WATCO
WATER CORPORATION OF ODISHA

Bid Identification No. WATCO (W)-27/2022-23, Dt.28.09.2022

AGREEMENT

Construction of 130MLD Water Treatment Plant and its Ancillary Structures for Improvement of Water Supply to Bhubaneswar City" on Engineering, Procurement & Construction (EPC) Contract Including Operation & Maintenance for a Period of Five Years

INDICATIVE ESTIMATED COST: Rs.31200.00 LAKH

(Construction Cost: Rs.26000.00 Lakh + O&M Cost: Rs.5200.00 Lakh)

BID PROCESSING FEE: Rs.30,000.00 + GST @ 18%

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Part I

Preliminary

ENGINEERING, PROCUREMENT AND CONSTRUCTION AGREEMENT

THIS AGREEMENT[1] is entered into on this the …….. day of ……, 2019.

BETWEEN

[THE GENRAL MANAGER, WATCO DIVISION-I, Bhubaneswar and having its office at **Bhubaneswar**, representative of **the Chief Executive Officer, WATCO, Bhubaneswar**, **under Government of Odisha** the "**Authority**" which expression shall, unless repugnant to the context or meaning thereof, include its administrators, successors and assigns of One Part;

AND

{----------,}[2] means the selected bidder[3] having its registered office at ……, (hereinafter referred to as the "**Contractor**" which expression shall, unless repugnant to the context or meaning thereof, include its successors and permitted assigns) of the Other Part.

WHEREAS:

(A) The Government of Odisha] had entrusted to the Authority for "**Construction of 130 MLD Water Treatment Plant and its Ancillary Structures for Improvement of Water Supply to Bhubaneswar City" on Engineering, Procurement & Construction (EPC) Contract Including Operation & Maintenance for a Period of Five Years** [4& 5].

(B) The Authority had resolved to "**Construction of 130 MLD Water Treatment Plant and its Ancillary Structures for Improvement of Water Supply to Bhubaneswar City" including Operation & Maintenance for a Period of Five Years** on Engineering, Procurement, Construction ("**EPC**") basis in accordance with the terms and conditions to be set forth in an agreement to be entered into.

(C) The Authority had accordingly invited single stage two part bidding proposal by its [Request for Proposal vide Tender ID No**. WATCO (W)-27/2022-23, dated 28.09.2022**] (the "**Request for Proposal" or "RFP**") from bidders for EPC of the above referred Water Supply Project and had shortlisted certain bidders including, inter alia, the selected bidder.

(D) The Authority had prescribed the technical and commercial terms and conditions, and invited bids (the "**Request for Proposals**" or "**RFP**") from the bidders pursuant to the RFP for undertaking the Project.

(E) After evaluation of the bids received, the Authority had accepted the bid of the selected bidder and issued its Letter of Acceptance No. …….. dated …….. (hereinafter called the "**LOA**") to the selected bidder for the work "**Construction of 130 MLD Water Treatment Plant and its Ancillary Structures for Improvement of Water Supply to Bhubaneswar City" including Operation & Maintenance for a Period of Five Years s**at the contract price specified hereinafter, requiring the selected bidder to inter alia:

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1 Serially numbered footnotes in this Agreement are for guidance of the Authority and should be omitted from the draft Agreement forming part of Bid Documents. Footnotes marked "$" shall be retained in the draft Agreement.

2 All provisions enclosed in curly parenthesis shall be retained in the Bid Documents and shall be modified as required after the selected bidder has been identified.

3 Refers to the single entity or the lead member of the consortium/joint venture, which is the selected bidder under the RFP.

4 All asterisks in this Model Agreement should be substituted by project-specific particulars in the draft Agreement forming part of Bid Documents.

5 All project-specific provisions in this Model EPC Agreement have been enclosed in square parenthesis and may be modified, as necessary, before issuing the draft Agreement forming part of Bid Documents.

(i) deliver to the Authority a legal opinion from the legal counsel of the selected bidder with respect to the authority of the selected bidder to enter into this Agreement and the enforceability of the provisions thereof, within 10 (ten) days of the date of issue of LOA; and

(ii) execute this Agreement within **15 (fifteen) days** of the date of issue of LOA.

(F) The Contractor has fulfilled the requirements specified in Recital (E) above;

NOW THEREFORE in consideration of the foregoing and the respective covenants and agreements set forth in this Agreement, the sufficiency and adequacy of which is hereby acknowledged,the Authority hereby covenants to pay the Contractor, in consideration of the obligations specified herein, the Contract Price or such other sum as may become payable under the provisions of the Agreement at the times and in the manner specified by the Agreement and intending to be legally bound hereby, the Parties agree as follows:

ARTICLE 1

DEFINITIONS AND INTERPRETATION

1.1 Definitions

The words and expressions beginning with capital letters and defined in this Agreement (including those in Article 28) shall, unless the context otherwise requires, have the meaning ascribed thereto herein, and the words and expressions defined in the Schedules and used therein shall have the meaning ascribed thereto in the Schedules.

1.2 Interpretation

1.2.1 In this Agreement, unless the context otherwise requires,

(a) references to any legislation or any provision thereof shall include amendment or re-enactment or consolidation of such legislation or any provision thereof so far as such amendment or re-enactment or consolidation applies or is capable of applying to any transaction entered into hereunder;

(b) references to laws of Odisha/ India or Indian law or regulation having the force of law shall include the laws, acts, ordinances, rules, regulations, bye laws or notifications which have the force of law in the territory of India and as from time to time may be amended, modified, supplemented, extended or re-enacted;

(c) references to a "person" and words denoting a natural person shall be construed as a reference to any individual, firm, company, corporation, society, trust, government, state or agency of a state or any association or partnership (whether or not having separate legal personality) of two or more of the above and shall include successors and assigns;

(d) the table of contents, headings or sub-headings in this Agreement are for convenience of reference only and shall not be used in, and shall not affect, the construction or interpretation of this Agreement;

(e) the words "include" and "including" are to be construed without limitation and shall be deemed to be followed by "without limitation" or "but not limited to" whether or not they are followed by such phrases;

(f) references to "construction" or "building" include, unless the context otherwise requires, survey and investigation, design, developing, engineering, procurement, supply of plant, materials, equipment, labour, delivery, transportation, installation, processing, fabrication, testing, and commissioning of the Water Supply Project, including **operation & maintenance** and removing of defects, if any, and other activities incidental to the construction and "construct" or "build" shall be construed accordingly;

(g) references to "development" include, unless the context otherwise requires, construction, renovation, refurbishing, augmentation, up-gradation and other activities incidental thereto during the Construction Period, and "develop" shall be construed accordingly;

(h) any reference to any period of time shall mean a reference to that according to Indian standard time;

(i) any reference to day shall mean a reference to a calendar day;

(j) references to a "business day" shall be construed as a reference to a day

(other than a Sunday) on which banks in [Odisha] are generally open for business;

(k) any reference to month shall mean a reference to a calendar month as per the Gregorian calendar;

(l) references to any date, period or Project Milestone shall mean and include such date, period or Project Milestone as may be extended pursuant to this Agreement;

(m) any reference to any period commencing "from" a specified day or date and "till" or "until" a specified day or date shall include both such days or dates; provided that if the last day of any period computed under this Agreement is not a business day, then the period shall run until the end of the next business day;

(n) the words importing singular shall include plural and vice versa;

(o) references to any gender shall include the other and the neutral gender;

(p) "lakh" means a hundred thousand (100,000) and "crore" means ten million (10,000,000);

(q) "indebtedness" shall be construed so as to include any obligation (whether incurred as principal or surety) for the payment or repayment of money, whether present or future, actual or contingent;

(r) references to the "winding-up", "dissolution", "insolvency", or "reorganisation" of a company or corporation shall be construed so as to include any equivalent or analogous proceedings under the law of the jurisdiction in which such company or corporation is incorporated or any jurisdiction in which such company or corporation carries on business including the seeking of liquidation, winding-up, reorganisation, dissolution, arrangement, protection or relief of debtors;

(s) save and except as otherwise provided in this Agreement, any reference, at any time, to any agreement, deed, instrument, licence or document of any description shall be construed as reference to that agreement, deed, instrument, licence or other document as amended, varied, supplemented, modified or suspended at the time of such reference; provided that this Clause shall not operate so as to increase liabilities or obligations of the Authority hereunder or pursuant hereto in any manner whatsoever;

(t) any agreement, consent, approval, authorisation, notice, communication, information or report required under or pursuant to this Agreement from or by any Party or the Authority's Engineer shall be valid and effective only if it is in writing under the hand of a duly authorised representative of such Party or the Authority's Engineer, as the case may be, in this behalf and not otherwise;

(u) the Schedules and Recitals to this Agreement form an integral part of this Agreement and will be in full force and effect as though they were expressly set out in the body of this Agreement;

(v) references to Recitals, Articles, Clauses, Sub-clauses or Schedules in this Agreement shall, except where the context otherwise requires, mean references to Recitals, Articles, Clauses, Sub-clauses and Schedules of or to this Agreement, and references to a Paragraph shall, subject to any contrary indication, be construed as a reference to a Paragraph of this

Agreement or of the Schedule in which such reference appears;

(w) the damages payable by either Party to the other of them, as set forth in this Agreement, whether on per diem basis or otherwise, are mutually agreed genuine pre-estimated loss and damage likely to be suffered and incurred by the Party entitled to receive the same and are not by way of penalty (the "**Damages**"); and

(x) time shall be of the essence in the performance of the Parties' respective obligations. If any time period specified herein is extended for the reasons specified in the Agreement, such extended time shall also be of the essence.

1.2.2 Unless expressly provided otherwise in this Agreement, any Documentation required to be provided or furnished by the Contractor to the Authority shall be provided free of cost and in three copies, and if the Authority is required to return any such Documentation with its comments and/or approval, it shall be entitled to retain two copies thereof.

1.2.3 The rule of construction, if any, that a contract should be interpreted against the parties responsible for the drafting and preparation thereof, shall not apply.

1.2.4 Any word or expression used in this Agreement shall, unless otherwise defined or construed in this Agreement, bear its ordinary English meaning and, for these purposes, the General Clauses Act, 1897 shall not apply.

1.3 Measurements and arithmetic conventions

All measurements and calculations shall be in the metric system and calculations done to 2 (two) decimal places, with the third digit of 5 (five) or above being rounded up and below 5 (five) being rounded down.

1.4 Priority of agreements and errors/discrepancies

1.4.1 This Agreement, and all other agreements and documents forming part of or referred to in this Agreement are to be taken as mutually explanatory and, unless otherwise expressly provided elsewhere in this Agreement, the priority of this Agreement and other documents and agreements forming part hereof or referred to herein shall, in the event of any conflict between them, be in the following order:

(a) this Agreement; and

(b) all other agreements and documents forming part hereof or referred to herein; i.e. this Agreement at (a) above shall prevail over the agreements and documents at (b).

1.4.2 Subject to the provisions of Clause 1.4.1, in case of ambiguities or discrepancies within this Agreement, the following shall apply:

(a) between two or more Clauses of this Agreement, the provisions of a specific Clause relevant to the issue under consideration shall prevail over those in other Clauses;

(b) between the Clauses of this Agreement and the Schedules, the Clauses shall prevail and between Schedules and Annexes, the Schedules shall prevail;

(c) between any two Schedules, the Schedule relevant to the issue shall prevail;

(d) between the written description on the Drawings and the Specifications and Standards, the latter shall prevail;

(e) between the dimension scaled from the Drawing and its specific written dimension, the latter shall prevail; and

(f) between any value written in numerals and that in words, the latter shall prevail.

1.5 Joint and several liability

1.5.1 If the Contractor has formed a Consortium of two or more persons for implementing the Project:

(a) these persons shall, without prejudice to the provisions of this Agreement, be deemed to be jointly and severally liable to the Authority for the performance of the Agreement; and

(b) the Contractor shall ensure that no change in the composition of the Consortium is effected without the prior consent of the Authority.

1.5.2 Without prejudice to the joint and several liability of all the members of the Consortium, the Lead Member shall represent all the members of the Consortium and shall at all times be liable and responsible for discharging the functions and obligations of the Contractor. The Contractor shall ensure that each member of the Consortium shall be bound by any decision, communication, notice, action or inaction of the Lead Member on any matter related to this Agreement and the Authority shall be entitled to rely upon any such action, decision or communication of the Lead Member. The Authority shall have the right to release payments solely to the Lead Member and shall not in any manner be responsible or liable for the *inter se* allocation of payments among members of the Consortium.}[$]

[$]This Clause 1.5 may be omitted if the Contractor is not a Consortium. Even if the Contractor is a Consortium, the Authority may, at its discretion, delete this provision.

Part II

Scope of Project

ARTICLE 2

SCOPE OF THE PROJECT

2.1 Scope of the Project

Under this Agreement, the scope of the Project (the "**Scope of the Project**") shall mean and include:

(a) **"Construction of 130 MLD Water Treatment Plant and its Ancillary Structures for Improvement of Water Supply to Bhubaneswar City" including Operation & Maintenance for a Period of Five Years** set forth in **Schedule-A** (Project) and as specified in **Schedule-B** together with provision of Project Facilities as specified in **Schedule-C,** and in conformity with the Specifications and Standards set forth in **Schedule-D;**

(b) Operation & maintenance of the above Water Supply Projects in accordance with the provisions of this Agreement and in conformity with the requirements set forth in Schedule-E; and

(c) Performance and fulfilment of all other obligations of the Contractor in accordance with the provisions of this Agreement and matters incidental thereto or necessary for the performance of any or all of the obligations of the Contractor under this Agreement.

ARTICLE 3

OBLIGATIONS OF THE CONTRACTOR

3.1 Obligations of the Contractor

3.1.1 Subject to and on the terms and conditions of this Agreement, the Contractor shall undertake the survey, investigation, design, engineering, procurement and construction and operation & maintenance of the Water Supply Project and observe, fulfil, comply with and perform all its obligations set out in this Agreement or arising hereunder.

3.1.2 The Contractor shall comply with all Applicable Laws and Applicable Permits (including renewals as required) in the performance of its obligations under this Agreement.

3.1.3 Subject to the provisions of Clauses 3.1.1 and 3.1.2, the Contractor shall discharge its obligations in accordance with Good Industry Practice and as a reasonable and prudent person.

3.1.4 The Contractor shall remedy any and all loss or damage to the Water Supply Project from the Appointed Date until the end of the Construction Period at the Contractor's cost, save and except to the extent that any such loss or damage shall have arisen from any default or neglect of the Authority.

3.1.5 The Contractor shall remedy any and all loss or damage to the Water Supply Project during the Defects Liability Period at the Contractor's cost to the extent that such loss or damage shall have arisen out of the reasons specified in Clause 17.3.

3.1.6 The Contractor shall remedy any and all loss or damage to the Water Supply Project during the Operation & Maintenance Period at the Contractor's cost, including those stated in Clause 14.1.2, save and except to the extent that any such loss or damage shall have arisen on account of any default or neglect of the Authority or on account of a Force Majeure Event.

3.1.7 The Contractor shall, at its own cost and expense, in addition to and not in derogation of its obligations elsewhere set out in this Agreement:

(a) make, or cause to be made, necessary applications to the relevant Government Instrumentalities with such particulars and details as may be required for obtaining Applicable Permits set forth in Schedule-F and obtain and keep in force and effect such Applicable Permits in conformity with the Applicable Laws;

(b) procure, as required, the appropriate proprietary rights, licences, agreements and permissions for Materials, methods, processes and systems used or incorporated into the Water Supply Project;

(c) make reasonable efforts to maintain harmony and good industrial relations among the personnel employed by it or its Sub-contractors in connection with the performance of its obligations under this Agreement;

(d) ensure and procure that its Sub-contractors comply with all Applicable Permits and Applicable Laws in the performance by them of any of the Contractor's obligations under this Agreement;

(e) not do or omit to do any act, deed or thing which may in any manner be violative of any of the provisions of this Agreement;

(f) support, cooperate with and facilitate the Authority in the implementation and operation of the Project in accordance with the provisions of this Agreement;

(g) ensure that the Contractor and its Sub-contractors comply with the safety and welfare measures for labour in accordance with the Applicable Laws

and Good Industry Practice;

(h) keep, on the Site, a copy of this Agreement, publications named in this Agreement, the Drawings, Documents relating to the Project, and Change of Scope Orders and other communications given under this Agreement. The Authority's Engineer and its authorised personnel shall have the right of access to all these documents at all reasonable times;

(i) cooperate with other contractors employed by the Authority and personnel of any public authority; and

(j) not interfere unnecessarily or improperly with the convenience of the public, or the access to and use and occupation of all roads and footpaths, irrespective of whether they are public or in the possession of the Authority or of others.

3.1.8 The Contractor shall undertake all necessary superintendence to plan, arrange, direct, manage, inspect and test the Works.

3.2 Obligations relating to sub-contracts and any other agreements

3.2.1 **The Contractor shall not sub-contract the construction Works of any Major Structures i.e. Units & Components of Intake Arrangement, WTP, GSR, ESR, Pumping Stations and Distribution Pipeline.** The contractor shall not sub-contract any works **excluding major structures as out lined above** in more than 50% (fifty per cent) of the Project and shall carry out Works directly under its own supervision and through its own personnel in at least 50% (fifty per cent) of the Project. Provided, however, that in respect of the Works carried out directly by the Contractor, it may enter into contracts for the supply and installation of Materials, Plant, equipment, road furniture, safety devices and labour, as the case may be, for such Works. For the avoidance of doubt, the Parties agree that the Contractor may sub-divide the aforesaid project of 50% (Fifty per cent) of the Project. The Parties further agree that all obligations and liabilities under this Agreement for the entire project shall at all times remain with the Contractor. {The Parties also agree that obligation of the Contractor to carry out Works directly in at least 50% (Fifty per cent) of the total Project shall be discharged solely by the Lead Member.}[$]

For Operation & Maintenance purpose, the Contractor can sub-contract any part of water supply project without detrimenting to quality of water and holistic service of the entire water supply system.

3.2.2. In the event any sub-contract for Works, or the aggregate of such sub-contracts with any Sub-contractor, **exceeds 5% (five percent)** of the Contract Price, the Contractor shall communicate the name and particulars, including the relevant experience of the sub-contractor, to the Authority prior to entering into any such sub-contract. The Authority shall examine the particulars of the sub-contractor from the national security and public interest perspective and may require the Contractor, no later than 15 (fifteen) business days from the date of receiving the communication from the Contractor, not to proceed with the sub-contract, and the Contractor shall comply therewith.

3.2.3 In the event any sub-contract referred to in Clause 3.2.2 relates to a sub-contractor who has, over the preceding 3 (three) years, not undertaken at least one work of a similar nature with a contract value exceeding 40% (forty per cent) of the value of the sub-contract to be awarded hereunder and received payments in respect thereof for an amount equal to at least such 40% (forty per cent), the Authority may, no later than 15 (fifteen) business days from the date of receiving the

[$] May be deleted if the Contractor is not a Consortium.

communication from the Contractor. The Contractor not to proceed with such sub-contract, and the Contractor shall comply therewith.

3.2.4 It is expressly agreed that the Contractor shall, at all times, be responsible and liable for all its obligations under this Agreement not withstanding anything contained in the agreements with its Sub-contractors or any other agreement that may be entered into by the Contractor, and no default under any such agreement shall excuse the Contractor from its obligations or liability hereunder.

3.3 Deleted

3.4 Contractor's personnel

3.4.1 The Contractor shall ensure that the personnel engaged by it or by its Sub-contractors in the performance of its obligations under this Agreement are at all times appropriately qualified, skilled and experienced in their respective functions in conformity with Good Industry Practice.

3.4.2 The Authority's Engineer may, for reasons to be specified in writing, direct the Contractor to remove any member of the Contractor's or Sub-contractor's personnel. Provided that any such direction issued by the Authority's Engineer shall specify the reasons for the removal of such person.

3.4.3 The Contractor shall on receiving such a direction from the Authority's Engineer order for the removal of such person or persons with immediate effect. It shall be the duty of the Contractor to ensure that such persons are evicted from the Site within 10 (ten) days of any such direction being issued in pursuance of Clause 3.4.2. The Contractor shall further ensure that such persons have no further connection with the Works or **Operation & Maintenance** under this Agreement. The Contractor shall then appoint (or cause to be appointed) a replacement.

3.5 Advertisement on Water Supply Project

The Water Supply Project or any part thereof shall not be used in any manner to advertise any commercial product or services.

3.6 Contractor's care of the Works

The Contractor shall bear full risk in and take full responsibility for the care of the Works, and of the Materials, goods and equipment for incorporation therein, from the Appointed Date until the date of Provisional Certificate (with respect to the Works completed prior to the issuance of the Provisional Certificate) and/or Completion Certificate (with respect to the Works referred to in the Punch List), save and except to the extent that any such loss or damage shall have arisen from any default or neglect of the Authority.

3.7 Electricity, Water and other services

The Contractor shall be responsible for procuring of all power, water and other services that it may require.

3.8 Unforeseeable difficulties

Except as otherwise stated in the Agreement:

(a) the Contractor accepts complete responsibility for having foreseen all difficulties and costs of successfully completing the Works;

(b) the Contract Price shall not be adjusted to take account of any unforeseen difficulties or costs; and

(c) the Scheduled Completion Date shall not be adjusted to take account of any unforeseen difficulties or costs.

ARTICLE 4

OBLIGATIONS OF THE AUTHORITY

4.1 Obligations of the Authority

4.1.1 The Authority shall, at its own cost and expense, undertake, comply with and perform all its obligations set out in this Agreement or arising hereunder.

4.1.2 The Authority shall be responsible for the correctness of the Scope of the Project, Project Facilities, Specifications and Standards and the criteria for testing of the completed Works.

4.1.3 The Authority shall provide to the Contractor:

(a) upon receiving the Performance Security under Clause 7.1.1, the land/site in accordance with the provisions of Clauses 8.2 and 8.3, within a period of 15 (fifteen) days from the date of this Agreement, on no less than 90% (ninety per cent) of the total land/site requirement for the Water Supply Project;

(b) approval of the general arrangement drawings (the "**GAD**") from appropriate authorities to enable the Contractor to lay the pipe lines across the railway line / roads on the Water Supply Project in accordance with the Specifications and Standards, and subject to the terms and conditions specified in such approval, within a period of 60 (sixty) days from the Appointed Date, and reimbursement of all the costs and expenses paid by the Contractor to the appropriate authorities for and in respect of the crossing of pipe lines; [56]

(c) all environmental clearances as required under Clause 4.3.[7]

4.1.4 Delay in providing the land/site or approval of GAD by appropriate authorities, as the case may be, in accordance with the provisions of Clause 4.1.3 shall entitle the Contractor to Damages in a sum calculated in accordance with the provisions of Clause 8.3 of this Agreement and Time Extension in accordance with the provisions of Clause 10.5 of this Agreement. For the avoidance of doubt, the Parties agree that the Damages for delay in approval of GAD by the appropriate authorities for a particular road / railway crossing shall be deemed to be equal to the Damages payable under the provisions of Clause 8.3 for delay in providing Railway / Road crossing clearance for a length of 500 mtr. for each such road / railway crossing.

4.1.5 Notwithstanding anything to the contrary contained in this Agreement, the Parties expressly agree that the aggregate Damages payable under Clauses 4.1.4, 8.3 and 9.2 shall not exceed 1% (one per cent) of the Contract Price. For the avoidance of doubt, the Damages payable by the Authority under the aforesaid Clauses shall not be additive if they arise concurrently from more than one cause but relate to the same part of the Water Supply Project.

Both the parties agree that payment of these Damages shall be full and final settlement of all claims of the Contractor and such compensation shall be the sole remedy against delays of the Authority and both parties further agree this as final cure against delays of the Authority.

4.1.6 The Authority agrees to provide support to the Contractor and undertakes to observe, comply with and perform, subject to and in accordance with the provisions of this Agreement and the Applicable Laws, the following:

(a) upon written request from the Contractor, and subject to the Contractor

[6] Clause (b) may be omitted if the Project does not include a major structure.

[7] Clause 4.1.3(c) may be suitably modified in the event that all the environmental clearances for the Water Supply Project have been received or are not required. It should be clearly stated that all the environmental clearances for the Water Supply Project have been received; or such environmental clearances for the Water Supply Project are not required.

complying with Applicable Laws, provide reasonable support to the Contractor in procuring Applicable Permits required from any Government Instrumentality for implementation of the Project;

(b) upon written request from the Contractor, provide reasonable assistance to the Contractor in obtaining access to all necessary infrastructure facilities and utilities, including water and electricity at rates and on terms no less favourable than those generally available to commercial customers receiving substantially equivalent services;

(c) procure that no barriers that would have a material adverse effect on the works are erected or placed on or about the Water Supply Project by any Government Instrumentality or persons claiming through or under it, except for reasons of Emergency, national security, law and order or collection of inter-state taxes;

(d) not do or omit to do any act, deed or thing which may in any manner be violative of any of the provisions of this Agreement;

(e) support, cooperate with and facilitate the Contractor in the implementation of the Project in accordance with the provisions of this Agreement; and

(f) upon written request from the Contractor and subject to the provisions of Clause 3.3, provide reasonable assistance to the Contractor and any expatriate personnel of the Contractor or its Sub-contractors to obtain applicable visas and work permits for the purposes of discharge by the Contractor or its Sub-contractors of their obligations under this Agreement and the agreements with the Sub-contractors.

4.2 Operation & Maintenance obligations prior to the Appointed Date - *Deleted*

4.3 Environmental Clearances

The Authority represents and warrants that the environmental clearances required **if any** for construction of the Project shall be procured by the Authority prior to the date of issue of LOA. For the avoidance of doubt, the present status of environmental clearances is specified in Schedule-A.[6]

[6]Clause 4.3 may be suitably modified in the event that all the environmental clearances for the Water Supply Project have been received or are not required. It should be clearly stated that all the environmental clearances for the Water Supply Project have been received; or such environmental clearances for the Water Supply Projectare not required.

ARTICLE 5

REPRESENTATIONS AND WARRANTIES

5.1 Representations and warranties of the Contractor

The Contractor represents and warrants to the Authority that:

(a) it is duly organised and validly existing under the laws of Odisha/India, and has full power and authority to execute and perform its obligations under this Agreement and to carry out the transactions contemplated hereby;

(b) it has taken all necessary corporate and/or other actions under Applicable Laws to authorise the execution and delivery of this Agreement and to validly exercise its rights and perform its obligations under this Agreement;

(c) this Agreement constitutes its legal, valid and binding obligation, enforceable against it in accordance with the terms hereof, and its obligations under this Agreement will be legally valid, binding and enforceable obligations against it in accordance with the terms hereof;

(d) it is subject to the laws of Odisha/ India, and hereby expressly and irrevocably waives any immunity in any jurisdiction in respect of this Agreement or matters arising there under including any obligation, liability or responsibility hereunder;

(e) the information furnished in the Bid and as updated on or before the date of this Agreement is true and accurate in all respects as on the date of this Agreement;

(f) the execution, delivery and performance of this Agreement will not conflict with, result in the breach of, constitute a default under, or accelerate performance required by any of the terms of its memorandum and articles of association or any Applicable Laws or any covenant, contract, agreement, arrangement, understanding, decree or order to which it is a party or by which it or any of its properties or assets is bound or affected;

(g) there are no actions, suits, proceedings, or investigations pending or, to its knowledge, threatened against it at law or in equity before any court or before any other judicial, quasi-judicial or other authority, the outcome of which may result in the breach of this Agreement or which individually or in the aggregate may result in any material impairment of its ability to perform any of its obligations under this Agreement;

(h) it has no knowledge of any violation or default with respect to any order, writ, injunction or decree of any court or any legally binding order of any Government Instrumentality which may result in any material adverse effect on its ability to perform its obligations under this Agreement and no fact or circumstance exists which may give rise to such proceedings that would adversely affect the performance of its obligations under this Agreement;

(i) it has complied with Applicable Laws in all material respects and has not been subject to any fines, penalties, injunctive relief or any other civil or criminal liabilities which in the aggregate have or may have a material adverse effect on its ability to perform its obligations under this Agreement;

(j) no representation or warranty by it contained herein or in any other document furnished by it to the Authority or to any Government Instrumentality in relation to Applicable Permits contains or will contain any untrue or misleading statement of material fact or omits or will omit to state a material fact necessary to make such representation or warranty not misleading;

(k) no sums, in cash or kind, have been paid or will be paid, by it or on its behalf, to any person by way of fees, commission or otherwise for securing the contract or entering into this Agreement or for influencing or attempting to influence any officer or employee of the Authority in connection therewith;

(l) all information provided by the {selected bidder/ members of the Consortium} in response to the Request for Qualification and Request for Proposals or otherwise,

is to the best of its knowledge and belief, true and accurate in all material respects; and

(m) nothing contained in this Agreement shall create any contractual relationship or obligation between the Authority and any Sub-contractors, designers, consultants or agents of the Contractor.

