitors have a “threshold effect”, which means that minor

amounts adsorb specifically to surface of micro-crystals thereby preventing further growth and precipitation of crystals.

Furthermore, free chlorine present in the filtered water may result in chemical oxidation of the membranes. Hence antioxidant is injected at the inlet of the cartridge filter to eliminate any oxidizing elements being present in the raw water and to protect the membranes, which are the most vital part of the plant. During startup, required amount of antioxidant is determined by inspection based on ORP in filtered water. If chlorine level at the inlet of RO system is higher than the desired value, then dump valve will open automatically and shall flow back to UF permeate tank/ Flushing Water tank.

Level switch shall be installed in all dosing tanks. At low level in dosing tanks, Dosing pumps shall trip.

Online analyzers are provided on the RO feed water line before cartridge filters to continuously monitor the RO feed water quality.

Differential Pressure Switch should be provided across the Micron Cartridge filter. Based on Pressure difference, required maintenance shall be carried out.
Suitable automation shall be provided, as low level in Treated water Tank, RO Feed pump shall trip resulting low pressure in suction and discharge line of High-pressure pumps. Alarm shall be annunciated and high-pressure pump shall also trip.

At higher pressure than the design pressure in discharge line of RO high pressure pumps, RO High pressure pumps will trip.

RO unit is equipped with inlet pressure transmitter, intermediate pressure transmitter and reject pressure transmitter. RO permeate and reject flow is monitored by online flow transmitters and flow meters. RO Permeate water quality is monitored by means of an online pH and Conductivity transmitter, at high level in conductivity meter alarm shall be annunciated and shall flow back to MBR treated water tank.

RO permeate water shall be collected in RO Permeate Tank. RO permeate from RO Permeate tank shall be used for HVAC requirement and transferred to HVAC water tank for distribution to all plots in south block. Separate transmitter for RO permeates transfer

pumps shall be provided for at low level in RO Permeate Tank in STP and at high level in HVAC water tank RO permeate transfer pumps shall trip.

RO unit shall have a CIP system. In CIP System. Level switch shall be installed. At low level, CIP Pump shall trip.

RO reject shall be routed to irrigation tank in STP for distribution for landscape. Separate transmitter for Irrigation water transfer pumps shall be provided.

8.0 STP – CIVIL/MSEP WORKS

The scope of work will consist of designing/sizing of various units as per the list given above in **Clause 2.0.** Contractor to submit civil GA, Structural and Fabrication Drawings for all units.
All required design calculations will be submitted by the BIDDER along with the drawings for approval.

The various tanks/chambers needed to be constructed for the Sewage treatment system and their details are as follows-

The scope of work will consist of design, detailed engineering, construction, manufacture/procurement, supply erection and commissioning of various components as per the lists given subsequently in which the sizes, quantity are indicative only.

If required, STP vendor has to coordinate with Main contractor, plumbing vendor, Electrical contractor, Project management / Client, Architect and Consultant to establish the plant and to run the plant successfully.
Contractor to design and provide the units and equipment as per their design. Preliminary Process Flow diagram TCE.12824A-CH-2032-PFD-20002 is attached for reference.

In addition, the following works shall be carried out by STP Vendor.

Sr. No.	Description	Size/ Capacity	Qty./ Nos.	MOC
1	Foundation of all pumps, blowers, tanks, skids and pipe work,	As per STP Vendor	As required. DDE	As per Tender specifications and approved by the consultant/ Client

Sr. No.	Description	Size/ Capacity	Qty./ Nos.	MOC
2	All drain trenches up to battery limit (Bidder's scope)	As per STP Vendor	As required. DDE	As per Tender specifications and approved by the consultant/ Client
3	Supports for electrical cables and pipes	As per STP Vendor	As required. DDE	As per Tender specifications and approved by the consultant/ Client
4.	Operation building housing MCC Room, Control Room, chemical storage area, etc. Including lighting within these rooms / shed	Suitable	As required. DDE	As per Tender specifications and approved by the consultant/ Client
5.	Blower room including lighting	Suitable	As required. DDE	As per Tender specifications and approved by the consultant/ Client
6.	Centrifuge Shed & RO shed including lighting	Suitable	As required. DDE	As per Tender specifications and approved by the consultant/ Client
7.	All required platforms, staircase, walkway and cutouts for maintenance	Suitable	As required. DDE	As per Tender specifications and approved by the consultant/ Client
8.	Lighting in the underground area allotted for Screen Chamber, Oil and Grease Tank and Equalisation Tank	Suitable	As required. DDE	As per Tender specifications and approved by the consultant/ Client

8.1 Preliminary List of Equipment, Piping, Electrical and Instrumentation Work

The scope of work will consist of design, engineering, manufacture/procurement, supply erection and commissioning of various components as per the lists given in which the sizes, quantity are indicative only.

Unit sizes and equipment's no's to be considered in design & supply as minimum requirement, Vendor can re-design & supply electro-mechanical equipment's as per their

design to achieve the process guarantee and outlet parameter as mentioned in tender document for prior approval.

The various equipment required to be provided for the sewage treatment system and their details are as follows-

Details of Equipment for Phase I – 2 x 0.5 MLD STP Equipment				
Sr. No.	**Unit / Equipment**	**Capacity / Sizes / Dimensions**	**Qty.**	**MOC**
1.	Manual Coarse Bar Screen	10 mm opening	1	SS 316
2.	Mechanical Coarse Bar Screen	10 mm opening	1	SS 316
3.	Manual Fine Bar Screen	6 mm opening	1	SS 316
4.	Mechanical FineBar Screen	6 mm opening	1	SS 316
5.	Slotted pipe skimmer	Suitable	1	MSEP
6.	Equalised Sewage Transfer Pumps	23 m^3/hr @ 15 m head, submersible pumps to transfer equalized sewage from Equalisation Tank to Anoxic Tank (Cutter Type) Solid handling size minimum 30 mm.	3 (2W for each module and 1 common standby)	CI with SS shaft & Impeller
7.	Air blowers with acoustic enclosure for Equalisation tank and Sludge holding tank	Air supply rate - 0.9 m^3 of air per m3 of Volume of the tanks.	2 (1W+1S)	CI
8.	Coarse bubble Air grid for Equalisation tank & Sludge Holding Tank	Suitable to fit	2 Lot	UPVC
9.	Drum screen prior to anoxic tank	2 mm punched hole	2	MOC-Body-CS, Drum-SS 304
10.	Submersible mixers for anoxic tank	Suitable (1 No. for each tank)	2	SS 304
11.	Twin Lobe Rotary Air Blowers (VFD) for Aeration tanks With Acoustic Enclosure	As per design (Approximately 300 Nm^3/hr)	3 (1W for each module and 1 common standby)	CI
12.	Fine Bubble tubular Air Diffusers Retrievable type	As per design	2 Lot	EPDM

Details of Equipment for Phase I – 2 x 0.5 MLD STP Equipment				
Sr. No.	**Unit / Equipment**	**Capacity / Sizes / Dimensions**	**Qty.**	**MOC**
	arrangement for Aeration tanks.	Air flow rate per diffuser- 8 m^3/hr per diffuser		

Sr. No.	**Unit / Equipment**	**Capacity / Sizes / Dimensions**	**Qty.**	**MOC**
13.	Membrane Modules (Membrane Warranty shall be 5 years from the date of commissioning)	As per manufacturers design. Maximum Flux permitted- 25 LMH (1 Lot per tank)	2 Lot	Virgin PP
14.	Return sludge Pumps	Minimum 84 m^3/hr and 12 m head, horizontal centrifugal pumps. Transferring mix liquor from MBR tank to Anoxic tank	3 nos (1 for each module and 1 common standby)	SS 316
15.	MBR Permeate pumps (vacuum) with VFD	Minimum 23 m3/hr @ 15 m head, horizontal centrifugal pumps.	3 nos (1 for each module and 1 common standby)	CI with SS impeller
16.	Back pulse pumps with VFD	As per manufacturers design	3 (1W for each module and 1 common standby)	CI with SS impeller
17.	Twin Lobe Rotary Air Blowers (VFD) for MBR tanks With Acoustic Enclosure	As per Membrane Supplier	3 (1W for each module and 1 common standby)	CI
18.	NaOCl dosing system for Disinfection	Dosing Tank- 1 No. Dosing Pumps – 2 Nos. (1W+1S)	1 Set	Tank – HDPE Pumps: PP
19.	Centrifuge feed pumps	3 m^3/hr @ 20 m Head, Horizontal centrifugal pumps for transferring sludge from sludge holding tank to Centrifuge	2 (1W+1S)	CI with SS shaft & impeller
20.	Decanter Centrifuge	3 m^3/hr. 16 hrs operation Sludge outlet consistency – 20%	2 (1W+1S)	Wetted parts SS 316

Sr. No.	Unit / Equipment	Capacity / Sizes / Dimensions	Qty.	MOC
21.	Centrate Transfer Pumps (for Phase 1 & 2)	10 m^3/hr @ 15 m Head, Horizontal centrifugal pumps for transferring centrate to Equalisation tank	2 (1W+1S)	CI with SS shaft & impeller

Sr. No.	Unit / Equipment	Capacity / Sizes / Dimensions	Qty.	MOC
22.	Dewatering (DWPE) poly dosing system	Dosing Tank- 1 No. Agitator- 1 No. Dosing Pumps – 2 Nos. (1W+1S)	1 Set	Tank – HDPE Agitator-SS 304 Pumps: PP
23.	Chain-pulley block for submersible pumps	Suitable	1 No	
24.	Electrically operated trolley for MBR maintenance	Suitable	1 No	
RO SECTION				
25.	RO feed pump	Min. 25 m^3/hr and 20 m head, horizontal centrifugal pumps. Transferring water from UF permeate tank to MCF	2 (1W + 1S)	CI with SS shaft & impeller
26.	Micron Cartridge filter (MCF)	5 micron	Suitable	PP Woven with SS 304 housing
27.	Antiscalant dosing system consisting of solution preparation tank with level indicator and level switches and with antiscalant dosing pumps-electronic diaphragm type of suitable capacity and head	Dosing Tank- 1 No. Dosing Pumps – 2 Nos. (1W+1S)	1 Set	Tank MOC-HDPE Dosing Pumps:PP
28.	SMBS (Anti-oxidant) dosing system consisting	Dosing Tank- 1 No.	1 Set	Tank MOC-HDPE

Sr. No.	Unit / Equipment	Capacity / Sizes / Dimensions	Qty.	MOC
	of solution preparation tank with agitator, level indicator and level switches and with anti-oxidant dosing pumps electronic diaphragm type of suitable capacity and head	Dosing Pumps – 2 Nos. (1W+1S) Agitator- 1 No		Agitator - SS 304 Dosing Pump :PP

Sr. No.	Unit / Equipment	Capacity / Sizes / Dimensions	Qty.	MOC
29.	pH correction system	Dosing Tank- 1 No. Dosing Pumps – 2 Nos. (1W+1S) Agitator- 1 No	1 Set	Tank MOC: HDPE Agitator:SS 304 Dosing Pump: PP
30.	RO High Pressure pumps	Min. 25 m^3/hr and Suitable head as per RO Projection.	2 (1W + 1S)	SS 316
31.	Skid mounted RO System (Membrane Warranty shall be 3 years from the date of commissioning)	RO system with 25 m^3hr feed flow, complete with required no. of spiral wound RO membrane elements mounted in pressure vessels, all mounted on a skid. RO to be designed for min. 60% recovery and flux not exceeding 25 LMH. Instruments to include Flowmeter, pH and conductivity meter at RO inlet, pH and conductivity transmitter on the permeate outlet, flow meter on the permeate outlet, a flow indicator on the reject line, pressure switches	RO Membrane : As per projection	Skid: SS 304, High pressure piping - SS 316, Low pressure piping – uPVC Membrane MOC : Polyether sulfone / Polysulfone

Sr. No.	Unit / Equipment	Capacity / Sizes / Dimensions	Qty.	MOC
		on the high pressure pump suction and discharge, pressure gauge on the RO inlet and reject, ORP analyser on the inlet. The system should be designed for automatic operation with necessary interlocks. Capacity: to be designed to produce permeate flow of 263 KLD in 20 hours.		

Sr. No.	Unit / Equipment	Capacity / Sizes / Dimensions	Qty.	MOC
		The membrane system must include membrane integrity test that is capable of demonstrating the membrane system is achieving a minimum of 4-log removal of particles greater than 2 microns. The membrane integrity test must be fully automated and capable of testing the membrane every 24 hours of operation. Each membrane module must have view glass for integrity test.		
32.	Cartridge Filter for CIP	Suitable	1 No.	MOC- SS 304
33.	CIP system for RO consisting of Cartridge filter, CIP tank with agitator, CIP pump, piping and hose pipes, flow indicator.	CIP Tank: 1 No. CIP pump 2 Nos, (1W+1S)	1 set	Tank: HDPE Agitator : SS 304 CIP pump : SS 316

Sr. No.	Unit / Equipment	Capacity / Sizes / Dimensions	Qty.	MOC
				1 no. trolley MS with FRP coating
34.	RO Permeate Transfer Pumps for HVAC requirements	45 m^3/hr @ 20 m Head, Horizontal centrifugal pumps for transferring RO permeate to HVAC tank	2 (1W + 1S)	CI with SS shaft & impeller

Sr. No.	Unit / Equipment	Capacity / Sizes / Dimensions	Qty.	MOC
35.	Irrigation Water Transfer Pump	45 m^3/hr @ 20 m Head, Horizontal centrifugal pumps for transferring Irrigation water to irrigation tank and with suitable bypass arrangement to sewer/storm water network	2 (1W + 1S)	CI with SS shaft & impeller
36.	Sewage Bypass Pump	45 m^3/hr @ 20 m Head, Horizontal centrifugal pumps for bypass the sewage	2 (1W + 1S)	CI with SS shaft & impeller
37.	Online monitoring System	Suitable	1	
38.	Odor Control unit	Suitable for Preliminary and sludge handling unit.	1	

8.2 In addition to the above listed equipment, the following would be in the scope of the bidder:

SR.	DESCRIPTION	SIZE/	QTY.	M.O.C.

NO.		CAPACITY	Nos.	
1.	Interconnecting piping & Valves as required	By Bidder	1 Lot	DI K9 for Pump suction and discharge, gravity sewage and sludge piping. Flexible Hose for Submersible pumps upto discharge header. GI class C for Air pipe above water and UPVC for submerged pipes and chemical dosing. High pressure piping - SS 316, Low pressure piping – uPVC
2.	**ELECTRICAL WORK**			
2a	Power cables from main STP Panel to all motors.	By Bidder	1 Lot	As per tender specifications.
2b	Push button stations near each motor.	By Bidder	1 Lot	As per tender specifications.
2c	Power / Control cables	By Bidder	1 Lot	As per tender specifications.
2d	Earthing	By Bidder	1 Lot	As per tender specifications.
2e	Separate KWh Meter	By Bidder	1 Lot	As per tender specifications.
3	**INSTRUMENTS AS PER THE INDICATIVE LIST GIVEN BELOW: PLEASE REFER CONTROL PHILOSOPHY**			

INDICATIVE LIST OF INSTRUMENTS FOR STP – 2 x 0.5 MLD - PHASE I

Sr. No.	Item & Specifications	Qty
1.	Pressure Gauges – At the discharge of each pump & Blowers, At the inlet and outlet of PSF and outlet of ACF	Lot
2.	Capacitance type Level Transmitters in Equalisation Tank, Treated water Tank, Flushing water Tank, Irrigation Tank, RO permeate Tank with provision for alarm at high level in the tank and alarm as well as tripping of pumps at low level.	Lot
3.	Level switches in Sludge Holding Tank, Centrate collection Sump, all Dosing Tanks with provision for alarm at high level in the tank and alarm as well as tripping of pumps at low level.	Lot
4.	DO meter in Aeration tank & MBR tank	4

5.	Electro- magnetic Flow transmitter with indicator and totalizer – At the discharge of Equalized sewage transfer Pumps – At the discharge of MBR Permeate Pumps – At the discharge of RO Feed Pumps – At the discharge of RO Permeate Line – At the discharge of Flushing Water Transfer Pumps – At the discharge of Irrigation Water Transfer Pumps – At the discharge of RO Permeate Transfer Pumps	10
6.	DPS across bag filter, Cartridge Filter, RO system	3
7.	Pressure switch at the suction & Discharge of RO High Pressure Pump	1
8.	Flow Transmitter on Reject Line	1
9.	pH Transmitter at RO Inlet and Permeate Line	2
10.	Conductivity Transmitter at RO Inlet and Permeate Line	2
11.	Pressure Transmitter for UF - RO skid	2
12.	ORP analyser with transmitter and controller	1
13.	Dump valve & Auto valve for RO system	Lot
14.	If required, Instrument air compressor with an air receiver tank, air filter-dryer and air filter regulator along with instrument air piping and tubing for pneumatically operated valves	
Note: For fully automation of RO system, if any additional instruments are required contractor must provide the same.		

8.3 Following activities / items is also in the scope of the Bidder.

- Foundation bolts for all equipment, puddle flanges, companion flanges with nuts, bolts, gaskets at terminal points.
- Final painting at site.
- Packing, forwarding, delivery to site, unloading at site.

- All consumables till the plant is handed over to the EMPLOYER/ENGINEER. Chemicals, Instruments and equipment required for the installation and performance test should be arranged by Bidder.

- Provision of auxiliary steel/supporting steel for supporting the equipment and piping, Access platforms, ladder, handrail and steel supporting base etc. common for all accessories as well as related drilling, welding work, painting of supports etc.

- All erection tools and tackles, cranes, hoisting equipments, etc as required.

- One (1) set of commissioning spares and maintenance tools.

- One (1) set of essential spares.

- Service water shall be made available by EMPLOYER/ENGINEER at one point of STP limit.

8.4 Erection and Commissioning Services

Following activities / items will be in the scope of the Bidder.

- Receiving material/ equipment at site, unloading all the equipment and material at site from carriages, checking against damages, storing in storage area provided by the EMPLOYER/ENGINEER, shall be in the in the scope of bidder.
- Movement of equipment and materials to erection at site by bidder.
- Suitable cutout shall be provided to facilitate smooth movement or replacement of equipment as and when required.
- Erection of all equipments and materials supplied under this contract.
- Grouting of equipment foundations.
- Hydro test and air leak test at site after completion of erection.
- Trial runs, testing, start-up, performance recalibration, commissioning and performance / Acceptance tests covered in the specification before handing over.
- Proper tagging of all civil units, equipments should be done by Bidder.
- The Bidder shall arrange following at his own cost.
  - Adequate quantum of welding electrodes including special electrodes and welding units required for erection.
  - All consumable required for erection and commissioning.
  - All erection tools and tackles, cranes, hoisting equipment, etc as required.

- All skilled, semi-skilled and unskilled labour required for erecting any facility, as required, for the labour force such as accommodation, transport, medical facility, insurance etc.
- First fill of lubricants and grease etc.
- Commissioning of the entire STP and accessories and handing over to EMPLOYER/ENGINEER.
- Training of the STP personnel for proper operation and maintenance.

8.5 Layout

Bidder should fit the STP within allocated area shown in the Layout ensuring adequate space provision for Phase I. All supports for all equipment and platforms, walkways, stairways for all equipment as required are in bidder's scope and same shall be indicated in layout.

The interconnecting pipe shall be laid out in such a way that they are easily accessible for any maintenance or repair and also permits easy movement of the personnel. Easily accessible dismantling joints shall be provided for maintenance purposes.

The exact layout considering the actual equipment dimensions, handling facilities, clearances as required for easy operation and maintenance, pipe support locations etc shall have to be firmed up by the bidder for satisfactory operation of the systems covered under the scope of work.

The preliminary / proposed layout for STP-Phase I along with space provision for Phase II & III is attached in drawing no. TCE.12824A-CH-2032-GA-20001.

8.6 Piping Material Specification

All the material of construction of piping should be compatible with the requirement and as mentioned in Tender Specifications.

8.7 Painting

All surfaces such as light gauge / glasses, required for clear visual observation shall be cleaned after paint application.

Special care shall be taken to avoid any paints from dropping on the machined moving parts of equipment, name plates or indicator dials of instruments and control valves. Prior to paint application or spraying paint removable adhesive tape shall be used to cover these.

On final completion of all work, the BIDDER shall leave the entire premises within the site of his operation clean and free from all rubbish resulting from his painting operation and shall remove any paint or other blemishes caused by him on adjacent walls, windows, equipment and finished surface.

All piping shall be painted after hydro test only. The iron and steel surfaces shall be thoroughly cleaned of all rust, scale, grease or oil and then primer coat shall be applied.

The EMPLOYER/ENGINEER reserves the right to inspect the cleaning down and painting operations at any stage and if required by EMPLOYER/ENGINEER unsatisfactory surface preparation or paint application shall be remedied at BIDDER'S expense.

On job site, no painting shall be carried out in a dust laden atmosphere or under unsuitable weather conditions viz. when raining or when metal surfaces are damp or when condensation is likely to affect the paint film before it is dry.
All the exposed non-insulated carbon steel surfaces of equipment, piping and structural & auxiliary steel for pipe and equipment support shall be painted as indicated below:
Surface preparation – removal of dust, dirt, oil, grease, scale and other foreign material by manual or power tools.

Primer –2 coat of red oxide primer (conforming to IS: 2074) with minimum dry film thickness (DFT) 25 microns per coat.

Finish–2 coat of synthetic enamel (conforming to IS: 2932) with minimum dry film thickness (DFT) 50 microns per coat.