5.2 Representations and warranties of the Authority

The Authority represents and warrants to the Contractor that:

(a) it has full power and authority to execute, deliver and perform its obligations under this Agreement and to carry out the transactions contemplated herein and that it has taken all actions necessary to execute this Agreement, exercise its rights and perform its obligations, under this Agreement;

(b) It has taken all necessary actions under the Applicable Laws to authorise the execution, delivery and performance of this Agreement;

(c) It has the financial standing and capacity to perform its obligations under this Agreement;

(d) This Agreement constitutes a legal, valid and binding obligation enforceable against it in accordance with the terms hereof;

(e) it has no knowledge of any violation or default with respect to any order, writ, injunction or any decree of any court or any legally binding order of any Government Instrumentality which may result in any material adverse effect on the Authority's ability to perform its obligations under this Agreement;

(f) It has complied with Applicable Laws in all material respects;

(g) It has good and valid right to the Site and has the power and authority to grant the clearance in respect thereof to the Contractor; and

(h) It has procured land / road and environment clearances such that the Contractor can commence construction forthwith on 90% (ninety per cent) of the total land/site requirement for the Water Supply Project.

5.3 Disclosure

In the event that any occurrence or circumstance comes to the attention of either Party that renders any of its aforesaid representations or warranties untrue or incorrect, such Party shall immediately notify the other Party of the same. Such notification shall not have the effect of remedying any breach of the representation or warranty that has been found to be untrue or incorrect nor shall it adversely affect or waive any obligation of either Party under this Agreement.

ARTICLE 6

DISCLAIMER

6.1 Disclaimer

6.1.1 The Contractor acknowledges that prior to the execution of this Agreement, the Contractor has, after a complete and careful examination, made an independent evaluation of the Request for Qualification, Request for Proposal, Scope of the Project, Specifications and Standards of design, construction and Operation & Maintenance, Site, local conditions, physical qualities of ground, subsoil and geology, source of water supply, suitability and availability of access routes to the Site and all information provided by the Authority or obtained, procured or gathered otherwise, and has determined to its satisfaction the accuracy or otherwise thereof and the nature and extent of difficulties, risks and hazards as are likely to arise or may be faced by it in the course of performance of its obligations hereunder. Save as provided in Clause 4.1.2 and Clause 5.2, the Authority makes no representation whatsoever, express, implicit or otherwise, regarding the accuracy, adequacy, correctness, reliability and/or completeness of any assessment, assumptions, statement or information provided by it and the Contractor confirms that it shall have no claim whatsoever against the Authority in this regard.

6.1.2 The Contractor acknowledges and hereby accepts to have satisfied itself as to the correctness and sufficiency of the Contract Price.

6.1.3 The Contractor acknowledges and hereby accepts the risk of inadequacy, mistake or error in or relating to any of the matters set forth in Clause 6.1.1 above and hereby acknowledges and agrees that the Authority shall not be liable for the same in any manner whatsoever to the Contractor, or any person claiming through or under any of them, and shall not lead to any adjustment of Contract Price or Scheduled Completion Date.

6.1.4 The Parties agree that any mistake or error in or relating to any of the matters set forth in Clause 6.1.1 above shall not vitiate this Agreement, or render it voidable.

6.1.5 In the event that either Party becomes aware of any mistake or error relating to any of the matters set forth in Clause 6.1.1 above, that Party shall immediately notify the other Party, specifying the mistake or error.

6.1.6 Except as otherwise provided in this Agreement, all risks relating to the Project shall be borne by the Contractor; and the Authority shall not be liable in any manner for such risks or the consequences thereof.

Part III
Construction and Operation & Maintenance

ARTICLE 7

PERFORMANCE SECURITY

7.1 *Performance Security*

7.1.1 The Contractor shall, for the performance of its obligations hereunder during the Construction Period, provide to the Authority, within **10 (ten) working** days of the date of this Agreement, an irrevocable and unconditional guarantee from a Nationalised Bank, counter guaranteed by its branch at Bhubaneswar in the form set forth in Schedule-G (the "**Performance Security**") for an amount equal to **7.5%** (seven and half percent) of the Contract Price for Construction Work. The Performance Security shall be valid until 60 (sixty) days after the Defects Liability Period. Until such time the Performance Security is provided by the Contractor pursuant hereto and the same comes into effect, the Bid Security shall remain in force and effect, and upon such provision of the Performance Security, the Authority shall release the Bid Security to the Contractor. For the avoidance of doubt, the parties expressly agree that the Contractor shall provide, no later than 30 (thirty) days prior to the expiry of the Performance Security for the defects Liability Period specified in Clause 17.1.1.

7.1.2 Notwithstanding anything to the contrary contained in this Agreement, the Parties agree that in the event of failure of the Contractor to provide the Performance Security in accordance with the provisions of Clause 7.1.1 and within the time specified therein or such extended period as may be provided by the Authority, in accordance with the provisions of Clause 7.1.3, the Authority may encash the Bid Security and appropriate the proceeds thereof as Damages, and thereuponall rights, privileges, claims and entitlements of the Contractor under or arising out of this Agreement shall be deemed to have been waived by, and to have ceased with the concurrence of the Contractor, and this Agreement shall be deemed to have been terminated by mutual agreement of the Parties.

7.1.3 In the event the Contractor fails to provide the Performance Security within **10 (ten) working** days of this Agreement, it may seek extension of time for a period not exceeding 20 (twenty) days on payment of Damages for such extended period in a sum calculated at the rate of 0.05% (zero point zero five per cent) of the Contract Price for each day until the Performance Security is provided.

7.2 Extension of Performance Security

The Contractor may initially provide the Performance Security for a period of **3 (three)** years; provided that it shall procure the extension of the validity of the Performance Security, as necessary, at least 2 (two) months prior to the date of expiry thereof. Upon the Contractor providing an extended Performance Security, the previous Performance Security shall be deemed to be released and the Authority shall return the same to the Contractor within a period of 7 (seven) business days from the date of submission of the extended Performance Security.

7.3 Appropriation of Performance Security

7.3.1 Upon occurrence of a Contractor's Default, the Authority shall, without prejudice to its other rights and remedies hereunder or in law, be entitled to encash and appropriate the relevant amounts from the Performance Security as Damages for such Contractor's Default.

7.3.2 Upon such encashment and appropriation from the Performance Security, the Contractor shall, within 30 (thirty) days thereof, replenish, in case of partial

appropriation, to its original level the Performance Security, and in case of appropriation of the entire Performance Security provide a fresh Performance Security, as the case may be, and the Contractor shall, within the time so granted, replenish or furnish fresh Performance Security as aforesaid failing which the Authority shall be entitled to **terminate the Agreement in accordance with Article 23.** Upon replenishment or furnishing of a fresh **Performance Security**, as the case may be, as aforesaid, the Contractor shall be entitled to an additional Cure Period of 30 (thirty) days for remedying the **Contractor's Default**, and in the event of the Contractor not curing its default within such Cure Period, the Authority shall be entitled to encash and appropriate such Performance Security as Damages, and to terminate this Agreement in accordance with **Article 23**.

7.4 Release of Performance Security

The Authority shall return the Performance Security to the Contractor within 60 (sixty) days of the expiry of the Defects Liability Period under this Agreement. Notwithstanding the aforesaid, the Parties agree that the Authority shall not release the Performance Security until all Defects identified during the Defects Liability Period have been rectified.

7.4.1 The Contractor shall for the performance of its obligations hereunder during the operation & maintenance period, provide to the Authority, on commencement of the O&M period, an irrevocable and unconditional guarantee from a Nationalized Bank, counter guaranteed by its branch at Bhubaneswar in the form set forth in Schedule-G (the **"Performance Security for O&M"**) for an amount equal to 10% (ten percent) of the contract price for O&M cost (excluding energy cost). The performance security shall be valid until 60 days after the O&M period of 5 (five) years. The Authority shall return the performance security for O&M within 60 (sixty) days of the expiry of the operation & maintenance period of 5 years. In case the bid amount for O&M cost is less than the estimated cost by more than 10%, the successful bidder will deposit additional performance security to the extent of the differential cost of bid amount and 90% of the estimated cost relating to O&M cost in shape of Bank Guarantee in Schedule-G within 10 working days of singing of agreement and the same shall remain valid until 60 days after the O&M period.

7.5 Retention Money[7]

7.5.1 From every payment for Works due to the Contractor in accordance with the provisions of Clause 19.5, the Authority shall deduct **6% (six per cent)** thereof as guarantee money for performance of the obligations of the Contractor during the Construction Period (the "**Retention Money**") subject to the condition that the maximum amount of Retention Money shall not **exceed 5% (five per cent)** of the Contract Price.

7.5.2 Upon occurrence of a Contractor's Default, the Authority shall, without prejudice to its other rights and remedies hereunder or in law, be entitled to appropriate the relevant amounts from the Retention Money as Damages for such Contractor's Default.

7.5.3 The Contractor may, upon furnishing an irrevocable and unconditional bank guarantee substantially in the form provided at Annex-II of Schedule-G, require the Authority to refund the Retention Money deducted by the Authority under the provisions of Clause 7.5.1. Provided that the refund hereunder shall be made in tranches of not less than 1% (one per cent) of the Contract Price.

[7]The Authority may, in its discretion, omit Clause 7.5 and in lieu thereof increase the Performance Security under Clause 7.1 from 7.5% (seven point five per cent) to 10% (ten percent).

7.5.4 Within 15 (fifteen) days of the date of issue of the Completion Certificate, the Authority shall discharge the bank guarantees furnished by the Contractor under the provisions of Clause 7.5.3 and refund the balance of Retention Money remaining with the Authority after adjusting the amounts appropriated under the provisions of Clause 7.5.2 and the amounts refunded under the provisions of Clause 7.5.3.

7.5.5 The Parties agree that in the event of Termination of this Agreement, the **Retention Money and the bank guarantees** specified in this Clause 7.5 shall be treated as if they are Performance Security and shall be reckoned as such for the **purposes of Termination Payment under Clause 23.6**.

Note: **1]** Bidders those desire to provide 10 % performance security instead of 7.5% as per clause 7.1.1, in such case no retention money shall be deducted as per clause 7.5.

2] The Contractor shall, for the performance of its obligations hereunder during the Construction Period, provide to the Authority, within 10 (ten) working days of the date of this Agreement, an irrevocable and unconditional guarantee from a Nationalised Bank, counter guaranteed by its branch at Bhubaneswar in the form set forth in Schedule-G (the "**Performance Security**") for an amount equal to **3% (three percent)** of the Contract Price for Construction Work in line with the **Finance Department OM No.8952/F Dt.18.03.2021, OM No.8475/F Dt.05.04.2022 & Works Dept. OM No.5992/W dated 27.04.2021).**

ARTICLE 8

SITES FOR THE PROJECT

8.1 The Site

The site of the Water Supply Project (the "**Site**") shall comprise the site described in Schedule-A in respect of which the land shall be provided by the Authority to the Contractor. The Authority shall be responsible for:

(a) acquiring and providing the site in accordance with the alignment finalised by the Authority, free from all encroachments and encumbrances, and free access thereto for the execution of this Agreement; and

(b) obtaining licences and permits for environment clearance for the Water Supply projects if requires.

8.2 Procurement of the Site for construction of structures :

8.2.1 The Authority Representative and the Contractor shall within 10 (ten) days of issue of LOA inspect the Site and prepare a memorandum containing an inventory of the Site including the vacant and unencumbered land, buildings, structures, road works, trees and any other immovable property on or attached to the Site. Subject to the provisions of Clause 8.2.3, such memorandum shall have appended thereto an appendix (the "**Appendix**") specifying in reasonable detail those parts of the Site to which vacant access and land has not been given to the Contractor. Signing of the memorandum, in two counterparts (each of which shall constitute an original), by the authorised representatives of the Parties shall be deemed to constitute a valid evidence of giving the land to the Contractor for discharging its obligations under and in accordance with the provisions of this Agreement and for no other purpose whatsoever.

Whenever the Authority is ready to hand over any part or parts of the Site included in the Appendix, it shall inform the Contractor, by notice, the proposed date and time such of handing over. The Authority Representative and the Contractor shall, on the date so notified, inspect the specified parts of the Site, and prepare a memorandum containing an inventory of the vacant and unencumbered land, buildings, structures, road works, trees and any other immovable property on or attached to the Site so handed over. Signing of the memorandum, in two counterparts (each of which shall constitute an original), by the authorised representatives of the Parties shall be deemed to constitute a valid evidence of giving the relevant land to the Contractor.

8.2.2 The Authority shall provide all land to the Contractor included in the Appendix by the date specified in Schedule-A for those parts of the Site referred to therein, or no later than 90 (ninety) days of the Appointed Date for those parts of the Site which have not been specified in Schedule-A, and in the event of delay for any reason other than Force Majeure or breach of this Agreement by the Contractor, it shall pay to the Contractor, Damages in a sum calculated in accordance with Clause 8.3.

8.2.3 Notwithstanding anything to the contrary contained in this Clause 8.2, the Authority shall specify the parts of the Site, if any, for which land shall be provided to the Contractor on the dates specified in Schedule-A. Such parts shall also be included in the Appendix prepared in pursuance of Clause 8.2.1. For avoidance of doubt, the Parties expressly agree that the Appendix shall in no event contain areas required for the Water Supply Project cumulative area of which exceeds 10% (ten per cent) of the total area of the Water Supply Project.

8.3 Damages for delay in handing over the Site for construction of structures / crossing of Pipe line.

8.3.1 In the event any part of the construction Site is not provided by the Authority on or before the date(s) specified in Clause 8.2 for any reason other than Force

Majeure or breach of this Agreement by the Contractor, the Authority shall pay Damages to the Contractor in a sum calculated in accordance with the following formula for and in respect of those parts of the Site which has not been provided:
Amount of Damages shall be paid in a sum calculated at the rate of Rs.5.00 (Rupees Five) per day for every 1000 (One thousand) square meters or part thereof, commencing from the 91st (Ninety first) day of the appointed date and until such site is procured.

In the event that any Damages are due and payable to the Contractor under the provisions of this Clause 8.3.1 for delay in providing the land, the Contractor shall, subject to the provisions of Clause 10.5, be entitled to Time Extension equal to the period for which the Damages have become due and payable under this Clause 8.3.1, save and except that:

(a) if any delays involve time overlaps, the overlaps shall not be additive; and
(b) such Time Extension shall be restricted only to the Works which are affected by the delay in providing the land.

For the avoidance of doubt, the Parties expressly agree that the Damages specified hereunder and the Time Extension specified in Clause 10.5 shall be restricted only to failure of the Authority to provide the land for and in respect of the construction of major structures.

8.3.2 Notwithstanding anything to the contrary contained in this Agreement, the Contractor expressly agrees that Works on all parts of the Site for which land is granted within 90 (ninety) days of the Appointed Date, or with respect to the parts of the Site provided in Schedule-A, no later than the date(s) specified therein, as the case may be, shall be completed before the Scheduled Completion Date and shall not qualify for any Time Extension under the provisions of Clause 8.3.1.

8.3.3 Notwithstanding anything to the contrary contained in this Agreement, the Authority may at any time withdraw any Works forming part of this Agreement, subject to such Works not exceeding an aggregate value, such value to be determined in accordance with Schedule-H, equal to 10(ten) percent of the Contract Price.

Provided that if any Works cannot be undertaken within the municipal limits of a town or within any area falling in a reserved forest or wildlife sanctuary, as the case may be, because the requisite clearances or approvals for commencing construction of Works therein have not been given within 240 (two hundred and forty) days of the Appointed date, the affected Works shall be deemed to be withdrawn under the provisions of this Clause 8.3.3 unless the Parties agree to the contrary, and such Works shall not be computed for the purposes of the aforesaid ceiling of 10% (ten per cent) hereunder.

8.3.4 In the event of withdrawal of Works under Clause 8.3.3, the Contract Price shall be reduced by an amount equal to 90 (ninety) per cent of the value of the Works withdrawn and the Contractor shall not be entitled to any other compensation or Damages for the withdrawal of Works.

Provided that if any Works are withdrawn after commencement of the Construction of such works, the Authority shall pay to the Contractor 110% (one hundred and ten per cent) of the fair value of the work done, as assessed by the Authority's Engineer.

8.4 Site to be free from Encumbrances

Subject to the provisions of Clause 8.2, the Site shall be made available by the Authority to the Contractor pursuant hereto free from all Encumbrances and occupations and without the Contractor being required to make any payment to the Authority on account of any costs, compensation, expenses and charges for the acquisition and use of such Site for the duration of the Project Completion Schedule. For the avoidance of doubt, it is agreed that the existing rights of way, easements, privileges, liberties and appurtenances to the Site shall not be deemed to be Encumbrances. It is further agreed that, unless

otherwise specified in this Agreement, the Contractor accepts and undertakes to bear any and all risks arising out of the inadequacy or physical condition of the Site.

8.5 Protection of Site from encroachments

On and after signing the memorandum and/or subsequent memorandum referred to in Clause 8.2.1, and until the issue of the Completion Certificate, the Contractor shall maintain a round-the-clock vigil over the Site and shall ensure and procure that no encroachment thereon takes place. During the Construction Period, the Contractor shall protect the Site from any and all occupations, encroachments or Encumbrances, and shall not place or create nor permit any Sub-contractor or other person claiming through or under the Agreement to place or create any Encumbrance or security threat over all or any part of the Site or the Project Assets, or on any rights of the Contractor therein or under this Agreement, save and except as otherwise expressly set forth in this Agreement. In the event of any encroachment or occupation on any part of the Site, the Contractor shall report such encroachment or occupation forthwith to the Authority and undertake its removal at its own cost and expenses.

8.6 Special/temporary land

The Contractor shall bear all costs and charges for any special or temporary land required by it in connection with access to the Site. The Contractor shall obtain at its cost such facilities on or outside the Site as may be required by it for the purposes of the Water Supply Project and the performance of its obligations under this Agreement.

8.7 Access to the Authority and the Authority's Engineer

8.7.1 The land given to the Contractor hereunder shall always be subject to the right of access of the Authority and the Authority's Engineer and their employees and agents for inspection, viewing and exercise of their rights and performance of their obligations under this Agreement.

8.7.2 The Contractor shall ensure, subject to all relevant safety procedures, that the Authority has un-restricted access to the Site during any emergency situation, as decided by the Authority's Engineer.

8.8 Geological and archaeological finds

It is expressly agreed that mining, geological or archaeological rights do not form part of this Agreement with the Contractor for the Works, and the Contractor hereby acknowledges that it shall not have any mining rights or interest in the underlying minerals, fossils, antiquities, structures or other remnants or things either of particular geological or archaeological interest and that such rights, interest and property on or under the Site shall vest in and belong to the Authority or the concerned Government Instrumentality. The Contractor shall take all reasonable precautions to prevent its workmen or any other person from removing or damaging such interest or property and shall inform the Authority forthwith of the discovery thereof and comply with such instructions as the concerned Government Instrumentality may reasonably give for the removal of such property. For the avoidance of doubt, it is agreed that any reasonable expenses incurred by the Contractor hereunder shall be reimbursed by the Authority. It is also agreed that the Authority shall procure that the instructions hereunder are issued by the concerned Government Instrumentality within a reasonable period.

ARTICLE 9

UTILITIES AND TREES

9.1 Existing utilities and roads

Notwithstanding anything to the contrary contained herein, the Contractor shall ensure that the respective entities owning the existing roads, land, level crossings, structures, or utilities on, under or above the Site are enabled by it to keep them in continuous satisfactory use, if necessary, by providing suitable temporary diversions with the authority of the controlling body of that road, landor utility.

9.2 Shifting of Obstructing Utilities

The Contractor shall, in accordance with Applicable Laws and with assistance of the Authority, cause shifting of any utility (including electric lines, water pipes and telephone cables) to an appropriate location or alignment, if such utility or obstruction adversely affects the execution of the **Works or Operation & Maintenance of the Water Supply Project** in accordance with this Agreement. The actual cost of such shifting, as approved and communicated by the entity owning the utility, shall be paid by the Contractor and reimbursed by the Authority to the Contractor on certification by the entity owning such utility that the work has been satisfactorily executed by the Contractor. In the event of any delay in such shifting by the entity owning the utility beyond a period of 180 (one hundred and eighty) days from the date of notice by the Contractor to the entity owning the utility and to the Authority, the Contractor shall be entitled to Damages in a sum calculated in accordance with the formula specified in Clause 8.3.1 for the period of delay, and to Time Extension in accordance with Clause 10.5 for and in respect of the part(s) of the Works affected by such delay; provided that if the delays involve any time overlaps, the overlaps shall not be additive.

9.3 New utilities

9.3.1 **Deleted.**

9.3.2 **Deleted.**

9.3.3 **Deleted.**

9.3.4 **Deleted.**

9.4 Felling of trees

The Authority shall assist the Contractor in obtaining the Applicable Permits for felling of trees to be identified by the Authority for this purpose if and only if such trees cause a Material Adverse Effect on the construction or **operation & maintenance** of the Water Supply Project. The cost of such felling shall be borne by the Authority and in the event of any delay in felling thereof for reasons beyond the control of the Contractor; it shall be excused for failure to perform any of its obligations hereunder if such failure is a direct consequence of delay in the felling of trees. The Parties hereto agree that the felled trees shall be deemed to be owned by the Authority and shall be disposed in such manner and subject to such conditions as the Authority may in its sole discretion deem appropriate. For the avoidance of doubt, the Parties agree that if any felling of trees hereunder is in a forest area, the Applicable Permit thereof shall be procured by the Authority within the time specified in the Agreement.

ARTICLE 10

DESIGN AND CONSTRUCTION OF THE WATER SUPPLY PROJECT

10.1 Obligations prior to commencement of Works

10.1.1 Within 20 (twenty) days of the Appointed Date, the Contractor shall:

(a) appoint its representative, duly authorised to deal with the Authority in respect of all matters under or arising out of or relating to this Agreement;

(b) appoint a design director (the "**Design Director**") who will head the Contractor's design unit and shall be responsible for surveys, investigations, collection of data, and preparation of preliminary and detailed designs;

(c) undertake and perform all such acts, deeds and things as may be necessary or required before commencement of Works under and in accordance with this Agreement, the Applicable Laws and Applicable Permits; and

(d) make its own arrangements for quarrying of materials needed for the Water Supply Project under and in accordance with the Applicable Laws and Applicable Permits.

10.1.2 The Authority shall, within 15 (fifteen) days of the date of this Agreement, appoint an engineer (the "**Authority's Engineer**") to discharge the functions and duties specified in this Agreement, and shall notify to the Contractor the name, address and the date of appointment of the Authority's Engineer forthwith.

10.1.3 Within 30 (thirty) days of the Appointed Date, the Contractor shall submit to the Authority and the Authority's Engineer a programme (the **"Programme")** for the Works, developed using networking techniques giving the following details:

Part I Contractor's organisation for the Project, the general methods and arrangements for design and construction, environmental management plan, Quality Assurance Plan including design quality plan and safety plan covering safety of users and workers during construction, Contractor's key personnel and equipment.

Part II Programme for completion of all stages of construction given in Schedule-H and Project Milestones of the Works as specified in Project Completion Schedule set forth in Schedule-J. The Programme shall include:

(a) the order in which the Contractor intends to carry out the Works, including the anticipated timing of design and stages of Works;

(b) the periods for reviews under Clause 10.2;

(c) the sequence and timing of inspections and tests specified in this Agreement.

The Contractor shall submit a revised programme whenever the previous programme is inconsistent with the actual progress or with the Contractor's obligations.

Part III Monthly cash flow forecast.

10.1.4 The Contractor shall compute, on the basis of the Drawings prepared in accordance with Clause 10.2.4, and provide to the Authority's Engineer, the length, area and numbers, as the case may be, in respect of the various items of work specified in Schedule-H and comprising the Scope of the Project. The Parties expressly agree that these details shall form the basis for estimating the interim payments for the Works in accordance with the provisions of Clause 19.3. For the avoidance of doubt, the sum of payments to be computed in respect of all the items of work shall not exceed the Contract Price, as may be adjusted in accordance with the provisions of this Agreement.

10.1.5 The Contractor shall appoint a safety consultant (the "**Safety Consultant**") to

carry out safety audit at the design / construction stage of the Water Supply Project in accordance with the Applicable Laws and Good Industry Practice.

10.1.6 The safety audit pursuant to Clause 10.1.5 shall be carried out by the Safety Consultant in respect of all such design details that have a bearing on safety of Users involved in or associated with accidents. The recommendations of the Safety Consultant shall be incorporated in the design of the Water Supply Project and the Contractor shall forward to the Authority's Engineer a certificate to this effect together with the recommendations of the Safety Consultant. In the event that any works required by the Safety Consultant shall fall beyond the scope of Schedule-B, Schedule-C or Schedule-D, the Contractor shall make a report thereon and seek the instructions of the Authority for Change in Scope. For the avoidance of doubt, the Safety Consultant to be engaged by the Contractor shall be independent of the design and implementation team of the Contractor.

10.2 Design and Drawings

10.2.1 Design and Drawings shall be developed in conformity with the Specifications and Standards set forth in Schedule-D. In the event, the Contractor requires any relaxation in design standards due to restricted area in any section, the alternative design criteria for such section shall be provided for review of the Authority's Engineer.

10.2.2 The Contractor shall appoint a proof check consultant (the "**Proof Consultant**") after proposing to the Authority a panel of three names of qualified and experienced firms from whom the Authority may choose one to be the Proof Consultant.

10.2.3 The Proof Consultant shall:

(a) evolve a systems approach with the Design Director so as to minimise the time required for final designs and construction drawings; and

(b) proof check the detailed calculations, drawings and designs, which have been approved by the Design Director.

10.2.4 In respect of the Contractor's obligations with respect to the design and Drawings of the Water Supply Project as set forth in Schedule-I, the following shall apply:

(a) The Contractor shall prepare and submit, with reasonable promptness and in such sequence as is consistent with the Project Completion Schedule, three copies each of the design and Drawings, duly certified by the Proof Consultant, to the Authority's Engineer for review. Provided, however, that in respect of Major Structures, the Authority's Engineer may require additional drawings for its review in accordance with Good Industry Practice.

(b) by submitting the Drawings for review to the Authority's Engineer, the Contractor shall be deemed to have represented that it has determined and verified that the design and engineering, including field construction criteria related thereto, are in conformity with the Scope of the Project, the Specifications and Standards and the Applicable Laws;

(c) within 15 (fifteen) days of the receipt of the Drawings, the Authority's Engineer shall review the same and convey its observations to the Contractor with particular reference to their conformity or otherwise with the Scope of the Project and the Specifications and Standards. The Contractor shall not be obliged to await the observations of the Authority's Engineer on the Drawings submitted pursuant hereto beyond the said period of 15 (fifteen) days and may begin or continue Works at its own discretion and risk; Provided, however that in case of a Major Structure, the aforesaid period of 15 (fifteen) days may be extended upto 30 (thirty) days;

(d) if the aforesaid observations of the Authority's Engineer indicate that the Drawings are not in conformity with the Scope of the Project or the Specifications and Standards, such Drawings shall be revised by the Contractor in conformity with the provisions of this Agreement and resubmitted to the Authority's Engineer for review. The Authority's Engineer shall give its observations, if any, within 10 (ten) days of receipt of the revised Drawings. In the event the Contractor fails to revise and resubmit such Drawings to the Authority's Engineer for review as aforesaid, the Authority's Engineer may withhold the payment for the affected works in accordance with the provisions of Clause 19.5.4. If the Contractor disputes any decision, direction or determination of the Authority's Engineer hereunder, the Dispute shall be resolved in accordance with the Dispute Resolution Procedure;

(e) no review and/or observation of the Authority's Engineer and/or its failure to review and/or convey its observations on any Drawings shall relieve the Contractor of its obligations and liabilities under this Agreement in any manner nor shall the Authority's Engineer or the Authority be liable for the same in any manner; and if errors, omissions, ambiguities, inconsistencies, inadequacies or other Defects are found in the Drawings, they and the construction works shall be corrected at the Contractor's cost, notwithstanding any review under this Article 10;

(f) the Contractor shall be responsible for delays in submitting the Drawing as set forth in Schedule-I caused by reason of delays in surveys and field investigations, and shall not be entitled to seek any relief in that regard from the Authority; and

(g) the Contractor warrants that its designers, including any third parties engaged by it, shall have the required experience and capability in accordance with Good Industry Practice and it shall indemnify the Authority against any damage, expense, liability, loss or claim, which the Authority might incur, sustain or be subject to arising from any breach of the Contractor's design responsibility and/or warranty set out in this Clause.

10.2.5 Any cost or delay in construction arising from review by the Authority's Engineer shall be borne by the Contractor.

10.2.6 Works shall be executed in accordance with the Drawings provided by the Contractor in accordance with the provisions of this Clause 10.2 and the observations of the Authority's Engineer thereon as communicated pursuant to the provisions of Clause 10.2.4 (d). Such Drawings shall not be amended or altered without prior written notice to the Authority's Engineer. If a Party becomes aware of an error or defect of a technical nature in the design or Drawings, that Party shall promptly give notice to the other Party of such error or defect.

10.2.7 Within 90 (ninety) days of the Project Completion Date, the Contractor shall furnish to the Authority and the Authority's Engineer a complete set of as-built Drawings, in 2 (two) hard copies and in micro film form or in such other medium as may be acceptable to the Authority, reflecting the Water Supply Project as actually designed, engineered and constructed, including an as-built survey illustrating the layout of the Water Supply Project and setback lines, if any, of the buildings and structures forming part of Project Facilities.

10.3 Construction of the Water Supply Project

10.3.1 The Contractor shall construct the Water Supply Project as specified in Schedule-B and Schedule-C, and in conformity with the Specifications and Standards set forth in Schedule-D. The Contractor shall be responsible for the correct

positioning of all parts of the Works, and shall rectify any error in the positions, levels, dimensions or alignment of the Works. The [as per the stipulated period of completion)* day from the Appointed Date shall be the scheduled completion date (the "**Scheduled Completion Date**") and the Contractor agrees and undertakes that the construction shall be completed on or before the Scheduled Completion Date, including any extension thereof.

*** Period of completion.**

10.3.2 The Contractor shall construct the Water Supply Projectin accordance with the Project Completion Schedule set forth in Schedule-J. In the event that the Contractor fails to achieve any Project Milestone or the Scheduled Completion Date within a period of 30 (thirty) days from the date set forth in Schedule-J, unless such failure has occurred due to Force Majeure or for reasons solely attributable to the Authority, it shall pay Damages to the Authority of a sum calculated at the rate of **0.05% (zero point zero five percent)** of the Contract Price for delay of each day reckoned from the date specified in Schedule –J and until such Project Milestone is achieved or the Works are completed; provided that if the period for any or all Project Milestones or the Scheduled Completion Date is extended in accordance with the provisions of this Agreement, the dates set forth in Schedule-J shall be deemed to be modified accordingly and the provisions of this Agreement shall apply as if Schedule-J has been amended as above; provided further that in the event the Works are completed within or before the Scheduled Completion Date including any Time Extension, applicable for that work or section, the Damages paid under this Clause 10.3.2 shall be refunded by the Authority to the Contractor, but without any interest thereon. For the avoidance of doubt, it is agreed that recovery of Damages under this Clause 10.3.2 shall be without prejudice to the rights of the Authority under this Agreement including the right of Termination thereof. The Parties further agree that Time Extension hereunder shall only be reckoned for and in respect of the affected works as specified in Clause 10.5.2.

10.3.3 **The** Authority shall notify the Contractor of its decision to impose Damages in pursuance with the provisions of this Clause 10.3. provided that no deduction on account of Damages shall be effected by the Authority without notifying the Contractor of its decision to impose the Damages, and taking into consideration the representation, if any, made by the Contractor within 20 (twenty) days of such notice. The Parties expressly agree that the **total amount of Damages under Clause 10.3.2 shall not exceed 10% (ten percent) of the Contract Price**.

10.4 Deleted.

10.5 Extension of time for completion

10.5.1 Without prejudice to any other provision of this Agreement for and in respect of extension of time, the Contractor shall be entitled to extension of time in the Project Completion Schedule (the **"Time Extension")** to the extent that completion of any Project Milestone is or will be delayed by any of the following, namely:

(a) delay in providing the land and clearances or approval of appropriate authorities, specified in Clause 4.1.4;

(b) Change of Scope (unless an adjustment to the Scheduled Completion Date has been agreed under Article 13);

(c) occurrence of a Force Majeure Event;

(d) any delay, impediment or prevention caused by or attributable to the Authority, the Authority's personnel or the Authority's other contractors on the Site; and

(e) any other cause or delay which entitles the Contractor to Time Extension in accordance with the provisions of this Agreement.

10.5.2 The Contractor shall, no later than 15 (fifteen) business days from the occurrence of an event or circumstance specified in Clause 10.5.1, inform the Authority's Engineer by notice in writing, with a copy to the Authority, stating in reasonable detail with supporting particulars, the event or circumstances giving rise to the claim for Time Extension in accordance with the provisions of this Agreement. Provided that the period of 15 (fifteen) business days shall be calculated from the date on which the Contractor became aware, or should have become aware, of the occurrence of such an event or circumstance.

Provided further that notwithstanding anything to the contrary contained in this Agreement, Time Extension shall be due and applicable only for the Works which are affected by the aforesaid events or circumstances and shall not in any manner affect the Project Completion Schedule for and in respect of the Works which are not affected hereunder.

10.5.3 In the event of the failure of the Contractor to issue to the Authority's Engineer a notice in accordance with the provisions of Clause 10.5.2 within the time specified therein, the Contractor shall not be entitled to any Time Extension and shall forfeit its right for any such claims in future. For the avoidance of doubt, in the event of failure of the Contractor to issue notice as specified in this clause 10.5.3, the Authority shall be discharged from all liability in connection with the claim.

10.5.4 The Authority's Engineer shall, on receipt of the claim in accordance with the provisions of Clause 10.5.2, examine the claim expeditiously within the time frame specified herein. In the event the Authority's Engineer requires any clarifications to examine the claim, the Authority's Engineer shall seek the same within 15 (fifteen) days from the date of receiving the claim. The Contractor shall, on receipt of the communication of the Authority's Engineer requesting for clarification, furnish the same to the Authority's Engineer within 10 (ten) days thereof. The Authority's Engineer shall, within a period of 60 (sixty) days from the date of receipt of such clarifications, forward in writing to the Contractor its determination of Time Extension.

Provided that when determining each extension of time under this Clause 10.5, the Authority's Engineer shall review previous determinations and may increase, but shall not decrease, the total Time Extension.

10.5.5 If the event or circumstance giving rise to the notice has a continuing effect:

(a) a fully detailed claim shall be considered as interim;

(b) the Contractor shall, no later than 10 (ten) days after the close of each month, send further interim claims specifying the accumulated delay, the extension of time claimed, and such further particulars as the Authority's Engineer may reasonably require; and

(c) the Contractor shall send a final claim within 30 (thirty) days after the effect of the event or the circumstance ceases.

Upon receipt of the claim hereunder, the Authority's Engineer shall examine the same in accordance with the provisions of Clause 10.5.4 within a period of 60 (sixty) days of the receipt thereof.

10.6 Incomplete Works

In the event the Contractor fails to complete the Works in accordance with the Project Completion Schedule, including any Time Extension granted under this Agreement, the Contractor shall endeavour to complete the balance work expeditiously and shall pay Damages to the Authority in accordance with the provisions of Clause 10.3.2 for delay of

each day until the Works are completed in accordance with the provisions of this Agreement. Recovery of Damages under this Clause shall be without prejudice to the rights of the Authority under this Agreement including the right to termination under Clause 23.1.

10.7 Operation & Maintenance Manual

No later than 60 (sixty) days prior to the Project Completion Date, the Contractor shall, in consultation with the Authority's Engineer, evolve a operation & maintenance manual (the **"Operation & Maintenance Manual"**) for the regular and preventive operation & maintenance of the Water Supply Project in conformity with the Specifications and Standards, safety requirements and Good Industry Practice, and shall provide 5 (five) copies thereof to the Authority's Engineer. The Authority's Engineer shall review the Operation & Maintenance Manual within 15 (fifteen) days of its receipt and communicate its comments to the Contractor for necessary modifications, if any.

ARTICLE 11

QUALITY ASSURANCE, MONITORING AND SUPERVISION

11.1 Quality of Materials and workmanship

The Contractor shall ensure that the Construction, Materials and workmanship are in accordance with the requirements specified in this Agreement, Specifications and Standards and Good Industry Practice.

11.2 Quality control system

11.2.1 The Contractor shall establish a quality control mechanism to ensure compliance with the provisions of this Agreement (the **"Quality Assurance Plan"** or **"QAP"**).

11.2.2 The Contractor shall, within 30 (thirty) days of the Appointed Date, submit to the Authority's Engineer its Quality Assurance Plan which shall include the following:

(a) organisation, duties and responsibilities, procedures, inspections and documentation;

(b) quality control mechanism including sampling and testing of Materials, test frequencies, standards, acceptance criteria, testing facilities, reporting, recording and interpretation of test results, approvals, check list for site activities, and proforma for testing and calibration in accordance with the Specifications for Water Supply Works issued by CPHEEO & relevant IS specifications and Good Industry Practice; and

(c) internal quality audit system.

The Authority's Engineer shall convey its comments to the Contractor within a period of 21 (twenty-one) days of receipt of the QAP stating the modifications, if any, required, and the Contractor shall incorporate those in the QAP to the extent required for conforming with the provisions of this Clause 11.2.

11.2.3 The Contractor shall procure all documents, apparatus and instruments, fuel, consumables, water, electricity, labour, Materials, samples, and qualified personnel as are necessary for examining and testing the Project Assets and workmanship in accordance with the Quality Assurance Plan.

11.2.4 The cost of testing of Construction, Materials and workmanship under this Article 11 shall be borne by the Contractor.

11.3. Methodology

The Contractor shall, at least 15 (fifteen) days prior to the commencement of the construction, submit to the Authority's Engineer for review the methodology proposed to be adopted for executing the Works, giving details of equipment to be deployed, traffic management and measures for ensuring safety. The Authority's Engineer shall complete the review and convey its comments to the Contractor within a period of 10 (ten) days from the date of receipt of the proposed methodology from the Contractor.

11.4. Inspection and technical audit by the Authority

The Authority or any representative authorised by the Authority in this behalf may inspect and review the progress and quality of the construction of Water Supply Project and issue appropriate directions to the Authority's Engineer and the Contractor for taking remedial action in the event the Works are not in accordance with the provisions of this Agreement.

11.5 External technical audit

At any time during construction, the Authority may appoint an external technical auditor

to conduct an audit of the quality of the Works. The findings of the audit, to the extent accepted by the Authority, shall be notified to the Contractor and the Authority's Engineer for taking remedial action in accordance with this Agreement. The Contractor shall provide all assistance as may be required by the auditor in the conduct of its audit hereunder. Notwithstanding anything contained in this Clause 11.5, the external technical audit shall not affect any obligations of the Contractor or the Authority's Engineer under this Agreement.

11.6 Inspection of construction records

The Authority shall have the right to inspect the records of the Contractor relating to the Works.

11.7 Monthly progress reports

During the Construction Period, the Contractor shall, no later than 10 (ten) days after the close of each month, furnish to the Authority and the Authority's Engineer a monthly report on progress of the Works and shall promptly give such other relevant information as may be required by the Authority's Engineer.

11.8 Inspection

11.8.1 The Authority's Engineer and its authorised representative shall at all reasonable times:

(a) have full access to all parts of the Site and to all places from which natural Materials are being obtained for use in the Works; and

(b) during production, manufacture and construction at the Site and at the place of production, be entitled to examine, inspect, measure and test the Materials and workmanship, and to check the progress of manufacture of Materials.

11.8.2 The Contractor shall give the Authority's Engineer and its authorised agents access, facilities and safety equipment for carrying out their obligations under this Agreement.

11.8.3 The Authority's Engineer shall submit a monthly inspection report (the "**Inspection Report**") to the Authority and the Contractor bringing out the results of inspections and the remedial action taken by the Contractor in respect of Defects or deficiencies. For the avoidance of doubt, such inspection or submission of Inspection Report by the Authority's Engineer shall not relieve or absolve the Contractor of its obligations and liabilities under this Agreement in any manner whatsoever.

11.9 Samples

The Contractor shall submit the following samples of Materials and relevant information to the Authority's Engineer for pre-construction review:

(a) manufacturer's test reports and standard samples of manufactured Materials; and

(b) samples of such other Materials as the Authority's Engineer may require.

11.10 Tests

11.10.1 For determining that the Works conform to the Specifications and Standards, the Authority's Engineer shall require the Contractor to carry out or cause to be carried out tests, at such time and frequency and in such manner as specified in this Agreement, and in accordance with Good Industry Practice for quality assurance. The test checks by the Authority's Engineer shall comprise at least 20 (twenty) percent of the quantity or number of tests prescribed for each category or type of test for quality control by the Contractor.

11.10.2 In the event that results of any tests conducted under this Clause 11.10 establish

any Defects or deficiencies in the Works, the Contractor shall carry out remedial measures and furnish a report to the Authority's Engineer in this behalf. The Authority's Engineer shall require the Contractor to carry out or cause to be carried out tests to determine that such remedial measures have brought the Works into compliance with the Specifications and Standards, and the procedure shall be repeated until such Works conform to the Specifications and Standards. For the avoidance of doubt, the cost of such tests and remedial measures in pursuance thereof shall be solely borne by the Contractor.

11.11 Examination of work before covering up

In respect of the work which the Authority's Engineer is entitled to examine, inspect, measure and/or test before it is covered up or put out of view or any part of the work is placed thereon, the Contractor shall give notice to the Authority's Engineer whenever any such work is ready and before it is covered up. The Authority's Engineer shall then either carry out the examination, inspection or testing without unreasonable delay, or promptly give notice to the Contractor that the Authority's Engineer does not require to do so. Provided, however, that if any work is of a continuous nature where it is not possible or prudent to keep it uncovered or incomplete, the Contractor shall notify the schedule of carrying out such work to give sufficient opportunity, not being less than 3 (three) business days' notice, to the Authority's Engineer to conduct its inspection, measurement or test while the work is continuing. Provided further that in the event the Contractor receives no response from the Authority's Engineer within a period of 3 (three) business days from the date on which the Contractor's notice hereunder is delivered to the Authority's Engineer, the Contractor shall be entitled to assume that the Authority's Engineer would not undertake the said inspection.

11.12 Rejection

If, as a result of an examination, inspection, measurement or testing, any Plant, Materials, design or workmanship is found to be defective or otherwise not in accordance with the provisions of this Agreement, the Authority's Engineer shall reject the Plant, Materials, design or workmanship by giving notice to the Contractor, with reasons. The Contractor shall then promptly make good the Defect and ensure that the rejected item complies with the requirements of this Agreement.

If the Authority's Engineer requires the Plant, Materials, design or workmanship to be retested, the tests shall be repeated under the same terms and conditions, as applicable in each case. If the rejection and retesting cause the Authority to incur any additional costs, such cost shall be recoverable by the Authority from the Contractor; and may be deducted by the Authority from any monies due to be paid to the Contractor.

11.13 Remedial work

11.13.1 Notwithstanding any previous test or certification, the Authority's Engineer may instruct the Contractor to:

(a) remove from the Site and replace any Plant or Materials which are not in accordance with the provisions of this Agreement;

(b) remove and re-execute any work which is not in accordance with the provisions of this Agreement and the Specification and Standards; &

(c) execute any work which is urgently required for the safety of the Water Supply Project, whether because of an accident, unforeseeable event or otherwise; provided that in case of any work required on account of a Force Majeure Event, the provisions of Clause 21.6 shall apply.

11.13.2 If the Contractor fails to comply with the instructions issued by the Authority's Engineer under Clause 11.13.1, within the time specified in the Authority's Engineer's notice or as mutually agreed, the Authority's Engineer may advise

the Authority to have the work executed by another agency. The cost so incurred by the Authority for undertaking such work shall, without prejudice to the rights of the Authority to recover Damages in accordance with the provisions of this Agreement, be recoverable from the Contractor and may be deducted by the Authority from any monies due to be paid to the Contractor.

11.14 Delays during construction

Without prejudice to the provisions of Clause 10.3.2, in the event the Contractor does not achieve any of the Project Milestones or the Authority's Engineer shall have reasonably determined that the rate of progress of Works is such that Completion of the Water Supply Project is not likely to be achieved by the end of the Scheduled Completion Date, it shall notify the same to the Contractor, and the Contractor shall, within 15 (fifteen) days of such notice, by a communication inform the Authority's Engineer in reasonable detail about the steps it proposes to take to expedite progress and the period within which it shall achieve the Project Completion Date.

11.15 Quality control records and Documents

The Contractor shall hand over to the Authority's Engineer a copy of all its quality control records and documents before the Completion Certificate is issued pursuant to Clause 12.2.

11.16 Video recording

During the Construction Period, the Contractor shall provide to the Authority for every calendar quarter, a video recording, which will be compiled into a 3 (three)-hour compact disc or digital video disc, as the case may be, covering the status and progress of Works in that quarter. The video recording shall be provided to the Authority no later than 15 (fifteen) days after the close of each quarter after the Appointed Date.

11.17 Suspension of unsafe Construction Works

11.17.1 Upon recommendation of the Authority's Engineer to this effect, the Authority may by notice require the Contractor to suspend forthwith the whole or any part of the Works if, in the reasonable opinion of the Authority's Engineer, such work threatens the safety of the Users.

11.17.2 The Contractor shall, pursuant to the notice under Clause 11.17.1, suspend the Works or any part thereof for such time and in such manner as may be specified by the Authority and thereupon carry out remedial measures to secure the safety of suspended works& the Users. The Contractor may by notice require the Authority's Engineer to inspect such remedial measures forthwith and make a report to the Authority recommending whether or not the suspension hereunder may be revoked. Upon receiving the recommendations of the Authority's Engineer, the Authority shall either revoke such suspension or instruct the Contractor to carry out such other and further remedial measures as may be necessary in the reasonable opinion of the Authority, and the procedure set forth in this Clause 11.17 shall be repeated until the suspension hereunder is revoked.

11.17.3 Subject to the provisions of Clause 21.6, all reasonable costs incurred for maintaining and protecting the Works or part thereof during the period of suspension (the "**Preservation Costs**"), shall be borne by the Contractor; provided that if the suspension has occurred as a result of any breach of this Agreement by the Authority, the Preservation Costs shall be borne by the Authority.

11.17.4 If suspension of Works is for reasons not attributable to the Contractor, the Authority's Engineer shall determine any Time Extension to which the Contractor is reasonably entitled.

ARTICLE 12

COMPLETION CERTIFICATE

12.1 Tests on completion

12.1.1 At least **30 (thirty)** days prior to the likely completion of the Water Supply Project, or a Section thereof, the Contractor shall notify the Authority's Engineer of its intent to subject the Water Supply Project or a Section thereof, to Tests. The date and time of each of the Tests shall be determined by the Authority's Engineer in consultation with the Contractor, and notified to the Authority who may designate its representative to witness the Tests. The Contractor shall either conduct the Tests as directed by the Authority's Engineer or provide such assistance as the Authority's Engineer may reasonably require for conducting the Tests. In the event of the Contractor and the Authority's Engineer failing to mutually agree on the dates for conducting the Tests, the Contractor shall fix the dates by giving not less than 10 (ten) days notice to the Authority's Engineer.

12.1.2 All Tests shall be conducted in accordance with **Schedule-K**. The Authority's Engineer shall either conduct or observe, monitor and review the Tests conducted by the Contractor, as the case may be, and review the results of the Tests to determine compliance of the Water Supply Project or a Section thereof, with Specifications and Standards and if it is reasonably anticipated or determined by the Authority's Engineer during the course of any Test that the performance of the Water Supply Project or Section or any part thereof, does not meet the Specifications and Standards, it shall have the right to suspend or delay such Test and require the Contractor to remedy and rectify the Defect or deficiencies. Upon completion of each Test, the Authority's Engineer shall provide to the Contractor and the Authority copies of all Test data including detailed Test results. For the avoidance of doubt, it is expressly agreed that the Authority's Engineer may require the Contractor to carry out or cause to be carried out additional Tests, in accordance with Good Industry Practice, for determining the compliance of the Water Supply Project or Section thereof with the Specifications and Standards.

12.2 Provisional Certificate

12.2.1 Subject to the provisions of Clause 12.2.5, upon completion of all Works forming part of the Water Supply Project, save and except the Works for which Time Extension has been granted under Clause 10.5, the Authority's Engineer shall, at the request of the Contractor, issue a provisional certificate of completion substantially in the form set forth in Schedule-L (the "**Provisional Certificate**") if the Tests for and in respect of the completed Works are successful. The Provisional Certificate shall have appended thereto a list of outstanding items of work (the "**Punch List**") that need to be completed in accordance with the provisions of this Agreement. The Contractor undertakes to complete the minor outstanding items of works in respect of those Sections of the Water Supply Project for which the Provisional Certificate has been issued, within a period of 30 (thirty) days of the date of Provisional Certificate, and those parts of the Works in respect of which Time Extension has been granted, within the extended period thereof. For the avoidance of doubt, the Parties agree that the Punch List shall include all Works for which Time Extension has been granted and shall also include any minor outstanding items of work forming part of the completed Sections if such works do not materially affect the use of the completed Sections for their intended purpose. The Parties further agree that Provisional Certificate shall not be issued if the completed Works can not be safely and reliably placed in service of the Users thereof.

12.2.2 Upon issue of Provisional Certificate, the provisions of Articles 14 and 17 shall apply to the completed parts of the Water Supply Project and the property and ownership of all such completed Works shall vest in the Authority.

12.2.3 If the Authority's Engineer determines that the Water Supply Project or any completed part thereof does not conform to the provisions of this Agreement and cannot be safely and reliably placed in operation, it shall forthwith make a report in this behalf and send copies thereof to the Authority and the Contractor and withhold issuance of the Provisional Certificate until the Defects or deficiencies are rectified by the Contractor and Tests are successful in accordance with this Article 12.

12.2.4 Notwithstanding anything to the contrary contained in Clause 12.2.3, the Authority may, at any time after receiving a report from the Authority's Engineer under that Clause, direct the Authority's Engineer to issue a Provisional Certificate under Clause 12.2.1 and such direction shall be complied forthwith.

12.2.5 No Provisional Certificate shall be issued under the provisions of this Clause 12.2 until the Contractor has submitted valid claims for payment of at least **80%** (eighty per cent) of the amount arrived at after reducing the lump sum price specified in Clause 19.1.1 by the amount attributable to works which have been withdrawn under the provisions of Clause 8.3.3. For the avoidance of doubt and by way of illustration, the Parties agree that if the Contract Price specified in Clause 19.1.1 is **Rs.105 cr**. (Rs. one hundred and five crore) and the works withdrawn under Clause 8.3.3 have a value of **Rs.5 cr.** (Rs. five crore), a Provisional Certificate shall not be issued until valid claims for payment of an amount of **Rs.80 cr.** (Rs. Eighty crore) have been submitted by the Contractor in accordance with the provisions of this Agreement. It is further agreed that all price adjustments made in pursuance of Clause 19.10 shall not be reckoned for computation of the claims for payments referred to in this Clause 12.2.5.

12.3 Completion of remaining Works

All items in the Punch List shall be completed by the Contractor in accordance with the provisions of this Agreement. For any delay in their completion other than for the reasons solely attributable to the Authority or due to Force Majeure, the Authority shall be entitled to recover Damages from the Contractor in accordance with the provisions of Clause 10.3.2 of this Agreement.

12.4 Completion Certificate

12.4.1 Upon completion of all Works, including the items specified in the Punch List, and the Authority's Engineer determining the Tests to be successful, it shall forthwith issue to the Contractor and the Authority a certificate substantially in the form set forth in Schedule-L (the "**Completion Certificate**").

12.4.2 Upon receiving the Completion Certificate, the Contractor shall remove its equipment, materials, debris and temporary works from the Site within a period of 30 (thirty) days thereof, failing which the Authority may remove or cause to be removed, such equipment, materials, debris and temporary works and recover from the Contractor an amount equal to 120% (one hundred and twenty per cent) of the actual cost of removal incurred by the Authority.

12.4.3 Without prejudice to the obligations of the Contractor specified in Articles 14 and 17, the property and ownership of all the completed Works forming part of the Water Supply Projectshall vest in the Authority.

12.5 Rescheduling of Tests

If the Authority's Engineer certifies to the Authority and the Contractor that it is unable to issue the Completion Certificate or Provisional Certificate, as the case may be, because of events or circumstances on account of which the Tests could not be held or had to be suspended, the Contractor shall be entitled to re-schedule the Tests and hold the same as soon as reasonably practicable.

ARTICLE 13

CHANGE OF SCOPE

13.1 Change of Scope

13.1.1 The Authority may, notwithstanding anything to the contrary contained in this Agreement, require the Contractor to make modifications/alterations to the Works ("**Change of Scope**") before the issue of the Completion Certificate either by giving an instruction or by requesting the Contractor to submit a proposal for Change of Scope involving additional cost or reduction in cost. Any such Change of Scope shall be made and valued in accordance with the provisions of this Article 13.