8.8 Codes and Standards

All the equipment, systems and works covered under this specification shall comply with the relevant Indian Standards, regulations and prevailing safety codes in the locality where the equipment will be installed. All the equipment shall comply in all respects with the requirements of latest edition of codes and standards.

In the event of any conflict between the codes and standards referred to in the specification and the requirements of this specification, the more stringent of this requirement shall govern.

8. 9 Performance Test and Guarantees & Operation & Maintenace for 5 years including 2 years Defect Liability period.

The BIDDER/Contractor shall guarantee the outlet requirements of the STP system as specified in the tender and shall carry out performance guarantee tests upon successful commissioning for a minimum period of one month (1 month) continuous operation to prove the following performance guarantees (a) Throughput of the STP in m3/day as per the sewage availability (b) Treated Sewage parameters compliance in normal and turndown conditions.

Quality of the Treated Sewage at the outlet shall be as specified in “Table -Design Basis” in these specifications, Analysis test reports from Third party NABL accredited laboratory shall be submitted (minimum twice a week) after the commissioning of the plant for a period of one month. (The quality requirement as specified above shall be confirmed by the BIDDER/Contractor).

Guaranteed power and chemical consumption of STP per day in kWh (as measured at a point before input into MCC). The BIDDER/Contractor shall guarantee the power/chemical consumption for the STP Plant in the prescribed format.

Chemical Consumption and Power Requirement

Bidder has to indicate the Chemical consumption and the Power required for the plant in the following format.

Chemical Consumption

Sl.No.	Chemical	Consumption(g/m3)	Kg/day
1.			
2.			

Power Consumption

Sl. No.	Equipment	Nos. Wkg.	Nos. Standby	kW (Rating)	I.kW (Input)	BkW	No. of Wkg. Hours	Total Power Consumption (Kwh)
1.								
2.								

Bidder to furnish the above information for each equipment in the STP system.

Consumables

Repair, Replacement of all electromechanical equipment, Membranes and repair of any civil structures during the 2 years operation and maintenance period is in contractors scope.

Minimum Manpower

Minimum manpower to be provided for commissioning and during O & M Period.

Sr. No	Role	Experience in Operating Similar Plants	Skilled / Semi-Skilled	Quantity
1.	Supervisor	5 years		1 (General)
2.	Operator -1	3 years	Skilled	1 Per Shift
3.	Operator -2	3 years	Skilled	1 Per Shift
4.	Operator -3	3 years	Skilled	1 Per Shift
5.	Operator - Reliever	3 years	Skilled	As Required
6.	Helper			1(General)

In case the performance guarantee cannot be proved due to the reasons attributable to the BIDDER/Contractor, then the BIDDER/Contractor shall carry out the required modifications/repairs/replacement to the plant at BIDDER's cost expeditiously and repeat the performance test runs until all specified guarantees are fully met.

The time period allowed for modifications/repairs/replacement of the STP system in the case as described in above shall be two months (60 days) from the date of commencement of performance tests.

The BIDDER/Contractor shall incorporate features including necessary instrumentation and controls to run the plant at lower loads and at the same time shall maintain the quality of Treated Sewage at the battery limit of STP as stipulated in this specification. The necessary arrangements required for loading the plant at lower loads shall be in the BIDDER/Contractor's scope of supply.

Uptime Guarantee

The contractor shall guarantee for the installed system an uptime of 98%. In case of shortfall in any month during the defect's liability period, the Defects Liability period shall get extended by a month for every month having shortfall and no reimbursement shall be made for the extended period.

8.10 Maintenance Requirements

In order to carry out preventive maintenance, it should be possible to readily disassemble, repair, and reassemble the equipment in the shortest period and to attend to any defect by a minimum disassembly.

The Bidder shall furnish one complete set of any special maintenance tools required for normal maintenance of equipment.

The Bidder shall confirm that space shown for the equipment is adequate from point of view of access, easy maintenance and for day-to-day operation.

Suitable cutout shall be provided to facilitate smooth movement or replacement of equipment as and when required.

All system must have convenient maintenance characteristics including:
Care should be taken to cause minimum disturbance to production during preventive maintenance.
The bidder shall ensure easy access to replacement part, which can be installed by personnel of minimum skill.

8.11 Availability Requirements

All equipment and accessories shall be designed for maximum reliability and availability, particularly in respect of the following:

The equipment shall be of proven design, using materials established as appropriate to the service intended. Fabrication / manufacturing processes shall be subjected to quality surveillance and tests.

8.12 Noise and Vibration

Noise level produced by any equipment individually or collectively shall not exceed 85 dB (A) measured at a distance of 1.5 metres from the source in any direction.

The overall vibration level shall be as per zones A and B of ISO 10816-1. Vibration isolators shall be provided.

9.0 DATA TO BE FURNISHED BY BIDDER FOR PHASE I, II & III

Minimum Drawing & Document Requirement

A. Contractor shall furnish with quotation the drawings/data as marked (X) in the "With Quote". Quantity required is one per each quotation sent.

B. Successful Contractor shall be required to furnish the minimum drawings/data as marked (X) within two weeks from date of order.

C. For documents marked (X), 1 CD (soft copy) and 5 hard copies shall be submitted for records and reference within one month before the shipment.

Sr. No.	Description of Drawings / Data Required	A	B	C
1.	Technical deviations & exceptions	**X**		
2.	Tender data sheets	**X**		
3.	Layout	**X**	**X**	**X**
4.	P&ID including specification of instrument control	**X**	**X**	**X**
5.	Process Flow Diagram indicating mass in/out from each unit in m^3/h	**X**	**X**	**X**
6.	List of Units and Equipments including MOC, Sizes, Qty, etc.	**X**	**X**	**X**
7.	Deviation List	**X**	**X**	
8.	Exclusion List	**X**		
9.	Instrument list	**X**	**X**	**X**
10.	Technical specification sheet	**X**	**X**	**X**
11.	Instrument data sheets		**X**	**X**

Sr. No.	Description of Drawings / Data Required	A	B	C
12.	Motor list	X	X	X
13.	Utility consumption	X	X	X
14.	List of special tools with pricing		X	X
15.	List of Commissioning Spares	X		
16.	Recommended spare for 2 years parts with Pricing	X	X	X
17.	List of bought out items with names of Contractors	X	X	X
18.	Catalogues		X	X
19.	Quality control plan		X	X
20.	Time Schedule (Bar Chart)	X		
21.	Complete drawing list		X	X
22.	General arrangement drawing		X	X
23.	UF and RO projections		X	X
24.	Foundation & load details		X	X
25.	Cross sectional drawing with B.O.M.		X	X
26.	Component drawings		X	X
27.	Assembly/Erection drawings		X	X
28.	Design calculations		X	X
29.	Performance curves / tables		X	
30.	Piping drawings		X	
31.	GA of control panel		X	X
32.	Schematic wiring diagrams		X	X
33.	Cable schedule		X	X
34.	Interlock / alarm / trip schedule		X	X
35.	Control logic diagrams / written sequence		X	X
36.	Electrical layout		X	X

Sr. No.	Description of Drawings / Data Required	A	B	C
37.	Electrical layouts (Power, Earthing, Lighting, Lightning Protection, etc.)		**X**	**X**
38.	Single Line Diagrams, Control schemes, Interconnection Diagram/Schedule.		**X**	**X**
39.	Welding procedure		**X**	**X**
40.	Inspection test reports			**X**
41.	Material (mill) test reports			**X**
42.	Installation, operation & maintenance manuals			**X**
43.	Storage procedures		**X**	**X**
44.	Bill of material (for site receiving)		**X**	**X**
45.	Lubrication schedule		**X**	**X**
46.	O&M Manual			**X**

The BIDDER shall ensure the following documentation are prepared and submitted to the consultant/ client for review, approval and records as applicable.

Final Documents:

BIDDER shall submit the three copies of operation and maintenance manuals at the time of commissioning in addition to one copy two weeks before dispatch. The manual shall be in sufficient detail with step-by-step instructions to enable others to inspect erect, commission, maintain, dismantle, repair, reassemble and adjust all parts of the equipment. Each manual shall also include a complete set of approved as built drawings together with performance / rating curves / charts of the equipment, maintenance schedule and test certificates wherever applicable.

The BIDDER shall submit Quality assurance documentation specific for the project.

10.0 COMPLETION PERIOD

The entire Phase I works for STP (Electro-mechanical) shall be completed within 8 months of receipt of LOI.

11.0 ELECTRICAL SPECIFICATION

11.1 Scope

- Scope of work shall include Design, Detail Engineering, supply, installation, carrying out stage-wise & shop floor inspections, testing and commissioning of all electrical equipment that are deemed necessary for the successful operation of the complete STP system including broadly the following items, but not limited to it: LT Motors, LPB (Local push button)stations, LT panels, JB's, power & control cabling system & its carrier system, earthing from equipment terminal to main conductor, civil support structures that are required for supporting the electrical equipment and services.
- Bidder shall submit all drawings (covering the scope) to the Client/ Engineering Consultant for their review and approval and deliverables submission schedule furnished / mentioned at time to time after issue of LOI.
- The electrical equipment supplied and installed by the contractor shall be compactable to connect with the Client's SCADA system. The numbers of input/output terminals required for the interconnectivity to SCADA shall be considered in adequate.
- Whether called for specifically or not, all accessories required for normal operation of equipment are deemed to be considered as a part of the BIDDER's scope of supply. Any hardware required for mounting and installation of the above listed is within the scope of work.
- The preparation of required earthing layout, cable tray layout equipment GA ,etc shall be in the scope of contractor.
- Preparation of as-built drawings is in the scope of the contractor.
- Supply of safety equipment for Electrical STP panel & other equipment, like rubber mat, danger board, etc. in the scope of STP contractor.
- It is not the intent to specify completely herein, all details of design and construction of the equipment. However, the equipment shall conform in all respects to high standard of engineering, design and workmanship and be capable of performing in continuous commercial operation up to the BIDDER's guarantees in a manner acceptable to the PURCHASER, who will interpret the meaning of the drawings and specifications and shall be entitled to reject any work or material which is not in full accordance therewith.

Scope Matrix:

Sr.No.	Description	Scope
1	**Panels**	
	STP Panel at STP area	STP Contractor
	All further downstream panels	STP Contractor
	LDBs & PDBs required for STP area	Electrical contractor
2	**Power & Control Cables**	
	Power & Control from CUB main panel to STP panel	Electrical Contractor
	Power & Control Cables from STP panel to downstream loads	STP Contractor
	Cable carrier system at STP pump house	STP Contractor
	Incoming and outgoing cables of LDB & PDB	Electrical Contractor
3	**Earthing**	
	Earthing conductor around STP area and connecting to equipment	STP Contractor

11.2 MCC Panels

- The scope includes design, supply, testing, erection & commissioning of Motor Control Centre required for STP loads as per the scope matrix.
- The MCC shall be located inside the area allotted for STP.
- The following feeders will be provided by the purchasers, All further downstream distribution is in the scope of STP contractor.

Sr. No	Feeder Rating	Location	Purpose
	STP MAIN MCC		
1.	2x Nos. of 630A MCCB with electrical interlock (4P microprocessor based with respective kA ratings)	STP	Panel Incomer

Sr. No	Feeder Rating	Location	Purpose
2.	As per Equipment capacity & 20 % spare Feeders	STP	Panel Outgoing
	UF & RO PLANT MCC		
3.	2x Nos. of 200A MCCB with electrical interlock (4P TM based with respective kA ratings)	STP	Panel Incomer
4.	As per Equipment capacity & 20 % spare Feeders	STP	Panel Outgoing

The Above configuration is similar for Both Phase A & Phase B

- LT panel shall be metal clad, self-standing dust proof construction, indoor cubicle type fitted with MCCB, fully draw-out type. Degree of protection of indoor LT panel shall be IP4X or better and outdoor panel shall be IP65, complying to form 4b and comply the IEC 60439 standards.
- MCCBs rated up to 200A shall be provided with TMD release. From 250 A & above shall be microprocess Releases.
- For outgoing motor feeders rated upto 30kW shall be provided with MPCB. Motor rated upto 3.0 kW DOL Starters shall be provided. Motors rated above 3.0 kW shall be with star delta starter.
- Required surge protection device with rated fuse shall be provided
- Dry run protection for the motor have to be added
- AHF for the pumps (THD(I)) to be less than 5%
- The thermal overload protection relays to have built in protection against single phasing.
- All motor feeders shall be provided with Dial type ammeter.
- Control & monitoring shall be from STP controller. In addition, monitoring & metering shall also be done from remote SCADA thro redundant communication link between STP controller & SCADA using Modbus or other open protocol.
- The thickness of the load bearing members shall be 3 mm and the non-load bearing members shall be 1.6mm.
- Electronic Multifunction meters (3 phase Current, 3 phase Voltage, KW, KWH, KVA, PF, Hz, KVAr) with 0.5 class accuracy shall be provided for all feeders with

communication port. Multifunction meters shall be EMC compliant, four quadrant type. Dual Source Energy meters should be considered.

- The bidder shall provide a minimum of 20% spare feeders per panel/ DB.
- 4 no's of 63A welding receptacles shall be provided in the STP area. The contractor shall consider the required feeders in the STP MCC.
- 1 Nos of 40A MCCB LDB feeder & 6 Nos of 63A MCCB PDB feeders shall be provided by the STP contractor at STP MCC for STP pump house lighting & small power.
- The control supply required for the MCCs shall be derived from the bus itself through control transformer.
- MCC shall meet the other requirements as specified in the enclosed technical specification and the corresponding Data Sheets attached.
- Potential free contacts have to be considered for remote monitoring.
- Selection of contactors & MPCB shall be TYPE 2 coordinated.

10.3 Motors

- The bidder scope of supply includes supply, erection, testing & commissioning of LT motors.
- The motor shall be energy efficient weatherproof with degree of protection for the motor enclosure shall be IP-54 for indoor & IP55 for outdoor and terminal boxes shall be provided with at least IP-55. For multi core cable termination, gland plates shall be of non-magnetic material type.
- LT Motors shall meet the other requirements as specified in the enclosed Induction motor technical specification and the corresponding Data Sheets attached.
- All the LT motors shall be IE3 type efficiency.

10.4 Push Button Station

- For the purpose of control of the motors installed along with this package, the push button/control stations shall be installed near to the motors. Individual channel supports shall be used for each of the push button stations. These shall be installed as per approved erection detail drawing.
- All outdoor push button/control stations shall have necessary canopies. Wiring of push button control station shall be checked before giving control supply.
- The Local Push Button Station shall be furnished in cast Aluminium enclosure (minimum 2.0 mm thick) of weatherproof gasketed construction with dust and

vermin proof suitable for outdoor use without canopy conforming to IPW-55 or better.

- The enclosures shall be suitable for mounting on column/wall and complete with push button, anodized aluminium inspection plate, earthing terminal and knockout for cable/conduit entry from top and bottom.
- Local start / stop push button stations lockable in stop position will be provided for all motors.

10.5 Earthing

- The scope includes the supply, laying & installation of earthing conductor around the STP building and connecting to the nearest earthing conductor for Motor, LPBS, MCC and any other equipment supplied by STP Vendor.
- Main earthing conductors shall be by the electrical contractor. STP contractor shall create the earthing grid at STP area. Connecting the STP earthing grid to main earthing grid is in the Electrical contractor scope. All connections between the main grid to STP equipment to be ensured by the STP contractor. Minimum two tap offs from main earthing loop will be taken near to the equipment and connected to the earthing conductor required for earthing the equipment. For all the equipment like motors, cable trays, tanks, earthing conductors shall be welded to the nearest available earth grid and connected to the equipment. A minimum of two leads are to be connected for the equipment.
- The following are earthing conductors shall be used by bidder for connecting equipment earthing leads to the main conductor. (Earthing conductor size will be finalised as per the fault level calculation). Earthing will comply the IS 3043.

SR. NO.	DESCRIPTION	SIZE	MATERIAL	NO. OF LEADS (MIN)
1.1	415V, UPTO 11 KW	10 Sq.mm insulated wire	Cu	2
1.2	415V, 13 KW TO 30 KW	6 Sq.mm insulated wire	Cu	2
1.3	415V, 37 KW TO 67.5 KW	25 x 3 Sq.mm flat	GI	2

SR. NO.	DESCRIPTION	SIZE	MATERIAL	NO. OF LEADS (MIN)
1.4	415V, 75 KW & ABOVE	40 x4 Sq.mm flat	GI	2
1.5	MCC Panels	50 x 10 sq.mm flat	GI	2
1.6	Metallic Non-Current Carrying Structures, Tanks, etc.	50 x 10 sq.mm flat	GI	2
1.7	Main earthing conductor	75 x 10 sq.mm flat	GI	2

10.6 Cables

- The Scope includes design, Engineering, supply, laying & installation of LT power & control cables required for STP system as per the scope matrix.
- The LT power cables shall be 1100V grade, single / multicore, stranded aluminium/copper conductor, XLPE insulated, with PVC inner sheath, armoured and outer sheath made of specially formulated FRLS PVC compound. Single core cables will have aluminium wire / formed wire armour, whereas multicore cables will have galvanised steel wire / formed wire armour. The cables will conform to IS-7098 - Part-I (1988) / IEC-502 (1983) in all respects. For Power cable laying, Installation & maintenance will confirm the IS 1255 Power cables upto 16Sq.mm shall be with copper conductor.
- The LT control cables shall be 1100V grade, multicore, 2.5 sq.mm cross section, stranded copper conductor having 7 strands, PVC insulated, inner PVC sheathed, galvanised steel wire/formed wire armoured and outer sheath made of FRLS PVC compound conforming to the performance requirements outlined above will be used The cables will conform to IS:1554 (Part-I) - 1988 / IEC-502 (1983) in all other respects.
- LT Power & control cables shall meet the other requirements as specified in the enclosed document and the corresponding Data Sheets attached.
- The cables should be sized in such a way that the voltage drop (less than 5% as per NEC standards) in cables between MCC to the motor terminals for full load

motor current shall be limited to 1% and the voltage dip during motor starting shall be limited to less than 15%. The cable size is also taken care of D-rating factor & inrush current of motor. The bidder should furnish the cable sizing document for purchasers/ consultant approval.

- The cable glands and lugs shall be of Nickel Plated brass double compression glands.
- The scope shall also include supply & installation of Lugs & glands, cable jointing kits for both the power & control cables installed under this scope of work.

10.7 Cable Carrier System

- The scope shall include supply, laying & installation of cable carrier system along with supports and accessories as per the scope matrix.
- Cable carrier system shall be designed such that in no location along the route of cable tray, the loading is greater than 75%.
- The cable trays shall be prefabricated ladder type/Perforated type galvanised iron trays. Separate cable trays will be used for, 415 V power and control cables. The arrangement of trays shall be Low voltage trays in 1st tier, electrical control trays in 2nd tier and instrumentation trays in 3rd tier and comply the IEC 61537 standards .
- Cable bending will confirm the IS 1255 as according to that cable tray size shall be select.
- All cable trays shall be of ladder type/perforated type construction of various sizes with accessories. There shall be a maximum spacing of 1500 mm between cable tray supports, except fittings (elbows, tees, etc.) This shall be supported at each splice.
- The flange height of the cable tray shall be 100MM for all the trays.
- 150MM,300MM,450MM,600MM,750MM width cable trays shall be used.
- Single core cable shall be laid in trefoil arrangement.

10.8 Approved Vendor List

Bidder shall strictly adhere to the list of vendors indicated in the vendor list for procuring any items.

10.9 As Built Drawings

The successful bidder shall submit the as built drawings to engineering design consultant for approval.

11.0 TECHNICAL SPECIFICATIONS FOR MECHANICAL EQUIPMENT AND COMPONENTS FOR SEWAGE TREATMENT PLANT

General Unit Operations

STP Contractor shall coordinate with the other Contractors to ensure all necessary works are incorporated.

Upon completion, all equipment and materials shall be cleaned, tested for static performance, and signed off by the Project Manager.
All the equipment shall be issued in catalogue form, together with working drawings for builder's work, layout arrangement, electrical control arrangements.

Prior to equipment being ordered and work starting, approval in writing shall be issued by the Project Manager.

Tenderer shall furnish proof to the satisfaction of the Employer that the plant equipment supplier shall be reputed one with good credentials in similar application and have a local qualified and experienced field servicing engineer who can furnish adequate servicing facilities to the owner and operator during normal operation and emergency.

All the equipment shall be provided with warrantee of 1 year after commissioning of project or 18 months after the erection of equipment. The equipment, pipes and valves shall be factory tested in terms of performance, Vibration, leakage, hydrostatic testing and given parameters/criteria in accordance with approved datasheet and QAP of respective equipment.

Oil & Grease Removal Unit:

Oil & Grease Removal unit shall be made of civil construction. Slotted pipe skimming provision shall be provided to remove the oil and grease from the tank surface and suitable mechanism shall be provided to collect the scum/grease for further treatment and safe disposal. The MOC of the skimmer shall be MSEP.

Submersible Sewage Pumps:

Submersible pump, with appropriate flow rate and head shall be installed as per Schematic Process Flow Diagram. The submersible pumps shall be used at Equalization tank.

Pumps shall be suitable for pumping grossly polluted raw sewage containing hairs, fibrous materials, coarse solids and tough plastic materials, free from clogging and catching. Solid handling capacity up to 30 mm.

Pumps shall be tested in accordance with ISO 9906.
Pump casing shall be of high grade cast iron, impeller shall be SS and shaft shall be of stainless steel. Double Mechanical Seals shall be provided. The entire pump assembly shall be adequately protected from corrosion. 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.
Pumps shall run smoothly without undue noise & vibration. Noise level shall be limited to 85 dBA at 1.86 m at sites. Vibration levels shall not exceed the levels given in BS 4675.