13.1.2 Change of Scope shall mean:

(a) change in specifications of any item of Works;

(b) omission of any work from the Scope of the Project except under Clause 8.3.3; provided that, subject to Clause 13.5, the Authority shall not omit any work under this Clause in order to get it executed by any other authority; and / or

(c) any additional work, Plant, Materials or services which are not included in the Scope of the Project, including any associated Tests on completion of construction.

13.1.3 If the Contractor determines at any time that a Change of Scope will, if adopted, (i) accelerate completion, (ii) reduce the cost to the Authority of executing, the Water Supply Project, (iii) improve the efficiency or value to the Authority of the completed Water Supply Project, or (iv) otherwise be of benefit to the Authority, it shall prepare a proposal with relevant details at its own cost. The Contractor shall submit such proposal, supported with the relevant details and the amount of reduction in the Contract Price to the Authority to consider such Change of Scope. The Authority shall, within 15 (fifteen) days of receipt of such proposal, either accept such Change of Scope with modifications, if any, and initiate proceedings thereof in accordance with this Article 13 or reject the proposal and inform the Contractor of its decision. For the avoidance of doubt, the Parties agree that the Contractor shall not undertake any Change of Scope without the express consent of the Authority, save and except any Works necessary for meeting any Emergency.

13.2 Procedure for Change of Scope

13.2.1 In the event of the Authority determining that a Change of Scope is necessary, it may direct the Authority's Engineer to issue to the Contractor a notice specifying in reasonable detail the works and services contemplated there under (the "**Change of Scope Notice**").

13.2.2 Upon receipt of a Change of Scope Notice, the Contractor shall, with due diligence, provide to the Authority and the Authority's Engineer such information as is necessary, together with preliminary documentation in support of:

(a) the impact, if any, which the Change of Scope is likely to have on the Project Completion Schedule if the works or services are required to be carried out during the Construction Period; and

(b) the options for implementing the proposed Change of Scope and the effect, if any, each such option would have on the costs and time thereof, including the following details:

(i) break down of the quantities, unit rates and cost for different items of work;

(ii) proposed design for the Change of Scope; and

(iii) proposed modifications, if any, to the Project Completion Schedule of the Water Supply Project.

For the avoidance of doubt, the Parties expressly agree that, subject to the provisions of Clause 13.4.2, the Contract Price shall be increased or decreased, as the case may be, on account of Change of Scope.

13.2.3 The Contractor's quotation of costs for the Change of Scope shall be determined on the following principles:

(a) For works where Schedule of Rates (SOR) of concerned circle of State's Public Works / P.H. Department are available shall be applicable for determination of costs. In case of non-availability of current SOR, the available Schedule of Rates shall be applied by updating the same based on WPI.

(b) For works not similar in nature to the Works being executed, the cost of work shall be derived on the basis of CPWD analysis of rates Standard Data Book and the applicable schedule of rates for the relevant circle, as published by the State Government, and such rates shall be indexed with reference to the WPI once every year, with the base being the month and year of the publication of the said schedule of rates; provided, however, that for any item not included in the schedule of rates, **the prevailing market rates** as determined by the Authority's Engineer shall apply, and for any item in respect of which CPWD analysis of rate does not provide the requisite details, the Authority's Engineer shall determine the rate in accordance with **Good Industry Practice**.

13.2.4 Upon reaching an agreement, the Authority shall issue an order (the "**Change of Scope Order**") requiring the Contractor to proceed with the performance thereof. In the event that the Parties are unable to agree, the Authority may:

(a) issue a Change of Scope Order requiring the Contractor to proceed with the performance thereof at the rates and conditions approved by the Authority till the matter is resolved in accordance with Article 26; or

(b) proceed in accordance with Clause 13.5.

13.2.5 The provisions of this Agreement, insofar as they relate to Works and Tests, shall apply *mutatis mutandis* to the works undertaken by the Contractor under this Article 13.

13.3 Payment for Change of Scope

Payment for Change of Scope shall be made in accordance with the payment schedule specified in the Change of Scope Order.

13.4 Restrictions on Change of Scope

13.4.1 No Change of Scope shall be executed unless the Authority has issued the Change of Scope Order save and except any Works necessary for meeting any Emergency.

13.4.2 Unless the Parties mutually agree to the contrary, the total value of all Change of Scope Orders shall not exceed 10 (ten) per cent of the Contract Price.

13.4.3 Notwithstanding anything to the contrary in this Article 13, no change made necessary because of any default of the Contractor in the performance of its obligations under this Agreement shall be deemed to be Change of Scope, and shall not result in any adjustment of the Contract Price or the Project Completion Schedule.

13.5 Power of the Authority to undertake works

13.5.1 In the event the Parties are unable to agree to the proposed Change of Scope Orders in accordance with Clause 13.2, the Authority may, after giving notice to the Contractor and considering its reply thereto, award such works or services to

any person on the basis of open competitive bidding from amongst bidders who are pre-qualified for undertaking the additional work; provided that the Contractor shall have the option of matching the first ranked bid in terms of the selection criteria, subject to payment of **2%** (two per cent) of the bid amount to the Authority[$], and thereupon securing the award of such works or services. For the avoidance of doubt, it is agreed that the Contractor shall be entitled to exercise such option only if it has participated in the bidding process and its bid does not exceed the first ranked bid by more than 10% (ten percent) thereof. It is also agreed that the Contractor shall provide assistance and cooperation to the person who undertakes the works or services hereunder, but shall not be responsible for rectification of any Defects and/ or operation & maintenance of works carried out by other agencies.

13.5.2 The works undertaken in accordance with this Clause 13.5 shall conform to the Specifications and Standards and shall be carried out in a manner that minimises the disruption in operation of the Water Supply Project. The provisions of this Agreement, insofar as they relate to Works and Tests, shall apply *mutatis mutandis* to the works carried out under this Clause 13.5.

[$] The Authority shall transfer 75% (seventy five percent) of the amount so received to the first ranked bidder whose bid shall have been matched by the Contractor.

ARTICLE 14

OPERATION & MAINTENANCE

14.1 Operation &Maintenance obligations of the Contractor

14.1.1 The contractor shall operate and maintain the water supply project for a period of 5 (five) yeas commencing from the date of issue of provisional certificate (the "operation & maintenance period"). The Energy charges shall be paid by the department directly to the concerned Electrical Authority. The energy consumption shall be assessed by the bidder basing on **energy efficient design** of the electro-mechanical equipment (those are covered under the scope of work) at **Intake, Raw Water, WTP & Zonal pumping stations etc.** The bidder shall offer towards yearly energy consumption considering the rated capacity of electromechanical equipment @ **Rs.7.00/KWH** in the online BoQ. From the offered price **WATCO** shall derive the assured energy consumption in the KWH unit during financial bid evaluation. The energy consumption charges for each month will be directly paid by the department up to the consumption units as assessed by the contractor, beyond which the cost of energy consumption shall be borne by the contractor and the excess amount will be deducted from the bill of the contractor for payment to the Electrical Authority. The price for manpower & materials for the respective years of the O&M period quoted by the bidder shall correspond to the Present Value (PV) which shall be adjusted as per the price adjustment clause mentioned in the contract document (Clause No. 19.12).

For the avoidance of doubt, it is agreed that in the event no Provisional Certificate is issued, the Operation & Maintenance Period shall commence from the date of the Completion Certificate.

Note-1: The detailed calculation towards Operation & Maintenance cost of the project to be executed by the Agency is provided at Annex-III of Schedule-E for reference and guidance only.

14.1.2 During the Operation & Maintenance Period, the Authority shall provide to the Contractor access to the Site for Operation & Maintenance in accordance with this Agreement. The obligations of the Contractor hereunder shall include:

(a) permitting safe &smooth functioning of Water Supply Project;
(b) undertaking routine maintenance including prompt repairs of Civil, Electrical & Mechanical installations including pipe lines;
(c) undertaking repairs to structures;
(d) informing the Authority of any unauthorised use of the water supply project;
(e) informing the Authority of any encroachments on the water supply project; and
(f) operation and maintenance of all conveyance systems necessary for the efficient operation & maintenance of the Water Supply Project in accordance with the provisions of this Agreement.

14.1.3 In respect of any Defect or deficiency not specified in Schedule-E, the Contractor shall, at its own cost, undertake repair or rectification in accordance with Good Industry Practice, save and except to the extent that such Defect or deficiency shall have arisen on account of any default or neglect of the Authority or a Force Majeure Event.

14.1.4 The Contractor shall remove promptly from the Water Supply Projectany waste materials (including hazardous materials and waste water), rubbish and other debris (including, without limitation, accident debris) and keep the Water Supply

Project in a clean, tidy and orderly condition, and in conformity with the Applicable Laws, Applicable Permits and Good Industry Practice.

14.2 Operation &Maintenance Requirements

The Contractor shall ensure and procure that at all times during the Operation & Maintenance Period, the Water Supply Project conforms to the operation & maintenance requirements set forth in Schedule-E (the "**Operation & Maintenance Requirements**").

14.3 Operation &Maintenance Programme

14.3.1 The Contractor shall prepare a monthly operation &maintenance programme (the **Operation &Maintenance Programme**") in consultation with the Authority and submit the same to the Authority not later than 10 (ten) days prior to the commencement of the month in which the Operation &Maintenance is to be carried out. For this purpose, a joint monthly inspection by the Contractor and the Authority shall be undertaken. The Operation &Maintenance Programme shall contain the following:

(a) The condition of the Civil, Electrical & Mechanical installations including pipe line in the format prescribed by the Authority,

(b) the proposed operation &maintenance works; and

(c) deployment of resources for operation &maintenance works.

14.4 Safety, vehicle breakdowns and accidents

14.4.1 Deleted

14.4.2 Deleted

14.5 Zone closure

14.5.1 The Contractor shall not close any Zone of the Water Supply Project for undertaking operation &maintenance works except with the prior written approval of the Authority. Such approval shall be sought by the Contractor through a written request to be made at least 10 (ten) days before the proposed closure of Zone and shall be accompanied by particulars thereof. Within 5 (five) business days of receiving such request, the Authority shall grant permission with such modifications as it may deem necessary.

14.5.2 Upon receiving the permission pursuant to Clause 14.5.1, the Contractor shall be entitled to close the designated Zone for the period specified therein, and in the event of any delay in re-opening such Zone, the Contractor shall, for every stretch of 250 (two hundred and fifty) metres, or part thereof, pay Damages to the Authority calculated at the rate of 0.1% (zero point one per cent) of the monthly operation &maintenance payment for each day of delay until the Zone has been re-opened for Water Supply.

14.6 Reduction of payment for non-performance of Operation &Maintenance obligations

14.6.1 In the event that the Contractor fails to repair or rectify any Defect or deficiency set forth in Schedule-E within the period specified therein, it shall be deemed as failure of performance of Operation &Maintenance obligations by the Contractor and the Authority shall be entitled to effect reduction in monthly lump sum payment for operation &maintenance in accordance with Clause 19.7 and Schedule-M, without prejudice to the rights of the Authority under this Agreement, including Termination thereof.

14.6.2 If the nature and extent of any Defect justifies more time for its repair or rectification than the time specified in Schedule-E, the Contractor shall be entitled to additional time in conformity with Good Industry Practice. Such additional time shall be determined by the Authority and conveyed to the Contractor.

14.7 Authority's right to take remedial measures

In the event the Contractor does not maintain and/or repair the Water Supply Projector any part thereof in conformity with the Operation &Maintenance Requirements, the Operation &Maintenance Manual or the Operation &Maintenance Programme, as the case may be, and fails to commence remedial works within 15 (fifteen) days of receipt of the Operation &Maintenance Inspection Report under Clause 15.2 or a notice in this behalf from the Authority, the Authority shall, without prejudice to its rights under this Agreement including Termination thereof, be entitled to undertake such remedial measures at the cost of the Contractor, and to recover its cost from the Contractor. In addition to recovery of the aforesaid cost, a sum equal to 20% (twenty per cent) of such cost shall be paid by the Contractor to the Authority as Damages.

14.8 Restoration of loss or damage to Water Supply Project

Save and except as otherwise expressly provided in this Agreement, in the event that the Water Supply Project or any part thereof suffers any loss or damage during the Operation & Maintenance from any cause attributable to the Contractor, the Contractor shall, at its cost and expense, rectify and remedy such loss or damage forthwith so that the Water Supply Project conforms to the provisions of this Agreement.

14.9 Overriding powers of the Authority

14.9.1 If in the reasonable opinion of the Authority, the Contractor is in material breach of its obligations under this Agreement and, in particular, the Operation & Maintenance Requirements, and such breach is causing or likely to cause material hardship or danger to the Users and pedestrians, the Authority may, without prejudice to any of its rights under this Agreement including Termination thereof, by notice require the Contractor to take reasonable measures immediately for rectifying or removing such hardship or danger, as the case may be.

14.9.2 In the event that the Contractor, upon notice under Clause 14.9.1, fails to rectify or remove any hardship or danger within a reasonable period, the Authority may exercise overriding powers under this Clause 14.9.2 and take over the performance of any or all the obligations of the Contractor to the extent deemed necessary by it for rectifying or removing such hardship or danger; provided that the exercise of such overriding powers by the Authority shall be of no greater scope and of no longer duration than is reasonably required hereunder; provided further that any costs and expenses incurred by the Authority in discharge of its obligations hereunder shall be recovered by the Authority from the Contractor, and the Authority shall be entitled to deduct any such costs and expenses incurred from the payments due to the Contractor under Clause 19.7 for the performance of its Operation & Maintenance obligations.

14.9.3 In the event of a national emergency, civil commotion or any other circumstances specified in Clause 21.3, the Authority may take over the performance of any or all the obligations of the Contractor to the extent deemed necessary by it, and exercise such control over the Water Supply Project or give such directions to the Contractor as may be deemed necessary; provided that the exercise of such overriding powers by the Authority shall be of no greater scope and of no longer duration than is reasonably required in the circumstances which caused the exercise of such overriding power by the Authority. For the avoidance of doubt, it is agreed that the consequences of such action shall be dealt in accordance with the provisions of Article 21. It is also agreed that the Contractor shall comply with such instructions as the Authority may issue in pursuance of the provisions of this Clause 14.9.3, and shall provide assistance and cooperation to the Authority, on a best effort basis, for performance of its obligations hereunder.

ARTICLE 15

SUPERVISION AND MONITORING DURING OPERATION & MAINTENANCE

15.1 Inspection by the Contractor

15.1.1 The Authority shall undertake regular inspections to evaluate continuously the compliance with the Operation & Maintenance Requirements.

15.1.2 The Contractor shall carry out a detailed inspection of all structures & Water Supply System in accordance with the guidelines contained in Manual on O&M of water supply systems published by CPHEEO. Report of this inspection together with details of proposed operation & maintenance works as required shall be conveyed to the Authority forthwith. The Contractor shall complete the proposed operation & maintenance works and send a compliance report to the Authority.

15.2 Inspection and payments

15.2.1 The Authority may inspect the Water Supply Project at any time, but at least once in every month, to ensure compliance with the Operation & Maintenance Requirements. It shall make a report of such inspection (**"Operation & Maintenance Inspection Report"**) stating in reasonable detail the Defects or deficiencies, if any, with particular reference to the Operation & Maintenance Requirements, the Operation & Maintenance Manual, and the Operation & Maintenance Programme and send a copy thereof to the Contractor within 10 (ten) days of such inspection.

15.2.2 After the Contractor submits to the Authority the Monthly Operation & Maintenance Statement for the Water Supply Project pursuant to Clause 19.6, the Authority shall carry out an inspection within 10 (ten) days to certify the amount payable to the Contractor. The Authority shall inform the Contractor of its intention to carry out the inspection at least 3 (three) business days in advance of such inspection. The Contractor shall assist the Authority in verifying compliance with the Operation & Maintenance Requirements.

15.2.3 For each case of non-compliance of Operation & Maintenance Requirements as specified in the inspection report of the Authority, the Authority shall calculate the amount of reduction in payment in accordance with the formula specified in Schedule-M.

15.2.4 Any deduction made on account of non-compliance will not be paid subsequently even after establishing the compliance thereof. Such deduction will continue to be made every month until the compliance is procured.

15.3 Tests

For determining that the Water Supply Project conforms to the Operation &Maintenance Requirements, the Authority shall require the Contractor to carry out, or cause to be carried out, tests specified by it in accordance with CPHEEO Manual/ Good Industry Practice. The Contractor shall, with due diligence, carry out or cause to be carried out all such tests in accordance with the instructions of the Authority and furnish the results of such tests forthwith to the Authority.

15.4 Reports of unusual occurrence

The Contractor shall, during the Operation & Maintenance Period, prior to the close of each day, send to the Authority by facsimile or e-mail, a report stating unusual occurrences on the Water Supply Project relating to the safety and security of the Users. A monthly summary of such reports shall also be sent within 3 (three) business days of the closing of month.

ARTICLE 16

TRAFFIC REGULATION

16.1 Traffic regulation by the Contractor

16.1.1 The Contractor shall take all the required measures and make arrangements for the safety of Users during the construction of the Water Supply Project or a Section thereof in accordance with the relevant provisions. It shall provide, erect and maintain all such barricades, signs, markings, flags, and lights as may be required by Good Industry Practice for the safety of the traffic passing through the Section under construction.

16.1.2 All works shall be carried out in a manner creating least interference to traffic passing through the Water Supply Project or a Section thereof. In stretches where construction works are taken up, the Contractor shall ensure that proper passage is provided for the traffic. Where it is not possible or safe to allow traffic on part width of the carriage way, a temporary diversion of proper specifications shall be constructed by the Contractor at its own cost. The Contractor shall take prior approval of the Authority's Engineer for any proposed arrangement for traffic regulation during Construction and Operation & Maintenance, which approval shall not be unreasonably withheld.

ARTICLE 17

DEFECTS LIABILITY

17.1 Defects Liability Period

17.1.1 The Contractor shall be responsible for all the Defects and deficiencies, except usual wear and tear in the Water Supply Project or any Section thereof, till the expiry of a period of **2 (Two) years** commencing from the date of Provisional Certificate (the "**Defects Liability Period**"). Provided that the Defects Liability Period shall in no case be less than **24 (Twenty) months** from the date of Completion Certificate for and in respect of works for which Time Extension was granted. Provided further that in the event no Provisional Certificate is issued, the Defects Liability Period shall commence from the date of the Completion Certificate. For the avoidance of doubt, any repairs or restoration on account of usual wear or tear in the Water Supply Project or any Section thereof shall form a part of the **Operation &Maintenance** obligations of the Contractor as specified in Article14.

17.1.2 **Deleted.**

17.2 Remedying Defects

The Contractor shall repair or rectify all Defects and deficiencies observed by the Authority's Engineer during the Defects Liability Period within a period of **15** (fifteen) days from the date of notice issued by the Authority's Engineer in this behalf, or within such reasonable period as may be determined by the Authority's Engineer at the request of the Contractor, in accordance with Good Industry Practice.

17.3 Cost of remedying Defects

For the avoidance of doubt, any repair or rectification undertaken in accordance with the provisions of Clause 17.2, including any additional testing, shall be carried out by the Contractor at its own risk and cost, to the extent that such rectification or repair is attributable to:

(a) the design of the Project;

(b) Plant, Materials or workmanship not being in accordance with this Agreement and the Specifications and Standards;

(c) improper operation &maintenance during construction of the Water Supply Project by the Contractor; and/ or

(d) failure by the Contractor to comply with any other obligation under this Agreement.

17.4 Contractor's failure to rectify Defects

In the event that the Contractor fails to repair or rectify such Defect or deficiency within the period specified in Clause 17.2, the Authority shall be entitled to get the same repaired, rectified or remedied at the Contractor's cost so as to make the Water Supply Project conform to the Specifications and Standards and the provisions of this Agreement. All costs consequent thereon shall, after due consultation with the Authority and the Contractor, be determined by the Authority's Engineer. The cost so determined and an amount equal to twenty percent of the cost as Damages shall be recoverable by the Authority from the Contractor and may be deducted by the Authority from any monies due to the Contractor.

17.5 Contractor to search cause

17.5.1 The Authority's Engineer may instruct the Contractor to examine the cause of any Defect in the Works or part thereof before the expiry of the Defects Liability Period.

17.5.2 In the event any Defect identified under Clause 17.5.1 is attributable to the Contractor, the Contractor shall rectify such Defect within the period specified by the Authority's Engineer, and shall bear the cost of the examination and rectification of such Defect.

17.5.3 In the event such Defect is not attributable to the Contractor, the Authority's Engineer shall, after due consultation with the Authority and the Contractor, determine the costs incurred by the Contractor on such examination and notify the same to the Contractor, with a copy to the Authority, and the Contractor shall be entitled to payment of such costs by the Authority.

17.6. Extension of Defects Liability Period

The Defects Liability Period shall be deemed to be extended till the identified Defects under Clause 17.2 have been remedied.

ARTICLE 18

AUTHORITY'S ENGINEER

18.1 Appointment of the Authority's Engineer

18.1.1 The Authority shall appoint a consulting engineering firm substantially in accordance with the selection criteria set forth in **Schedule-N**, to be the engineer under this Agreement (the "**Authority's Engineer**").

18.1.2 The appointment of the Authority's Engineer shall be made no later than 15 (fifteen) days from the date of this Agreement. The Authority shall notify the appointment or replacement of the Authority's Engineer to the Contractor.

18.1.3 The staff of the Authority's Engineer shall include suitably qualified engineers and other professionals who are competent to assist the Authority's Engineer to carry out its duties.

18.2 Duties and authority of the Authority's Engineer

18.2.1 The Authority's Engineer shall perform the duties and exercise the authority in accordance with the provisions of this Agreement, and substantially in accordance with the terms of reference ("**Terms of Reference" or "TOR")** set forth in Annex 1 of Schedule N, but subject to obtaining prior written approval of the Authority before determining:

(a) any Time Extension;

(b) any additional cost to be paid by the Authority to the Contractor;

(c) the Termination Payment; or

(d) any other matter which is not specified in (a), (b) or (c) above and which creates an obligation or liability on either Party for a sum exceeding Rs.50,00,000 (Rupees Fifty Lakh).

18.2.2 No decision or communication of the Authority's Engineer shall be effective or valid unless it is accompanied by an attested true copy of the approval of the Authority for and in respect of any matter specified in Clause 18.2.1.

18.2.3 The Authority's Engineer shall submit regular periodic reports, at least once every month, to the Authority in respect of its duties and functions under this Agreement. Such reports shall be submitted by the Authority's Engineer within 10 (ten) days of the beginning of every month. For the avoidance of doubt, the Authority's Engineer shall include in its report, compliance of the recommendations of the Safety Consultant.

18.3 Delegation by the Authority's Engineer

18.3.1 The Authority's Engineer may, by order in writing, delegate any of his duties and responsibilities to suitably qualified and experienced personnel who are accountable to Authority's Engineer, or may revoke any such delegation, under intimation to the Authority and the Contractor. Provided, however, that the Authority's Engineer shall be responsible and liable for all actions and omissions of such personnel.

18.3.2 Any failure of the Authority's Engineer to disapprove any work, Plant or Materials shall not constitute approval, and shall therefore not prejudice the right of the Authority to reject the work, Plant or Materials, which is not in accordance with the provisions of this Agreement and the Specifications and Standards.

18.3.3 Notwithstanding anything stated in Clause 18.3.1 above, the Authority's Engineer shall not delegate the authority to refer any matter for the Authority's prior approval wherever required in accordance with the provisions of Clause 18.2.

18.4 Instructions of the Authority's Engineer

18.4.1 The Authority's Engineer may issue to the Contractor instructions for remedying any Defect. The Contractor shall take such instructions from the Authority's Engineer, or from an assistant to whom appropriate authority has been delegated under Clause 18.3.

18.4.2 The instructions issued by the Authority's Engineer shall be in writing. However, if the Authority's Engineer issues any oral instructions to the Contractor, it shall confirm in writing the oral instructions within 2 (two) working days of issuing them.

18.4.3 In case the Contractor does not receive the confirmation of the oral instruction within the time specified in Clause 18.4.2, the Contractor shall seek the written confirmation of the oral instructions from the Authority's Engineer. The Contractor shall obtain acknowledgement from the Authority's Engineer of the communication seeking written confirmation. In case of failure of the Authority's Engineer or its delegated assistant to reply to the Contractor within 2 (two) days of the receipt of the communication from the Contractor, the Contractor may not carry out the instruction.

18.4.4 In case of any dispute on any of the instructions issued by the delegated assistant, the Contractor may refer the dispute to the Authority's Engineer, who shall then confirm, reverse or vary the instructions within [3 (three)] business days of the dispute being referred.

18.5 Determination by the Authority's Engineer

18.5.1 The Authority's Engineer shall consult with each Party in an endeavour to reach agreement wherever this Agreement provides for the determination of any matter by the Authority's Engineer. If such agreement is not achieved, the Authority's Engineer shall make a fair determination in accordance with this Agreement having due regard to all relevant circumstances. The Authority's Engineer shall give notice to both the Parties of each agreement or determination, with supporting particulars.

18.5.2 Each Party shall give effect to each agreement or determination made by the Authority's Engineer in accordance with the provisions of this Agreement. Provided, however, that if any Party disputes any instruction, decision, direction or determination of the Authority's Engineer, the Dispute shall be resolved in accordance with the Dispute Resolution Procedure.

18.6 Remunerationof the Authority's Engineer

The remuneration, cost and expenses of the Authority's Engineer shall be paid by the Authority.

18.7 Termination of the Authority's Engineer

18.7.1 The Authority may, in its discretion, replace the Authority's Engineer at any time, but only after appointment of another Authority's Engineer in accordance with Clause 18.1.

18.7.2 If the Contractor has reasons to believe that the Authority's Engineer is not discharging its duties and functions in accordance with the provisions of this Agreement, it may make a written representation to the Authority and seek termination of the appointment of the Authority's Engineer. Upon receipt of such representation, the Authority shall hold a tripartite meeting with the Contractor and Authority's Engineer and make best efforts for an amicable resolution of the representation. In the event that the appointment of the Authority's Engineer is terminated hereunder, the Authority shall appoint forthwith another Authority's Engineer in accordance with Clause 18.1.

Part IV

Financial Covenants

ARTICLE 19

PAYMENTS

19.1 Contract Price

19.1.1 The Authority shall make payments to the Contractor for the Works on the basis of the lump sum price accepted by the Authority in consideration of the obligations specified in this Agreement for an amount of Rs. … … … … (Rs. … … … … … … … …) (the **"Contract Price"),** which shall be subject to adjustments in accordance with the provisions of this Agreement. The Parties further agree that save and except as provided in this Agreement, the Contract Price shall be valid and effective until Completion of O&M period.

19.1.2 (a) **The Contract Price shall be excluding of GST which will be paid as applicable.**

(b) The Contract Price includes all other **Duties, Taxes, Royalty, Cess and Fees** that may be levied in accordance with the laws and regulations in force as on the Base Date on the Contractor's equipment, Plant, Materials and supplies acquired for the purpose of this Agreement and on the services performed under this Agreement. Nothing in this Agreement shall relieve the Contractor from its responsibility to pay any tax including any other tax that may be levied in India on profits made by it in respect of this Agreement. Statutory deduction of taxes as applicable & royalty shall be made from each bill at the time of payment.

(c**)** The Building & Other Construction Workers Welfare Cess Act 1996: In accordance with the provisions under the said Act 1% (One) of the approved agreement value will be deducted from the R/A Bill at the time of making payment to the contractor and such amount shall be remitted in favour of **The Odisha Building & Other Construction Workers Welfare Board**.

19.1.3 The Contract Price shall not be adjusted for any change in costs stated in Clause 19.1.2 above, except as stated in Clauses 19.10 and 19.17.

19.1.4 The Contract Price shall not be adjusted to take account of any unforeseen difficulties or costs, unless otherwise provided for in this Agreement.

19.1.5 Unless otherwise stated in this Agreement, the Contract Price covers all the Contractor's obligations for the Works under this Agreement and all things necessary for the Construction and the remedying of any Defects in the Water Supply Project.

19.1.6 All payments under this Agreement shall be made in Indian Rupees.

19.2 Advance Payment

19.2.1 The Authority shall make an interest-bearing advance payment @ **10%** per Annum (the **"Advance Payment"**), equal in amount to 10 (ten) percent of the Contract Price **for construction works**, for mobilization expenses and for acquisition of equipment. The Advance Payment shall be made in four instalments. The first instalment shall be an amount equal to **2%** (two percent) of the Contract Price **for construction works**, the second instalment shall be equal to **3%** (three percent) of the Contract Price **for construction works**, the third instalment shall be equal to **3%** (three percent) of the Contract Price **for construction works** and the fourth instalment shall be equal to **2%** (two percent) of the Contract Price **for construction works**.

19.2.2 The Contractor may apply to the Authority for the first installment of Advance Payment at any time after the Appointed Date, along with an irrevocable and

unconditional Bank Guarantee from a Nationalised Bank, counter guaranteed by its branch at Bhubaneswar for an amount equivalent to 110% (one hundred and ten per cent) of such installment, substantially in the form provided at **Annex-III** of **Schedule-G**, to remain effective till the complete and full repayment thereof.

19.2.3 At any time after 30 (thirty) days from the Appointed Date, the Contractor may apply for the second instalment of the Advance Payment along with an irrevocable and unconditional Bank Guarantee from a Nationalised Bank, counter guaranteed by its branch at Bhubaneswar for an amount equivalent to 110% (one hundred and ten per cent) of such instalment, substantially in the form provided at Annex-III of Schedule-G, to remain effective till the complete and full repayment thereof.

19.2.4 At any time, after 60 (sixty) days from the Appointed Date, the Contractor may apply to the Authority for the third instalment of the Advance Payment along with an irrevocable and unconditional Bank Guarantee from a Nationalised Bank, counter guaranteed by its branch at Bhubaneswar for an amount equivalent to 110% (one hundred and ten per cent) of such instalment, substantially in the form provided at Annex-III of Schedule-G, to remain effective till the complete and full repayment thereof.

19.2.4.1 At any time, after 90 (Ninety) days from the Appointed Date on verification of acquisition of required materials and equipment by S.E., concerned P.H. Circle, the Contractor may apply to the Authority for the fourth installment of the Advance Payment along with an irrevocable and unconditional Bank Guarantee from a Nationalised Bank, counter guaranteed by its branch at Bhubaneswar for an amount equivalent to 110% (one hundred and ten per cent) of such installment, substantially in the form provided at Annex-III of Schedule-G, to remain effective till the complete and full repayment thereof

19.2.5 The first, second, third and the fourth instalments shall be paid by the Authority to the Contractor within 15 (fifteen) days of the receipt of its respective requests in accordance with the provisions of this Clause 19.2.

19.2.6 Each instalment of Advance Payment shall be repaid by the Contractor to the Authority **no later than 365 (three hundred and sixty-five) days** from the respective date of Advance Payment.

19.2.7 The Contractor shall repay each instalment of the Advance Payment on or before the due date of repayment. In the event of the Contractor's failure to make the repayment on time, the Authority shall be entitled to encash the Bank guarantee for Advance Payment. The Parties expressly agree that for any delay in repayment of the Advance Payment, the Contractor shall pay interest to the Authority for each day of delay, such interest to be calculated at the rate of **18% (eighteen per cent)** per annum.

19.2.8 If the Advance Payment has not been fully repaid prior to Termination under Clause 21.7 or Article 23, as the case may be, the whole of the balance then outstanding shall immediately become due and payable by the Contractor to the Authority. Without prejudice to the provisions of Clause 19.2.7, in the event of Termination for Contractor Default, the Advance Payment shall be deemed to carry interest at the rate of 10% (ten per cent) per annum from the date of Advance Payment to the date of recovery by encashment of the Bank Guarantee for the Advance Payment. For the avoidance of doubt, the aforesaid interest shall be payable on each instalment of the Advance Payment, regardless of whether the instalment or any part thereof has been repaid to the Authority prior to Termination.

19.3 Procedure for estimating the payment for the Works

19.3.1 The Authority shall make interim payments to the Contractor as certified by the

Authority's Engineer on completion of a stage, in a length, number or areaas specified and valued in accordance with the proportion of the Contract Price assigned to each item and its stage in Schedule-H.

19.3.2 The Contractor shall base its claim for interim payment for the stages completed till the end of the month for which the payment is claimed, valued in accordance with Clause 19.3.1, supported with necessary particulars and documents in accordance with this Agreement.

19.3.3 Any reduction in the Contract Price arising out of Change of Scope or the works withdrawn under Clause 8.3 shall not affect the amounts payable for the items or stage payments thereof which are not affected by such Change of Scope or withdrawal. For avoidance of doubt and by way of illustration, the Parties agree that if the amount assigned to Major structures is reduced owing to Change of Scope or withdrawal of work, the reduction in payment shall be restricted to relevant payments for Major structures only and the payment due in respect of all other stage payments shall not be affected in any manner. The Parties further agree that the adjustments arising out of the aforesaid modifications shall be carried out in a manner that the impact of such modifications is restricted to the said Change of Scope or withdrawal, as the case may be, and does not alter the payments due for and in respect of items or stage payments which do not form part of such Change of Scope or withdrawal.

19.4 Stage Payment Statement for Works

The Contractor shall submit a statement (the **"Stage Payment Statement")**, in 3 copies, by the 7th (Seventh) day of the month to the Authority's Engineer in the form set forth in Schedule-O, showing the amount calculated in accordance with Clause 19.3 to which the Contractor considers himself entitled for completed stage(s) of the Works. The Stage Payment Statement shall be accompanied with the progress reports and any other supporting documents. The Contractor shall not submit any claim for payment of incomplete stages of work.

19.5 Stage Payment for Works

19.5.1 Within 10 (ten) days of receipt of the Stage Payment Statement from the Contractor pursuant to Clause 19.4, the Authority's Engineer shall broadly determine the amount due to the Contractor and recommend the release of 90 (ninety) percent of the amount so determined as part payment against the Stage Payment Statement, pending issue of the Interim Payment Certificate by the Authority's Engineer. Within 10 (ten) days of the receipt of recommendation of the Authority's Engineer, the Authority shall make electronic payment directly to the Contractor's bank account.

19.5.2 Within 15 (fifteen) days of the receipt of the Stage Payment Statement referred to in Clause 19.4, the Authority's Engineer shall determine and shall deliver to the Authority and the Contractor an IPC certifying the amount due and payable to the Contractor, after adjusting the payments already released to the Contractor against the said statement. For the avoidance of doubt, the Parties agree that the IPC shall specify all the amounts that have been deducted from the Stage Payment Statement and the reasons there for.

19.5.3 In cases where there is a difference of opinion as to the value of any stage, the Authority's Engineer's view shall prevail and interim payments shall be made to the Contractor on this basis; provided that the foregoing shall be without prejudice to the Contractor's right to raise a Dispute.

19.5.4 The Authority's Engineer may, for reasons to be recorded, withhold from payment:

(a) the estimated value of work or obligation that the Contractor has failed to perform in accordance with this Agreement and the Authority's Engineer had notified the Contractor; and

(b) the estimated cost of rectification of work done being not in accordance with this Agreement.

19.5.5 Payment by the Authority shall not be deemed to indicate the Authority's acceptance, approval, consent or satisfaction with the work done.

19.6 Monthly Operation &Maintenance Statement of the Water Supply Project

19.6.1 The Contractor shall submit to the Authority a monthly operation & maintenance statement ("**Monthly Operation &Maintenance Statement")/claim** in 3 (three) copies by the 7th (seventh) day of each month in the format set forth in Schedule-O for the Operation & Maintenance of the Water Supply Project during the previous month.

19.6.2 The monthly lump sum amount payable for Operation &Maintenance shall be 1/12th (one-twelfth) of the annual cost of Operation &Maintenance as specified in Clause 14.1.1.

19.7 Payment for Operation &Maintenance of the Water Supply Project

19.7.1 Within 15 (fifteen) days of receipt of the Monthly Operation & Maintenance Statement/claim from the Contractor pursuant to Clause 19.6, the Authority shall verify the Contractor's monthly operation & maintenance statement and certify the amount to be paid to the Contractor taking into account:

(a) Compliance with the Operation & Maintenance Requirements; and

(b) reduction for non-compliance with the Operation & Maintenance Requirement in accordance with Clause 19.7.2.

The Authority shall approve or amend the monthly operation & maintenance statement/claim to reflect the amount due to the Contractor in accordance with this Agreement.

19.7.2 Payment for Operation & Maintenance shall be made on monthly basis which shall be 1/12th of the amount for the year of maintenance in accordance with this Agreement. If the Operation & Maintenance Requirements set forth in Schedule-E are not met, reduction in payments shall be made in accordance with the provisions of Schedule-M. The reductions for non-compliance with the Operation & Maintenance Requirements shall be applied on the basis of monthly inspections by the Authority.

19.7.3 The deduction made on account of non-compliance with the Operation & Maintenance Requirements shall not be subsequently considered for payment after the compliance is achieved by repair or rectification.

19.7.4 The Authority shall pay to the Contractor every month any amount due under this Clause 19.7. The payment shall be made no later than 30 (thirty) days from the date of submission of the last claim for the relevant month.

19.8 Payment of Damages

19.8.1 The Contractor may claim Damages due and payable to it in accordance with the provisions of this Agreement.

19.8.2 The Authority, within 15 (fifteen) days of the receipt of the claim under Clause 19.8.1, after making adjustments in accordance with the provisions of this Agreement shall pay to the Contractor the amount due within a period of 30 (thirty) days from the date of the submission of the claim under this Clause 19.8. In the event of the failure of the Authority to make payment to the Contractor within the specified time, the Authority shall be liable to pay to the Contractor interest thereon and the provisions of Clause 19.9 shall apply *mutatis mutandis* thereto.

19.9 Time of payment and interest

19.9.1 The Authority shall pay to the Contractor any amount due under any payment certificate issued by the Authority's Engineer in accordance with the provisions of this Article 19, or in accordance with any other clause of this Agreement as follows:

(a) payment shall be made no later than 30 (thirty) days from the date of submission of the Stage Payment Statement by the Contractor to the Authority's Engineer for certification in accordance with the provisions of Clause 19.4 for an IPC; provided that, in the event the IPC is not issued by the Authority's Engineer within the aforesaid period of 30 (thirty) days, the Authority shall pay the amount shown in the Contractor's Stage Payment Statement and any discrepancy therein shall be added to, or deducted from, the next payment certificate issued to the Contractor; and

(b) payment shall be made no later than30 (thirty) days from the date of submission of the **Final Payment Certificate** for Works along with the discharge submitted to the Authority's Engineer in accordance with the provisions of Clause 19.15 for certification.

19.9.2 In the event of the failure of the Authority to make payment to the Contractor within the time period stated in this Clause 19.9, the Authority shall be liable to pay to the Contractor interest at the Base Rate plus 2% (two percent), calculated at quarterly rests, on all sums remaining unpaid from the date on which the same should have been paid, calculated in accordance with the provisions of Clause 19.9.1(a) and (b) and till the date of actual payment.

19.10. Price adjustment for the Works

19.10.1 The amounts payable to the Contractor for Works shall be adjusted in accordance with the provisions of this Clause 19.10.

19.10.2 Subject to the provisions of Clause 19.10.3, the amounts payable to the Contractor for Works, shall be adjusted in the **IPC** issued by the Authority's Engineer for the increase or decrease in the index cost of inputs for the Works, by the addition or subtraction of the amounts determined by the formulae prescribed in Clause 19.10.4.

19.10.3 To the extent that full compensation for any increase or decrease in costs to the Contractor is not covered by the provisions of this or other Clauses in this Agreement, the costs and prices payable under this Agreement shall be deemed to include the amounts required to cover the contingency of such other increase or decrease of costs and prices.

19.10.4 The Contract Price shall be adjusted for increase or decrease in rates and price of labour, cement, steel, Plant, machinery and spares, bitumen, pipes, fuel and lubricants, and other material inputs in accordance with the principles, procedures and formulae specified below **(as per OM No.15847/W Dt.19.11.2019 of Works Department, Govt. of Odisha)**:

(a) Price adjustment shall be applied on completion of the specified stage of the respective item of work in accordance with Schedule-H;

(b) Adjustment for each item of work/stage shall be made separately.

(c) Deleted

(d) Deleted

(e) Deleted

(f) In case an IPC relates to a month which is within 3 (three) months from the Base Date, no price adjustment shall be applicable.

19.10.5 Contract price shall be adjusted for increase or decrease in rates and price of labour, materials, fuels and lubricants in accordance with the following principles and procedures and as per formula given in following Paras.

(a) The price adjustment shall apply for the work done from the start date given in the contract data up to end of the initial intended completion date or extensions granted by the Engineer and shall not apply to the work carried out beyond the stipulated time for reasons attributable to the contractor.

(b) The price adjustment shall be determined during each month from the formula given in following Paras.

(c) Following expressions and meanings are assigned to the work done during each month:

R= Total value of work done during the month. It would include the amount of secured advance granted, if any, during the month, less the amount of secured advance recovered, if any during the month. It will exclude value for works executed for extra items under variations.

19.10.6 To the extent that full compensation for any rise or fall in costs to the contractor is not covered by the provisions of this or other clauses in the contract, the unit rates and prices included in the contract shall be deemed to include amounts to cover the contingency of such other rise or fall in costs

The formula (e) for adjustment of prices are:

19.10.6 (a)(i): **Adjustment of Other Materials Component**

Price adjustment for increase or decrease in cost of local materials other than cement, steel, bitumen, pipe and POL procured by the contractor shall be paid in accordance with the following formula:

$V_M = 0.85 \times P_m/100 \times R \times (M_1 - M_0)/M_0$

V_M = Increase or decrease in the cost of work during the month under consideration due to changes in rates for local materials other than cement, steel, bitumen and POL.

M_o = The all India wholesale price index (all commodities) on 28 days preceding the date of opening of Bids, as published by the Ministry of Commerce and Industry, Government of India, New Delhi.

M_1 = The all India wholesale price index (all commodities) for the month under consideration as published by the Ministry of Commerce and Industry, Government of India, New Delhi.

P_m = Percentage of local material component (other than cement, steel, bitumen and POL) of the work.

19.10.6 (a)(ii): **Adjustment for Cement Component**

Price adjustment for increase or decrease in the cost of cement procured by the contractor shall be paid in accordance with the following formula:

$V_c = 0.85 \times P_c/100 \times R \times (C_1 - C_0)/C_0$

V_c = Increase or decrease in the cost of work during the month under consideration due to changes in the rates for cement

C_0 = The all India wholesale price index for Ordinary Portland Cement (OPC) on 28 days preceding the date of opening of Bids as published by the Ministry of Commerce and Industry, Government of India, New Delhi.

C_1= The all India wholesale price index for Ordinary Portland Cement (OPC) for the month under consideration as published by the Ministry of Commerce and Industry, Government of India, New Delhi.

P_c = Percentage of Cement Component of the Work.

19.10.6 (a)(iii): **Adjustment for Steel Component**

Price adjustment for increase or decrease in the cost of steel procured by the contractor shall be paid in accordance with the following formula:

$V_s = 0.85 \times P_s/100 \times R \times (S_1 - S_0)/S_0$

V_s = Increase or decrease in the cost of work during the month under consideration due to changes in the rates for steel.

S_0 = The all India wholesale price index for steel (Mild Steel long products) on 28 days preceding the date of opening of Bids as published by the Ministry of Commerce and Industry, Government of India, New Delhi

S_1= The all India wholesale price index for steel (Mild Steel long products) for the month under consideration as published by the Ministry of Commerce and Industry, Government of India, New Delhi.

P_s = Percentage of steel component of the work

Note: For the application of this clause, index of (Mild Steel long products) has been chosen to represent steel group.

19.10.6 (a)(iv): **Adjustment of Bitumen Component**

Price adjustment for increase or decrease in the cost of bitumen shall be paid in accordance with the following formula:

$V_b = 0.85 \times P_b/100 \times R \times (B_1 - B_0)/B_0$

V_b = Increase or decrease in the cost of work during the month under consideration due to changes in the rate for bitumen.

B_0 = The official retail price of bulk bitumen at the IOCL/ BPCL depot at nearest center on the day 28 days prior to date of opening of Bids.

B_1 = The official retail price of bulk bitumen at IOCL/ BPCL depot at nearest center for the 15th day of the month under consideration.

P_b = Percentage of bitumen component of the work

19.10.6 (a)(v): **Adjustment towards differential cost of Pipes.**

Price adjustment for increase or decrease in the cost of pipe shall be paid in accordance with the following formula:

$V_{pi} = 0.85 \times P_{pi}/100 \times R \times (P_{i1} - P_{i0})/P_{i0}$

V_{pi} = Differential cost of pipe i.e. amount of increase or decrease in rupees to be paid or recovered during the month under consideration.

P_{pi} = Percentage of pipe component of the work

P_{i1} = **All India Whole sale price index of pipe** for the period under consideration as published by the Ministry of Commerce and Industry, Government of India, New Delhi.

P_{i0} = All India Whole sale price index of pipe on 28 days preceding the date of opening of Bids as published by the Ministry of Commerce and Industry, Government of India, New Delhi.

19.10.6 (b): **Adjustment of Labour Component**

Price adjustment for increase or decrease in the cost due to labour shall be paid in accordance with the fallowing formula:

$V_L = 0.85 \times P_l/100 \times R \times (L_1 - L_0)/L_0$

V_L = Increase or decrease in the cost of work during the month under consideration due to changes in rates for local labour.

L_0= The minimum wages for unskilled labour as Notified by Government of Odisha as prevailed on the last stipulated date of receipt of tender including extension, if any.

L_1 = The minimum wages for unskilled labour as Notified by Government of Odisha as prevailed on the last date of the Month previous to the one under consideration.

P_l = Percentage of labour component of the work.

19.10.6 (c) : **Adjustment of POL (fuel and lubricant) Component**

Price adjustment for increase or decrease in cost POL (fuel and lubricant) shall be paid in accordance with the following formula:

$V_f = 0.85 \times P_f/100 \times R \times (F_1 - F_0)/F_0$

V_f = Increase or decrease in the cost of work during the month under consideration due to changes in the rates for fuel and lubricants.

F_0 = The official retail price of High-Speed Diesel (HSD) at the existing consumer pumps of IOCL/ BPCL/ HPCL at nearest center on the day 28 days prior to the date of opening of Bids.

F_1 = The official retail price of HSD at the existing consumer pumps of IOCL/ BPCL/ HPCL at nearest center for the 15th day of the month under consideration .

P_f = Percentage of fuel and lubricants component of the work

Note: ***For the application of this clause, the price of High-Speed Diesel oil has been chosen to represent fuel and lubricants group.***

19.10.6 (d): **Adjustment for Plant and Machinery Spares Component**

(vi) Price adjustment for increase or decrease in the cost of plant and machinery spares procured by the Contractor shall be paid in accordance with the following formula:

$V_p - 0.85 \times P_p/100 \times R \times (P_1 - P_0)/P_0$

V_p- Increase or decrease in the cost of work during the month under consideration due to changes in the rates for plant and machinery spares.

P_0- The all India wholesale price index for manufacture of machinery for mining, quarrying and construction on 28 days preceding the date of opening of Bids as published by the Ministry of Commerce and Industry, Government of India, New Delhi.

P_1- The all India wholesale price index for manufacture of machinery for mining, quarrying and construction for the month under consideration as published by the Ministry of Commerce and Industry, Government of India, New Delhi.

P_p- Percentage of plant and machinery spares component of the work.

Note: ***For the application of this clause, index of manufacturing of machinery for mining, quarrying and construction has been chosen to represent the Plant and machinery Spares group.***

Regarding wholesale price Index (WPI) for appropriate commodity for payment of price adjustment, due to change of base year of WPI from 1993- 94 to 2004-05 & 2011-12, it is observed that, the commodity 'Bars and Rod', 'Cement', 'Heavy machinery and parts' included in the list of WPI 1993-94 series are not mentioned as such in the WPI 2004-05 & 2011-12 series. Therefore, the following items in the WPI 2004-05 & 2011-12 series shall be considered corresponding to items in WPI 1993-94 series:

Sl. No.	**Item in WPI 1993-94 series**	**Item in WPI 2004-05 series**	**Item in WPI 2011-12 series**
1.	Cement	Grey Cement	Ordinary Port land cement
2.	Bars & rods	Rebars	Mild steel long products
3.	Heavy Machinery & parts	Construction Machinery	Manufacture of machinery for mining, quarrying & construction.

19.10.6 (e): **APPLICATION OF ESCALATION CLAUSE:**

The contractor shall for the purpose of **availing reimbursement/refund of differential cost of steel, bitumen, cement, pipe, POL and wages, keep such books of account and other documents as are necessary to show that the amount of increase claimed or reduction available and shall allow inspection of the same by a duly authorized representative of Government and further, shall at the request of the Engineer-in-Charge**, furnish documents to be verified in such a manner as the Engineer-in-Charge may require any document and information kept. The contractor shall within a reasonable time of 15 days of his becoming aware of any alteration in the price of such material, wages of Labour and/or price of POL give notice thereof to the Engineer-in-Charge stating that the same is given pursuant to this condition along with information relating to there to which he may be in a position to supply.

Percentage Table

Sl. No.	Category of works		% Component (cost wise)		
			Labour (P_l)	P.O.L (P_f)	Steel (P_s)+ Cement (P_c) + Bitumen (P_b) + Pipes (P_{pi}) + Plant & Machinery Spare & Component (P_p) + Other Materials*
1.	R&B works (% of component)	Road works	5	5	90
		Bridge works	5	5	90
		Building works	5	5	90
2.	Irrigation works (% of component)	Structural work	5	5	90
		Earth, Canal & Embankment work	5	5	90
3.	P.H. Work	Structural work	5	5	90
		Pipeline work	5	5	Pipe – 70% * Machinery + Other material -20%
		Sewer line	5	5	Pipe – 70% * Machinery + Other material -20%

Note: Further break up may be worked out considering the consumption of Cement. Steel, Bitumen, pipe and Plant & Machinery Spare Component in the concerned works and shall be provided in the bid document in shape of "Schedule of Adjustment Data" as an "Appendix to Bid". (Enclosed herewith).

Appendix to Bid

Schedule of Adjustment Data

[For all works, adjustment factor for Labour and POL shall be considered @ 5% each. Steel, Cement, Pipes, other Materials and Machinery shall contribute to 90% of Price Adjustment and shall be calculated for each work separately during preparation of estimate, shall be approved by the authority during technical sanction as a "Schedule of Adjustment Data" and shall form part of the Bid Document]

Cl. No.6.19 of F2/P1 Contracts Sl. No.	Index description	Source of index	Base value *	Base Date*	Weightage of Item**
19.10.6 (a)(i)	Other Materials	All India Whole sale price index (all commodities) as published by the Office of the Economic Advisor to the Govt. of lndia, Ministry of Commerce and lndustry.			
19.10.6 (a)(ii)	Cement	All India Whole sale price index for Cement (Ordinary Portland Cement) as published by the Office of the Economic Advisor to the Govt. of lndia, Ministry of Commerce and lndustry.			
19.10.6 (a)(iii)	Steel	All India Whole sale price index for Steel (Mild Steel-Long Products) as published by the Office of the Economic Advisor to the Govt. of lndia, Ministry of Commerce and lndustry.			
19.10.6 (a)(iv)	Bitumen (VG-30)	Official retail price of bulk bitumen at the nearest IOC/HPCL Depot.			
19.10.6 (a)(v)	Pipes	All India Whole sale price index for the **type of pipe under consideration**, as published by the Office of the Economic Advisor to the Govt. of lndia, Ministry of Commerce and lndustry.			
19.10.6 (b)	Labour	Minimum Wage notified by the Labour and Employee's State Insurance Department of Government of Odisha, India.			5%
19.10.6 (c)	POL	Official retail price of HSD at nearest IOCL/ HPCL/ BPCL Consumer Pump Depot.			5%
19.10.6 (d)	Plant and Machinery	All India Whole sale price index for Manufacture of Machinery for Mining, Quarrying and Construction as published by the Office of the Economic Advisor to the Govt. of lndia, Ministry of Commerce and lndustry.			
		Total :			**100%**

**** Values to be filled up at the time of drawl of contract.***

***** Values to be filled up in the bid document.***

19.11 Restrictions on price adjustment

Price adjustment shall be due and payable only in respect of the stages of Works for which the Stage Payment Statement has been submitted by the Contractor no later than 30 (thirty) days from the date of the applicable Project Milestone or the Scheduled Completion Date, as the case may be, including any Time Extension granted there for in accordance with the provisions of this Agreement. For the avoidance of doubt, in the event of submission of any Stage Payment Statement after the period specified herein, price adjustment shall be applicable until the date of the respective Project Milestone or the Scheduled Completion Date, as the case may be.

19.12. Price adjustment on labour for Operation & Maintenance of water supply Project.

The contract price for operation & maintenance shall be adjusted **quarterly** for increase or decrease in rates and prices of labour, materials& spare parts, fuel & lubricants & chemical etc. in accordance with the principles, procedures & formula specified below.

19.12.1: Price Adjustment on labour component

Differential cost of labour due to enhancement of minimum wages by the State Government will be adjusted in accordance with the following formula.

VOL = 0.85xPLx R(L1 – Lo)/Lo

Where,

VOL = Increase in the payment on labour

PL = % of Labour component of the O&M contract price.

Lo = Minimum wages prevailing on the bid due date

L1 = The minimum wages for the first day of relevant quarter under consideration for determining price adjustment.

R = Value of O&M work done**.**

19.12.2: Price adjustment on O&M materials & Spare parts

Price adjustment for O&M materials & Spare parts component of the contract price for O&M shall be made in accordance with Wholesale Price Index (WPI) as per following formula.

VOM = 0.85 PM x R (M1 – M0)/M0

Where,

VOM = Increase or decrease in the cost of O&M materials & Spare parts component during the period under consideration due to changes in the rates for relevant components as stated in 19.12.5.

PM = Materials& spare parts component of the O&M contract price.

M1 = The WPI for materials& Spare parts on the first day of month three months prior to the month to which the IPC relates.

M0 = The wholesale price index as published by the Ministry of Commerce &Industry, Government of India (Hereinafter called as "WPI") for materials & Spare parts for the month of base date.

R = Value of O&M work done.

19.12.3: Price adjustment on Fuel & Lubricants

VOF = 0.85 PF x R(F1 – F0)/F0

VOF = Increase or decrease in the cost of Fuel & Lubricants component during the period under consideration due to changes in the rates for relevant components as stated in 19.12.5

PF is the percentage of fuel & lubricant component for the relevant item as stated in sub-paragraph 19.12.5

FI = The official retail price of HSD at the existing consumer pumps of IOC in the State of [Odisha] on the first day of the month three months prior to the

month to which the IPC relates.
FO = The official retail price of high speed diesel (HSD) oil at the existing consumer pumps of Indian Oil Corporation ("IOC") in the State of [Odisha] on the Base Date.
R = Value of O&M work done.