Pump flange shall be suitable for automatic coupling to discharge pedestal with single guide rail of stainless steel. Motor shall be of submersible type, insulated against heat and humidity to Class “F” with bimetallic thermal overload protectors incorporated in motor windings. Operating voltage shall be of 415V three phase 50 Hz supply with permissible speed not exceeding 1500rpm. Motors shall be EFF-2 Energy Efficient type. Electrical cable of sufficient length which shall be waterproofed shall be supplied by pump manufacturer.

Duck foot discharge connection, stainless steel (AISI 304) lifting chain with stainless steel (AISI 304) guide bar, stainless steel hooks for chains shall be provided so that pump can be automatically connected to the discharge pipe work. One set of operating valve and non-return valve shall be provided at the discharge pipe of each pump in case the pumps share the common discharge line or outlet point is submersed in water. All necessary accessories for fixing such as bolts, nuts, washers, etc. shall be included. Detailed of fixing to pump shall be submitted to the Consultant for approval.

The operation of pumps shall be controlled by level transmitters. All the pumps shall be able to operate as the duty pump. The standby pump shall be arranged to start automatically on failure of the duty pump and the electricity supply to the failed unit shall be cut off. The switch gear shall be suitable for automatic operation with manual override. The pump shall be designed to have pump starts less than 10 times per hour.

End Suction Pump

End suction centrifugal pump, with appropriate flow rate and head shall be installed as per process requirements. The End suction pumps shall be used as nitrifying liquor transfer

pump, RAS/WAS Pumps, Filter feed pumps, UF feed Pumps, RO feed pumps, Centrifuge feed pumps, Permeate transfer pump, Irrigation water transfer pumps, flushing water transfer pumps, HVAC water transfer pumps etc.

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.

Pumps shall be tested in accordance with ISO 9906.

Pump casing shall be of high grade cast iron, impeller shall be SS and shaft shall be of stainless steel. Mechanical Seals shall be provided. The entire pump assembly shall be adequately protected from corrosion. 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.

Pumps shall run smoothly without undue noise & vibration. Noise level shall be limited to 85 dBA at 1.86 M at sites. Vibration levels shall not exceed the levels given in BS 4675.

The dimensions of the pump shall be metric conforming to BS 5257 or its equivalent standard. Flanges shall conform to BS EN 1092-1/ BS 4504.

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.
The velocity at the entrance to the pump impeller shall not exceed 3.5 m/s.
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.

Motor shall be of Squirrel Cage Induction type, insulated against heat and humidity to Class “F” with bimetallic thermal overload protectors incorporated in motor windings. Operating voltage shall be of 415V three phase 50 Hz supply. Motors shall be EFF-2 Energy Efficient type. Electrical cable of sufficient length which shall be waterproofed shall be supplied by pump manufacturer. Pumps shall be provided with VFD drives as mentioned in the specifications.

Flushing facilities shall be provided for mechanical seals where pump fluid may be contaminated with abrasive material.

Lubrication arrangements shall be so designed that there is no contamination of the pumped fluid.

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.

Tappings shall be provided at both the suction and discharge flanges for pressure gauge equipment.

Rotary Drum Screen

The rotary drum screen, with screen opening of 2 mm, shall be provided before the MBR module. It shall consist of screen, a screw conveyor and compactor.
During operation, solids within the incoming flow shall enter into the drum screen and progressively collect into the screen mesh. The upstream water level shall rise and at a predetermined level, the drum screen and screw conveyor shall activate and rotate immersing a clean section of the screen into the effluent.

During rotation the solids or screenings shall become inverted and then fall into the screw conveyor. Spray nozzles and a roller brush shall be fixed to the periphery of the drum screen to clean away any residual solids from the mesh.
The material of construction shall be SS316.The screen shall be easy to install.

Membrane Bio-Reactor

Equalised Sewage from Equalisation tank via Drum screen shall enter in to Anoxic tanks. From anoxic zone mixed liquor shall be conveyed to aeration Tanks, where air (with fine bubble diffused aeration system) is supplied to provide oxygen for carbonaceous BOD removal and nitrification (ammonia conversion to nitrates).The Membrane (ultra-filtration) Filtration process shall comprise of the following unit processes and services:

Bidder may consider Membrane type of;

Hollow fibre membrane

General arrangement of the Works;

- Outside-in submerged arrangement for Membranes

- Membrane flux maximum 25 litres/m2/hr during average day (design) flow conditions.
- Back-pulsing as per system requirement
- Membrane Filtration Cartridges
- Membrane Cartridge Cassettes
- Air Distribution Piping
- Air Blower Equipment
- Internal Recycle Pumping Equipment
- CIP Equipment and Instrumentation
- Automated Pneumatic Valves
- Process Instrumentation
- PLC System
- Process Tankage (as applicable)
- Pressure Membrane Filtration System (include backwash & permeate pumps, clean-in-place system, pressure measurement, membrane air scour and other ancillary equipment)
- Membrane shall comprise of homogeneous hollow fibre type with nominal pore size in the range of 0.01 to 0.04 µm.
- Membrane material and components to be chlorine resistant and membrane material shall be of PVDF and shall be reinforced type.
- Membrane backwash system shall use a filtrate backwash together with external air scour to remove accumulated particles and maintain a design filtrate production rate.
- In-situ chemical cleanings (maintenance or recovery cleaning) shall be considered to maintain the membrane TMP.
- Chemical enhanced backwash shall be provided to maintain membrane permeability.
- The membrane system must include membrane integrity test that is capable of demonstrating the membrane system is achieving a minimum of 4-log removal of particles greater than 3 microns. The membrane integrity test must be fully automated and capable of testing the membrane every 24 hours of operation. In addition, the bidder shall provide an appropriate test method to locate a single faulty fibre within the array of membrane modules in housing units.
- All unit operations within a membrane system shall be fully automated and suitable for unattended operation including but not limited to backwash, chemical

enhanced backwash, membrane integrity monitoring and clean-in-place (CIP) sequence.

- The membrane supporting frames shall be SS304.

End Suction Pump

End suction centrifugal pump, with appropriate flow rate and head shall be installed as per process requirements. The End suction pumps shall be used as nitrifying liquor transfer/ RAS pump, MBR permeate pump, Back uplse pump, CIP Pumps, Filter feed pumps, RO feed pumps, Centrifuge feed pumps, Permeate transfer pump, Irrigation water transfer pumps, flushing water transfer pumps, HVAC water transfer pumps etc.

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.
Pumps shall be tested in accordance with ISO 9906.

Pump casing shall be of high grade cast iron, impeller shall be SS and shaft shall be of stainless steel. Mechanical Seals shall be provided. The entire pump assembly shall be adequately protected from corrosion. 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.

Pumps shall run smoothly without undue noise & vibration. Noise level shall be limited to 85 dBA at 1.86 M at sites. Vibration levels shall not exceed the levels given in BS 4675.

The dimensions of the pump shall be metric conforming to BS 5257 or its equivalent standard. Flanges shall conform to BS EN 1092-1/ BS 4504.
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.

The velocity at the entrance to the pump impeller shall not exceed 3.5 m/s.
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.

Motor shall be of Squirrel Cage Induction type, insulated against heat and humidity to Class “F” with bimetallic thermal overload protectors incorporated in motor windings. Operating voltage shall be of 415V three phase 50 Hz supply. Motors shall be EFF-2 Energy Efficient type. Electrical cable of sufficient length which shall be waterproofed shall be supplied by pump manufacturer. Pumps shall be provided with VFD drives as mentioned in the specifications.

Flushing facilities shall be provided for mechanical seals where pump fluid may be contaminated with abrasive material.
Lubrication arrangements shall be so designed that there is no contamination of the pumped fluid.

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.
Tappings shall be provided at both the suction and discharge flanges for pressure gauge equipment.

Submersible Mixer

Propeller

The propeller shall be of the cast marine type or welded type of material SS 304. For a welded propeller, only full penetration welds are acceptable. The propeller shall be checked thoroughly for welding defects, especially at the blade root, where stresses are at a maximum.

The propeller shall be locked to the shaft. Positive fixing of the propeller to the shaft may be achieved by a taper-to-taper, side fitting key and a corrosion resistant impeller retainer cone with cap screw. Keys shall not be allowed if clad shaft material is used.

All propellers shall be statically and dynamically balanced in air as well as hydraulically balanced to ensure vibration free operation and optimum cavitation’s free conditions and to promote maximum pumping rate and entrainment for any given power.

Shaft

The shaft shall be designed to be stiff and shall be machined from solid bar. It shall be a one-piece component, without intermediate couplings. The first critical speed shall be not less than 2.5 times the operating speed.

Mechanical Seal

A mechanical seal shall be applied for sealing the mixer shaft.

The primary seal shall be a replaceable cartridge mechanical seal. The seal shall be an inside seal of fire-resistant construction and a balanced design.

The mechanical seal shall have a provision for venting the seal chamber to ensure that it is completely filled with liquid prior to start-up. A back-up bushing of non-sparking material having a small clearance shall be provided in the flange or housing in order to restrict the product leakage rate in the event of a mechanical seal failure.

Bearings

Mixers shall be provided with oil or grease lubricated bearings. All bearings, including those of the motor and gearbox, if fitted, shall be either of the anti-friction or hydrodynamic type and shall have a minimum L-10 rating life of 40 000 hours in continuous operation at rated mixing conditions.

Lifting arrangement

The mixer shall be supported by the lifting chain from a hanging point and have a sliding guide bracket of stainless steel Grade 316 S31 to BS 970-1 (partially replaced by BS EN 10084) mounted on a vertical guide rail. It shall be possible to remove and replace the mixer safely without lowering the level in the sump or leaning into or entering the sump. The guide rail and hanging arrangement shall permit full adjustment of the depth and direction of the mixer. The guide system shall be retained at the lower end and upper end by stainless steel mounting brackets. Rails shall be installed to within ±05mm/m length of the vertical with no more than +1mm -0mm tolerance between parallel rails.

Air Blowers

General

(a) Blowers shall be of the rotary tri or twin lobe positive displacement type, each provided with inlet filter and silencer, pressure reducing valve, pressure gauges, pressure relief valve, drain, air flow indicator and acoustic bend or silencer in the delivery branch. Bearing housings and gear boxes shall be separated from the

blower housings by air spaces. The units shall be complete with a self-contained oil cooling system for the bearings. The noise level shall not exceed 85 dBA at 1 meter from the Blower. Vibration levels shall not exceed the levels given in BS 4675. Suitable lifting arrangement shall be provided for easy handling of blowers in the event of installation or maintenance.

(b) Blowers shall be installed for aeration at Equalization tank & Sludge Holding Tank and Aeration / MBR Tank. All blowers shall be of appropriate flow rate and pressure as per Process requirement. The blowers for equalization tank and Aeration Tank shall be of continuous duty. For every eight hours blowers' operation, the blowers shall be interchanging automatically for equal operation hours.

(c) The blowers shall be rated to deliver required quantity of oil free air at the design pressure while operating at not more than 1500 rpm. The blower shall be driven by a squirrel cage induction motor selected for 125% of the power absorbed at the rated discharge and pressure. The drive shall be with multiple V belts or suitable inline coupling and shall be protected through a suitable guard. The air blowers should have acoustic enclosure & with anti-vibration pads.

(d) The bearings shall be generously designed to give long operational life. Bearings 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 bearings shall have a minimum working life of 40000 hours of working. The blower shall be arranged for horizontal inlet and vertical outlet, delivery velocity not exceeding 25 m/s and each blower shall be provided with following components but not limited to:

(1) Common base frame for Blower & Motor.

(2) Inlet silencer and filter.

(3) Discharge Silencer & non-return valve in delivery branch.

(4) Screwed end metallic Ball valves in both inlet and delivery branches with metal to metal sealing.

(5) Pressure relief valve or excess pressure safety device.

(6) Bellows type couplings on inlet and delivery branches.

(7) Acoustics Enclosure.

(8) Isolating valves, Pressure reducing valves & Pressure gauges

(9) Air Flow meters, Temperature gauges.

(10) Water trap.

(e) The interconnecting pipe work shall be flanged to BS EN 1092-1/BS: 4504. A drain cock shall be provided at the lowest point in each delivery pipe work along with reflux valve. Individual stop valves and safety valves shall be provided for each unit.

(f) Each blower shall contain one inlet air pressure, one discharge air pressure, and one discharge air temperature gauge. The pressure gauges shall be calibrated in kPa absolute and be of the compound type. The gauges shall have circular dials, minimum 100 mm diameter with black figures on white background. Pressure gauges shall be furnished with pulsation damper. Temperature gauges shall be manufactured with standard temperature bulb.

(g) Air Blower Motors shall be EFF-2 Energy Efficient type. Motor shall be of Squirrel Cage Induction type, insulated against heat and humidity to Class “F” with bimetallic thermal overload protectors incorporated in motor windings. Operating voltage shall be of 415V three phase 50 Hz supply. Electrical cable of sufficient length which shall be waterproofed shall be supplied by Blower manufacturer. Process Aeration Tank Blowers Motors shall be provided with VFD.

(h) Appropriate cooling arrangement shall be provided at the blower discharge line so as to bring down the outlet air temperature within tolerable limits, so as to safeguard the life of both fine and coarse bubble diffuser.

Accessories

a) Inlet filter and silencer :

Each blower shall be provided with an inlet filter/silencer mounted directly on the inlet of the Blower via a flexible connection. Such mounting is for the purpose of reducing pressure drop across the inlet appurtenances and of minimizing noise

from pipes. Filter/silencer housing shall consist of galvanized steel plate and acoustical sound-deadening material on the inside.

Filters shall be removable through easily accessible doors and have very high removal efficiency and shall be sized for maximum face of velocity of 2m/sec at peak air flow.

b) Discharge Flex Connector:

Each blower shall be provided with discharge expansion joint. The expansion joint shall alleviate stress caused by thermal expansion and contraction in the piping system. The expansion joints shall be capable of withstanding the pressure under all operating conditions and shall be rated for temperatures up to 160°C.

c) Discharge Cone Diffuser Silencer:

Each blower shall be supplied with a combined discharge cone diffuser-silencer to increase the discharge from the blower outlet to the discharge pipe, thus reducing the air velocity to max. 20 m/sec. The length of the discharge cone shall be aerodynamically designed in order to recover dynamic pressure head and minimize discharge turbulence. The discharge cone shall be constructed of galvanized steel plate and acoustical sound-deadening material on the inside, with flanges, and be equipped with a stud for a possible measuring device.

d) Blow-off (Bypass) Valve:

Each blower shall be provided with a blow-off valve to allow unloaded start-up and unloaded stop. The valve shall be a Screwed end metallic ball valve, for air service.

Blow-off silencer shall be provided for each blower and mounted on the discharge by-pass line. The blow-off valve silencer shall be constructed of galvanized steel and contain sound absorption material encased in an outer shell. The silencer shall have one sleeve inlet connection for mounting onto the end of the bypass line.

e) Discharge check valve (Back-flow Barrier):

Each blower shall be provided with one discharge check valve located in the discharge side pipe work, spring loaded butterfly design for mounting between flanges according BS EN 1092-1/ BS 4504. The pressure losses of the fully open

valve must not exceed 1.0 kPa. The valves shall be rated for temperatures up to 160°C.

f) Base plate and anchor bolts:

Each blower unit shall be furnished with a frame of adequate size to support the blower, motor, magnetic bearing controller frequency converter, control cabinet and other accessories. The base plate shall be constructed of fabricated steel, provided with lifting lugs and of sufficient rigidity to permit lifting by a fork-lift, with all equipment mounted, without distortion or other damage to the base plate or to components parts of the machinery.

Material of Construction:

Sl. No.	**Part Description**	**Material of Construction**
A	Blower Housing	Cast Iron
B	Lobe	Cast Iron
C	Shaft	Carbon steel (high tensile)
D	Acoustic enclosure	As per BOQ
E	All connecting accessories and anchor bolts	AISI 316

Performance Guarantee

The Performance of the blowers shall be guaranteed according to the requested project design values subject allowed tolerances on Flow & Pressure: +/- 0%, and Power: 2%. Blower or any portion thereof is liable for rejection, if it fails to give any of the guaranteed performance parameters.

Fine Bubble Membrane Diffusers

Provide a removable header arrangement (Retrievable Type) that provides complete mixing of aeration basin contents.

Space diffusers evenly along each header to provide full floor coverage.

Furnish all components necessary to provide a complete mixing system within each Aeration Tank. Work shall include but not necessarily be limited to the following:

- Flanged connections at the upstream side of each drop leg for connection to an isolation butterfly valve.
- SS 316 Drop legs.
- Slip joint connections to the air distribution header
- Air distribution headers.
- Diffuser connectors.
- Diffusers (tubular) in EPDM with PTFE coating.
- Anchored Supports (SS 316)
- Gaskets.
- Header joints (CPVC).
- Bolts, nuts and washers (SS 316).
- Space diffusers evenly along the air headers.
- Provide two tubular diffusers at each header connection. Mount to a reinforced tee located on the bottom center line of the header. The reinforced Tee shall be adjustable to allow accurate alignment of the diffuser.
- The Diffusers should be able to withstand high blower air and water temperature.

Diffuser Assembly

- Field Oxygen transfer efficiency: minimum 18.0 %.
- Non-clog, tubular design with inverted air reservoir.
- Bottom deflector to prevent debris from entering diffuser assembly.
- Full profile end caps to prevent air blow off.
- Minimum length: 1000 mm.
- Installation pitch: 100 -600 mm.
- Provide orifice flow control to ensure orifice head loss is at least 2.5 times the head loss in the air header at all air flow rates in the diffuser's design operating range.
- Space diffusers along air header to provide uniform mixing of the aeration tank contents.

Air Header and Drop-legs

- Header shall be GI-Class C and drop legs submerged in water shall be UPVC.
- Fabricate air distribution header in sections up to a maximum of 12 meters in length.
- Bottom elevation of the air distribution header shall be same throughout the tank.
- Provide removable end cap at header ends.

- Design connections between sections of the air distribution header to allow individual header sections to rotate independently of adjacent header sections.
- Remove all discoloration and deposits left by welding by pickling.
- Factory weld all diffuser connections. Stiffen both the diffuser connectors and the headers to withstand a moment of 56.5 N.m at the connector without permanent deformation.

Supports and Anchors

- Provide wall and floor mounting supports for all drop legs and air headers as necessary to anchor firmly on the wall and to the bottom of the tank and as specified herein.
- Anchor supports to concrete walls and floors using stainless steel expansion bolts sized and spaced as required for the loads encountered.
- Design supports to allow levelling the air header and diffuser assemblies to within specified tolerances.
- Provide expansion couplings in the drop legs and air headers as necessary to accommodate anticipated thermal expansion and contraction.
- The raw wastewater temperature is expected to vary between 20 and 35 degrees Centigrade.
- The ambient air temperature is expected to vary between 20 and 36 degrees Centigrade.
- The aeration air will be compressed to a pressure of approximately 0.55 bar.
- Submit expansion coupling design as well as computations for sizing.

Spare Parts

Provide spare parts in the quantities indicated.

Item	**Quantity**
Diffuser Assemblies	10%

Installation

- Install all components in accordance with the manufacturer's instructions and recommendations.
- Install all diffusers to within +/- 10 mm of a common horizontal plane.

Field testing

- All Fine bubble diffused aeration systems will be field tested.
- 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.
- Levelling tests:
- Introduce clear water into each tank to the top of the diffuser elements.
- Check the level of the diffusers to document that all element horizontal surfaces are within 10 mm of a common horizontal place and at the specified elevation.

Leakage and distribution of flow tests:

- After successful completion of the levelling tests, raise the water level to 50mm above the manifold.
- Visually inspect the water surface to ensure that the airflow is uniformly distributed across the tank.
- Pressure test:
- All of air supply pipe line shall be tested by pressure. Test pressure shall be at least 2 times higher than normal operation pressure.
- If client is unsatisfied any test result, repeat the test until the installation is essentially void of air leaks.
- Repair any leaks in the element's holders, elements, pipes, or the like.

Submersible Mixer

Propeller

The propeller shall be of the cast marine type or welded type of material SS 304. For a welded propeller, only full penetration welds are acceptable. The propeller shall be checked thoroughly for welding defects, especially at the blade root, where stresses are at a maximum.

The propeller shall be locked to the shaft. Positive fixing of the propeller to the shaft may be achieved by a taper-to-taper, side fitting key and a corrosion resistant

impeller retainer cone with cap screw. Keys shall not be allowed if clad shaft material is used.

All propellers shall be statically and dynamically balanced in air as well as hydraulically balanced to ensure vibration free operation and optimum cavitation's free conditions and to promote maximum pumping rate and entrainment for any given power.

Shaft

The shaft shall be designed to be stiff and shall be machined from solid bar. It shall be a one-piece component, without intermediate couplings. The first critical speed shall be not less than 2.5 times the operating speed.

Mechanical Seal

A mechanical seal shall be applied for sealing the mixer shaft.

The primary seal shall be a replaceable cartridge mechanical seal. The seal shall be an inside seal of fire-resistant construction and a balanced design.

The mechanical seal shall have a provision for venting the seal chamber to ensure that it is completely filled with liquid prior to start-up. A back-up bushing of non-sparking material having a small clearance shall be provided in the flange or housing in order to restrict the product leakage rate in the event of a mechanical seal failure.