19.12.4: Price adjustment on Chemicals & chemicals products

VOC = 0.85 PC x R(C1 – C0)/C0

VOC = Increase or decrease in the cost of Chemicals & chemicals products component during the period under consideration due to changes in the rates for relevant components as stated in 19.12.5

PC is the percentage of chemicals, chemical product for the relevant item as stated in sub-paragraph 19.12.5.

C1 = The WPI for chemical & chemical products on the 1st day of month three months prior to the month to which the IPC relates.

CO = The WPI for chemical & chemical products for the month of base date

R = Value of O&M work done.

19.12.5 The following percentages shall govern the price adjustment of the contract price for O&M excluding the cost of energy.

Sl.No	Components	Percentage
01	Labour component (PL)	**60 %**
02	O&M materials & Spare parts (PM)	**29 %**
03	Fuel & Lubricants (PF)	**3 %**
04	Chemicals, chemicals products (PC)	**8 %**
	Total	**100%**

Schedule of Adjustment Data

[For all works, adjustment factor for Labour and POL shall be considered @ 5% each. Steel, Cement, Pipes, other Materials and Machinery shall contribute to 90% of Price Adjustment and shall be calculated for each work separately during preparation of estimate, shall be approved by the authority during technical sanction as a "Schedule of Adjustment Data" and shall form part of the Bid Document]

Cl. No.6.19 of F2/P1 Contracts Sl. No.	Index description	Source of index	Base value*	Base Date*	Weightage of Item**
6.19 (a)(i)	Other Materials	All India Whole sale price index (all commodities) as published by the Office of the Economic Advisor to the Govt. of lndia, Ministry of Commerce and lndustry.			
6.19 (a)(ii)	Cement	All India Whole sale price index for Cement (Ordinary Portland Cement) as published by the Office of the Economic Advisor to the Govt. of lndia, Ministry of Commerce and lndustry.			

6.19 (a)(iii)	Steel	All India Whole sale price index for Steel (Mild Steel-Long Products) as published by the Office of the Economic Advisor to the Govt. of lndia, Ministry of Commerce and lndustry.			
6.19 (a)(iv)	Bitumen (VG-30)	Official retail price of bulk bitumen at the nearest IOC/HPCL Depot.			
6.19 (a)(v)	**Pipes**	All India Whole sale price index for the **type of pipe under consideration**, as published by the Office of the Economic Advisor to the Govt. of lndia, Ministry of Commerce and lndustry.			
6.19 (b)	Labour	Minimum Wage notified by the Labour and Employee's State Insurance Department of Government of Odisha, India.			5%
6.19 (c)	POL	Official retail price of HSD at nearest IOCL/ HPCL/ BPCL Consumer Pump Depot.			5%
6.19 (d)	Plant and Machinery	All India Whole sale price index for Manufacture of Machinery for Mining, Quarrying and Construction as published by the Office of the Economic Advisor to the Govt. of lndia, Ministry of Commerce and lndustry.			
		Total :			**100%**

**** Values to be filled up at the time of drawl of contract.***
***** Values to be filled up in the bid document.***

19.13 Final Payment Statement

19.13.1 Within 60 (sixty) days after receiving the Completion Certificate under Clause 12.4, the Contractor shall submit to the Authority's Engineer for consideration six copies of a Final Payment Statement (the "**Final Payment Statement**") for Works, with supporting documents showing in detail, in the form prescribed by the Authority's Engineer:

(a) the summary of Contractor's Stage Payment claims for Works as submitted in accordance with Clause 19.4;
(b) the amounts received from the Authority against each claim; and
(c) any further sums which the Contractor considers due to it from the Authority.

If the Authority's Engineer disagrees with or cannot verify any part of the Final Payment Statement, the Contractor shall submit such further information as the Authority's Engineer may reasonably require. The Authority's Engineer shall deliver to the Authority:

(i) an IPC for those parts of the Final Payment Statement which are not in dispute, along with a list of disputed items which shall then be settled in accordance with the provisions of Article 26; or
(ii) a Final Payment Certificate in accordance with Clause 19.15 if there are no disputed items.

19.13.2 If the Authority's Engineer does not prescribe the form referred to in Clause 19.13.1 within 15 (fifteen) days of the date of issue of the Completion Certificate, the Contractor shall submit the statement in such form as it deems fit.

19.14 Discharge

Upon submission of the Final Payment Statement for Works under Clause 19.13, the Contractor shall give to the Authority, with a copy to the Authority's Engineer, a written discharge confirming that the total of the Final Payment Statement represents full and final settlement of all monies due to the Contractor in respect of this Agreement for all the Works arising out of this Agreement, except for any monies due to either Party on account of any Defect. Provided that such discharge shall become effective only after the payment due has been made in accordance with the Final Payment Certificate issued pursuant to Clause 19.15.

19.15 Final Payment Certificate

19.15.1 Within 30 (thirty) days after receipt of the Final Payment Statement for Works under Clause 19.13, and the written discharge under Clause 19.14, and there being no disputed items of claim, the Authority's Engineer shall deliver to the Authority, with a copy to the Contractor, a final payment certificate (the "**Final Payment Certificate")** stating the amount which, in the opinion of the Authority's Engineer, is finally due under this Agreement or otherwise. For the avoidance of doubt, before issuing the Final Payment Certificate, the Authority's Engineer shall ascertain from the Authority all amounts previously paid by the Authority and for all sums to which the Authority is entitled, the balance, if any, due from the Authority to the Contractor or from the Contractor to the Authority, as the case may be.

19.15.2 The Authority shall, in accordance with the provisions of Clause 19.9, pay to the Contractor the amount which is stated as being finally due in the **Final Payment Certificate**.

19.16 Final payment statement for Operation & Maintenance of Water Supply Project.

19.16.1 Within 30 (thirty) days after completion of the Operation & Maintenance Period, the Contractor shall submit to the Authority six copies of the final payment statement for Operation & Maintenance of the Water Supply Project, with supporting documents showing the details set forth below in the form prescribed by the Authority:

(a) the total amount claimed in accordance with the monthly statement for Operation & Maintenance of Water Supply Project;

(b) the amount paid in accordance with the **Interim Payment Certificates**/claims; and

(c) any sums which the Contractor considers to be due to it, with supporting documents.

19.16.2 The Authority shall check and approve the final payment within 30 (thirty) days of the receipt of the final payment statement of Operation & Maintenance under Clause 19.16.1, segregating the items of amount payable from the items of amount disallowed. The Authority shall make payment on the basis of the final payment statement within a period of 30 (thirty) days thereafter.

19.16.3 If the Authority does not prescribe the form within 15 (fifteen) days of the date of issue of the Completion Certificate, the Contractor shall submit the statement in such form as it deems fit.

19.17 Change in law

19.17.1 If as a result of Change in Law, the Contractor suffers any additional costs in the execution of the Works or in relation to the performance of its other obligations under this Agreement, the Contractor shall, within 15 (fifteen) days from the date it becomes reasonably aware of such addition in cost, notify the Authority with a copy to the Authority's Engineer of such additional cost due to Change in Law.

19.17.2 If as a result of Change in Law, the Contractor benefits from any reduction in costs for the execution of this Agreement or in accordance with the provisions of this Agreement, either Party shall, within 15 (fifteen) days from the date it becomes reasonably aware of such reduction in cost, notify the other Party with a copy to the Authority's Engineer of such reduction in cost due to Change in Law.

19.17.3 The Authority's Engineer shall, within15 (fifteen) days from the date of receipt of the notice from the Contractor or the Authority, determine any addition or reduction to the Contract Price, as the case may be, due to the Change in Law.

19.18 Correction of Interim Payment Certificates

The Authority's Engineer may by an Interim Payment Certificate make any correction or modification in any previous Interim Payment Certificate issued by the Authority's Engineer.

19.19 Authority's claims

If the Authority considers itself to be entitled to any payment from the Contractor under any Clause of this Agreement, it shall give notice and particulars to the Contractor 20 (twenty) days before making the recovery from any amount due to the Contractor, and shall take into consideration the representation, if any, made by the Contractor in this behalf, before making such recovery.

19.20 Bonus for early completion

In the event that the Project Completion Date occurs prior to the Scheduled Completion Date, the Contractor shall be entitled to receive a payment of bonus equivalent to 0.03% (zero point zero three percent) of the Contract Price for each day by which the Project Completion Date precedes the Scheduled Completion Date, but subject to a **maximum of 3% (three percent)** of the Contract Price. Provided, however, that the payment of bonus, if any, shall be made only after the issue of the Completion Certificate. For the avoidance of the doubt, the Parties agree that for the purpose of determining the bonus payable hereunder, the Contract Price shall always be deemed to be the amount specified in Clause 19.1.1, and shall exclude any revision thereof for any reason. The Parties also agree that bonus shall be payable only if each work for which Extension of Time has been granted is completed within respective Extended Time.

ARTICLE 20

INSURANCE

20.1 Insurance for Works

20.1.1 The Contractor shall effect and maintain at its own cost the insurances specified in Schedule-Pand as per the requirements under the Applicable Laws.

20.1.2 Subject to the provisions of Clause 21.6, the Authority and the Contractor shall, in accordance with its obligations as provided for in this Agreement, be liable to bear the cost of any loss or damage that does not fall within the scope of this Article 20 or cannot be recovered from the insurers.

20.1.3 Subject to the exceptions specified in Clause 20.1.4 below, the Contractor shall, save and except as provided for in this Agreement, fully indemnify, hold harmless and defend the Authority from and against any and all losses, damages, costs, charges and/or claims with respect to:

(a) the death of or injury to any person; or

(b) the loss of or damage to any property (other than the Works);

that may arise out of or in consequence of any breach by the Contractor of this Agreement during the execution of the Works or the remedying of any Defects therein.

20.1.4 Notwithstanding anything stated above in Clause 20.1.3, the Authority shall fully indemnify the Contractor from and against any and all losses, damages, costs, charges, proceedings and/or claims arising out of or with respect to

(a) the use or occupation of land or any part thereof by the Authority;

(b) the right of the Authority to execute the Works, or any part thereof, on, over, under, in or through any land;

(c) the damage to property which is the unavoidable result of the execution and completion of the Works, or the remedying of any Defects therein, in accordance with this Agreement; and

(d) the death of or injury to persons or loss of or damage to property resulting from any act or neglect of the Authority, its agents, servants or other contractors, not being employed by the Contractor.

Provided that, in the event of any injury or damage as a result of the contributory negligence of the Contractor, the Authority shall be liable to indemnify the Contractor from and against any and all losses, damages, costs, charges, proceedings and/or claims to the extent as may be proportionately determined to be the liability of the Authority, its servants or agents or other contractors not associated with the Contractor in such injury or damage.

20.1.5 Without prejudice to the obligations of the Parties as specified under Clauses 20.1.3 and 20.1.4, the Contractor shall maintain or effect such third party insurances as may be required under the Applicable Laws.

20.1.6 The Contractor shall provide to the Authority, within 30 days of the Appointed Date, evidence of professional liability insurance maintained by its Design Director and/or consultants to cover the risk of professional negligence in the design of Works. The professional liability coverage shall be for a sum of not less than [3% (three per cent)] of the Contract Price and shall be maintained until the end of the Defects Liability Period.

20.1.7. **Insurance for Construction as well as O & M period shall be in the scope of bidder.**

20.2 Notice to the Authority

` No later than 15 (fifteen) days after the date of this Agreement, the Contractor shall by notice furnish to the Authority, in reasonable detail, information in respect of the insurances that it proposes to effect and maintain in accordance with this Article 20. Within 15 (fifteen) days of receipt of such notice, the Authority may require the Contractor to effect and maintain such other insurances as may be necessary pursuant hereto, and in the event of any difference or disagreement relating to any such insurance, the Dispute Resolution Procedure shall apply.

20.3 Evidence of Insurance Cover

20.3.1 All insurances obtained by the Contractor in accordance with this Article 20 shall be maintained with insurers on terms consistent with Good Industry Practice. Within10 (ten) days from the Appointed Date, the Contractor shall furnish to the Authority notarised true copies of the certificate(s) of insurance, copies of insurance policies and premium payment receipts in respect of such insurance, and no such insurance shall be cancelled, modified, or allowed to expire or lapse until the expiration of at least 45 (forty-five) days after notice of such proposed cancellation, modification or non-renewal has been delivered by the Contractor to the Authority. The Contractor shall act in accordance with the directions of the Authority. Provided that the Contractor shall produce to the Authority the insurance policies in force and the receipts for payment of the current premium.

20.3.2The Contractor shall ensure the adequacy of the insurances at all times in accordance with the provisions of this Agreement.

20.4 Remedy for failure to insure

If the Contractor shall fail to effect and keep in force all insurances for which it is responsible pursuant hereto, the Authority shall have the option to either keep in force any such insurances, and pay such premium and recover the costs thereof from the Contractor, or in the event of computation of a Termination Payment, treat an amount equal to the Insurance Cover as deemed to have been received by the Contractor.

20.5 Waiver of subrogation

All insurance policies in respect of the insurance obtained by the Contractor pursuant to this Article 20 shall include a waiver of any and all rights of subrogation or recovery of the insurers there under against, inter alia, the Authority, and its assigns, successors, undertakings and their subsidiaries, Affiliates, employees, insurers and underwriters, and of any right of the insurers to any set-off or counterclaim or any other deduction, whether by attachment or otherwise, in respect of any liability of any such person insured under any such policy or in any way connected with any loss, liability or obligation covered by such policies of insurance.

20.6 Contractor's waiver

The Contractor hereby further releases, assigns and waives any and all rights of subrogation or recovery against, inter alia, the Authority and its assigns, undertakings and their subsidiaries, Affiliates, employees, successors, insurers and underwriters, which the Contractor may otherwise have or acquire in or from or in any way connected with any loss, liability or obligation covered by policies of insurance maintained or required to be maintained by the Contractor pursuant to this Agreement (other than third party liability insurance policies) or because of deductible clauses in or inadequacy of limits of any such policies of insurance.

20.7 Cross liabilities

Any such insurance maintained or effected in pursuance of **this Article 20** shall include a cross liability clause such that the insurance shall apply to the Contractor and to the Authority as separately insured.

20.8 Accident or injury to workmen

Notwithstanding anything stated in this Agreement, it is hereby expressly agreed between the Parties that the Authority shall not be liable for or in respect of any damages or compensation payable to any workman or other person in the employment of the Contractor or Sub-contractor, save and except as for death or injury resulting from any act, omission or default of the Authority, its agents or servants. The Contractor shall indemnify and keep indemnified the Authority from and against all such claims, proceedings, damages, costs, charges, and expenses whatsoever in respect of the above save and except for those acts, omissions or defaults for which the Authority shall be liable.

20.9 Insurance against accident to workmen

The Contractor shall effect and maintain during the Agreement such insurances as may be required to insure the Contractor's personnel and any other persons employed by it on the water supply Project from and against any liability incurred in pursuance of this Article 20. Provided that for the purposes of this Clause 20.9, the Contractor's personnel/any person employed by the Contractor shall include the Sub-contractor and its personnel. It is further provided that, in respect of any persons employed by any Sub-contractor, the Contractor's obligations to insure as aforesaid under this Clause 20.9 shall be discharged if the Sub-contractor shall have insured against any liability in respect of such persons in such manner that the Authority is indemnified under the policy. The Contractor shall require such Sub-contractor to produce before the Authority, when required, such policy of insurance and the receipt for payment of the current premium within 10 (ten) days of such demand being made by the Authority.

20.10 Application of insurance proceeds

The proceeds from all insurance claims, except for life and injury, shall be applied for any necessary repair, reconstruction, reinstatement, replacement, improvement, delivery or installation of the water supply Project and the provisions of this Agreement in respect of construction of works shall apply *mutatis mutandis* to the works undertaken out of the proceeds of insurance.

20.11 Compliance with policy conditions

Each Party hereby expressly agrees to fully indemnify the other Party from and against all losses and claims arising from its failure to comply with conditions imposed by the insurance policies affected in accordance with this Agreement.

Part V

Force Majeure and Termination

ARTICLE 21

FORCE MAJEURE

21.1 Force Majeure

As used in this Agreement, the expression "Force Majeure" or "Force Majeure Event" shall mean occurrence in India of any or all of Non-Political Event, Indirect Political Event and Political Event, as defined in Clauses 21.2, 21.3 and 21.4 respectively, if it affects the performance by the Party claiming the benefit of Force Majeure (the "**Affected Party**") of its obligations under this Agreement and which act or event (i) is beyond the reasonable control of the Affected Party, and (ii) the Affected Party could not have prevented or overcome by exercise of due diligence and following Good Industry Practice, and (iii) has Material Adverse Effect on the Affected Party.

21.2 Non-Political Event

A Non-Political Event shall mean one or more of the following acts or events:

(a) act of God, epidemic, extremely adverse weather conditions, lightning, earthquake, landslide, cyclone, flood, volcanic eruption, chemical or radioactive contamination or ionising radiation, fire or explosion (to the extent of contamination or radiation or fire or explosion originating from a source external to the Site);

(b) strikes or boycotts (other than those involving the Contractor, Sub-contractors or their respective employees/representatives, or attributable to any act or omission of any of them) interrupting supplies and services to the Water Supply Project for a continuous period of 24 (twenty-four) hours and an aggregate period exceeding 30 (thirty) days in an Accounting Year, and not being an Indirect Political Event set forth in Clause 21.3;

(c) any failure or delay of a Sub-contractor but only to the extent caused by another Non-Political Event;

(d) any judgement or order of any court of competent jurisdiction or statutory authority made against the Contractor in any proceedings for reasons other than (i) failure of the Contractor to comply with any Applicable Lawor Applicable Permit, or (ii) on account of breach of any Applicable Law or Applicable Permit or of any contract, or (iii) enforcement of this Agreement, or (iv) exercise of any of its rights under this Agreement by the Authority;

(e) the discovery of geological conditions, toxic contamination or archaeological remains on the Site that could not reasonably have been expected to be discovered through a site inspection; or

(f) any event or circumstances of a nature analogous to any of the foregoing.

21.3 Indirect Political Event

An Indirect Political Event shall mean one or more of the following acts or events:

(a) an act of war (whether declared or undeclared), invasion, armed conflict or act of foreign enemy, blockade, embargo, riot, insurrection, terrorist or military action, civil commotion or politically motivated sabotage;

(b) industry-wide or State-wide strikes or industrial action for a continuous period of 24 (twenty-four) hours and exceeding an aggregate period of 30 (thirty) days in an Accounting Year;

(c) any civil commotion, boycott or political agitation which prevents construction of the Water Supply Project by the Contractor for an aggregate period exceeding 30 (thirty) days in an Accounting Year;

(d) any failure or delay of a Sub-contractor to the extent caused by any Indirect Political Event;

(e) any Indirect Political Event that causes a Non-Political Event; or

(f) any event or circumstances of a nature analogous to any of the foregoing.

21.4 Political Event

A Political Event shall mean one or more of the following acts or events by or on account of any Government Instrumentality:

(a) Change in Law, only if consequences thereof cannot be dealt with under and in accordance with the provisions of Clause 19.17;

(b) compulsory acquisition in national interest or expropriation of any Project Assets or rights of the Contractor or of the Sub-Contractors;

(c) unlawful or unauthorised or without jurisdiction revocation of, or refusal to renew or grant without valid cause, any clearance, licence, permit, authorisation, no objection certificate, consent, approval or exemption required by the Contractor or any of the Sub-contractors to perform their respective obligations under this Agreement; provided that such delay, modification, denial, refusal or revocation did not result from the Contractor's or any Sub-contractor's inability or failure to comply with any condition relating to grant, maintenance or renewal of such clearance, licence, authorisation, no objection certificate, exemption, consent, approval or permit;

(d) any failure or delay of a Sub-contractor but only to the extent caused by another Political Event; or

(e) any event or circumstances of a nature analogous to any of the foregoing.

21.5 Duty to report Force Majeure Event

21.5.1 Upon occurrence of a Force Majeure Event, the Affected Party shall by notice report such occurrence to the other Party forthwith. Any notice pursuant hereto shall include full particulars of:

(a) the nature and extent of each Force Majeure Event which is the subject of any claim for relief under this Article 21 with evidence in support thereof;

(b) the estimated duration and the effect or probable effect which such Force Majeure Event is having or will have on the Affected Party's performance of its obligations under this Agreement;

(c) the measures which the Affected Party is taking or proposes to take for alleviating the impact of such Force Majeure Event; and

(d) any other information relevant to the Affected Party's claim.

21.5.2 The Affected Party shall not be entitled to any relief for or in respect of a Force Majeure Event unless it shall have notified the other Party of the occurrence of the Force Majeure Event as soon as reasonably practicable, and in any event no later than 10 (ten) days after the Affected Party knew, or ought reasonably to have known, of its occurrence, and shall have given particulars of the probable material effect that the Force Majeure Event is likely to have on the performance of its obligations under this Agreement.

21.5.3 For so long as the Affected Party continues to claim to be materially affected by such Force Majeure Event, it shall provide the other Party with regular (and not less than weekly) reports containing information as required by Clause 21.5.1, and such other information as the other Party may reasonably request the Affected Party to provide.

21.6 Effect of Force Majeure Event on the Agreement

21.6.1 Upon the occurrence of any Force Majeure after the Appointed Date, the costs incurred and attributable to such event and directly relating to this Agreement (the "**Force Majeure costs**") shall be allocated and paid as follows:

(a) upon occurrence of a Non-Political Event, the Parties shall bear their respective Force Majeure costs and neither Party shall be required to pay to

the other Party any costs thereof;

(b) upon occurrence of an Indirect Political Event, all Force Majeure costs attributable to such Indirect Political Event, and not exceeding the Insurance Cover for such Indirect Political Event, shall be borne by the Contractor, and to the extent Force Majeure costs exceed such Insurance Cover, one half of such excess amount shall be reimbursed by the Authority to the Contractor for the Force Majeure events; and

(c) upon occurrence of a Political Event, all Force Majeure costs attributable to such Political Event shall be reimbursed by the Authority to the Contractor.

For the avoidance of doubt, Force Majeure costs may include costs directly attributable to the Force Majeure Event, but shall not include debt repayment obligations, if any, of the Contractor.

21.6.2 Save and except as expressly provided in this Article 21, neither Party shall be liable in any manner whatsoever to the other Party in respect of any loss, damage, cost, expense, claims, demands and proceedings relating to or arising out of occurrence or existence of any Force Majeure Event or exercise of any right pursuant hereto.

21.6.3 Upon the occurrence of any Force Majeure Event during the Construction Period, the Project Completion Schedule for and in respect of the affected Works shall be extended on a day for day basis for such period as performance of the Contractor's obligations is affected on account of the Force Majeure Event or its subsisting effects.

21.7 Termination Notice for Force Majeure Event

21.7.1 If a Force Majeure Event subsists for a period of 60 (sixty) days or more within a continuous period of 120 (one hundred and twenty) days, either Party may in its discretion terminate this Agreement by issuing a Termination Notice to the other Party without being liable in any manner whatsoever, save as provided in this Article 21, and upon issue of such Termination Notice, this Agreement shall, notwithstanding anything to the contrary contained herein, stand terminated forthwith; provided that before issuing such Termination Notice, the Party intending to issue the Termination Notice shall inform the other Party of such intention and grant 15 (fifteen) days time to make a representation, and may after the expiry of such 15 (fifteen) days period, whether or not it is in receipt of such representation, in its sole discretion issue the Termination Notice.

21.8 Termination Payment for Force Majeure Event

21.8.1 In the event of this Agreement being terminated on account of a Non-Political Event, the Termination Payment shall be an amount equal to the sum payable under Clause 23.5.

Provided that in the event Termination occurs during the Operation & Maintenance Period, the Authority's Engineer shall only determine the value of Works associated with **Operation & Maintenance**.

21.8.2 If Termination is on account of an Indirect Political Event, the Termination Payment shall include:

(a) any sums due and payable under Clause 23.5; and

(b) the reasonable cost, as determined by the Authority's Engineer, of the Plant and Materialsprocured by the Contractor and transferred to the Authority for use in Construction or Operation & Maintenanceonly if such Plant and Materials are in conformity with the Specifications and Standards;

Provided that in the event Termination occurs during the Operation & Maintenance Period, the Authority's Engineer shall only determine the value of Works associated with Operation & Maintenance.

21.8.3 If Termination is on account of a Political Event, the Authority shall make a Termination Payment to the Contractor in an amount that would be payable under Clause 23.6.2 as if it were an Authority Default.

21.9 Dispute resolution

In the event that the Parties are unable to agree in good faith about the occurrence or existence of a Force Majeure Event, such Dispute shall be finally settled in accordance with the Dispute Resolution Procedure; provided that the burden of proof as to the occurrence or existence of such Force Majeure Event shall be upon the Party claiming relief and/or excuse on account of such Force Majeure Event.

21.10 Excuse from performance of obligations

If the Affected Party is rendered wholly or partially unable to perform its obligations under this Agreement because of a Force Majeure Event, it shall be excused from performance of such of its obligations to the extent it is unable to perform on account of such Force Majeure Event; provided that:

(a) the suspension of performance shall be of no greater scope and of no longer duration than is reasonably required by the Force Majeure Event;

(b) the Affected Party shall make all reasonable efforts to mitigate or limit damage to the other Party arising out of or as a result of the existence or occurrence of such Force Majeure Event and to cure the same with due diligence; and

(c) when the Affected Party is able to resume performance of its obligations under this Agreement, it shall give to the other Party notice to that effect and shall promptly resume performance of its obligations hereunder.

ARTICLE 22

SUSPENSION OF CONTRACTOR'S RIGHTS

22.1 Suspension upon Contractor Default

Upon occurrence of a Contractor Default, the Authority shall be entitled, without prejudice to its other rights and remedies under this Agreement including its rights of Termination hereunder, to (i) suspend carrying out of the Works or Operation & Maintenance or any part thereof, and (ii) carry out such Works or Operation & Maintenance itself or authorise any other person to exercise or perform the same on its behalf during such suspension (the "**Suspension**"). Suspension hereunder shall be effective forthwith upon issue of notice by the Authority to the Contractor and may extend up to a period not exceeding 90 (ninety) days from the date of issue of such notice.

22.2 Authority to act on behalf of Contractor

During the period of Suspension hereunder, all rights and liabilities vested in the Contractor in accordance with the provisions of this Agreement shall continue to vest therein and all things done or actions taken, including expenditure incurred by the Authority for discharging the obligations of the Contractor under and in accordance with this Agreement shall be deemed to have been done or taken for and on behalf of the Contractor and the Contractor undertakes to indemnify the Authority for all costs incurred during such period. The Contractor hereby licences and sub-licences respectively, the Authority or any other person authorised by it under Clause 22.1 to use during Suspension, all Intellectual Property belonging to or licenced to the Contractor with respect to the Water Supply Project and its design, engineering, construction and operation & maintenance, and which is used or created by the Contractor in performing its obligations under the Agreement.

22.3 Revocation of Suspension

22.3.1 In the event that the Authority shall have rectified or removed the cause of Suspension within a period not exceeding 60 (sixty) days from the date of Suspension, it shall revoke the Suspension forthwith and restore all rights of the Contractor under this Agreement. For the avoidance of doubt, the Parties expressly agree that the Authority may, in its discretion, revoke the Suspension at any time, whether or not the cause of Suspension has been rectified or removed hereunder.

22.3.2 Upon the Contractor having cured the Contractor Default within a period not exceeding 60 (sixty) days from the date of Suspension, the Authority shall revoke the Suspension forthwith and restore all rights of the Contractor under this Agreement.

22.4 Termination

22.4.1 At any time during the period of Suspension under this Article 22, the Contractor may by notice require the Authority to revoke the Suspension and issue a Termination Notice. The Authority shall, within 15 (fifteen) days of receipt of such notice, terminate this Agreement under and in accordance with Article 23.

22.4.2 Notwithstanding anything to the contrary contained in this Agreement, in the event that Suspension is not revoked within 90 (ninety) days from the date of Suspension hereunder, the Agreement shall, upon expiry of the aforesaid period, be deemed to have been terminated by mutual agreement of the Parties and all the provisions of this Agreement shall apply, *mutatis mutandis*, to such Termination as if a Termination Notice had been issued by the Authority upon occurrence of a Contractor Default.

ARTICLE 23

TERMINATION

23.1 Termination for Contractor Default

23.1.1 Save as otherwise provided in this Agreement, in the event that any of the defaults specified below shall have occurred, and the Contractor fails to cure the default within the Cure Period set forth below, or where no Cure Period is specified, then within a Cure Period of 60 (sixty) days, the Contractor shall be deemed to be in default of this Agreement (the "**Contractor Default**"), unless the default has occurred solely as a result of any breach of this Agreement by the Authority or due to Force Majeure. The defaults referred to herein shall include:

(a) the Contractor fails to provide, extendor replenish, as the case may be, the Performance Security in accordance with this Agreement;

(b) subsequent to the replenishment or furnishing of fresh Performance Security in accordance with Clause 7.3, the Contractor fails to cure, within a Cure Period of 30 (thirty) days, the Contractor Default for which the whole or part of the Performance Security was appropriated;

(c) the Contractor does not achieve the latest outstanding Project Milestone due in accordance with the provisions of Schedule-J, subject to any Time Extension, and continues to be in default for 45 (forty-five) days;

(d) the Contractor abandons or manifests intention to abandon the construction or Operation & Maintenance of the Water Supply Project without the prior written consent of the Authority;

(e) the Contractor fails to proceed with the Works in accordance with the provisions of Clause 10.1 or stops Works and/or the operation & maintenance for 30 (thirty) days without reflecting the same in the current programme and such stoppage has not been authorised by the Authority's Engineer;

(f) the Project Completion Date does not occur within the period specified in Schedule-J for the Scheduled Completion Date, or any extension thereof;

(g) failure to complete the Punch List items within the periods stipulated there for in Clause 12.2.1;

(h) the Contractor fails to rectify any Defect, the non-rectification of which shall have a Material Adverse Effect on the Project, within the time specified in this Agreement or as directed by the Authority's Engineer;

(i) the Contractor subcontracts the Works or any part thereof in violation of this Agreement or assigns any part of the Works without the prior approval of the Authority;

(j) the Contractor creates any Encumbrance in breach of this Agreement;

(k) an execution levied on any of the assets of the Contractor has caused a Material Adverse Effect ;

(l) the Contractor is adjudged bankrupt or insolvent, or if a trustee or receiver is appointed for the Contractor or for the whole or material part of its assets that has a material bearing on the Project;

(m) the Contractor has been, or is in the process of being liquidated, dissolved, wound-up, amalgamated or reconstituted in a manner that would cause, in the reasonable opinion of the Authority, a Material Adverse Effect;

(n) a resolution for winding up of the Contractor is passed, or any petition for winding up of the Contractor is admitted by a court of competent jurisdiction and a provisional liquidator or receiver is appointed and such order has not been set aside within 90 (ninety) days of the date thereof or the Contractor is ordered to be wound up by court except for the purpose of

amalgamation or reconstruction; provided that, as part of such amalgamation or reconstruction, the entire property, assets and undertaking of the Contractor are transferred to the amalgamated or reconstructed entity and that the amalgamated or reconstructed entity has unconditionally assumed the obligations of the Contractor under this Agreement; and provided that:

(i) the amalgamated or reconstructed entity has the capability and experience necessary for the performance of its obligations under this Agreement; and

(ii) the amalgamated or reconstructed entity has the financial standing to perform its obligations under this Agreement and has a credit worthiness at least as good as that of the Contractor as at the Appointed Date;

(o) any representation or warranty of the Contractor herein contained which is, as of the date hereof, found to be materially false or the Contractor is at any time hereafter found to be in breach thereof;

(p) the Contractor submits to the Authority any statement, notice or other document, in written or electronic form, which has a material effect on the Authority's rights, obligations or interests and which is false in material particulars;

(q) the Contractor has failed to fulfil any obligation, for which failure Termination has been specified in this Agreement; or

(r) the Contractor commits a default in complying with any other provision of this Agreement if such a default causes a Material Adverse Effect on the Project or on the Authority.

23.1.2 Without prejudice to any other rights or remedies which the Authority may have under this Agreement, upon occurrence of a Contractor Default, the Authority shall be entitled to terminate this Agreement by issuing a Termination Notice to the Contractor; provided that before issuing the Termination Notice, the Authority shall by a notice inform the Contractor of its intention to issue such Termination Notice and grant 15 (fifteen) days to the Contractor to make a representation, and may after the expiry of such 15 (fifteen) days, whether or not it is in receipt of such representation, issue the Termination Notice.

23.1.3 After termination of this Agreement for Contractor Default, the Authority may complete the Works and/or arrange for any other entities to do so. The Authority and these entities may then use any Materials, Plant and equipment, Contractor's documents and other design documents made by or on behalf of the Contractor.

23.2 Termination for Authority Default

23.2.1 In the event that any of the defaults specified below shall have occurred, and the Authority fails to cure such default within a Cure Period of 90 (ninety) days or such longer period as has been expressly provided in this Agreement, the Authority shall be deemed to be in default of this Agreement (the "**Authority Default**") unless the default has occurred as a result of any breach of this Agreement by the Contractor or due to Force Majeure. The defaults referred to herein shall include:

(a) the Authority commits a material default in complying with any of the provisions of this Agreement and such default has a Material Adverse Effect on the Contractor;

(b) the Authority has failed to make payment of any amount due and payable to the Contractor within the period specified in this Agreement;

(c) the Authority has failed to provide, within a period of 180 (one hundred and eighty) days from the Appointed Date, the environmental clearances

required for construction of the Water Supply Project;

(d) the Authority repudiates this Agreement or otherwise takes any action that amounts to or manifests an irrevocable intention not to be bound by this Agreement; or

(e) the Authority's Engineer fails to issue the relevant Interim Payment Certificate within 60 (sixty) days after receiving a statement and supporting documents.

23.2.2 Without prejudice to any other right or remedy which the Contractor may have under this Agreement, upon occurrence of an Authority Default, the Contractor shall be entitled to terminate this Agreement by issuing a Termination Notice to the Authority; provided that before issuing the Termination Notice, the Contractor shall by a notice inform the Authority of its intention to issue the Termination Notice and grant 15 (fifteen) days to the Authority to make a representation, and may after the expiry of such 15 (fifteen) days, whether or not it is in receipt of such representation, issue the Termination Notice.

If on the consideration of the Authority's representation or otherwise, the contractor does not issue the Termination Notice on such 15th day and prefers to continue with the project, it is deemed that the cause of action of the Termination Notice has been condoned by the Contractor. Hence, he forfeits his right to any other remedy on that count.

23.3 Termination for Authority's convenience

Notwithstanding anything stated hereinabove, the Authority may terminate this Agreement for convenience. The termination shall **take effect 30 (thirty)** days from the date of notice hereunder.

23.4 Requirements after Termination

Upon Termination of this Agreement in accordance with the terms of this Article 23, the Contractor shall comply with and conform to the following:

(a) deliver to the Authority all Plant and Materials which shall have become the property of the Authority under this Article 23;

(b) deliver all relevant records, reports, Intellectual Property and other licences pertaining to the Works, Operation & Maintenance other design documents and in case of Termination occurring after the Provisional Certificate has been issued, the "as built' Drawings for the Works;

(c) transfer and/or deliver all Applicable Permits to the extent permissible under Applicable Laws; and

(d) vacate the Site within 15 (fifteen) days.

23.5 Valuation of Unpaid Works

23.5.1 Within a period of 45 (forty-five) days after Termination under Clause 23.1, 23.2 or 23.3, as the case may be, has taken effect, the Authority's Engineer shall proceed in accordance with Clause 18.5 to determine as follows the valuation of unpaid Works (the "**Valuation of Unpaid Works**"):

(a) value of the completed stage of the Works, less payments already made;

(b) reasonable value of the partially completed stages of works as on the date of Termination, only if such works conform with the Specifications and Standards; and

(c) Deleted

and shall adjust from the sum thereof (i) any other amounts payable or recoverable, as the case may be, in accordance with the provisions of this Agreement; and (ii) all taxes due to be deducted at source.

23.5.2 The Valuation of Unpaid Works shall be communicated to the Authority, with a copy to the Contractor, within a period of 30 (thirty) days from the date of Termination.

23.6 Termination Payment

23.6.1 Upon Termination on account of Contractor's Default under Clause 23.1, the Authority shall:

(a) encash and appropriate the Performance Security and Retention Money, or in the event the Contractor has failed to replenish or extend the Performance Security, claim the amount stipulated in **Clause 7.1.1**, as agreed pre-determined compensation to the Authority for any losses, delays and cost of completing the Works and 'Operation & Maintenance if any;

(b) encash and appropriate the bank guarantee, if any, for and in respect of the outstanding Advance Payment and interest thereon; and

(c) pay to the Contractor, by way of Termination Payment, an amount equivalent to the Valuation of Unpaid Works after adjusting any other sums payable or recoverable, as the case may be, in accordance with the provisions of this Agreement.

23.6.2 Upon Termination on account of an Authority Default under Clause 23.2 or for Authority's convenience under Clause 23.3, the Authority shall:

(a) return the Performance Security and Retention Money forthwith;

(b) encash and appropriate the bank guarantee, if any, for and in respect of the outstanding Advance Payment; and

(c) pay to the Contractor, by way of Termination Payment, an amount equal to:

(i) Valuation of Unpaid Works;

(ii) the reasonable cost, as determined by the Authority's Engineer, of the Plant and Materialsprocured by the Contractor and transferred to the Authority for its use, only if such Plant and Materials are in conformity with the Specifications and Standards;

(iii) the reasonable cost of temporary works, as determined by the Authority's Engineer; and

(iv) 10% (ten percent) of the cost of the Works and **Operation & Maintenance** that are not commenced or not completed,

and shall adjust from the sum thereof(i) any other amounts payable or recoverable, as the case may be, in accordance with the provisions of this Agreement, and (ii) all taxes due to be deducted at source.

23.6.3 Termination Payment shall become due and payable to the Contractor within 30 (thirty) days of a demand being made by the Contractor to the Authority with the necessary particulars, and in the event of any delay, the Authority shall pay interest at the Base Rate plus 2% (two percent), calculated at quarterly rests, on the amount of Termination Payment remaining unpaid; provided that such delay shall not exceed 90 (ninety) days. For the avoidance of doubt, it is expressly agreed that Termination Payment shall constitute full discharge by the Authority of its payment obligations in respect thereof hereunder.

23.6.4 The Contractor expressly agrees that Termination Payment under this Article 23 shall constitute a full and final settlement of all claims of the Contractor on account of Termination of this Agreement and that it shall not have any further right or claim under any law, treaty, convention, contract or otherwise.

23.7 Other rights and obligations of the Parties

Upon Termination for any reason whatsoever

(a) property and ownership in all Materials, Plant and Works and the Water Supply Project shall, as between the Contractor and the Authority, vest in the Authority in

whole; provided that the foregoing shall be without prejudice to Clause 23.6

(b) risk of loss or damage to any Materials, Plant or Works and the care and custody thereof shall pass from the Contractor to the Authority; and

(c) the Authority shall be entitled to restrain the Contractor and any person claiming through or under the Agreement from entering upon the Site or any part of the Project except for taking possession of materials, stores, implements, construction plants and equipment of the Contractor, which have not been vested in the Authority in accordance with the provisions of this Agreement.

23.8 Survival of rights

Notwithstanding anything to the contrary contained in this Agreement any Termination pursuant to the provisions of this Agreement shall be without prejudice to the accrued rights of either Party including its right to claim and recover money damages, insurance proceeds, security deposits, and other rights and remedies, which it may have in law or Agreement. All rights and obligations of either Party under this Agreement, including Termination Payments, shall survive the Termination up to a period of 3 (three) years for giving effect to such rights and obligations.

Part VI

Other Provisions

ARTICLE 24

ASSIGNMENT AND CHARGES

24.1 Restrictions on assignment and charges

This Agreement shall not be assigned by the Contractor to any person, save and except with the prior consent in writing of the Authority, which consent the Authority shall be entitled to decline without assigning any reason.

24.2 Hypothecation of Materials or Plant

Notwithstanding the provisions of Clause 24.1, the Contractor may pledge or hypothecate to its lenders, any Materials or Plant prior to their incorporation in the Works. Further, the Contractor may, by written notice to the Authority, assign its right to receive payments under this Agreement either absolutely or by way of charge, to any person providing financing to the Contractor in connection with the performance of the Contractor's obligations under this Agreement. The Contractor acknowledges that any such assignment by the Contractor shall not relieve the Contractor from any obligations, duty or responsibility under this Agreement.

ARTICLE 25

LIABILITY AND INDEMNITY

25.1 General indemnity

25.1.1 The Contractor will indemnify, defend, save and hold harmless the Authority and its officers, servants, agents, Government Instrumentalities and Government owned and/or controlled entities/enterprises, (the "**Authority Indemnified Persons**") against any and all suits, proceedings, actions, demands and third party claims for any loss, damage, cost and expense of whatever kind and nature, whether arising out of any breach by the Contractor of any of its obligations under this Agreement or from any negligence under the Agreement, including any errors or deficiencies in the design documents, or tort or on any other ground whatsoever, except to the extent that any such suits, proceedings, actions, demands and claims have arisen due to any negligent act or omission, or breach or default of this Agreement on the part of the Authority Indemnified Persons.

25.2 Indemnity by the Contractor

25.2.1 Without limiting the generality of Clause 25.1, the Contractor shall fully indemnify, hold harmless and defend the Authority and the Authority Indemnified Persons from and against any and all loss and/or damages arising out of or with respect to:

(a) failure of the Contractor to comply with Applicable Laws and Applicable Permits;

(b) payment of taxes required to be made by the Contractor in respect of the income or other taxes of the Sub-contractors, suppliers and representatives; or

(c) non-payment of amounts due as a result of Materials or services furnished to the Contractor or any of its Sub-contractors which are payable by the Contractor or any of its Sub-contractors.

25.2.2 Without limiting the generality of the provisions of this Article 25, the Contractor shall fully indemnify, hold harmless and defend the Authority Indemnified Persons from and against any and all suits, proceedings, actions, claims, demands, liabilities and damages which the Authority Indemnified Persons may hereafter suffer, or pay by reason of any demands, claims, suits or proceedings arising out of claims of infringement of any domestic or foreign patent rights, copyrights or other intellectual property, proprietary or confidentiality rights with respect to any materials, information, design or process used by the Contractor or by the Sub-contractors in performing the Contractor's obligations or in any way incorporated in or related to the Project. If in any such suit, action, claim or proceedings, a temporary restraint order or preliminary injunction is granted, the Contractor shall make every reasonable effort, by giving a satisfactory bond or otherwise, to secure the revocation or suspension of the injunction or restraint order. If, in any such suit, action, claim or proceedings, the Water Supply Project, or any part thereof or comprised therein, is held to constitute an infringement and its use is permanently enjoined, the Contractor shall promptly make every reasonable effort to secure for the Authority a licence, at no cost to the Authority, authorising continued use of the infringing work. If the Contractor is unable to secure such licence within a reasonable time, the Contractor shall, at its own expense, and without impairing the Specifications and Standards, either replace the affected work, or part, or process thereof with non-infringing work or part or process, or modify the same so that it becomes non-infringing.

25.3 Notice and contest of claims

In the event that either Party receives a claim or demand from a third party in respect of which it is entitled to the benefit of an indemnity under this Article 25 (the "**Indemnified Party**") it shall notify the other Party (the "**Indemnifying Party**") within 15 (fifteen) days

of receipt of the claim or demand and shall not settle or pay the claim without the prior approval of the Indemnifying Party, which approval shall not be unreasonably withheld or delayed. In the event that the Indemnifying Party wishes to contest or dispute the claim or demand, it may conduct the proceedings in the name of the Indemnified Party, subject to the Indemnified Party being secured against any costs involved, to its reasonable satisfaction.

25.4 Defence of claims

25.4.1 The Indemnified Party shall have the right, but not the obligation, to contest, defend and litigate any claim, action, suit or proceeding by any third party alleged or asserted against such Party in respect of, resulting from, related to or arising out of any matter for which it is entitled to be indemnified hereunder, and reasonable costs and expenses thereof shall be indemnified by the Indemnifying Party. If the Indemnifying Party acknowledges in writing its obligation to indemnify the Indemnified Party in respect of loss to the full extent provided by this Article 25, the Indemnifying Party shall be entitled, at its option, to assume and control the defence of such claim, action, suit or proceeding, liabilities, payments and obligations at its expense and through the counsel of its choice; provided it gives prompt notice of its intention to do so to the Indemnified Party and reimburses the Indemnified Party for the reasonable cost and expenses incurred by the Indemnified Party prior to the assumption by the Indemnifying Party of such defence. The Indemnifying Party shall not be entitled to settle or compromise any claim, demand, action, suit or proceeding without the prior written consent of the Indemnified Party, unless the Indemnifying Party provides such security to the Indemnified Party as shall be reasonably required by the Indemnified Party to secure the loss to be indemnified hereunder to the extent so compromised or settled.

25.4.2 If the Indemnifying Party has exercised its rights under Clause 25.3, the Indemnified Party shall not be entitled to settle or compromise any claim, action, suit or proceeding without the prior written consent of the Indemnifying Party (which consent shall not be unreasonably withheld or delayed).

25.4.3 If the Indemnifying Party exercises its rights under Clause 25.3, the Indemnified Party shall nevertheless have the right to employ its own counsel, and such counsel may participate in such action, but the fees and expenses of such counsel shall be at the expense of the Indemnified Party, when and as incurred, unless:

(a) the employment of counsel by such party has been authorised in writing by the Indemnifying Party; or

(b) the Indemnified Party shall have reasonably concluded that there may be a conflict of interest between the Indemnifying Party and the Indemnified Party in the conduct of the defence of such action; or

(c) the Indemnifying Party shall not, in fact, have employed independent counsel reasonably satisfactory to the Indemnified Party, to assume the defence of such action and shall have been so notified by the Indemnified Party; or

(d) the Indemnified Party shall have reasonably concluded and specifically notified the Indemnifying Party either:

(i) that there may be specific defences available to it which are different from or additional to those available to the Indemnifying Party; or

(ii) that such claim, action, suit or proceeding involves or could have a material adverse effect upon it beyond the scope of this Agreement:

Provided that if Sub-clauses (b), (c) or (d) of this Clause 25.4.3 shall be applicable, the counsel for the Indemnified Party shall have the right to direct the defence of

such claim, demand, action, suit or proceeding on behalf of the Indemnified Party, and the reasonable fees and disbursements of such counsel shall constitute legal or other expenses hereunder.

25.5 No consequential claims

Notwithstanding anything to the contrary contained in this Article 25, the indemnities herein provided shall not include any claim or recovery in respect of any cost, expense, loss or damage of an indirect, incidental or consequential nature, including loss of profit, except as expressly provided in this Agreement.

25.6 Survival on Termination

The provisions of this **Article 25** shall survive Termination.

ARTICLE 26

DISPUTE RESOLUTION

26.1 Dispute Resolution

26.1.1 Any dispute, difference or controversy of whatever nature howsoever arising under or out of or in relation to this Agreement (including its interpretation) between the Parties, and so notified in writing by either Party to the other Party (the "**Dispute**") shall, in the first instance, be attempted to be resolved amicably in accordance with the conciliation procedure set forth in Clause 26.2.

26.1.2 The Parties agree to use their best efforts for resolving all Disputes arising under or in respect of this Agreement promptly, equitably and in good faith, and further agree to provide each other with reasonable access during normal business hours to all non-privileged records, information and data pertaining to any Dispute.

26.2 Conciliation

In the event of any Dispute between the Parties, either Party may call upon the Authority's Engineer, or such other person as the Parties may mutually agree upon (the "**Conciliator**") to mediate and assist the Parties in arriving at an amicable settlement thereof. Failing mediation by the Conciliator or without the intervention of the Conciliator, either Party may require such Dispute to be referred to the Engineer-in-Chief (PH), Odisha and the Chairman of the Board of Directors of the Contractor for amicable settlement, and upon such reference, the said persons shall meet no later than 7 (seven) business days from the date of reference to discuss and attempt to amicably resolve the Dispute. If such meeting does not take place within the 7 (seven) business day period or the Dispute is not amicably settled within 15 (fifteen) days of the meeting or the Dispute is not resolved as evidenced by the signing of written terms of settlement within 30 (thirty) days of the notice in writing referred to in Clause 26.1.1 or such longer period as may be mutually agreed by the Parties, either Party may refer the Dispute to arbitration in accordance with the provisions of Clause 26.3.

26.3 Arbitration

26.3.1 Any Dispute which is not resolved amicably by conciliation, as provided in Clause 26.2, shall be finally decided by reference to arbitration by a Board of Arbitrators appointed in accordance with Clause 26.3.2. Such arbitration shall be held in accordance with the Arbitration and Conciliation Act, 1996 of India. The venue of such arbitration shall be [Bhubaneswar], and the language of arbitration proceedings shall be English.

26.3.2 There shall be a Board of three arbitrators, of whom each Party shall select one, and the third arbitrator shall be appointed by the two arbitrators so selected and in the event of disagreement between the two arbitrators, the appointment shall be made in accordance with the Rules.

26.3.3 The arbitrators shall make a reasoned award (the "**Award**"). Any Award made in any arbitration held pursuant to this Article 26 shall be final and binding on the Parties as from the date it is made, and the Contractor and the Authority agree and undertake to carry out such Award without delay.

26.3.4 The Contractor and the Authority agree that an Award may be enforced against the Contractor and/or the Authority, as the case may be, and their respective assets wherever situated.

26.3.5 This Agreement and the rights and obligations of the Parties shall remain in full force and effect, pending the Award in any arbitration proceedings hereunder.

26.3.6 In the event the Party against whom the Award has been granted challenges the Award for any reason in a court of law, it shall make an interim payment to the

other Party for an amount equal to **75%** (seventy five per cent) of the Award, pending final settlement of the Dispute. The aforesaid amount shall be paid forthwith upon furnishing an irrevocable Bank Guarantee for a sum equal to 120 % (one hundred and twenty per cent) of the aforesaid amount. Upon final settlement of the Dispute, the aforesaid interim payment shall be adjusted and any balance amount due to be paid or returned, as the case may be, shall be paid or returned with interest calculated at the rate of 10% (ten per cent) per annum from the date of interim payment to the date of final settlement of such balance.

26.4 Adjudication by Regulatory Authority, Tribunal or Commission

In the event of constitution of a statutory regulatory authority, tribunal or commission, as the case may be, with powers to adjudicate upon disputes between the Contractor and the Authority, all Disputes arising after such constitution shall, instead of reference to arbitration under Clause 26.3, be adjudicated upon by such regulatory authority, tribunal or commission in accordance with the Applicable Law and all references to Dispute Resolution Procedure shall be construed accordingly. For the avoidance of doubt, the Parties hereto agree that the adjudication hereunder shall not be final and binding until an appeal against such adjudication has been decided by an appellate tribunal or court of competent jurisdiction, as the case may be, or no such appeal has been preferred within the time specified in the Applicable Law.

ARTICLE 27

MISCELLANEOUS

27.1 Governing law and jurisdiction

This Agreement shall be construed and interpreted in accordance with and governed by the laws of Odisha/ India, and the courts at [Bhubaneswar] shall have exclusive jurisdiction over matters arising out of or relating to this Agreement.

27.2 Waiver of immunity

Each Party unconditionally and irrevocably:

(a) agrees that the execution, delivery and performance by it of this Agreement constitute commercial acts done and performed for commercial purpose;

(b) agrees that, should any proceedings be brought against it or its assets, property or revenues in any jurisdiction in relation to this Agreement or any transaction contemplated by this Agreement, no immunity (whether by reason of sovereignty or otherwise) from such proceedings shall be claimed by or on behalf of the Party with respect to its assets;

(c) waives any right of immunity which it or its assets, property or revenues now has, may acquire in the future or which may be attributed to it in any jurisdiction; and

(d) consents generally in respect of the enforcement of any judgement or award against it in any such proceedings to the giving of any relief or the issue of any process in any jurisdiction in connection with such proceedings (including the making, enforcement or execution against it or in respect of any assets, property or revenues whatsoever irrespective of their use or intended use of any order or judgement that may be made or given in connection therewith).

27.3 Delayed payments

The Parties hereto agree that payments due from one Party to the other Party under the provisions of this Agreement shall be made within the period set forth therein, and if no such period is specified, within 30 (thirty) days of receiving a demand along with the necessary particulars. In the event of delay beyond such period, the defaulting Party shall pay interest for the period of delay calculated at a rate equal to Base Rate plus 2 (two) percent, calculated at quarterly rests, and recovery thereof shall be without prejudice to the rights of the Parties under this Agreement including Termination thereof.

27.4 Waiver

27.4.1 Waiver, including partial or conditional waiver, by either Party of any default by the other Party in the observance and performance of any provision of or obligations under this Agreement:-

(a) shall not operate or be construed as a waiver of any other or subsequent default hereof or of other provisions of or obligations under this Agreement;

(b) shall not be effective unless it is in writing and executed by a duly authorised representative of the Party; and

(c) shall not affect the validity or enforceability of this Agreement in any manner.

27.4.2 Neither the failure by either Party to insist on any occasion upon the performance of the terms, conditions and provisions of this Agreement or any obligation there under nor time or other indulgence granted by a Party to the other Party shall be treated or deemed as waiver of such breach or acceptance of any variation or the relinquishment of any such right hereunder.

27.5 Liability for review of Documents and Drawings

Except to the extent expressly provided in this Agreement:

(a) no review, comment or approval by the Authority or the Authority's Engineer of any Document or Drawing submitted by the Contractor nor any observation or inspection of the construction or operation & maintenance of the Water Supply Project nor the failure to review, approve, comment, observe or inspect hereunder shall relieve or absolve the Contractor from its obligations, duties and liabilities under this Agreement, the Applicable Laws and Applicable Permits; and

(b) the Authority shall not be liable to the Contractor by reason of any review, comment, approval, observation or inspection referred to in Sub-clause (a) above.

27.6 Exclusion of implied warranties etc.

This Agreement expressly excludes any warranty, condition or other undertaking implied at law or by custom or otherwise arising out of any other agreement between the Parties or any representation by either Party not contained in a binding legal agreement executed by both Parties.

27.7 Survival

27.7.1 Termination shall:

(a) not relieve the Contractor or the Authority, as the case may be, of any obligations hereunder which expressly or by implication survive Termination hereof; and

(b) except as otherwise provided in any provision of this Agreement expressly limiting the liability of either Party, not relieve either Party of any obligations or liabilities for loss or damage to the other Party arising out of, or caused by, acts or omissions of such Party prior to the effectiveness of such Termination or arising out of such Termination.