Bearings

Mixers shall be provided with oil or grease lubricated bearings. All bearings, including those of the motor and gearbox, if fitted, shall be either of the anti-friction or hydrodynamic type and shall have a minimum L-10 rating life of 40 000 hours in continuous operation at rated mixing conditions.

Lifting arrangement

The mixer shall be supported by the lifting chain from a hanging point and have a sliding guide bracket of stainless steel Grade 316 S31 to BS 970-1 (partially replaced by BS EN 10084) mounted on a vertical guide rail. It shall be possible to remove and replace the mixer safely without lowering the level in the sump or leaning into or entering the sump. The guide rail and hanging arrangement shall permit full adjustment of the depth and direction of the mixer. The guide system shall be retained at the lower end and upper end by stainless steel mounting brackets. Rails

shall be installed to within ±05mm/m length of the vertical with no more than +1mm -0mm tolerance between parallel rails.

Chemical Dosing Pumps

Mechanical diaphragm type positive displacement pumps for dosing shall be provided for

a. NaOCl dosing system for disinfection

b. RO chemicals dosing system

c. Polyelectrolyte dosing system

Chemical dosing pumps shall be piston, piston diaphragm or mechanical diaphragm type as specified. The pump design shall incorporate positive stroke return. The maximum stroking speed shall not exceed 100 strokes per minute (spm). Pump, motor and driving arrangement shall be mounted on a robust combined base plate. 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.

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 stepless 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.

Materials shall be selected to suit the chemicals being pumped. Liquid ends shall be polypropylene, 316 stainless steel, glass, or Hastelloy C. Diaphragm materials shall be butyl rubber, PTFE, or Hypalon and glands shall be PTFE or Neoprene.

Each pump shall be provided with inlet and outlet isolating valves and where necessary, with pressure relief with a set point of 110% of system maximum working pressure 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.

The open end of the return pipe shall be located where it is visible, so that any relief valve leakage/operation can be detected. Pump transferring/dosing chemicals to systems under pressure shall incorporate a pressure gauge on the pump delivery. Air cocks shall be provided for release of air where necessary.

Flushing connections shall be provided at each pump 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.

Dosing pumps and motors 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 be provided with filling and drain connections and visible oil level indication.

Motor shall be of Squirrel Cage Induction type, insulated against heat and humidity to Class “F” with bimetallic thermal overload protectors incorporated in motor windings. Operating voltage shall be of 415V three phase 50 Hz supply with permissible speed not exceeding 1500rpm. Motors shall be EFF-2 Energy Efficient type. Electrical cable of sufficient length which shall be waterproofed shall be supplied by pump manufacturer.

All dosing pumps shall have facility/terminals for pulse input & output (4-20 mA) to facilitate online control via plant PLC.

Dosing Tank and Mixer

General

Dewatering Polymer and Citric acid tank shall have 1 no. of mixer per tank; this tank shall be used to dissolve the Dewatering polymer and citric acid to required concentration. It shall be a vertical tank and shall be composed of tank main body, mixer, manhole, level transmitters, direct reading level gauge, ladder, air exhaust pipe etc. However, for the NaOCl the required concentration shall be directly prepared in separate tank and no mechanical mixers are required for NaOCl tanks.

(i) Fabrication

a) The tank shall be made of corrosion resistant material (HDPE)

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 rectangular 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.

(ii) Materials

a) Main Tank body : HDPE

b) Mixer frame : SS 304

c) Mixer shaft : SS 304

d) Blade : SS 304

(iii) 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

Reverse Osmosis System

Reverse Osmosis (RO) system shall comprise of the following processes and services:

a) The RO system shall be designed for average flow.

b) RO membranes shall be Spiral wound

c) Dimensions of membrane shall be suitable

d) Membrane shall be of Thin film composite polyether sulfone / Polysulfone membrane for brackish water services having following stability characteristics and with minimum life of 3 years under stated operating feed conditions.

e) Stability Characteristics:

f) Chlorine stability: Minimum of 1000 ppm-hr free chlorine for doubling the salt passage

g) pH stability: 2-11 (Continuous) ; 1-12 (Short-term)

h) Thermal stability: Upto 450C

i) Mechanical stability: 1000 psi (7.0 MPa)

j) Average Flux Rate shall not exceed 25 LMH.

k) System should be provided with victaulic coupling.

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 materials. 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 360o 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.

Provide a factory assembled acoustical enclosure around the entire centrifuge assembly. Disassemble the enclosure as necessary for shipment. Provide either removable or hinged doors for access to all centrifuge parts and components for servicing and maintenance. Size access panels to allow easy access by a single operator. Hinges, fasteners and appurtenances shall be stainless steel.

The free field A-weighted sound pressure level measured in four quadrants at 1 metre distance from the enclosure shall average 85 dBA, or less. Measure with a Type 1 instrument suited for checking compliance with Environmental and Occupational Noise Rating Recommendations.

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.

- **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.

- **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.

Instrument Air Compressor with Air Receiver and Dryer
(If required)

- Rotary screw Air Compressor with Air receiver and dryer of suitable capacity shall be provided for instrument air supply.
- The compressors shall be designed and constructed for a minimum service life of 20 years. The equipment shall be designed for continuous operation for a minimum period of 16000 working hrs at specified duty conditions. The minimum outage shall be limited to replacement of cylinder packing and valves as dictated by the maintenance schedule.
- The compressors and the drivers shall be designed to run satisfactorily up to trip speed and relief valve setting without damage.
- Compressor shall be supplied with V-belt drive and guard, suction air filter, silencer, automatic unloaded and control equipment, safety / pressure relief valves, common bed plate for compressor and motor, high temperature protection by fusible plug in the compressor outlet, low lube oil pressure switch, isolating valve and all necessary accessories required to form a fully-automatic unit supplying compressed air, continuously or intermittently as required, and

at the specified rate and pressure. The pipe work and valves shall be arranged so that either of the compressors can be used to supply the compressed air to the surge vessels.

- Compressors shall be rated for continuous operation at full duty.
- The motor shall be suitable for star delta starting with 415 V, 3 Phase, and 50 Hz supply. The power supply to control panel for auto / manual system together with power and control cabling between the panel and compressor and cabling to all accessories such as level switches, pressure / temperature devices and solenoid valves shall be provided.
- Compressor systems for the supply of air for the operation of valves and instruments shall comprise compressors, after-coolers and air/dryers, duty/standby air receivers together with control equipment, oil eliminating filters, flow regulators and oil mist lubricators as required.

Air Filter

Bidder shall provide a dry disposable type air intake filter sized for 150% capacity (Suitable for removing 1 micron or higher size particles with a minimum efficiency of 99.5%) cum silencer. The air intake shall be at least 5 mtrs above the ground level with provision of support and access for maintenance. An inertial separator with dust removal facility ahead of the fine filter is recommended.

Bidder shall provide the pressure differential switch with facility for an alarm when the pressure drop becomes excessive.

When required the Bidder shall provide a silencer to be located after the air filter along with access and supports for installation to limit the noise bellow 85 dB.

Air Dryer

Air dryer shall be for operating continuously and alternating on automatic timer between air drying and reactivation of medium. And it shall be designed rated pressure.

The dryer shall be designed, fabricated and tested to meet the requirement of ASME VIII Div1 for the rated pressure. The inlet and outlet connection on the air dryer shall be of flanged.

Each dryer shall be provided with duty and standby safety relief valves, dryer pressure relief system shall be provided with isolation and interlocking facility to allow only one relief valve on line.

The instrument air quality shall be in accordance with the ISO 8573-1, Class 1. Pressure drop over all the filters at normal working pressure shall be less than 0.1 bar.

1 Duty and 1 standby compressor sets shall be provided complete with the following:

- Common base frame for Compressor & Motor
- Air-cooled unit
- Isolating valves
- Air filter and silencer
- Pressure relief valve or excess pressure safety device
- Pressure reducing valves
- Pressure gauges
- Offloading piston
- Automatic changeover (failure of duty unit)
- Drain pipes
- Isolating valve
- V-Belt drive arrangement with Belt Guard
- Stoppers
- Air-receivers
- Others necessary appurtenances

Fire Extinguishers

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 stringent. All the extinguishers shall have ISI mark / TAC approved. Two nos. of capacity of each 2 Kg shall be provided.

Electrically Operated Hoists

Electric 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, contractor panel, all wiring, limit switches, etc.

Electric hoist of suitable capacity shall be provided for Membrane (MBR) tank, Centrifuge and Equalisation tank.

Electric hoists shall conform 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.

Rope drums shall be either cast or welded to sustain concentrated loads resulting from rope pull. Drums shall be machine grooved right and left with grooves of a proper shape for the rope used.

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. Hoist ropes shall be extra flexible, improved plough steel rope with a well lubricated hemp core.

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.

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. Brake shall apply when either the motor controller or the main power switch is in ‘OFF’ position or in the event of power failure.

Drive motors shall be designed for frequent reversal, braking and acceleration and shall be as per IS:325. Pendant control switch, controllers and resistors, controls, electrical protective devices, cables and conductors, earthing guards etc. shall be as per IS:3938. Limit switches shall be provided for over-hoisting and over-lowering.

The electric hoists shall be of Class II duty.

25% overload test, speed tests, limit switch tests and brake test shall be conducted for the hoist and trolley at manufacturer’s works

Contractor shall provide access of Chain Pulley Block / electric hoist with monorail for the equipment, weighted more 200 kg. And also in case of regular basis operation of ‘more the 20 kg equipment’, electric hoist with monorail is to be provided. The capacity of hoist shall be of 1.25 times weight of the heaviest item to be lifted.

Hand Operated Hoists and Trolleys

Manual hoists 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.

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 conforming to I.S. 3109/B.S. 1663/B.S. 3114. The load wheel is to be made from heavy duty malleable castings. The hand chain is to Conform with B.S. 6405:1984 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 or heat treated alloy steel. Strength, Quality of Steel, heat treatment, face, pitch of teeth and design shall confirm to BS-436, BS-545 and BS-721. Spur and helical gears must comply with B.S. 436 and worm with B.S. 721. Bearing must be ball and roller type conforming to I.S. 2513/B.S.2525-32:1954. Proper lubricating arrangements are to be provided for bearings and pinions. The brake for the lifting gear shall be automatic and always in action.

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 way that is clearly visible from the operating level.

Sluice Gate

Sluice gate of suitable size approved as per Hydraulics, process flow diagram and layout shall be provided. The construction of sluice gate shall be in accordance with the specification and generally as per AWWA C501 or IS: 13349. The sluice gate shall be capable of performing the duties set out 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 maximum heads specified with a minimum safety factor of five. Sluice gate shall be of the rising spindle type.

a) Frame

The frame shall be of ample section and cast in one piece. All surface forming joints and bearings shall be machined. The frame shall be of the flange back type and shall be machined on the rear face to bolt directly to the machined face of the wall thimble.

b) Guide

Guide shall be bolted to the frame or 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 up to 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 surfaces on the slides.

c) Seating Faces

Seating faces shall be made of full width, solid section, and dove-tail strips of stainless steel. They shall be secured firmly by means of counter sunk fixings in finished dove-tail grooves in the frame and slide faces in such a way as to ensure that they will remain permanently in place, free from distortion and loosening during the life of the sluice gate. The faces shall be of ample section and finished smooth. The maximum clearance between the seating surfaces, with the slide in the closed position shall not exceed 0.10 mm.

d) Wedging Devices

Sluice gate shall be equipped with adjustable side, top and bottom wedging devices as required to provide 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 with suitable adjusting screws and lock-nuts and so designed that they will remain in the fixed position after adjustment.

e) Gate Slides

The slide shall be with strengthening ribs where required and a reinforced section to receive the seating faces. The slide shall have tongues on each side extending its full length, and the tongues shall be machined accurately on contact surfaces. Surfaces of the slide that come in contact with the seat facing and wedges shall be

machined accurately. The maximum allowable clearances between the slide and the slide guide shall be 1.6 mm. An integrally cast stem nut pocket with reinforced ribs shall be provided above the horizontal center line of the slide. The stem nut pocket shall be provided with drain.

f) Stem Nut and Lift Nut

Gate shall be provided with a lower fixed stem nut for connecting the stem to the slide and a revolving lift nut located in the lifting mechanism in the head stock. They shall be of ample design to endure the thrust developed during gate operation under maximum gate operating condition loads in opening and closing direction. The stem nut and slide shall be constructed to prevent turning of the stem nut in the pocket in the slide. The stem nut shall be threaded and keyed or threaded and pinned to the stem.

g) Stem

The operating stem shall be designed for a tensile strength to withstand force resulting due to closing/opening action. The threads of the stem shall be machine cut or rolled and of the square or acme type. The number of threads per inch shall be such as to work most effectively with the lift mechanism used. The top of the stem shall be provided with a stop collar.

h) Stem Coupling

The coupling shall be threaded and keyed or threaded and bolted and shall be of greater strength than the stem.

i) Stem Guides

Stem guides shall be cast, with bushings and mounted on cast brackets. Guides shall be adjustable in two directions and shall be so constructed that when properly spaced they shall hold the stem in alignment. Number of stem guides shall be such that unsupported length of stem shall not exceed one hundred times its diameter. The guide shall be suitably lined. The slenderness ratio of stem (l/r) shall not be greater than 200.

j) Fasteners

All anchor bolts, assembly bolts, screws, nuts, etc shall be of ample section to safely withstand the forces created by operation of the gate.

k) Wall Thimbles

Wall thimbles are separate pieces required to be embedded in the mass concrete wall before installation of gate. It shall be supplied along with the gate by the gate manufacturer. 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 or studs. The depth of the wall thimbles is usually equal to thickness of wall but shall not be more than 300 mm. To permit entrapped air to escape as the thimble is being encased in concrete, holes not lesser than 35 mm dia. 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.

l) Lifting lug

Lifting lugs shall be provided for all gates.

Materials of Construction of Sluice Gate

(a)	Wall thimble	:	Cast Iron IS:210 Grade FG 200
(b)	Frame and Slide	:	Cast Iron IS:210 Grade FG 200
(c)	Seating faces	:	SS ASTM A276 type 316
(d)	Wedge	:	SS ASTM A743 CF8M or SS 316
(e)	Stem and stem extension	:	SS ASTM A276 type 316
(f)	Stem guide	:	Cast Iron IS:210 Gr. FG 200
(g)	Stem nut	:	SS ASTM 743 Gr. CF8M
(h)	Stem coupling	:	SS ASTM A276 type 316
(i)	Fasteners, anchor bolts and nuts	:	SS ASTM A276 type 316
(k)	Lift nut	:	Bronze ASTM B148 (CA952, CA954 or CA958)
(l)	Flush bottom seal	:	EPDM Rubber

Valves

Valves shall be as per internationally recognized standards. Flanges shall be machined on faces and edges. Flanges shall conform to ISO 7005, IS 6392, BS EN 1092-1/ BS 4504.

Valves shall be double flanged type and the faces shall be parallel to each other. The flange face should be at right angles to the valve centre line. Back side of valve flanges shall be machined, or spot faced for proper seating of the head and nut.

Valves buried or installed in underground chamber, where access to a hand wheel would be impractical, shall be operated by means of extension spindle and/or keys. Wherever extension spindle is provided, the valve shall also be provided with suitable headstock.

Valve of diameter 450 mm and above shall be provided with lifting eyes and shall have detachable bolted covers for inspection, cleaning and servicing.

Valve shall be suitable for frequent operation as well as operation after long periods of idleness in either open or closed position.

The valve stem, thrust washers, screws, nuts and all other components exposed to the water shall be of a corrosion resistant grade of stainless steel.

Valves shall be free from sharp projections which are likely to catch and hold stringy material.

All valves shall be of Minimum PN-10 rating.

Sluice Valves

Sluice valve shall generally confirm to IS 14846.

Sluice valves shall be of non-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 400 mm and above. The gap between the shoe and channel shall be limited to 1.5 mm.

Valves of 400mm and above shall be provided with thrust bearing arrangement for ease of operation.

Valves of diameter 400 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 an unbalanced head 15% in excess of the maximum specified rating. Valve 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 wheels shall be arranged to turn in a clockwise direction to close the valve. The direction of rotation for opening and closing of the valve shall be indicated on the hand wheels.

The material of construction of valve shall be as follows:

S. No.	Component	Material
1	Body and Doors	Cast Iron : IS:210 Gr FG 220
2	Spindle	Stainless Steel: BS:970 Gr 431
3	Seat Rings	Stainless Steel: BS:970 Gr 304
4	Back seat bush	Bronze : IS:318 Gr LTB2
5	Shoe and channel linings	Stainless Steel : BS:970 Gr 304
6	Internal Fasteners	SS 316

Knife Gate Valves

The valve shall meet requirements of MSS SP 81.

Outer body shall be provided with inner liner in corrosion resistant Stainless Steel which shall extend into the gland. The body shall be devoid of any wedge / dead pockets to avoid settling of suspended particles and solids in the service fluid.

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 movement.

Seat shall be so designed that there is no recess / relieved groove to harbor 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.

The stem shall have double start threads cut in order to ensure smooth and speedy operation.

Gland packing shall offer minimal frictional resistance and precludes external lubrication. As positive sealing element, the packing shall also include a resilient rubber ring.

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 to ensure the fluid contact with the seat ring is minimal.

The material of construction of valve shall be as follows :

Sr.No.	Component	Material
1	Body	Cast Iron : IS:210 Gr FG 260
2	Inner lining	Stainless Steel: BS:970 Gr 304
3	Knife gate / plate	Stainless Steel: BS:970 Gr 304
4	Stem	Stainless Steel : BS:970 Gr 304
5	Seat ring / Boss	Stainless Steel : BS:970 Gr 304
6	Gland housing	Cast Iron : IS:210 Gr FG 260
7	Gland packing	Teflon impregnated with the asbestos + rubber

Non-Return Valve

The valves shall be suitable for mounting on horizontal/vertical pipe line.

The internal parts shall be easily accessible for inspection through inspection hole.

Hydraulic passages and doors shall be designed to avoid cavitation.

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.

Valves shall be quick closing type with non-slam characteristics. In case of swing type, the non- slam characteristics shall be achieved by providing suitable

combination of door and hydraulic passages without any external lever/damping arrangement.

Valves 450 mm and above shall be provided with supporting foot.

Swing door valves of size 600mm and above shall be of multidoor type.

Direction of the flow shall be clearly embossed on the valve body.

Maximum pressure drop across the valve shall be 0.4 mwc.

Maximum allowable leakage rate shall be 7cc/hr/mm diameter.

The material of construction of valve shall be as follows:

Sr. No	Component	Material
1.	Body and Door	Cast Iron : IS 210 Gr. FG 200
2.	Body and Door Ring	Stainless Steel : ASTM A743 CF8, BS970 Gr. 304 S11
3.	Hinge Pin	Stainless Steel : BS970 431 S29
4.	Bearings	Teflon

Pressure / Vacuum relief valves

Pressure relief valves shall be capable of relieving pressure in the system to prevent the system being pressurised in excess of a preset maximum allowable pressure. The valves shall be drops tight under no flow conditions.

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.

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.

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.

Body ends shall be flanged and drilled to BS EN 1092-1/BS 4504.

Spares and consumables

The mandatory spares and consumables required for satisfactory, and trouble free operation of the plant shall be included in quoted price and recommended quantity shall be submitted by the bidder.

Pipe work and Fittings

Contractor shall be responsible for coordination and location of all piping and equipment with the Main Contractor and other Contractors before installation. Contractor shall be responsible before commencing work for checking all levels / gradients shown on drawing and for relating them to site conditions and restrictions shown on drawings including architectural, structural, etc., to ascertain that conditions on site permit execution of work as shown on drawings.

All pipes, fittings, joints, and jointing media used shall be suitable for the substances conveyed in the pipes and shall not deteriorate due to chemical or atmospheric action. The pipes and fittings shall have ample strength for the pressure involved.

Contractor is to provide, for dissimilar metal joints in the piping system, special flanged connections with insulating gaskets plus insulating sleeves for the flange bolts.

All pipe work shall be free from burrs, rust and scale and shall be thoroughly cleaned before erection. Open ends during the progress of work shall be blanked-off with purpose-made metal or plastic caps with proper protection and the use of wooden plugs is forbidden. Should any stoppage in the circulation occur after the various systems have been put into operation, owing to non-compliance with this requirement, the Contractor shall rectify the matter at his own expense.

Pipes are to be installed with correct falls for venting and draining and attention must be paid to neatness of installation. Groups of pipes to be accurately spaced and valves, joints, etc. symmetrically arranged. Where two or more pipes are visible and change direction together, bends shall be struck from a common radius points.

Adequate clearances to be maintained at all cases, to allow for the application of the insulation and finishing if any.

Valves etc. should be installed in such a manner that future maintenance of glands, etc. is made as easy as possible. All hand wheels must also be accessible.

On all systems long radius bends and pitcher tees are to be used wherever possible. All fittings to be suitable for a working and test pressure not lower than that specified for the pipe work system concerned.

Reductions in bore of pipe to be made eccentric for horizontal pipes (to prevent air locking) and concentric taper fittings are to be fitted for vertical pipes.

Access shall be provided at the base of all stacks, opposite joints, on bends and elsewhere where required whether shown on the drawings or not and in such a position that they can be conveniently inspected and cleaned at all times.

Positioning of Pipe work:

The position of pipe work shown is approximate and the Contractor is required to produce detail drawings showing pipe runs, and levels and conflicts / crossovers with other services, and to submit these to the Architects / Consultants for approval.

All pipes runs when not underground or in ducts shall be concealed as far as possible by careful positioning or shall be chased into walls, laid in screed, etc. as directed by the Consultant.

All vertical and horizontal runs of pipe work, unless adjacent to concrete ceilings to be built into walls in the lavatories and elsewhere.

All exposed pipe work to be parallel to the building grid, diagonal pipe runs will not be accepted.

Where required the Contractor is to mark, free of charge, the exact position of the pipes on site before installation commences.

Pipe runs, where exposed, shall be positioned at least 40mm from the finished surface or hard against the finished surface as directed by the Consultant.

Pipe Supports:

All pipe supports shall be mild steel with epoxy coating.

The use of flat bar as supports shall be strictly limited to a length of 80mm only. Weld fabricated supports, comprising or pad with two fixing bolts to structure, steel angle post, terminating with split pipe rings, shall be used. Steel tubing may be used in lieu of angle, but steel rods shall not be permitted.

All pipe work, fittings, valves, connections, etc. shall be sufficiently supported and bracketed. All pipe work shall be supported at intervals, not greater than the following on straight runs; and additional supports shall be provided at bends, valves, etc.

All pipe supports shall be of such design and type to allow for the removal of any pipe section without the necessity of disconnecting other adjacent pipes.

Wherever possible exposed Pipe work shall be supported against the finish wall or soffit with 'Saddle' brackets.

The discharge pipe work from pumps and all pipe work where vibration could be transmitted to the building structure shall be supported with brackets etc. through neoprene-in-shear hangers or with tough neoprene / rubber washers at contact of bracket to pipe.

Contractor shall be responsible for the building in of all supports, etc. and when tendering, shall allow for bolt fixing for concrete, and brilling and building in brackets in brick work, etc. All fixing details / method should be well coordinated with the Main Contractor / other Contractor. Contractor shall particularly note that if it is not possible to fix the supports directly above the pipes to be supported, then cantilever supports shall be used.

Sleeves:

Where pipes pass through walls, floors, ceilings, etc. the Contractor shall provide pipe sleeves. Sleeves shall be black steel; and be of short pipe length. Where sleeves are fitted through floors they shall extend to at least 100 mm clear of the finished floor. Where sleeves are fitted through external walls which are not fire barrier walls, the sleeves shall be GI.

Sleeves shall be of sufficient size to allow free movement of pipes and furthermore, where pipes are insulated the sleeves are to be oversized to allow the insulation to be carried through the sleeves.

The gap between a pipe and its sleeve shall be packed with fiberglass blanket material. However, for pipes / sleeves through fire barriers, the gaps must be firmly sealed with soft packing having a period of fire resistance equal to the fire barriers. The ends of sleeves are to be caulked with non-hardening mastic to the Consultant's approval.

Details of pipes through walls and floors shall be approved by the Government Authority and the Consultant before installation.

Contractor shall set all sleeves in walls, floors, etc. and in shuttering before concrete is poured. Contractor shall also be responsible to check all the sleeves are put in the correct locations and levels and are in correct sizes for their installation of pipe work.

Velocity:

All pump suction shall be designed for velocity not more than 1.5 m/s, the pump discharge shall be designed for velocity not more than 2.0 m/s, all gravity pipelines shall be designed for velocity 0.8 m/s, and all air lines shall be designed for velocity not more than 15 m/s.

12.0 TECHNICAL SPECIFICATIONS FOR INSTRUMENTATION & CONTROL FOR SEWAGE TREATMENT PLANT

12.1	**SPECIFIC INSTRUMENTATION AND CONTROL REQUIREMENTS**
	Bidder to provide I&C equipment & systems for entire Sewage Treatment Package as specified.
12.1.1	**SCOPE OF WORKS FOR I&C SYSTEM**
	Supply, erection and commissioning of all field instruments (gauges/ sensors/ transmitters/ switches etc.) for control/ monitoring/ alarm annunciation for complete Sewage Treatment Plant (STP) equipment & systems on as required basis together with specified requirement detailed subsequently.
	Supply, erection & commissioning of PLC based control system for complete sewage treatment plant comprising of sewage water intake & screening, grit removal, equalisation tank, anoxic tank, pre-aeration tank,

	MBR, chemical dosing system, RO System, treated water tank & transfer pumps system equipment complete with all hardware, software, system cabinets, marshalling cabinets, interfaces & accessories as required with specified requirement detailed subsequently. The system / panel should be compatible for software integration with any third-party services over any open protocol.	
	Supply, erection & commissioning of all erection hardware and accessories for cable trays, junction boxes, power distribution board including structural steel support.	
	Supply, erection & commissioning of Local 230 V AC UPS Power supply distribution boards & distribution to Bidder's I&C system equipment.	
	Supply, laying & termination of Instrumentation, power supply & Control cables as required for complete control/ monitoring of entire sewage treatment plant.	
	Supply of necessary consoles & other furniture & accessories to mount MMI & peripherals including two (2) Nos. good quality high back cushioned wheeled chairs each in STP LCR envisaged at Electrical and I&C common building.	
	Supply of Commissioning and Essential spares as following:	
	a)	Commissioning Spares: On as required basis.
	b)	Essential Spares: As specified subsequently.
	Submission of engineering documentation as specified.	
	Provision of any other Instrumentation and control equipment not specified but required for proper functioning of the system.	
12.2	**SPECIFIC I&C SYSTEM EQUIPMENT REQUIREMENT (INCLUDED UNDER BIDDER'S SCOPE)**	
	PLC Based Control System	

	a) Controllers as required complete with required I/O modules to be located at plant local control room (air conditioned). Size of PLC controller to be based on I/O handling capacity, specified I/O spare philosophy and controller spare loading requirement. b) PC based VDU/Keyboard type Operator Cum Engineering Stations (OES) complete with SCADA MMI software to be located in plant local control room (LCR) complete with associated furniture for mounting the same. c) One (1) No. A4 size B/W laser printer. d) Provision of communication hardware for redundant OPC communication link (Ethernet on TCP/IP protocol) for future interfacing with overall site/ plant master control system. e) The system / panel should be compatible for software integration with any third-party services over any open protocol. f) I/O Quantity: I/O channel as required considering the I/O spares philosophy specified below. g) Earthing connection within the panels, cabinets and between bidder's panels, cabinets for both frame and electronic earth to independent Instruments earthing pit are included in Bidder's scope (Refer Electrical systems section for more details). The Bidder shall furnish the requirement of different earthing requirement for Power and PLC. h) Field instruments shall be provided as indicated in the P&ID's. However the instruments indicated are the minimum required any other instruments required for automation and operation of the STP shall be included in the scope of the bidder.
12.2.1	**OPERATION PHILOSOPHY**
	Complete operation & monitoring of complete sewage treatment plant will be carried out from respective local control room (air conditioned) through

	VDU/KB based Operator Station (OS) to perform normal start-up, shutdown and emergency operations. In case of failure of PLC system, facility shall be provided to operate the plant manually with required hardwired interlocks for safety of plant. The system functionality should be supervised from control room & control in case of any emergency or failure of system operator work station.	
	When operated from Operator Station operator shall be able to call for various types of displays for all parameters as required on the screen and to perform normal start-up, shutdown and emergency operations of the system/ equipment.	
	In addition to the control room (LCR) operation/ monitoring facility, local start/ stop operation facility from local pushbuttons (LPB) shall be provided for all Motor drives as a testing and maintenance facility as detailed below:	
	a)	Local Start operation (without local monitoring facility) through local push button is envisaged for all uni-directional motor drives. Start command will be interfaced to respective control system. Emergency stop push button will be directly wired to Swgr./ MCC for emergency stop and the operation of the same will be monitored in control system through Operator Station.
	b)	Local open/ close operation (without local monitoring facility) through local push buttons is envisaged for all bi-directional motor drives except for Solenoid operated drives. Open/ close command will be interfaced to respective control system.
	c)	Local/ remote operation location selection will be carried out from LCR located OWS.
12.2.2	**CONTROL PHILOSOPHY**	
	Complete control and monitoring of complete sewage treatment plant with associated auxiliaries and electrical system shall be carried out in PLC based control system.	

12.2.3	**CONTROL SYSTEM DESIGN PHILOSOPHY**	
	General Requirement	
	The safety interlock system for the complete sewage treatment plant shall include complete protection for operating personnel and equipment under conditions that may jeopardise their safety without causing unnecessary trips or imposing undue delay during start-up from a standstill condition or following a trip.	
	The design of the safety interlocking system is based on the following basic principles and is intended to shut down the plant and/ or disconnect the plant equipment from the electric power supply under certain abnormal operating conditions.	
	a)	To trip the minimum equipment in the sequence during abnormal operating conditions leaving all the other equipment running which may safely be permitted to continue operation.
	b)	To indicate initiating cause for tripped equipment.
	c)	To prevent restarting of equipment until safe conditions are restored.
	d)	To retain as much flexibility of operation as is consistent with safety.
	e)	To operate from rugged, reliable initiating elements independent of normal control or alarm devices.
	f)	To prevent mal-operation of equipment on interruptions and restoration of control voltage.
	g)	To eliminate the necessity for any manual bypassing of an interlock to permit starting and stopping of equipment.
	h)	To emphasise eliminating false trips by providing component reliability.
12.2.4	**Specific Requirement for STP:**	

	a. Ultrasonic type level transmitters shall be provided in all tanks used for deriving various tank level conditions for the purpose of alarm/ interlock/ dry run protection of pumps and equipment. b. All the screens shall be auto operated based on level difference in upstream and downstream across the screens. c. The operation of the belt conveyors shall be interlocked with screen operation. d. All flow elements as required for flow measurements will be provided. For measurement of water flow, orifice plates will be used as primary sensing device. Ultrasonic/ electromagnetic type flow meters will be used for large dia. pipe flow measurements. e. All drives of grit removal mechanism shall be auto operated. f. The MBR unit shall be auto operated as per the control logic defined by the technology provider. Operation of the permeate pumps, backpulse pumps, membrane cleaning process, process and membrane aeration blowers shall all be controlled by the PLC. g. The treated water transfer pumps and irrigation pumps shall be hydro-pneumatic system. h. Turbidity analyzer shall be provided on the permeate line. Residual Chlorine analyzer shall be provided on the discharge of treated sewage and irrigation pumps.	
12.3	**SPECIFIC I&C SYSTEM DESIGN REQUIREMENT**	
	Sensors shall be provided for pre-trip alarm for all protection conditions.	
	Instrument range selection criteria to be followed:	
	a)	For pressure and draft measurements, the maximum operating pressure will be within 70 to 80% of the maximum scale range. All pump suction measurement and steam pressure measurements in extraction steam and in heaters will cover the negative pressure

		range also and all draft gauges will cover the negative pressure as well as the positive pressure as the case may be.
	b)	For pressure switches and temperature switches, the set points shall fall within 0% to 100% scale range selected.
	c)	For level measurement, the maximum of the range shall cover the overflow point or six inches below the top of the vessel and the minimum of the range shall be six inches above the bottom of the vessel. Also, the gauge glasses shall be stacked with overlap to cover permissive, alarm and trip levels.
	d)	For flow measurement, the maximum range shall be fixed at about 10 to 15% above the maximum operating flow.
	e)	For temperature measurement, the maximum operating temperature will be within 80 to 90% of the maximum scale range.
	f)	Size of Tapping point stub and root valve for Pressure and differential pressure measurement shall be 15 NB and for level & flow measurement shall be 25 NB.
	Signal exchange for motor drives between PLC & MCC are detailed in TABLE-1. Control system design for the STP system shall meet the specified requirement.	
	I&C cables usage shall be as follows:	
	For analog & other low level signals (4-20 mA, DC),etc. with circuit voltage upto 24 V DC, individual pair shielded & overall shielded instrumentation cables to be used.	
	For binary signals with circuit voltage upto 24 V DC only overall shielded instrumentation cables to be used.	
	For RTD signals, individual pair shielded & overall shielded TRIAD cables to be used.	

	For circuit voltage above 24 V DC/ power supply applications etc. control cables to be used.	
	In all I&C cables, spare cores/ pair to be provided as follows:	
	For multicore / multipair cables, minimum 20% cores/pairs to be provided.	
	230V AC UPS power supply to be used for I&C system equipment including solenoid valves. 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.	
	Name tag shall be provided for all instruments, control equipment etc.,	
	All panels, cabinets local panels, JBs etc. shall comply with protection class indicated below:	
	a)	Indoor air-conditioned area – IP 32
	b)	Outdoor – IP 65
	For solenoid valves or other pneumatic devices instrument lines separate & independent air filter regulator (AFR) to be provided.	
	Tagging procedure to be followed for complete package.	
12.4	**SPECIFICATION OF I&C SYSTEM EQUIPMENT**	
12.4.1	Field Instruments	
	All the necessary field instruments like RTD, T/C, Ultrasonic/ Radar Level Indicators, Pressure Switch etc., and Instruments required for other associated systems shall be included in Bidder's scope. All the sub-vendors, make, model, Technical features, QAP tests are subject to Purchaser's approval.	
12.4.2	**Pressure Indicators**	
	Direct reading, pipe mounted Pressure gauges of Stainless Steel with 6 inch phenolic dial (white dial with black numerals), 316 SS Bourdon tube,	

	nylon movements and micrometer type adjustable aluminum pointer with accuracy of +/-0.01% of span including accessories like siphons for steam services, snubbers for pump discharge applications and chemical diaphragm for corrosive and oil/suspended solids services and name plate, etc. Material of accessories shall be SS. IP65 degree of protection for enclosure. Over range protection shall be 50% above maximum pressure. Armoured capillary of 15 M shall be provided as required.
12.4.3	**Pressure Switches**
	Non indicating type, field mounted Pressure Switches of aluminium casing (epoxy coated), and 316 SS element and accuracy of +/-0.01% of span, including accessories like snubbers for pump discharge applications and chemical diaphragm for corrosive and oil services, name plate & mounting brackets. Material of accessories shall be SS. Auto reset micro switch with internal adjustment for set values with 2 SPDT contacts rated for 0.2 A at 220 V DC. IP 65 degree of protection for enclosure. Over range protection 50% above maximum pressure. Scale for setting shall be provided.
12.4.4	**Pressure Transmitters**
	Accuracy: +/-0.065% of FSD or better; Over-range protection: 50% of max. pressure; External zero & span adjustment; Rack mounting, LCD display; Power supply: 24 V DC (loop powered); Output signal: 4-20 mA DC, 2 wire with HART protocol; IP 65 protection; Housing material die cast aluminum with epoxy coating; Sensing element/ body/ seal material: SS 316, All transmitters provided will be diaphragm sealed with SS.
12.4.5	**Level Gauges**
	Tubular/ float type level gauges with brass guard rods & brass holders shall be provided. Material of float & float chord shall be 316 SS & cage material shall be fabricated steel and the material of accessories (name plate, etc.) shall be SS. IP65 degree of protection for enclosure. Connection shall be screwed or flanged (ANSI class 150 RF).
12.4.6	**Level Switches**

	Top/side mounted float type level switches shall be supplied with still tubes as required to suit the requirement. Micro switch with 2 SPDT contacts rated for 0.2 A, 220 V DC. Material of float & float chord shall be 316 SS & cage material shall be fabricated steel and the material of accessories shall be SS. IP65 degree of protection for enclosure. Top mounted ultrasonic type (time of flight) level switches for sewage sumps/ equalisation tanks shall be supplied with accuracy of ± 0.25 of span, Housing MOC: PBT, Sensor MOC: PVDF. Accessories like name plate, drain valve for external case type level switches, mating flange, gaskets (asbestos), fasteners, bolts & nuts, etc. shall be supplied.
12.4.7	a) **Level Transmitters**
	Capacitance type level transmitters with LCD indicator shall be provided. IP-65 protection, 4-20 mA DC output (2 wire system), +24 V DC supply, isolated and ungrounded electrical circuits, Auto tuning, connector cable of required length, the material of accessories will be SS. All transmitters provided will be diaphragm sealed with SS.
12.4.8	**Ultrasonic Flowmeter**
	Ultrasonic type level transmitters with transit time principle, single traverse, clamp on type. Accuracy +/-1% of reading, Repeatability +/-0.3% of reading, LCD indicator shall be provided. IP-65 protection, 4-20 mA DC output (2 wire system), +24 V DC supply, isolated and ungrounded electrical circuits, Auto tuning, connector cable of required length, the material of accessories will be SS. All transmitters provided will be diaphragm sealed with SS.
12.4.9	**Magnetic Flowmeter**
	Online, flange type. Accuracy +/-0.75% of reading. Repeatability +/-0.5% of reading. Integral display of flow & totaliser in engg. units. Electronic housing – Di cast aluminium with epoxy coating. Body material – Di Cast aluminium; electrode material – 316L/ ALLOY C-22; Measuring tube

	material – SS; Liner – hard rubber/ PTFE. Enclosure protection IP65. All transmitters provided will be diaphragm sealed with SS.
12.4.10	b) **DO Sensor**
	c) Electro chemical type, microprocessor based, Accuracy +/-1% of reading, sensitivity of 0.5 ppb, Continuous measurement, Auto temp. compensation, auto zero & span calibration, self diagnosis feature, integral LCD display, housing enclosure IP 65, output isolated 4-20 mA DC, Electrode material: Gold cathode & Silver anode
12.4.11	**Turbidity Analyser**
	d) Turbidity analyser shall be single channel based on the principle nephelometric (IR A or equivalent. It shall be provided with complete probe, necessary Sample Handling System, transmitter, calibration arrangement and sample disposal arrangement. Transmitter shall be microprocessor based with 4-20 mA output. The complete analyser shall be mounted on the free standing cabinet. The enclosure shall be provided with Air Conditioner. Analyser shall be provided with serial output and shall be integrated with purchaser control system.
12.4.12	**pH TRANSMITTER**
	e) The sensor should able to provide online pH value of aqueous solutions. The system shall provide 4-20mA output. It shall also have optional relay output. f) Power Supply : 18- 24 VDC g) Output signal : 4 mA to 20 mA h) Output Range : 0-12 PH i) Operating Temperature Range : 30 to 140 deg F or 0 to 60 deg C

	j) Operating Humidity Range : 99% non condensing k) Enclosure : IP 65
12.4.13	**WATER HARDNESS ANALYSERS**
	l) The sensor shall continuously monitor hardness of water system. It shall simple and ready to use. The enclosure shall be IP 62 rating. It shall design for continuous and unattended use. m) n) Range : Upto 100ppm (expressed as mg/l CaCo3) o) Accuracy : ±25% of set point value p) Operating Temperature : 32 to 104 deg F or 5 to 40 deg C q) Operating Humidity : 5% to 95 % non condensing r) Flow Rate : 50 to 500 ml/min s) Enclosure : IP 62 t) Inlet Pressure : 1 to 5 psig u) Repeatability : ± 4 of set point value
12.4.14	**TDS Analyser**
	v) Meter shall monitor the TDS (Total Dissolved Solids) levels for drinking water, water filters, hydroponics, Aquariums, Food and Coffee, Pools and Spas and residential RO applications. Measurement range is 0-9990 ppm. w) Automatic Temperature Compensation (ATC) x) 1000+ Hours of Continuous Use

	TDS Range	: 0-9990 ppm (parts per million)
	Temp Range	: 0-80 degrees Celsius
	Resolution	: 1 ppm, 1 degree Celsius
	Accuracy	: ± 2%
	Battery life	: 1000 hours
12.4.15	**Junction Boxes (JB)**	
	Wall/ column mounted junction boxes having 32 (2x16) terminals and cable entry only at the bottom and sealed with fire proof compound with quantity as required shall be provided.	
12.4.16	**System/ Marshalling Cabinets**	
	These cabinets shall house signal-conditioning cards, input/ output cards, processor cards & associated power supply units. Indoor located, free standing vertical type system cabinets with IP-42 enclosure and with 3 mm thick sheet metal of cold rolled steel; double doors with neoprene gaskets; anti-vibration pads of 15 mm thick; blower & louvers in each cabinet with brass mesh; fire proof compound (50 mm thickness) for sealing cable entry (bottom); fire detector for each cabinet. Beacon lamp shall be provided in each cabinet to indicate the cabinet having fault condition. The colour of the cabinets shall be indicated at detailed engineering stage. Doors shall have concealed type of hinges and swing of 100^0. The doors shall be provided both at the front and rear. Power supply distribution shall be provided on per cabinet basis with all associated MCBs, protections, etc. The system cabinets, racks in system cabinets, slots in the racks & the terminals shall have identification numbers. A stainless steel metal tag (plate) shall be fixed to the inside of the door & the layout of the racks, slots & details of the card type/ service shall be inscribed on this metal tag. Each cabinet shall be provided with one each 3 pin receptacles for 220 V AC, 1¢, 50 HZ and for +24V DC. Cabinet shall be delivered totally wired. All electronics shall be mounted & wiring connections at these hardwares shall be terminated by Bidder. Quantity shall be as required. All cabinets shall have common key	

	for the locks. In each cabinet a 24 V DC Voltmeter shall be provided to check the Field Interrogation voltage.
12.4.17	**Instrumentation & Control Cables**
	y) Instrumentation cables shall be 1100 V AC grade, stranded high conductivity annealed, tinned copper, twisted pair (with min. 10 twists for meter) extruded PVC insulated with overall and/ or individual screening, extruded PVC inner sheathed, galvanized steel wire armoured, extruded outer sheathed with FRLS PVC compound. The conductor size shall be min. 0.5 sq. mm. Triplex cables similar to instrumentation cables can be used for RTDs. Instrumentation cables carrying digital signals shall have overall screening along with drain wire and analogue signal carrying cables shall have each pair screening and overall screening along with each pair drain wire and overall drain wire.
12.4.18	**Control Cables**
	z) Control cables shall be 1100 V AC grade, multicore, minimum 1.5 sq. mm. cross section, stranded copper conductor having 7 strands, PVC insulated inner FRLS PVC sheathed of type ST-1, galvanized steel wire armoured and outer sheath made of FRLS PVC compound of type ST-1. In situation where accuracy of measurement or voltage drop in control circuit, warrant, high cross sections as required shall be used. For all CT & PT cables, minimum 2.5 sq. mm. Cables shall be used. Solenoid valve Power supply cables shall be minimum 2.5 sq. mm.
12.4.19	**Interposing Relay (IPR)**
	aa) Electromagnetic type IPRs with plug-in type connections, suitable for channel/ rail mounting in cabinets; coil rating 24V DC. 2 set of change over contacts rated for 0.2A 220V DC. Freewheeling diode across relay coil and self reset type status indicator flag (electronic) shall be provided. Interposing relays shall be provided for all the DO's including spares.
12.4.20	**Solenoid valves**

	bb) Direct operated solenoid valves with shut of class (leakage) IV, body rating ANSI 150 material of SS 304 plunger material of 316 SS, rated for continuous duty. IP 65 equivalent protection class for enclosure. Operating Voltage solenoid valves shall be 230 V AC. Insulation class of "F" for the solenoid, moulded type of coil, single/ dual coil.	
12.5	**Programmable Logic Controller (PLC)**	
	cc) Microprocessor based programmable logic controller shall be of reputed make and the equipment supplied shall be of their latest series with proven performance record.	
	dd) The Equipment to be supplied shall comprise PLC complete with processor, I/O cards, memory modules, racks, mounting accessories completely wired and tested. The other modules, in the scope of supply shall include power supply modules, PC based Programmer, printer, operating file, system cabinets and signal distribution hardware.	
	ee) AI/ AO cards shall be of 16 channel type (maximum) and DI/ DO cards 32 Channel type (maximum).	
	ff) All digital inputs shall be potential free and the interrogation voltage from PLC shall be 24 V DC. The digital outputs from PLC shall be 24V DC logic level signal which drives the interposing relays (IPR). IPRs for motorised drives will be located in MCC.	
	gg) PLC system shall meet the following	
	a)	hh) Power supply variation with limits: Voltage variation + 10%; ii) Frequency variation + 5%; Voltage & frequency combined variation + 10%
	b)	jj) All card replacements on power on conditions etc.
	The PLCs processors and PC based operator terminal shall be mounted in standard cabinets/ consoles and these cabinets shall be located in the ACV System control room.	

	The operating cum engineering workstation for SCADA Desktop shall have a 24" LED colour monitor with latest processor i7 or better; 8 GB RAM, HDD: 1TB, Windows 11 or 64-Bit OS HDD, DVD R/RW, antivirus software, MS office, keyboard, mouse along with Multimedia Speakers
	The PLC offered to be compatible to standard OPC communication with Ethernet on TCP/IP protocol for establishment of redundant link with the future envisaged master control system for entire plant.
	DVD's shall be provided for data handling facility for control system software features of control and engineering. Provision shall be made for accessing DVDs and this shall enable easy file handling/ data transfer.
	PLC system located in air-conditioned area shall also be designed to operate for short periods (minimum 2 hours), when air-conditioning system is not available without loss of any function.
12.6	**CPU**
	The system may be composed of one or more processors, and they shall perform all the data handling and computing functions required by the control strategies, logic, sequences, and batch operations.
	In the event of disruption of program execution or scan, loss of logic power, loss of communication between CPU and essential devices, memory error, etc. PLC shall have generated a system failure alarm.
	Automatic restarts after power failure shall be provided.
	A key locking arrangement at the CPU shall prevent memory modification.
	Rechargeable battery backup unit of minimum 2 days duration or flash RAM memory module shall be provided for CPU configuration memory. An alarm indication shall be provided to alert operating personnel on failure of the battery backup unit.
	The battery shall be capable of being replaced without shutting down the PLC.

12.7	**PLC PROGRAMMING**
	The Contractor shall supply, install, program and commission the PLC using the PLC manufacturers recommended windows-based PLC coding and documentation software. The PLC code shall be structured in the manner of the best industry standard and have comprehensive subroutine and rung annotation.
	PLC programming under this contract shall be implemented using functional block diagrams (FBD). The logic shall be prepared using proprietary programming software and shall be comprehensively annotated with subroutine and rung comments to assist further development and maintenance.
	The system shall support a simple programming of the application software comply with IEC 61131-3.
	The system shall support a structured, modular programming. At least the following standard operations shall be applicable: (1) Logic functions (such as AND/OR/AND NOT etc.); (2) Timer functions (externally adjustable); (3) Counter functions; (4) Skip functions; (5) Comparison functions; (6) Limit value functions; (7) Arithmetic functions; (8) Physical unit functions; (9) Closed-loop functions such as P/PI/PID/etc.
	The Contractor shall submit the logic diagrams for review & approval as an integral part of FDS submissions.

	The Contractor shall provide all required IT Hardware complete with PLC coding and documentation software as specified in the bid document & as agreed with the Employer representative based on the FDS submitted.	
12.8	**SCADA SYSTEM**	
	Operational/control requirements Project Engineer shall finalise the operations/control requirements for the plant with Client i.e. Local/Remote SCADA or Local and Remote SCADA with RTU/PLC &/back-up panels. Manned / Unmanned operations of the plant.	
	Based on different options of SCADA, Project Engineer shall list out the components of SCADA System Configuration and GPS/non-GPS based time synchronisation. This will form tentative bill of material (BOM) of system required for project	
	Communication & Interfacing with RTU/PLC, IEDs, Numerical Relays, interfacing with third party RTU/PLC/DCS/ SCADA /GIS/MIS system with reference to SCADA system configuration options shall be clearly indicated by the Project.	
12.9	**TRAINING REQUIREMENT**	
	Vendor shall provide training course on offered PLC system in the following areas:	
	a)	Maintenance training
	b)	Hardware training
	c)	Application Software training
	d)	Operation training
12.10	**CODES & STANDARD**	
	Degree of protection: IEC 60529;	

	SIL certification: IEC 61508;	
12.7	**TESTS**	
	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.	
	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 99.7% and shall be demonstrated by an analysis of system availability during system design.	
	Tests to be included for individual instruments shall be as per enclosed TABLE-2.	
12.8	**SPARES**	
	Startup 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)	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.
		ii)	Terminals of each type
		v)	Male & female parts of pre-fabricates Cables – 6 Nos., of each type.
	d)	Solenoid valves (for each valve):	
		i)	Coil – 2 Nos., of each rating and insulation.
		ii)	Plunger – 1 No. of each type and size.
		ii)	Seat – 1 No. of each type and size
		v)	Gaskets – 2 sets of each type and size.
		v)	O-rings – 5 sets of each type and size.
		vi)	Diaphragm – 2 Nos., of each type and size.
	e)	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
		ii)	Terminals of each type.
		v)	Space heater with thermostatic controls.
		v)	Fire detectors.
		vi)	Blower.
		ii)	Blank CD's for software back-up: 30 Nos.
		ii)	Cable clamps each type.
		x)	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.
		ii)	Wiring raceways to accommodate additional 30% space of total quantity.
12.9	**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
	e)		PLC Sizing Details
	f)		List of Spares
	g)		Quantity of PLC Cabinets With tentative dimensions

	h)	Power consumption details for I&C equipment-List of Feeders with Feeder Loads
	i)	Confirmation of all the clauses of the specification/ deviations
12.10	**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)	PLC I/O List
	e)	G.A Drawing For PLC cabinets
	f)	List of Feeders with Feeder Loads for 230 V AC (UPS)
	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 equipment supplied by vendor.
	i)	Junction Box Grouping Details
	j)	Cable Schedule
	k)	Interconnection Schedule
	l)	Data sheet along with catalogues of manufacturer's for all field instruments and equipment supplied by vendor
	m)	QA Plan For I&C Equipment
	n)	Final List Of Essential Spares
	o)	Earthing requirement for PLC system cabinets.
		Vendor to furnish engineering documents in the format as detailed in TABLE-3.

Table – 1

Signal Exchanges Between PLC & MCC For Drive Control

Sl. No.	From	To	Signal Description	Remarks	PLC Signal Type
A	**FOR LT UNI-DIRECTIONAL MOTOR DRIVES**				
1	PLC	MCC	Command To Start	CMD to MCC	DO
2	PLC	MCC	Command To Stop	CMD to MCC	DO
3	MCC	PLC	Motor Running	Feedback to PLC	DI
4	MCC	PLC	Motor Tripped (Thermal Overload)	Feedback to PLC	DI
5	MCC	PLC	Motor Ready To Start (By anding Thermal O/L not Operated/ Control Supply available/ MCC not isolated)	Feedback to PLC	DI
6	MCC	PLC	Motor Current (4-20 mA DC)	Feedback to PLC (For Motor KW> 30)	AI
7	LPB	PLC	Local Start Command	CMD 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

NOTES (FOR TABLE-1):

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 are 24 V DC logic level type. 24 V DC IPR to be located in SWGR./ MCC (vendor'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).

Table – 2
Tests To Be Performed For Field Instruments

1.1 Accuracy, repeatability, Calibration tests, hydro test (1.5 times max. pr), over range test (1.5 times range) shall be provided for all field measuring instruments.

1.2 Material test (for all temp. meas.ins), insulation test (for RTD & T/C), Bore concentricity test: ±5% for thermometers, RTDs, T/Cs & ±1.5 % for temperature switches.

1.3 Functional tests, temperature rise test, HV test, insulation tests, and contact rating test for Inter Posing Relays.

1.4 Verification of Degree of protection, type & routine tests as per relevant Indian Stds. for local, system panels.

1.5 Compensating cables: Thermo-emf characteristic/ Continuity test/ Measurement on capacitance, inductance, and loop resistance/ Insulation resistance/ High voltage test as per latest IS/ Tensile and elongation test/ Oxygen index test/ Any other test applicable.

Table – 3
Engineering Documents Format

Bidder shall prepare the engineering documents in this table & submit for PURCHASER/ CONSULTANT review & approval. The engineering documents shall have all fields as listed under 'Details of Fields' in this table and the Bidder shall furnish all the engineering documents in CD or DVD in addition to hard printout for each revision. Finally Bidder shall submit as installed and commissioned drawings/ documents.

SL	TYPE OF DOCUMENTS	DETAILS OF FIELDS	
1.	Drive List	1,	Sl. No. (*), tag number.
		2.	General Data

			(a)	Bidder: Motor (Bidder's name) (*), drive equipment (*).
			(b)	Type/ Form: Type (*), reference standard (*), manufacturer's dwg. No.
			(c)	Mounting, coupling method (*).
			(d)	Motor Equipment Location: Layout dwg. No. co-ordinates, elevation.
		3.	Data required for electrical engineering:	
			(a)	Rating: Output (kW) (*), full load speed (RPM) (*), voltage.
			(b)	Enclosure, Indoor/ Outdoor, starting method, direction of rotation, winding insulation class, Integral starter, Integral starter wiring diagram No.
			(c)	Space Heater: Number provided, Rating (kW)
			(d)	Performance at rated volts & Hz: Rated current (IFL) Amps (*) starting % IFL (*), starting current %IFL (*), power factor (*), starting torque %IFL, pull out torque.
			(e)	Terminal box: Cable size (mm2), cable OD (mm), location.
		4.	Data required for instrumentation & control	
			Type of control (interlocked/ non-interlocked), Type of operation, Type of actuator, Control cable gland size, status/ position feedback, actuator wiring diagram No., local control panel operation, control system scope.	
		5.	Solenoid Valve Data (*)	
			(a)	Sl. No. Service, fluid (*), quantity (*)
			(b)	Type: 2 way, 3 way, 4 way.
			(c)	Size: Pipe, Body, Orifice

			(d)	Operating conditions: Pressure – (kg/cm2)
			(e)	CV: Selected, Rated
			(f)	Action: Coil # 1, (E/DE), Coil # 2 (E/DE)
			(g)	Coil: Single coil
			(h)	Voltage 110V AC, 220V DC.
			(i)	VA: Normal, Inrush.
2.	Inputs to Bidder from Purchaser's System	Sl. No. signal category (analog/ digital), signal type (isolated 4-20 mA DC/ NO/ NC/ CO), No. of signals required by Bidder, Vendor tag No., signal description, signal range/ set value, signal destination in Bidder's system, purpose, reference dwg. No. Remarks.		
3.	Outputs from Bidder's System to Purchaser's System	Sl. No. signal category, signal type, No. of signals available to purchaser, vendor tag No., Signal description, signal range/ set value, signal location in Bidder's system, purpose, Reference dwg. No., contact rating, Remarks.		
4.	Junction Box Schedule	Vendor JB No. service description, instrument/ signal tag. No., terminal No., -/ com, terminal No. SH/ NC, Incoming cable type, Incoming cable No., JB location, Remarks,		
5.	Terminal Details – Analog	Sl. No., signal description, signal category (AI/ AO), source equipment, source equipment tag No., vendor tag No., signal type (RTD/ T/C/ 4-20 mA DC), terminal block No., terminal numbers (+, -, SH), Reference dwg. No.		
6.	Terminal details – Digital	Sl. No. signal description, signal category (DI/ DO), source equipment, No., vendor tag No., contact type (NO/ NC/ CO), terminal block No., terminal numbers (NO, C, NC) Reference dwg. No., Remarks		
7.	Schedule of Instruments with Settings	(a)	Sl. No., (Service Status condition to be indicated for contact signals), Scope, Instrument type, (Indicator/ Switch/ Transmitter, etc.)	
		(b)	General Data	

			Vendor tag, Location in elevation/ rows/ columns, flow diagram reference	
		(c)	Design Data:	
			(i)	Pressure: (Kg/cm2, unit shall be mm wcl for sub-atmospheric pressure): Normal operating pressure, maximum operating pressure, design pressure, design temperature.
			(ii)	Temperature (0C): Type of element (For RTD – PT100, C4-53 & for T/C – K.R.S.J, etc.,) normal operating temperature, maximum operating temperature, and design temperature.
			(iii)	Flow: Fluid, pipe size, velocity (mts/sec), viscosity, maximum pressure loss, normal flow (m3/hr), maximum flow (m3/hr), design flow (m3/hr), DP at maximum flow (mmwcl).
			(iv)	Level: Normal level, maximum level, instrument range, engineering units.
			(v)	Accessories, body rating (ANSI), remarks (redundancy of instruments to be indicated here).
8.	List of panels/ cabinets & control room mounted equipment	Sl. No., control room layout reference, description, tag No., panel/ cabinet, location, qty/ unit, scope, dimensions – height (mm), width (mm), depth (mm), weight (kg), power dissipation (watts), reference dwg. for panel mounting dwg. No. showing external wiring.		
9.	3rd party instrument list	Sl. No., description, vendor tag No., location, qty./ unit, scope, dimensions-height (mm), width (mm), depth (mm), weight (kg), power dissipation (watts), reference dwg. No., showing mounting details, reference dwg. No. showing external wiring, remarks.		
11.	Equipment List	Equipment, equipment code, equipment location, remarks.		

12.	Cable List (For all cables in Bidder's scope)	Cable scope, cable No., cable type, source, source location, destination, destination location, signal tag No., service description, remarks, cable length in metres.
13.	Loop Drawings	Loop Drawings shall be submitted for all signals between the field instruments & system cabinet/ local panels in Bidder's scope of supply. The loop drawing shall indicate the field instrument tag No., service, field JB No. (to which the instrument is connected), system cabinet No., TFT/ CPU indicator/ to Purchaser's system. The drawing shall also indicate the terminal numbers, polarity & cable numbers for all junctions & hardware/ components forming the loop. Loop drawing shall be prepared for each & every signal going to Bidder's system.

STP Works Automation System (PLC/SCADA) – ICCC Integration Requirement:

- The proposed STP Works Automation System (PLC/SCADA) shall include an inbuilt/onboard facility to enable seamless integration with the Integrated Command and Control Centre (ICCC) Head-End System.

- Accordingly, the STP Contractor/Bidder must account for and include all necessary additional modules (such as IoT devices, communication interfaces, or middleware) required for this integration within their cost estimation.

- All relevant input and output points must be made accessible and open for ICCC system interfacing. No additional cost or claim shall be entertained for the enablement of this integration post-award. It is the responsibility of the Contractor/Bidder to ensure that the system is ICCC-ready as part of the base scope of work.

Technical Data Sheets - Sewage Treatment Plant (STP)

(To Be Filled By The Tenderer)

The Bidder shall furnish the following details as a part of technical bid. Bidder shall furnish all relevant catalogues relevant to the equipment, required in the proposed STP for Phase I: 2 x 0.5 MLD and Phase II 1 x 1 MLD and Phase III 1 x 2 MLD.

In case of datasheet for any particular equipment is not available, vendor can furnish datasheet in their own format.

a. Process and Civil Units

Sr. No.	Units	Employers Requirement	Bidder to Indicate
1.1	**General & Process**		
(i)	Total land area (Sq.mt) proposed for STP.		
1.2	Sewage Collection and Pumping Equalization Tank	To handle peak flow 1W	
1.2	**Sewage Treatment Plant**		
i(ii)	**Manual & Mechanical Coarse Screen Chamber**		
	No. of units	2 W	
	Capacity of each unit in MLD	To handle peak flow	
	Size of chamber (m)		
(iii)	Oil & Grease trap	1W	
	Size (m)		
	HRT (hrs)		
(iv)	Equalization Tank	1W	
	(i) Size (m)		

Sr. No.	Units	Employers Requirement	Bidder to Indicate
	(ii) HRT (hrs)		
(v)	Anoxic tanks(s) / Zone(s) (i) No. of tanks / zones		
	(ii) Volume of each tank (m3)		
	(iii) HRT (Hrs)		
	(iv) Depth of Liquid (m)		
	(v) Recirculation ratio		
(vi)	Aeration Tank		
	No. of tanks		
	Volume of each tank (m3)		
	F/M ratio (Kg BOD removal / Kg of MLVSS /day)		
	MLSS (mg/l)		
	MLVSS (mg/l)		
	SRT (days)		
	Recirculation ratio		
	Excess Sludge (kg/day)		
	Operating DO in Tank (mg/l)		
	HRT (Hrs)		
	Depth of Liquid (m)		
(vii)	MBR Tank		
	No. of tanks		
	Volume of each tank (m3)		

Sr. No.	Units	Employers Requirement	Bidder to Indicate
	Dimension (m)		
	Membrane effective surface area		
	No. of Modules/cassettes		
	Design flux	Max 25 LMH	
	Trans-Membrane Pressure		
(viii)	MBR Treated Water tank		
	No. of tanks / zones		
	Volume of each tank (m3)		
	HRT (Hrs)		
	Depth of Liquid (m)		
(v)	Irrigation Tank		
	(i) No. of tanks / zones		
	(ii) Volume of each tank (m3)		
	(iii) HRT (Hrs)		
	(iv) Depth of Liquid (m)		
(v)	Sludge Holding Tank (i) No. of tanks / zones	1W	
	(ii) Volume of each tank (m3)		
	(iii) HRT (Hrs)		
	(iv) Depth of Liquid (m)		

Sr. No.	Units	Employers Requirement	Bidder to Indicate
(x)	Centrifuge Shed	To accommodate 1W Centrifuge	
	(i) Size (m)		
	RO Shed	To accommodate and RO	
	Size (m)		
(xi)	(i) MCC/Control Room Size of the Room		
	(v) Blower Room Size of the Room		

TECHNICAL DATA SHEETS

STP- MECHANICAL

(To be filled by the Tenderer)

The Tenderer shall furnish the following details as a part of technical tender. Tenderer shall furnish all relevant catalogues relevant to the equipment, required in the proposed STP.

A. Manual Bar Screen (Coarse Screen)

Sl. No.	Description	Units	Particulars
	Manual Bar Screen (Coarse)		
a	**Quantity**		
b	Screen size		

Sl. No.	Description	Units	Particulars
c	Opening size		
d	MOC		
e	Size of bar		
f	Width		
g	Height		
	Container		
a	Capacity		
b	MOC		
	Manual Bar Screen (Fine)		
a	Quantity		
b	Screen size		
c	Opening size		
d	MOC		
e	Size of bar		
f	Width		
g	Height		
	Container		
a	Capacity		
b	MOC		

B. Mechanical Screen (Fine Screen)

Sl. No.	Description	Units	Particulars
(a)	**General**		
(i)	Make		
(ii)	Model		
(iii)	Quantity	Nos.	
(iv)	Type		

Sl. No.	Description	Units	Particulars
(b)	**Screen**		
(i)	Width	mm	
(ii)	Height	mm	
(iii)	Raking speed	m/min	
(iv)	Motor rating	kW	
(c)	**Materials of Construction**		
(i)	Frame		
(ii)	Rake carriage		
(iii)	Screen bars		
(iv)	Fasteners		
(v)	Canopy		

C. OIL & GREASE TANK / SKIMMER

S. No.	Description	Units	Particulars
a	Quantity		
b	Chamber dimensions (LxBxH)	mm	
c	Surface Loading Rate	$m^3/m^2/d$	
d	Retention time	Min.	
e	Drive details		
G	Oil Skimmer Details		
	Container		
a	Capacity		
b	MOC		

D. Submersible Pump Set (Equalized Sewage Bypass Pump to Municipal Sewer)

Sl. No.	Description	Units	Particulars
(a)	**General**		

Sl. No.	Description	Units	Particulars
	Make		
	Model		
	Type		
	Quantity (W+S)	Nos.	
(b)	**Performance**		
	Capacity	cu.m/hr	
	Total head	mlc	
	Speed	rpm	
	Overall efficiency (Pump + Motor)	%	
	Motor Rating	kW	
(c)	**Materials of Construction**		
	Impeller		
	Casing		
	Shaft		

E. Submersible Mixer

Sr.No.	Description	Units	Particulars
(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		

Sr.No.	Description	Units	Particulars
(ix)	Shaft material		

F. Rotary Drum Screen

Sl. No.	Description	Units	Particulars
(i)	Quantity		
(ii)	Type		
(iii)	Capacity	cum/hr	
(iv)	Length	m	
(v)	Width m	m	
(vi)	Size of opening	mm	
(vii)	MOC of Screen		
(viii)	Motor power rating	kW	

G. Membrane Bio Reactor

Sl. No.	Description	Units	Particulars
(i)	Membrane Module		
(ii)	Membrane Flux		
(iii)	Flow Direction - Inside - Out arrangement		
(iv)	Flow Direction - Outside - In arrangement		
(v)	Pore Size		
(vi)	Trans-Membrane Pressure		
(vii)	Height required		
(viii)	Head room required		
(ix)	MOC of membrane		
(x)	Operating pH range		
(xi)	Temperature		

(xii)	Cleaning frequency		
(xiii)	Chemical enhance backwash & recovery cleaning		
(xiv)	Configuration		
(xv)	Membrane Material		
(xvi)	Length	M	
(xvii)	Width m	M	
(xviii)	Height	M	
(xviv)	Motor power rating	kW	

H. Sludge Recirculation Pump (RAS/WAS)

Sl. No.	Description	Units	Particulars
(a)	**General**		
	Make		
	Model		
	Type		
	Quantity (W+S)	Nos.	
(b)	**Performance**		
	Capacity	cu.m/hr	
	Total head	mlc	
	Speed	rpm	
	Overall efficiency (Pump + Motor)	%	
	Motor Rating	kW	
(c)	**Materials of Construction**		
	Impeller		
	Casing		
	Shaft		

I. Nitrifying Liquor Transfer Pumps

Sl. No.	Description	Units	Particulars
(a)	**General**		
	Make		
	Model		
	Type		
	Quantity (W+S)	Nos.	
(b)	**Performance**		
	Capacity	cu.m/hr	

Sl. No.	Description	Units	Particulars
	Total head	mlc	
	Speed	rpm	
	Overall efficiency (Pump + Motor)	%	
	Motor Rating	kW	
(c)	**Materials of Construction**		
	Impeller		
	Casing		
	Shaft		

J. Fine Bubble Air Diffusers

Sl. No.	Description	Units	Particulars
(a)	**General**		
	Make		
	Model		
	Type		
	Diffuser OD x Length	mm x mm	
	Tank Dimensions (L x W x SWD)	mm x mm	
	Design Air-Flow per Tank (Maximum/Average)	Nm3/hr	
	Quantity per Aeration/Tank	No.	
	Quantity	No.	
	Weight per Diffuser	Kg	
	Design air flow per diffuser	m3/hr	
	Efficiency per diffuser	%	
(b)	**Membrane Diffuser**		
	Type-self cleaning (Yes/No)		

Sl. No.	Description	Units	Particulars
	No. of Membranes - Total	No.	
	Membrane Material and Shape		
	Means of attachment		
	Membrane OD X Length	mm x mm	
	Pore size (Average)	mm	
	No. of Pores per length of Diffuser	No./m	
	Bubble size (Avg)	mm	
(c)	**Diffuser Assembly**		
	Make		
	Type		
	Length x Width	mm x mm	
	Material of Construction		
	Coupling Type • Make • Model/Size		
	Diffuser Assembly Weight	Kg	
(d)	**Materials of Construction**		
	Diffuser Tube		
	Membrane		
	Pipe clamps & Hardware		
	Pipe Grid		
(e)	**Performance**		
	SOTE Oxygen transfer rate • Clear water • Field	%	
	Zone of influence	m	

Sl. No.	Description	Units	Particulars
	Zone of oxygenation	m	
	Depth of mixing	m	
	Velocity thro' the Diffuser	m/sec	
	Diffuser Head loss & Efficiency V/s Submergence Curve attach Diffuser Grid Drawing with retrievable arrangement details attached	Yes/No Yes/No	

K. Air Blowers (Equalisation Tank / Sludge holding tank)

Sl. No.	Description	Units	Particulars
(a)	**General**		
	Make		
	Type		
	Quantity (W+S)	Nos.	
	Capacity at NTP	m3/min	
	Design maximum discharge pressure	mlc	
	Efficiency	%	
	Speed, blower	rpm	
	Absorbed power	kW	
	Motor rating	kW	
	Speed, motor	rpm	
	Noise level at Duty Point in dB(A) at 1.86 m from the unit	dB(A)	
	With Acoustic Hood	dB(A)	
	Without Acoustic Hood	dB(A)	
	Vibration	mm/sec	
	Weight – Blower	kgs	
	Maximum lifting weight	kgs	

Sl. No.	Description	Units	Particulars
	Dimensions (L x W x H)	m x m x m	
	Coupling Type		
	Coupling Make		
	Cooling System		
(b)	**Material of construction:**		
	Casing		
	Impeller/Lobes		
	Shaft		
	Common Base frame		
	Orientation		
(c)	**Acoustic Hood:**		
	Type		
	Material of Construction		
(d)	**Inlet/Outlet silencer**		
	Type		
	Make		
	Filter media		
	Mean air velocity	m/s	

L. Submersible Mixer

Sr.No.	Description	Units	Particulars
(i)	Make		
(ii)	Model		
(iii)	Type		
(iv)	Quantity (W+S)		
(v)	Motor rating	kW	

Sr.No.	Description	Units	Particulars
(vi)	Motor speed	rpm	
(vii)	Mixer speed	rpm	
(viii)	Impeller material		
(ix)	Shaft material		

M. Air Blowers (Aeration Tank and MBR tank)

Sl. No.	Description	Units	Particulars
(a)	**General**		
	Make		
	Type		
	Quantity (W+S)	Nos.	
	Capacity at NTP	m3/min	
	Design maximum discharge pressure	mlc	
	Efficiency	%	
	Speed, blower	rpm	
	Absorbed power	kW	
	Motor rating	kW	
	Speed, motor	rpm	
	Noise level at Duty Point in dB(A) at 1.86 m from the unit	dB(A)	
	With Acoustic Hood	dB(A)	
	Without Acoustic Hood	dB(A)	
	Vibration	mm/sec	
	Weight – Blower	kgs	
	Maximum lifting weight	kgs	
	Dimensions (L x W x H)	m x m x m	
	Coupling Type		
	Coupling Make		
	Cooling System		
(b)	**Material of construction:**		
	Casing		
	Impeller/Lobes		
	Shaft		
	Common Base frame		

Sl. No.	Description	Units	Particulars
	Orientation		
(c)	**Acoustic Hood:**		
	Type		
	Material of Construction		
(d)	**Inlet/Outlet silencer**		
	Type		
	Make		
	Filter media		
	Mean air velocity	m/s	

N. MBR Permeate Pump

Sl.NO.	Description	Units	Particulars
(a)	**General**		
	Make		
	Model		
	Type		
	Quantity (W+S)	No.	
(b)	**Performance**		
	Capacity	cu.m/hr	
	Total head	mlc	
	Speed	rpm	
	Overall efficiency (Pump + Motor)	%	
	Motor Rating	kW	
(c)	**Materials of Construction**		
	Impeller		
	Casing		

Sl.NO.	Description	Units	Particulars
	Shaft		
(g)	**Motor:**		
	Make		
	Type		
	Model		
	Quantity (W+S)		
	Rating	kW	
	Weight	kgs	
	VFD		

O. Sodium Hypochlorite Dosing System

Sl. No.	Description	Units	Particulars
(a)	**Pumps**		
	Make		
	Type		
	Quantity (W+S)	Nos.	
	Model		
	Capacity max/min	l/s	
	Head	mlc	
	Stroke adjustment	mm	
	Stroking speed max/min	spm	
	Casing material		
	Diaphragm material		
	Shaft material		
	Motor rating	kW	
(b)	**Dosing Tank**		
	Make		
	Model		
	Quantity (W+S)		

Sl. No.	Description	Units	Particulars
	Size (Diameter x Height)	m x m	
	Material of Construction		

P. MBR Backpulse Pumps

Sl.NO.	Description	Units	Particulars
(a)	**General**		
	Make		
	Model		
	Type		
	Quantity (W+S)	No.	
(b)	**Performance**		
	Capacity	cu.m/hr	
	Total head	mlc	
	Speed	rpm	
	Overall efficiency (Pump + Motor)	%	
	Motor Rating	kW	
(c)	**Materials of Construction**		
	Impeller		
	Casing		
	Shaft		
(g)	**Motor :**		
	Make		
	Type		
	Model		
	Quantity (W+S)		
	Rating	kW	
	Weight	kgs	

Sl.NO.	Description	Units	Particulars
	VFD		

Q. MBR Chemical Cleaning System (NaOCl)

Sl.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)	**NaOCl preparation Tank:**			
	(i)	Make		
	(ii)	Model		
	(iii)	Quantity (W+S)		
	(iv)	Size (Diameter x Height)	m x m	
	(v)	Material of construction		

R. MBR Chemical Cleaning System (Citric Acid)

Sr.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)	**Acid preparation Tank:**			
	(i)	Make		
	(ii)	Model		
	(iii)	Quantity (W+S)		
	(iv)	Size (Diameter x Height)	m x m	
	(v)	Material of construction		

S. RO FEED PUMPS

Sl. No.	Description	Units	Particulars
(a)	**General**		
	Make		

Sl. No.	Description	Units	Particulars
	Model		
	Type		
	Quantity (W+S)	Nos.	
(b)	**Performance**		
	Capacity	cu.m/hr	
	Total head	mlc	
	Speed	rpm	
	Overall efficiency (Pump + Motor)	%	
	Motor Rating	kW	
	VFD Details		
(c)	**Materials of Construction**		
	Impeller		

T. Micron Cartridge Filter

8.	**Micron Cartridge Filter**	
i	Make	
ii	Model	
iii	Quantity	
iv	Type	
v	Technical specs.	
vi	Capacity	
vii	Temperature	
viii	Operating pressure	
ix	Design Pressure	
x	Filtration levels	
xi	Filtration media	
xii	Size of cartridge	
xiii	No. of Cartridge/filter housing	
xiv	Inlet size	
xv	Outlet size	

xvi	MOC of filter housing	
8a.	**Filter valves**	
i	Number	
ii	Diameter	
iii	Type	
iv	Make	
8b.	**Pipes & Fittings**	
i	Quantity	
ii	Diameter	
iii	Type	
iv	Make	

U. SMBS Dosing System

Sl. No.	**Description**	**Units**	**Particulars**
(a)	**Pumps**		
	Make		
	Type		
	Quantity (W+S)	Nos.	
	Model		
	Capacity max/min	l/s	
	Head	mlc	
	Stroke adjustment	mm	
	Stroking speed max/min	spm	
	Casing material		
	Diaphragm material		
	Shaft material		
	Motor rating	kW	
(b)	**DOSING TANK**		
	Make		
	Model		
	Quantity (W+S)		
	Size (Diameter x Height)	m x m	
	MOC		

V. pH Correction Dosing System

Sl. No.	Description	Units	Particulars
(a)	**Pumps**		
	Make		
	Type		
	Quantity (W+S)	Nos.	
	Model		
	Capacity max/min	l/s	
	Head	mlc	
	Stroke adjustment	mm	
	Stroking speed max/min	spm	
	Casing material		
	Diaphragm material		
	Shaft material		
	Motor rating	kW	
(b)	**DOSING TANK**		
	Make		
	Model		
	Quantity (W+S)		
	Size (Diameter x Height)	m x m	
	MOC		

W. Anti-Scalant Dosing System

Sl. No.	Description	Units	Particulars
(a)	**Pumps**		
	Make		
	Type		

Sl. No.	Description	Units	Particulars
	Quantity (W+S)	Nos.	
	Model		
	Capacity max/min	l/s	
	Head	mlc	
	Stroke adjustment	mm	
	Stroking speed max/min	spm	
	Casing material		
	Diaphragm material		
	Shaft material		
	Motor rating	kW	
(b)	**DOSING TANK**		
	Make		
	Model		
	Quantity (W+S)		
	Size (Diameter x Height)	m x m	
	MOC		

X. RO System & Its Components

Sr. No.	Item	Particulars (Vendor to provide)
1	**System**	
i	Operation Hours	
ii	Capacity	
iii	Type of water	
iv	Feed flow	
v	Permeate Flow (Design / Max)	
vi	Array configuration	
vii	Operating Flux	
viii	System Recovery	
ix	Reject Flow	
x	Auto-flushing Requirement Yes / No	
2.	**High Pressure Pump**	

Sr. No.	Item	Particulars (Vendor to provide)
i	Make	
ii	Model	
iii	Type	
iv	Quantity (W+S)	
v	Capacity	
vi	Differential Head	
vii	Suction head requirement	
viii	Discharge head	
ix	Speed	
x	Overall efficiency	
xi	Impeller MOC	
xii	Casing MOC	
xiii	Shaft MOC	
2a	**Motor**	
i	Make	
ii	Type	
iii	Model	
iv	Quantity (W+S)	
v	Rating	
vi	Weight	
vii	VFD	
viii	Total Weight of Pump	
3.	**Membrane Details**	
i	Type of membrane	
ii	Make of Membrane	
iii	MOC Membrane	
iv	Membrane Size and Dia	
4.	**Pressure Tubes**	
i	Design & Manufacturing Code	
ii	MOC	
iii	Quantity	
iv	Maximum no. of membrane / Tube	
v	Nozzle Type & MOC	

Sr. No.	Item	Particulars (Vendor to provide)
5.	**Reject Valve**	
i	Reject Valve Operation	Manual /Auto
ii	Reject Valve actuation	Pneumatic /Motorised
iii	Reject Valve type , MOC & rating	
6.	**Skid & Piping**	
i	RO Skid MOC	
ii	RO Piping MOC	
iii	Feed pipe / header dia	
iv	Permeate pipe / header dia	
v	Reject pipe / header dia	
7.	**CIP System**	
7a.	**CIP Tanks**	
i	Quantity	
ii	Make and Model	
iii	Size (Dimensions)	
iv	MOC	
v	Overall Weight	
7b.	**CIP Tank Agitator**	
i	Quantity	
ii	Make and Model	
iii	Blade Type	
iv	MOC	
v	Overall Weight	
vi	Agitator Motor Speed / Rating	
vii	Support MOC	
7c.	**CIP Pumps**	
i	Quantity	
ii	Make and Model	
iii	Type	
iv	Capacity (Min/Max)	
v	Pressure	
vi	Stroke adjustment	

Sr. No.	Item	Particulars (Vendor to provide)
vii	Stroke speed	
viii	Casing Material	
ix	Diaphragm Material	
x	Motor Rating	
xi	Motor Make	
8.	**Micron Cartridge Filter for CIP**	
i	Make	
ii	Model	
iii	Quantity	
iv	Type	
v	Technical specs.	
vi	Capacity	
vii	Temperature	
viii	Operating pressure	
ix	Design Pressure	
x	Filtration levels	
xi	Filtration media	
xii	Size of cartridge	
xiii	No. of Cartridge/filter housing	
xiii	Inlet size	
xiv	Outlet size	
xv	MOC of filter housing	
8a.	**Filter valves**	
i	Number	
ii	Diameter	
iii	Type	
iv	Make	
8b.	**Pipes & Fittings**	
i	Quantity	
ii	Diameter	
iii	Type	
iv	Make	

Sr. No.	Item	Particulars (Vendor to provide)
9.	**Instrumentation & Control Provided**	Vendor to indicate numbers and locations
i	pH Meter	
ii	ORP Meter	
iii	DPT	
iv	Pressure Switches	
v	Temp. indicator	
vi	Conductivity meter	
vii	Flow Meter	
10.	**Performance Guarantee**	
i	System recovery	
ii	Permeate flow	
iii	RO feed pressure	
iv	Permeate Quality (pH, TDS, Hardness)	
v	Reject	
vi	Total Load of RO system, KW	
vii	Membrane Warranty (years)	
11.	**Essential Spares**	
i	Victaulics -25%	Provided **: Yes / No**
ii	Brine seals – 25%	Provided **: Yes / No**
iii	End cap assembly-2 nos.	Provided **: Yes / No**
iv	Permeate ports – 25%	Provided **: Yes / No**
v	Permeate Plugs -25%	Provided **: Yes / No**
vi	Permeate Hoses -25%	Provided : Yes / No
vii	Reject Valve -1 no.	Provided : Yes / No
viii	'O' ring of all sizes – 100%	Provided : Yes / No
12.	**Enclosures with Bid**	
i	Projection @ 25^0C 3 years	Enclosed : Yes / No
ii	GA drawing of skid	Enclosed : Yes / No
iii	GA drawing of all components	Enclosed : Yes / No

Y. RO Permeate Pumps

Sr.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		
(g)	**Motor :**			
	(i)	Make		
	(ii)	Type		
	(iii)	Model		
	(iv)	Quantity (W+S)		
	(v)	Rating	kW	
	(vi)	Weight	kgs	

Z. Irrigation Water Transfer Pumps

Sr.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		
(g)	**Motor :**			
	(i)	Make		
	(ii)	Type		
	(iii)	Model		
	(iv)	Quantity (W+S)		
	(v)	Rating	kW	
	(vi)	Weight	kgs	

AA. Flushing Water Transfer Pumps

Sr.No.	Description	Units	Particulars
(a)	**General**		

Sr.No.	Description		Units	Particulars
	(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		
(g)	**Motor :**			
	(i)	Make		
	(ii)	Type		
	(iii)	Model		
	(iv)	Quantity (W+S)		
	(v)	Rating	kW	
	(vi)	Weight	kgs	

BB. Flushing Water Transfer Pumps

Sr.No.	Description		Units	Particulars
(a)	**General**			
	(i)	Make		

Sr.No.	Description		Units	Particulars
	(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		
(g)	**Motor :**			
	(i)	Make		
	(ii)	Type		
	(iii)	Model		
	(iv)	Quantity (W+S)		
	(v)	Rating	kW	
	(vi)	Weight	kgs	

CC. Dewatering Poly Dosing System

Sr.No.	Description		Units	Particulars
(a)	**Pumps**			
	(i)	Make		
	(ii)	Type		

Sr.No.	Description		Units	Particulars
	(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)	**PE preparation Tank:**			
	(i)	Make		
	(ii)	Model		
	(iii)	Quantity (W+S)		
	(iv)	Size (Diameter x Height)	m x m	
	(v)	Material of construction		

DD. Centrifuge

Sl. No.	Description	Unit	Bidder To Indicate
(a)	**General**		
(i)	Manufacturer		
(ii)	Type		
(iii)	Model		
(iv)	Quantity	No.s	
(v)	Feed rate per centrifuge	m^3/hr	
(vi)	Dewatered sludge cake thickness		

Sl. No.	Description	Unit	Bidder To Indicate
(vii)	% dried solids		
(viii)	Noise level (dBA) at 1m distance from the machine	dB(A)	
(ix)	Vibration level		
(x)	Feed pressure required	Kg/cm2	
(xi)	Bowl Diameter	mm	
(xiii)	Bowl length	mm	
(xiv)	Taper Angle	degrees	
(xv)	Bowl speed	rpm	
(xvi)	Centrifugal force	N	
(xvii)	Gear Box ratio		

EE. Piping

Sl. No.	Description	Particulars
Sewage/Sludge & Treated Sewage piping Data		
1	Quantity	
2	MOC	
3	Pressure	
4	Make	
Air piping Data		
1	Quantity	
2	MOC	
3	Class	
4	Make	
Chemical Dosing Piping Data		
1	Quantity	
2	MOC	
3	Class	
4	Make	

FF. Motor Operated Hoists and Trolleys

Sr.No.	Description		Units	Particulars
(a)	(i)	Manufacturer		
	(ii)	Type and class		
	(iii)	Model		
	(vi)	Safe working Load	tonne	
	(v)	Span	metres	
	(vi)	Lift	metres	

GG. Valves

S. No.	Item	Description	Unit	Particulars
(a)		**Butterfly valves :#**		
	(i)	Manufacturer		
	(ii)	Type		
	(iii)	Model		
	(iv)	Service		
	(v)	Quantity	Nos.	
	(vi)	Size	mm	
	(vii)	Rating	bar	
	(viii)	Test pressure	bar	
	(ix)	Body material		
	(x)	Disc material		
	(xi)	Sealing face material		
	(xii)	Shaft material		
	(xiv)	Gear Reducers		
	(xv)	Manufacturer		
	(xvi)	Material		
	(xvii)	Flange Drilling standard		
(b)		**Butterfly Valve Actuators #**		
	(i)	Manufacturer		
	(ii)	Type		
	(iii)	Model		
	(iv)	Service		
	(v)	Quantity	Nos.	
	(vi)	Motor rating	kW	
	(vii)	Design Torque	N-m	

S. No.	Item	Description	Unit	Particulars
	(viii)	Time for full open to full close	minutes	
(c)		**Non-return valves #**		
	(i)	Manufacturer		
	(ii)	Type		
	(iii)	Model		
	(iv)	Service		
	(v)	Quantity	Nos.	
	(vi)	Size	mm	
	(vii)	Rating	bar	
	(viii)	Test Pressure	bar	
	(ix)	Design standard		
(d)		**Material of construction:**		
	(i)	Body		
	(ii)	Disc/plates		
	(iii)	Spring		
	(iv)	Shaft		
	(v)	Flange drilling standard		
(e)		**Sluice valves :#**		
	(i)	Manufacturer		
	(ii)	Type		
	(iii)	Model		
	(iv)	Service		
	(v)	Number	Nos	
	(vi)	Size	mm	
	(vii)	Rating	kg/cm^2	
	(viii)	Test pressure	kg/cm^2	
	(ix)	Body material		

S. No.	Item	Description	Unit	Particulars
	(x)	gate material		
	(xi)	Sealing face material		
	(xii)	Shaft material		
	(xiv)	Gear Reducers :		
	(xv)	Manufacturer		
	(xvi)	Material		
	(xvii)	Flange Drilling standard		
(f)		**Sluice Valve Actuators #**		
	(i)	Manufacturer		
	(ii)	Type		
	(iii)	Number		
	(iv)	Motor rating	kW	
	(v)	Design Torque	N-m	
	(vi)	Time for full open to full close	minutes	
(g)		**Knife Gate valves:#**		
	(i)	Manufacturer		
	(ii)	Type		
	(iii)	Model		
	(iv)	Service		
	(v)	Number		
	(vi)	Size	mm	
	(vii)	Rating	kg/cm2	
	(viii)	Test pressure	bar	
	(ix)	Body material		
	(x)	gate material		
	(xi)	Sealing face material		

S. No.	Item	Description	Unit	Particulars
	(xii)	Shaft material		
	(xiv)	Gear Reducers :		
	(xv)	Manufacturer		
	(xvi)	Material		
	(xvii)	Flange Drilling standard		
(h)		**Knife Gate Valve Actuators #**		
	(i)	Manufacturer		
	(ii)	Type		
	(iii)	Number		
	(iv)	Motor rating	kW	
	(v)	Design Torque	kg-m	
	(vi)	Time for full open to full close	minutes	

Bidder to provide above details for each size, type of Valve and Service.

INSTRUMENTATION & CONTROL SYSTEM

1. Pressure Indicator:

1.	**1.0 GENERAL**	
2.	MANUFACTURER :	*
3.	MODEL NO.:	*
4.	**2.0 TYPE**	
5.	**3.0 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.	**4.0** ENCLOSURE PROTECTION	
18.	**5.0 FOR PRESSURE INDICATOR WITH SWITCHING CONTACTS:** **6.0 WEATHER PROTECTION: IP 65** ☒ EX-PROOF TO ZONE __ ☐ GROUP IIA ☐ IIB ☐ IIC ☐ TEMPERATURE CLASS :	✓
19.	**7.0 SWITCH DETAILS:** NO. OF CONTACTS : 2 NO + 2 NC ☐ 2 CHANGEOVER ☐ CONTACT RATING :	x
20.	**8.0** MATERIAL OF CONSTRUCTION	
21.	**9.0** HOUSING: DIE CAST ALUMINIUM ☒	✓
22.	**10.0 PRESSURE ELEMENT:** **11.0 SS 316** ☒ **NEOPRENE DIAPHRAGM** ☐ PTFE COATING ☐ PHOSPHOR BRONZE ☐	✓
23.	MOVEMENT : SS 316 ☒ SS 304 ☐	✓
24.	**12.0 SOCKET : SS 316** ☒ **SS 304** ☐	✓
25.	**13.0 GLASS : SHATTERPROOF** ☒	✓
26.	CHEMICAL DIAPHRAGM SEAL : SS316 ☒ HASTELLOY ☐ TANTALUM ☐ ☐	✓
27.	**14.0** CONNECTION & DIMENSIONS	
28.	**15.0 PROCESS CONNECTION: THREADED** ☒ **16.0 FLANGED** ☐	✓
29.	**17.0 THREADED PROCESS CONNECTION:** **18.0 ½ "NPT (M)** ☒ **¼ " NPT (M)** ☐ 1" NPT (M) ☐ ☐	✓
30.	**19.0 FLANGED PROCESS CONNECTION:** FLANGE RATING : FLANGE SIZE :	*
31.	**20.0 PROCESS CONNECTION LOCATION:** BOTTOM ☒ BACK ☐	✓
32.	**21.0 CABLE ENTRY: ½" NPT (F)** ☐ ☐	x
33.	**22.0 ACCESSORIES (REFER NOTE 3)**	
34.	NAME PLATE / METAL TAG : (Refer note 6)	✓
35.	**23.0 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.	**24.0 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 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.

2. Pressure Indicating Transmitter:

49.	**GENERAL**	
50.	**Manufacturer:**	
51.	Model no.:	
52.	**FEATURE**	
53.	Type: Microprocessor based Smart (2-wire) ,indicating	✓
54.	Mounting: pipe mounted ☒	✓
55.	External Zero and Span adj.: Required	✓
56.	Accuracy: ± 0.075% of span	✓
57.	Over range Protection: 130% of full range	✓
58.	Stability: ±0.125% of FSR for minimum 5 years	✓
59.	Operation Principle:	*
60.	Display: Backlit LCD with Engineering units	
61.	SIL ___ compliance ☐ SIL Not required ☒	X

62.	Isolation Min : 500Vac & EMC compatibility as per EN 61326	✓
63.	**ENCLOSURE**	
64.	Case protection class: IP-65	✓
65.	Case Colour: Grey ☒ Black ☐	*
66.	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
67.	Intrinsic safe certified: For Hazardous area	X
68.	**SUPPLY / SIGNAL**	
69.	Power Supply: 24V DC	✓
70.	Output signal: 4-20mA HART ☒	✓
71.	**MATERIAL**	

72.	Housing: Aluminum with epoxy coating	✓
73.	Body: SS	✓
74.	Sensing Element: SS 316☒	✓
75.	Diaph. Seal / Body: SS 316☒	✓
76.	Capillary and Armour: SS 316	✓
77.	Fill fluid : (Refer note -7)	X
78.	Wetted part: Refer follow-up sheet	X
79.	**CONNECTIONS & DIMENSIONS**	
80.	Process Conn: Flanged ☒	✓
81.	Process conn. details: Refer follow-up sheet	X
82.	Location: Bottom ☒ Back ☐	*
83.	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.	
84.	**ACCESSORIES** (Refer note-4)	
85.	Name Plate: Removable - SS	✓
86.	Mounting Bracket: SS (2" pipe bracket)	✓
87.	Diaphragm Seal : Refer follow-up sheet	✓
88.	Armoured Capillary – Refer follow-up sheet	✓
89.	2 Valve manifold: SS	✓
90.	Flushing ring : SS	✓
91.	Syphon: Refer follow-up sheet	✓
92.	Snubber: Refer follow-up sheet	✓
93.	Application : Raw Water	✓

1.0	(*) - Bidder to furnish details; (✓) - Required; (x) - Not required / Not applicable.
2.0	Intrinsic Safe Instruments if provided for instruments located in hazardous areas shall comply with relevant hazardous area classification codes.
3.0	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.
4.0	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).

5.0	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.
6.0	Fill fluid selection shall be suitable for process fluid temperature and for hygiene application such as Food, Parma and Beverage.
7.0	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.

3. Electromagnetic Flow Meter :

1.	**25.0 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.	**26.0** PROCESS DATA	**
18.	**27.0** FLOW TUBE	
19.	Process connection : Flanged	✓
20.	Electrical connections : ½" NPTF	✓
21.	**28.0 Electrode type: EMF Meter** ☒	✓
22.	**29.0 Liner: Required** ☒	
23.	**30.0 Grounding type: Grounding Ring** ☒ **Grounding Electrode** ☐	✓
24.	**31.0 Coil insulation: Class F suitable for high temperature as per IEC60085 / IS 1271**	✓
25.	**32.0** MATERIAL OF CONSTRUCTION	
26.	**33.0 Metering tube: SS316**	✓

27.	**34.0 Liner: Teflon ☐ PTFE ☐ PFA ☐ Hard Rubber ☒**	✓
28.	**35.0 Electrodes:**	**
29.	**36.0 Flanges:**	**
30.	**37.0 Coil housing: Di Cast Al ☒**	✓
31.	**38.0 Jacket: Required ☒ Not Required ☐**	✓
32.	**39.0 Converter/ electronic housing: Di Cast Al**	✓
33.	**40.0** 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.	**41.0** 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.	**42.0** 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.

4. On-Line Turbidity/ TSS Meter :

1.	**43.0 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.	<u>TRANSMITTER</u>	✓
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.	**<u>ENCLOSURE PROTECTION</u>**	✓
24.	WEATHER PROOF TO IP 68 ☒	✓
25.		
26.	**<u>SIGNAL & POWER SUPPLY DETAILS</u>**	✓
27.	POWER SUPPLY : 230 V AC ☒ 110 V AC ☐ ☐	✓
28.	OUTPUT SIGNAL : 4-20 mA DC ☒	✓
29.	COMMUNICATION PORTS : RS 232 ☐ RS 485 ☒ ☐	✓
30.	<u>ALARM SWITCH DETAILS</u>	
31.	NO. OF CONTACTS 1 NO + 1 NC ☐ 1 CHANGEOVER ☐ ☐	x
32.	CONTACT RATING :	x
33.		
34.	**44.0 MATERIAL of CONSTRUCTION**	
35.	TRANSMITTER ENCLOSURE : NON-CORROSIVE	*
36.	WETTED PARTS : NON-CORROSIVE	*
37.		
38.	**45.0 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.	**46.0 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 pressurized line.

7.0 A mounting rack shall be provided for mounting of strainer, rotameter, adjustment valve, sensor holder flow through assembly, transmitter etc.

5. pH Analyser

1.	**GENERAL.**	
2.	MANUFACTURER :	*
3.	MODEL NO. :	*
4.	QUANTITY & RANGE :	✓
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	Applicable if auto calibration is selected.
3.0	Fault diagnosis data shall include faults in analogue / digital circuits, faults in calibrated values, and power supply failure.

4.0	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.
5.0	Any accessories other than specified and are required for the functioning of the system shall also be supplied along with the equipment.
6.0	Terminal size shall be suitable to accept 0.5sq. Mm cable for signals and 1.5/2.5sq.mm cable for power supply.

6. 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	

Sr. No.	Description	Employer's requirement
20.	Electrode Body	Ryton
21.	Measuring surface	Platinum or gold
22.	Holder	SS 316
	SUPPLY/ SIGNAL	
23.	Power supply	110 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
	Installation hardware	Required

7. On-Line Residual Chlorine Measurement

1.	**47.0 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	**48.0 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	**49.0 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 sight	x
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	**50.0 ACCESSORIES (REFER NOTE 3)**	✓
61	Name plate / metal tag :	✓
62	Ph sensor :	✓
63	RTD temperature sensor :	✓
64	All installation hardware :	✓
65	**51.0 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

8. On-Line Residual Chlorine Measurement

73	**52.0 GENERAL**	
74	Manufacturer:	*
75	Model no.	*
76	Tag No:	*
77	Quantity :	*
78	Area classification: Zone 0 ☐ 1 ☐ 2 ☐; Group IIA☐ IIB☐ IIC☐ ; Temp. Class T1☐ T2☐ T3☐ T4 ☐ T5☐ T6☐	x
79	**ENCLOSURE PROTECTION**	✓
80	Weather protection class: IP 65 ☒ IP 66 ☐	✓
81	Ex-Proof : Exd ☐	x
82	**PROCESS DATA**	*
83	**FEATURES**	✓
84	**SENSOR**	✓
85	Type : Amperometric ☐ Colorimetric ☐	*
86	Sensitivity : 0.05 PPM ☐ 0.005 PPM ☒	✓
87	Response time :	*
88	Integral cable connecting sensor & transmitter	✓
89	Operating life :	*
90	Ambient temperature : 0º C to 60º C	✓
91	**TRANSMITTER**	✓
92	**53.0 Type of microprocessor based transmitter:** 2 Wire ☐ 4 Wire ☐	*
93	Integral display : Backlit LCD ☒ LED ☐	✓
94	Zero & Span adjustment :	✓
95	Automatic temperature compensation :	✓
96	Automatic pH compensation :	✓
97	Overall accuracy of measurement loop : ±2% of reading ☒	✓
98	Mounting : Panel ☐ Field ☒ Rack ☐	✓
99	Inlet/ Outlet connection :	*
10(	Calibration interval :	*
10	Calibration method :	*
10	Self diagnostic features :	✓
10	**SIGNAL & POWER SUPPLY DETAILS**	✓
10	Power supply : 24V DC ☐ 110 VAC ☐ 230 VAC ☒ Power Supply (for wireless) : Easy to replace Lithium batteries (Note – 10) ☐	✓
10	Output signal : 4-20 mA HART Loop Power ☒ Field Bus ☐ Modbus RS- 485 ☐ Wireless HART ☐ Wireless ISA 100.11a ☐	✓
10	**ALARM SWITCH DETAILS**	x
10	Alarms : Yes ☐ No ☐ HI ☐ LO ☐ Fault ☐	x
10	No. and type of contacts: 1 No SPDT ☐ 1 No DPDT ☐	x
10	Contact rating: 5A@ 230 V AC ☐ 2A@24VDC ☐	x
11	**54.0 MATERIAL OF CONSTRUCTION**	✓
11	Measurement electrode (cathode) : platinum ☐ gold ☐	*
11	Reference electrode (anode) : Silver ☐ Copper ☐	*
11	Wetted parts : SS316 ☒ PVC ☐ polycarbonate ☐	✓

11	Transmitter enclosure : ABS plastic ☐ Epoxy coated die cast aluminium ☒ Epoxy coated MS ☐	✓
11	**CONNECTION & DIMENSIONS:**	
11	Instrument Process connection type : Flanged ☒ Threaded ☐	✓
11	Threaded size :	x
11	Flange size & rating :	*
11	Cable entry: 1"ET ☐ ½ " NPT ☐ others ☐	*
12	**WIRELESS TRANSMITTER**	x
12	Transmitter update rate: Selectable between 4 sec to 60 sec	x
12	Battery Voltage and Drain time:	x
12	Battery life: Min. 2 yrs with 4 sec. update rate or better	x
12	Antenna type : Integrated Omni directional Antenna ☐ Remote mount Omni directional Antenna ☐	x
12	Signal Range: Minimum 200m or better without any repeater & with clear line of sight	x
12	Wireless Frequency : 2.4GHz license free ISM Band	x

12	Radio security : AES 128 bit encryption	x
12	Wireless Protocol: ISA 100.11a (IEC 62734) / Wireless HART (IEC62591-1)	x
12	Transmitter Configuration : Via gateway over wireless network	x
13	Device programming: Transmitter to work as input device, repeater and Access point	x
13	Network: Note-10	x
13	**55.0 ACCESSORIES (REFER NOTE 3)**	✓
13	Name plate / metal tag :	✓
13	Ph sensor :	✓
13	RTD temperature sensor :	✓
13	All installation hardware :	✓
13	**56.0 CODES & STANDARDS (Refer Note 2)**	✓
13	Weather proof – IP / NEMA IS 13947 :1993	✓
13	Explosion proof - IS 2148-1981/ BS EN 50014:1998 / BS EN 60079-0:2004/FM/CSA	✓
14	Electrical compliant with IEC / EN 61326-3-2	✓
14	**TESTS**	✓
14	Performance	✓
14	Calibration	✓
14	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

1.	**57.0 GENERAL**	
2.	Manufacturer :	*
3.	Model No:	*
4.	Tag No:	*
5.	**58.0 Quantity:**	*
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 ☐	x
9.	Enclosure material: Di Cast Al ☐ Epoxy coated aluminium ☒ Polyurethane Covered Aluminium ☐	✓
10.	**59.0 PROCESS DATA:**	*
11.	**60.0** FEATURES:	✓
12.	Type: Magnetic float with guide tube ☒ Tilt type ☐	✓
13.	Accuracy: ± 2 mm	✓
14.	Mounting: Direct ☒ External chamber ☐	✓
15.	Switch Diff: Fixed ☐ Adjustable ☒	✓
16.	**GUIDED FLOAT TYPE**	
17.	Switch type: glass encapsulated hermetically sealed reed switch ☒	✓
18.	No. of floats with stopper: single ☐ multiple ☐	*
19.	C-C distance for external chamber mounted switches: ……..mm	*
20.	**TILT TYPE**	x

21.	Switch type: Microswitch encapsulated in float	x
22.	No. of floats: single ☐ multiple ☐ Refer follow-up sheet	x
23.	**61.0** MATERIAL OF CONSTRUCTION:	
24.	External chamber with drain/ vent arrangement: CS A105 ☐ SS 316 ☐ PP ☐	x
25.	Float: 316 SS ☐ PP ☒ Others ☐	✓
26.	Guide tube: 316 SS ☐ PP ☒	✓
27.	Bolts & nuts : ASTM A 193 Gr.B7 / A194 Gr.2H	✓
28.	Gaskets : PTFE ☒ OTHERS ☐	✓
29.	Wetted parts: SS 316 ☐ PP ☒ OTHERS ☐	✓
30.	Flange: SS 316 ☐ PP ☒	✓
31.	Cable for tilt switch:	x
32.	Counter weight for tilt type switch:	x
33.	**62.0** CONNECTION & DIMENSIONS	
34.	External chamber connection type: Upper side - lower side ☐ **63.0 Upper side - lower bottom** ☐	x

35.	External chamber process connection size: ½" ☐ 1" ☐ others ☐ Type : NPT ☐ flange ☐ SW ☐	x
36.	Drain arrangement for external chamber Valve ☐ Plug ☐	x
37.	Vent plug :	x
38.	Instrument Process connection (**Refer note 3.0**): 4" ANSI class 150 RF flanged ☐ 3" ANSI class 150 RF flanged ☐	*
39.	Cable entry: 1"ET ☐ ½ " NPT ☐ others ☐	*
40.	**SWITCH DETAILS:**	✓
41.	Controller : Required for converting reed switch to POT Free Relay Output	✓
42.	Alarms : HI ☐ LO ☐	*
43.	**64.0 No. and type of contacts: 1 No SPDT ☐ 1 No DPDT ☒**	✓
44.	**65.0 Contact rating: 5A@ 230 V AC ☐ 2A@24VDC ☐**	✓
45.	**66.0** ACCESSORIES:	
46.	**67.0 Still well for direct mounting**	✓
47.	**68.0 Counter weight to keep tilt type switch cable and float in position**	x
48.	Name plate : Removable – SS	✓
49.	Metal tag – SS	✓
50.	**CODES AND STANDARDS** (REFER NOTE 2)	
51.	Weather proof – IP / NEMA IS 13947 :1993	✓
52.	Explosion proof - IS 2148-1981/ BS EN 50014:1998 / BS EN 60079-0:2004	x
53.	Electrical compliant with IEC / EN 61326-3-2	✓
54.	**TESTS**	
55.	**Calibration**	✓
56.	Material test certificate	✓
57.	Performance test	✓

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 mm2 cable for signal and 2.5 mm2 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

Sr.No.	Description	
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

11. **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	
INDIVIDUAL PAIR / TRIAD SCREENING	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			
	18.	Size		NA	NA		$0.5mm^2$, with 7 strands, each of 0.3 mm dia.			
OVERALL SCREENING	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								
	23.	Material		NA	Annealed Tinned Copper					
	24.	Size		NA	$0.5mm^2$, with 7 strands, each of 0.3 mm dia.					

12. Programmable Logic Controller (PLC)

Sl. 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	:		

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.	
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 indicated in schedule of personnel. 5. Training of owner's engineer for both hardware & software development at site. Duration: ____ No. of engineers: _____	
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	
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	
		:	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 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)**		Centralized SCADA interface purpose	
5.1	Quantity	:		

5.2	Make/model	:		
5.3	Type	:	Refer Clause No. 18: 'Minimum Specifications for Engineering & Operator Workstations'	
5.4	**Features of Data Acquisition & Control System Software**		**Centralized 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	
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, stuckup status for every sequence	:	Required, to know where the process sequence has stuckup	
5.4.22	Scan time setting for individual sequence table	:	Required	
5.4.23	Timers counting capacity	:	Upto 9999 seconds and/or 9999 minutes	
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 (FO) (1Gbps). Refer PLC configuration drg.	
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	:	Xx 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 located in Hazardous area	:	Required	
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	:	*	
8.11.9	Interface Module	:	*	
8.12	**I/O Summary**			
8.12.1	Analog inputs (4-20 mA)	:	Refer Appendix –1 for I/O Count summary of each 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	:	x no.	
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	mum accessories to be provided			

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	:	___% of used I/Os of each type	X
13.2	Wired slots for mounting the spare modules	:	_20__ % of used slots	X
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	:	___% of used MCBs	X
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.	:	____% of used	X
1.5	Operating workstation along with monitor, mouse, keyboard & 1 TB portable hard disk	:	_____ nos.	X
1.6	Fuses of each rating	:	____% of used	

1.7	Bulk power supply unit of each rating	:	____nos. of each rating	
1.8	Communication system components such as hubs, switches, router	:	____% of used	X
1.9	Disks, disk drives, switches, lamps, push buttons, etc	:	____% of used	X
1.10	Consumable including printer cartridges, Paper or any other consumable items	:	For ____ months / years after handing over.	X
2.	**MCBs**	:	___% of used MCBs	X
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 Data sheet (TCE. M4-109-FAT-111) enclosed	:	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.	
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, 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			
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			
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 licenses for various software to be supplied			
19.16	Guarantee certificate			
20	**The product warranty must include following points:**			
a)	Provide ____ 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 Annual Maintenance Contract rate valid for **1** years after the warranty period	

The tender document is based on a turnkey basis that covers both civil construction and electrical package only. Kindly make recommendation