27.7.2 All obligations surviving Termination/ final settlements shall only survive for a period of 3 (three) years following the date of such Termination/ final settlements.

27.8 Entire Agreement

This Agreement and the Schedules together constitute a complete and exclusive statement of the terms of the agreement between the Parties on the subject hereof, and no amendment or modification hereto shall be valid and effective unless such modification or amendment is agreed to in writing by the Parties and duly executed by persons especially empowered in this behalf by the respective Parties. All prior written or oral understandings, offers or other communications of every kind pertaining to this Agreement are abrogated and withdrawn. For the avoidance of doubt, the Parties hereto agree that any obligations of the Contractor arising from the Request for Qualification or Request for Proposals, as the case may be, shall be deemed to form part of this Agreement and treated as such.

27.9 Severability

If for any reason whatever, any provision of this Agreement is or becomes invalid, illegal or unenforceable or is declared by any court of competent jurisdiction or any other instrumentality to be invalid, illegal or unenforceable, the validity, legality or enforceability of the remaining provisions shall not be affected in any manner, and the Parties will negotiate in good faith with a view to agreeing to one or more provisions which may be substituted for such invalid, unenforceable or illegal provisions, as nearly as is practicable to such invalid, illegal or unenforceable provision. Failure to agree upon any such provisions shall not be subject to the Dispute Resolution Procedure set forth under this Agreement or otherwise.

27.10 No partnership

This Agreement shall not be interpreted or construed to create an association, joint venture or partnership between the Parties, or to impose any partnership obligation or liability upon either Party, and neither Party shall have any right, power or authority to enter into any agreement or undertaking for, or act on behalf of, or to act as or be an agent or representative of, or to otherwise bind, the other Party.

27.11 Third parties

This Agreement is intended solely for the benefit of the Parties, and their respective successors and permitted assigns, and nothing in this Agreement shall be construed to create any duty to, standard of care with reference to, or any liability to, any person not a Party to this Agreement.

27.12 Successors and assigns

This Agreement shall be binding upon, and inure to the benefit of the Parties and their respective successors and permitted assigns.

27.13 Notices

Any notice or other communication to be given by any Party to the other Party under or in connection with the matters contemplated by this Agreement shall be in writing and shall:

(a) in the case of the Contractor, be given by facsimileor e-mail and by letter delivered by hand to the address given and marked for attention of the person set out below or to such other person as the Contractor may from time to time designate by notice to the Authority; provided that notices or other communications to be given to an address within Odisha may, if they are subsequently confirmed by sending a copy thereof by registered acknowledgement due, air mail or by courier, be sent by facsimile or e-mail to the person as the Contractor may from time to time designate by notice to the Authority;
[***]

(b) in the case of the Authority, be given by facsimile or e-mail and by letter delivered by hand and be addressed to the Authority with a copy delivered to the Authority Representative or such other person as the Authority may from time to time designate by notice to the Contractor; provided that if the Contractor does not have an office in [Bhubaneswar] it may send such notice by facsimile or e-mail and by registered acknowledgement due, air mail or by courier; and

(c) any notice or communication by a Party to the other Party, given in accordance herewith, shall be deemed to have been delivered when in the normal course of post it ought to have been deliveredand in all other cases, it shall be deemed to have been delivered on the actual date and time of delivery; provided that in the case of facsimile or e-mail, it shall be deemed to have been delivered on the working day following the date of its delivery.

27.14 Language

All notices required to be given by one Party to the other Party and all other communications, Documentation and proceedings which are in any way relevant to this Agreement shall be in writing and in English language.

27.15 Counterparts

This Agreement may be executed in two counterparts, each of which, when executed and delivered, shall constitute an original of this Agreement.

27.16 Confidentiality

The Parties shall treat the details of this Agreement as private and confidential, except to the extent necessary to carry out obligations under it or to comply with Applicable Laws. The Contractor shall not publish, permit to be published, or disclose any particulars of the

Works in any trade or technical paper or elsewhere without the previous agreement of the Authority.

27.17 Copyright and Intellectual Property rights

27.17.1 As between the Parties, the Contractor shall retain the copyright and other intellectual property rights in the Contractor's Documents and other design documents made by (or on behalf of) the Contractor. The Contractor shall be deemed (by signing this Agreement) to give to the Authority a non-terminable transferable non-exclusive royalty-free licence to copy, use and communicate the Contractor's Documents, including making and using modifications of them. This licence shall:

(a) apply throughout the actual or intended working life (whichever is longer) of the relevant parts of the Works,

(b) entitle any person in proper possession of the relevant part of the Works to copy, use and communicate the Contractor's Documents for the purposes of completing, operating, maintaining, altering, adjusting, repairing and demolishing the Works, and

(c) in the case of Contractor's Documents which are in the form of computer programs and other software, permit their use on any computer on the Site and other places as envisaged by this Agreement, including replacements of any computers supplied by the Contractor:

27.17.2 The Contractor's Documents and other design documents made by (or on behalf of) the Contractor shall not, without the Contractor's consent, be used, copied or communicated to a third party by (or on behalf of) the Authority for purposes other than those permitted under this Clause 27.17.

27.17.3 As between the Parties, the Authority shall retain the copyright and other intellectual property rights in this Agreement and other documents made by (or on behalf of) the Authority. The Contractor may, at its cost, copy, use, and obtain communication of these documents for the purposes of this Agreement. They shall not, without the Authority's consent, be copied, used or communicated to a third party by the Contractor, except as necessary for the purposes of the contract.

27.18 Limitation of Liability

27.18.1 Neither Party shall be liable to the other Party for loss of use of any Works, loss of profit, loss of any contract or for any indirect or consequential loss or damage which may be suffered by the other Party in connection with this Agreement, save and except as provided under Articles 23 and 25.

27.18.2 The total liability of one Party to the other Party under and in accordance with the provisions of this Agreement, save and except as provided in Articles 23 and 25, shall not exceed the Contract Price. For the avoidance of doubt, this Clause shall not limit the liability in any case of fraud, deliberate default or reckless misconduct by the defaulting Party.

ARTICLE 28

DEFINITIONS

28.1 Definitions

In this Agreement, the following words and expressions shall, unless repugnant to the context or meaning thereof, have the meaning hereinafter respectively assigned to them:

"**Accounting Year**" means the financial year commencing from the first day of April of any calendar year and ending on the thirty-first day of March of the next calendar year;

"**Advance Payment**" shall have the meaning set forth in Clause 19.2;

"**Affected Party**" shall have the meaning set forth in Clause 21.1;

"**Affiliate**" means, in relation to either Party {and/or Members}, a person who controls, is controlled by, or is under the common control with such Party {or Member} (as used in this definition, the expression "control" means, with respect to a person which is a company or corporation, the ownership, directly or indirectly, of more than 50% (fifty per cent) of the voting shares of such person, and with respect to a person which is not a company or corporation, the power to direct the management and policies of such person, whether by operation of law or by contract or otherwise);

"Agreement" means this Agreement, its Recitals, the Schedules hereto and any amendments thereto made in accordance with the provisions contained in this Agreement;

"Applicable Laws" means all laws, brought into force and effect by GOI or the State Government including rules, regulations and notifications made there under, and judgements, decrees, injunctions, writs and orders of any court of record, applicable to this Agreement and the exercise, performance and discharge of the respective rights and obligations of the Parties hereunder, as may be in force and effect during the subsistence of this Agreement;

"Applicable Permits" means all clearances, licences, permits, authorisations, no objection certificates, consents, approvals and exemptions required to be obtained or maintained under Applicable Laws in connection with the construction, operation and maintenance of the Water Supply Projects during the subsistence of this Agreement;

"**Appointed Date**" means that date which is later of the 15th day of the date of this Agreement, the date on which the Contractor has delivered the Performance Security in accordance with the provisions of Article 7 and the date on which the Authority has provided the land / site on no less than **90%** (Ninety per cent) of the required area of major structures of the ***Water Supply Project***;

"Arbitration Act" means the Arbitration and Conciliation Act, 1996 and shall include modifications to or any re-enactment thereof, as in force from time to time;

"Authority" shall have the meaning attributed thereto in the array of Parties hereinabove as set forth in the Recitals;

"Authority Default" shall have the meaning set forth in Clause 23.2;

"Authority's Engineer" shall have the meaning set forth in Clause 18.1;

"Authority Representative" means such person or persons as may be authorised in writing by the Authority to act on its behalf under this Agreement and shall include any person or persons having authority to exercise any rights or perform and fulfil any obligations of the Authority under this Agreement;

"Bank" means a Nationalised Bank in India;

"Base Rate" means the floor rate of interest announced by the State Bank of India for all its lending operations;

"Base Date" means the last date of that calendar month, which date precedes the Bid Due Date by at least 28 (twenty eight) days;

"Bid" means the documents in their entirety comprised in the bid submitted by the [selected bidder/Consortium] in response to the Request for Proposalsin accordance with the provisions thereof;

"**Bid Security**" means the bid security provided by the Contractor to the Authority in accordance with the Request for Proposal, and which is to remain in force until substituted by the Performance Security;

"Change in Law" means the occurrence of any of the following after the Base Date:

(a) the enactment of any new Indian law;

(b) the repeal, modification or re-enactment of any existing Indian law;

(c) the commencement of any Indian law which has not entered into effect until the Base Date;

(d) a change in the interpretation or application of any Indian law by a judgement of a court of record which has become final, conclusive and binding, as compared to such interpretation or application by a court of record prior to the Base Date; or

(e) any change in the rates of any of the Taxes or royalties that have a direct effect on the Project;

"Change of Scope" shall have the meaning set forth in Article 13;

"Change of Scope Notice" shall have the meaning set forth in Clause 13.2.1;

"Change of Scope Order" shall have the meaning set forth in Clause 13.2.4;

"Completion Certificate" shall have the meaning set forth in Clause 12.4;

{"Consortium" means the consortium of entities which have formed a joint venture for implementation of this Project;}[$]

"Construction" shall have the meaning set forth in Clause 1.2.1 (f);

"Construction Period" means the period commencing from the Appointed Date and ending on the date of the Completion Certificate;

"Contract Price" means the amount specified in Clause 19.1.1;

"Contractor" shall have the meaning attributed thereto in the array of Parties hereinabove as set forth in the Recitals;

"Contractor Default" shall have the meaning set forth in Clause 23.1;

"Cure Period" means the period specified in this Agreement for curing any breach or default of any provision of this Agreement by the Party responsible for such breach or default and shall:

(a) commence from the date on which a notice is delivered by one Party to the other Party asking the latter to cure the breach or default specified in such notice;

(b) not relieve any Party from liability to pay Damages or compensation under the provisions of this Agreement; and

(c) not in any way be extended by any period of Suspension under this Agreement; provided that if the cure of any breach by the Contractor requires any reasonable action by the Contractor that must be approved by the Authority or the Authority's Engineer hereunder, the applicable Cure Period shall be extended by the period taken by the Authority or the Authority's Engineer to accord their approval;

"CPHEEO" means Central Public Health & Environmental Engineering Organisation, MoUD, Govt. of India.

[$]This definition may be omitted if the Contractor is not a Consortium.

"Damages" shall have the meaning set forth in paragraph (w) of Clause 1.2.1;

"Defect" means any defect or deficiency in Construction of the Works or any part thereof, which does not conform with the Specifications and Standards, and in the case of

Operation & Maintenance, means any defect or deficiency which is specified in **Schedule-E**;

"Defects Liability Period" shall have the meaning set forthin Clause 17.1;

"Dispute" shall have the meaning set forth in Clause 26.1.1;

"Dispute Resolution Procedure" means the procedure for resolution of Disputes set forth in Article 26;

"Drawings" means all of the drawings, calculations and documents pertaining to the Water Supply Project as set forth in Schedule-I, and shall include 'as built' drawings of the Water Supply Project;

"Document" or "Documentation" means documentation in printed or written form, or in tapes, discs, drawings, computer programmes, writings, reports, photographs, films, cassettes, or expressed in any other written, electronic, audio or visual form;

"Emergency" means a condition or situation that is likely to endanger the safety or security of the individuals on or about the Water Supply Project, including Users thereof, or which poses an immediate threat of material damage to any of the Project Assets;

"Encumbrances" means, in relation to the Water Supply Project, any encumbrances such as mortgage, charge, pledge, lien, hypothecation, security interest, assignment, privilege or priority of any kind having the effect of security or other such obligations, and shall include any designation of loss payees or beneficiaries or any similar arrangement under any insurance policy pertaining to the Water Supply Project, where applicable herein but excluding utilities referred to in Clause 9.1;

"EPC" means engineering, procurement and construction;

"Final Payment Certificate"shall have the meaning set forth in Clause 19.15.1;

"**Final Payment Statement**"shall have the meaning set forth in Clause 19.13.1;

"Force Majeure" or "Force Majeure Event" shall have the meaning ascribed to it in Clause 21.1;

"GAD" or "General Arrangement Drawings" shall have the meaning set forth in Clause 4.1.3 (b);

"GOI" or "Government" means the Government of India;

"Good Industry Practice" means the practices, methods, techniques, designs, standards, skills, diligence, efficiency, reliability and prudence which are generally and reasonably expected from a reasonably skilled and experienced contractor engaged in the same type of undertaking as envisaged under this Agreement and which would be expected to result in the performance of its obligations by the Contractor in accordance with this Agreement, Applicable Laws and Applicable Permits in reliable, safe, economical and efficient manner;

"Government Instrumentality" means any department, division or sub-division of the Government or the State Government and includes any commission, board, authority, agency or municipal and other local authority or statutory body including panchayat under the control of the Government or the State Government, as the case may be, and having jurisdiction over all or any part of the Water Supply Project or the performance of all or any of the services or obligations of the Contractor under or pursuant to this Agreement;

"IRC" means the Indian Roads Congress;

"Indemnified Party" means the Party entitled to the benefit of an indemnity pursuant to Article 25;

"Indemnifying Party" means the Party obligated to indemnify the other Party pursuant to Article 25;

"Indirect Political Event" shall have the meaning set forth in Clause 21.3;

"Insurance Cover" means the aggregate of the maximum sums insured under the

insurances taken out by the Contractor pursuant to Article 20, and includes all insurances required to be taken out by the Contractor under Clauses 20.1 and 20.9 but not actually taken, and when used in the context of any act or event, it shall mean the aggregate of the maximum sums insured and payable or deemed to be insured and payable in relation to such act or event;

"Intellectual Property" means all patents, trademarks, service marks, logos, get-up, trade names, internet domain names, rights in designs, blue prints, programmes and manuals, drawings, copyright (including rights in computer software), database rights, semi-conductor, topography rights, utility models, rights in know-how and other intellectual property rights, in each case whether registered or unregistered and including applications for registration, and all rights or forms of protection having equivalent or similar effect anywhere in the world;

"**Interim Payment Certificate**" or "**IPC**" means the interim payment certificate issued by the Authority's Engineer for payment to the Contractor in respect of Contractor's claims for payment raised in accordance with the provisions of this Agreement;

{"Lead Member" shall, in the case of a consortium, mean the member of such consortium who shall have the authority to bind the contractor and each member of the Consortium; and shall be deemed to be the Contractor for the purposes of this Agreement;}[$]

"LOA" or **"Letter of Acceptance"** means the letter of acceptance referred to in Recital (E);

"Operation & Maintenance" means the operation & maintenance of the Water Supply Projectas set forth in Article 14 for the period specified therein;

"**Operation & Maintenance Inspection Report**" shall have the meaning set forth in Clause 15.2.1;

"Operation & Maintenance Manual" shall have the meaning ascribed to it in Clause 10.7;

"Operation & Maintenance Programme" shall have the meaning set forth in Clause 14.3;

"Operation & MaintenancePeriod" shall have the meaning set forth in Clause 14.1.1;

"Operation & Maintenance Requirements" shall have the meaning set forth in Clause 14.2;

"Major structures" means different units & components of WTP, ESR, GSR, Intake arrangement, pumping stations;

"**Manual**" shall mean the Manual on water supply published by CPHEEO, MoUD, GoI;

"Material Adverse Effect" means a material adverse effect of any act or event on the ability of either Party to perform any of its obligations under and in accordance with the provisions of this Agreement and which act or event causes a material financial burden or loss to either Party;

"Materials" are all the supplies used by the Contractor for incorporation in the Works or for the Operation & Maintenance of the Water Supply Project;

"Monthly Operation & Maintenance Statement shall have the meaning set forth in Clause 19.6.1;

"**MoUD**" means the Ministry of Urban Development, GoI;

"**Non-Political Event**" shall have the meaning set forth in Clause 21.2;

"Parties" means the parties to this Agreement collectively and "Party" shall mean any of the parties to this Agreement individually;

$This definition may be omitted if the Contractor is not a Consortium.

“Performance Security” shall have the meaning set forth in Clause 7.1;

“Plant” means the apparatus and machinery intended to form or forming part of the Works;

“Political Event” shall have the meaning set forth in Clause 21.4;

“Programme” shall have the meaning set forth in Clause 10.1.3;

“Project” means the construction and operation & maintenance of the Water Supply Project in accordance with the provisions of this Agreement, and includes all works, services and equipment relating to or in respect of the Scope of the Project;

“Project Assets” means all physical and other assets relating to (a) tangible assets such as civil works, electrical works, mechanical works and equipments, electrical systems, communication systems, rest areas and administrative offices, laboratory facilities; and (b) Project Facilities situated on the Site; etc.

“Project Completion Date” means the date on which the Provisional Certificate is issued and in the event no Provisional Certificate is issued, the date on which the Completion Certificate is issued;

“Project Completion Schedule” means the progressive Project Milestones set forth in Schedule-J for completion of the Water Supply Project on or before the Scheduled Completion Date;

“Project Facilities” means all the amenities and facilities situated on the Site, as described in Schedule-C;

“**Water Supply Project**” means the proposed water supply project to be executed as mentioned at Annex –I of schedule –A in accordance with this Agreement;

“Project Milestone” means the project milestone set forth in Schedule-J;

“Proof Consultant” shall have the meaning set forth in Clause 10.2.2;

“Provisional Certificate” shall have the meaning set forth in Clause 12.2;

“Punch List” shall have the meaning set forth in Clause 12.2.1;

“Quality Assurance Plan” or **“QAP”** shall have the meaning set forth in Clause 11.2**;**

“Re.”, “Rs.” or “Rupees” or “Indian Rupees” means the lawful currency of the Republic of India;

“**Request for Proposals**” *or* “**RFP**” shall have the meaning set forth in Recital ‘D’;

“Request for Qualification” or “RFQ” shall have the meaning set forth in Recital ‘C’;

“Retention Money” shall have the meaning set forth in Clause 7.5.1;

“Land / Site” means the constructive possession of the Site free from encroachments and encumbrances, together with all way leaves, easements, unrestricted access and other rights of way, howsoever described, necessary for construction and operation & maintenance of the Water Supply Project in accordance with this Agreement;

“**Safety Consultant**” shall have the meaning set forth in Clause 10.1.5;

“Scheduled Completion Date” shall be the date set forth in Clause 10.3.1;

“Scope of the Project” shall have the meaning set forth in Clause 2.1;

“Section” means a part of the ***Water Supply Project***;

“Site” shall have the meaning set forth in Clause 8.1;

“Specifications and Standards” means the specifications and standards relating to the quality, quantity, capacity and other requirements for the Water Supply Project, as set forth in Schedule-D, and any modifications thereof, or additions thereto, as included in the design and engineering for the Water Supply Project submitted by the Contractor to, and expressly approved by, the Authority;

"**Stage Payment Statement**" shall have the meaning set forth in Clause 19.4;

"**Structures**" means all civil, electrical and mechanical installations, as the case may be;

"Sub-contractor" means any person or persons to whom a part of the Works or the Operation & Maintenance has been subcontracted by the Contractor and the permitted legal successors in title to such person, but not an assignee to such person;

"Suspension" shall have the meaning set forth in Article 22;

"Taxes" means any Indian taxes including **GST**, customs duties, cess and any impost or surcharge of like nature (whether Central, State or local) on the goods, Materials, equipment and services incorporated in and forming part of the ***Water Supply Project*** charged, levied or imposed by any Government Instrumentality, but excluding any interest, penalties and other sums in relation thereto imposed on any account whatsoever. For the avoidance of doubt, Taxes shall not include taxes on corporate income;

"Termination" means the expiry or termination of this Agreement;

"Termination Notice" means the communication issued in accordance with this Agreement by one Party to the other Party terminating this Agreement;

"Termination Payment" means the amount payable by either Party to the other upon Termination in accordance with Article 23;

"Terms of Reference" or "TOR" shall have the meaning set forth in Clause 18.2.1;

"Tests" means the tests set forth in Schedule-K to determine the completion of Works in accordance with the provisions of this Agreement;

"Time Extension" shall have the meaning set forth in Clause 10.5.1;

"User" means a person who uses or intends to use water from the Water Supply Project.

"**Valuation of Unpaid works**" shall have the meaning set forth in Clause 23.5.1;

"Works" means all works including survey and investigation, design, engineering, procurement, construction, Plant, Materials, operation & maintenance, temporary works and other things necessary to complete the Water Supply Project in accordance with this Agreement; and

"WPI" means the wholesale price index for various commodities as published by the Ministry of Commerce and Industry, GOI and shall include any index which substitutes the WPI, and any reference to WPI shall, unless the context otherwise requires, be construed as a reference to the WPI published for the period ending with the preceding month.

IN WITNESS WHEREOF THE PARTIES HAVE EXECUTED AND DELIVERED THIS AGREEMENT AS OF THE DAY, MONTH AND YEAR FIRST ABOVE WRITTEN.

SIGNED, SEALED AND DELIVERED For and on behalf of **[CHIEF EXECUTIVE OFFICER, WATCO]** by: (Signature) (Name) (Designation) In the presence of: 1. 2.	SIGNED, SEALED AND DELIVERED For and on behalf of THE CONTRACTOR by: (Signature) (Name) (Designation)

{COUNTERSIGNED and accepted by:
Name and particulars of other members of the Consortium}

SCHEDULES

Schedule A & B for "Construction of 130MLD Water Treatment Plant and its Ancillary Structures for Improvement of Water Supply to Bhubaneswar City" – Page: 107 – 142

SCHEDULE – A
(See Clauses 2.1 and 8.1)

SITE OF THE PROJECT

1. The Site Bhubaneswar

1. Site of the Water Supply Project shall include **Construction of "Double 'D' Type" Intake well of 20 M depth for lifting of 130.00 MLD water from river Mahanadi (at Mundali), 130 MLD capacity Conventional Water Treatment Plant, Laying of Raw water & Clear water Rising Main, 30.00 ML capacity RCC Double Chamber Master Balancing Reservoir (MBR), 2 (Two) Nos 3.00 ML capacity RCC Elevated Storage Reservoir (ESR) and supply & installation of Pump sets, Sub-stations along with transformer, DG Sets and with other Ancillary Structures for Improvement of Water Supply to Bhubaneswar City**, etc. as described in Annex-I of this Schedule-A.

2. The dates of handing over the site to the Contractor are specified in Annex-II of this Schedule-A.

3. An inventory of the Site including the land, buildings, structures, road works, trees and any other immovable property on, or attached to, the Site shall be prepared jointly by the Authority Representative and the Contractor, and such inventory shall form part of the memorandum referred to in Clause 8.2.1 of this Agreement.

4. The alignment plans of the Water Supply Project are specified in Annex-III.

5. The status of the environment clearances obtained or awaited is given in Annex IV.

SCHEDULE – A
(Annex – I)

SITE

[Note: Through suitable drawings and description in words, the land, buildings, structures and road works comprising the Site shall be specified briefly but precisely in this Annex-I.]

1. Site

The work **"Construction of 130 MLD Water Treatment Plant and its Ancillary Structures for Improvement of Water Supply to Bhubaneswar City" on Engineering, Procurement & Construction (EPC) Contract Including Operation & Maintenance for a Period of Five Years** comprises the "Double 'D' Type" Intake well of 20 M depth inside river Mahanadi at Mundali, 130 MLD capacity Conventional WTP, Laying of Raw water & Clear water Rising Main, 30.00 ML capacity RCC Double Chamber Master Balancing Reservoir (MBR), 2 (Two) Nos 3.00 ML capacity RCC Elevated Storage Reservoir (ESR) and supply & installation of Pump sets, Sub-stations along with transformer, DG Sets and with other Ancillary Structures for Improvement of Water Supply to Bhubaneswar City in the State of Odisha. The details of which are described below.

2. Intake Arrangement (in River Mahanadi at Mundali)

SN	Place	Location	Area	Remarks
1.	Mundali	Naraj		Intake will be constructed on the bank of the river Mahanadi at Mundali

3. Water Treatment Plant site

SN	Place	Land Mark	Mouza / Khata No/ Plot No/ Kisam	Area	Remarks
1.	Mundali	Naraj Barrage	Mundali	Available	Govt. land

4. Alignment of Raw Water Rising Main

The Raw water Rising Main will originate from Intake Point at Mundali & will be laid up to proposed **130.00 MLD** capacity WTP at Naraj which is 800mtr away from Intake Arrangement.

5. Storage Reservoirs & Pumping Stations:

Zone No.	**Proposed Storage Reservoir & pumping stations**	**Place**	**Land Mark**	**Mouza/ Khata No./ Plot No./ Kissam**	**Area**	**Remarks**
1.	MBR 30 ML &	Sikharachandi		IDCO land	Ac.4.00	
2	ESR 3.0 ML					
3	ESR 3.0 ML					

- Appropriate area of land shall be alienated out of the total plot area mentioned above.

8. Alignment of Clear Water Rising Main & Distribution System

The Clear water Rising Main & distribution lines will be laid as per scope of work along the PWD Road/ RD Department Road/ ULB Road.

Annex - II
(Schedule-A)

Dates for providing different construction site

The dates on which the Authority shall provide site to the Contractor are stated below:

BHUBANESWAR

Sl. No	Details of location	Date of providing the site
1	**2**	**3**
1.	**130 MLD Water Treatment Plant**	Within 90 Days
2.	**MBR & ESR**	Within 30 Days

* The dates specified herein shall in no case be beyond 180 (One hundred and eighty) days after the Appointed Date.

Annex – III
(Schedule-A)

Alignment Plans

The proposed Layout Plan of Water Supply Project and General Arrangement of Intake Point, WTP & Zonal Distribution Areas of **Bhubaneswar** are as indicated below:

(i) Intake arrangement in River Mahanadi near Mundali/Naraj (Permission to be given by Water Resources Department.

(ii) Line plan of Raw water main to WTP & Clear water rising main to proposed MBR & 2 Nos ESR at Sikharachandi .

Annex - IV
(Schedule-A)

Environment Clearances

Requirement of any Environment clearance is being assessed.

SCHEDULE - B

(See Clause 2.1)

Development of the Water Supply Projects

1 Development of the Water Supply Projects

Development of the Water Supply Projects shall include design and construction of the Water Supply Project as described in this Schedule-B and in Schedule-C.

2 [Improvement and augmentation]

Improvement and augmentation shall include up-gradation of the existing system as described in Annex-I of Schedule-B and Schedule-C.

3 Specifications and Standards

The Water Supply Projects shall be designed and constructed in conformity with the Scope, Specifications and Standards specified in Annex-I of Schedule-D.

Annex - I

(Schedule-B)

Description of the Water Supply Project

1. General Features of the Water Supply Project

The intent of this Section is to specify the work items to be covered on **'EPC Contract Basis'** in conformity with the technical specifications as enumerated in the subsequent clauses for the work **"Construction of 130 MLD Water Treatment Plant and its Ancillary Structures for Improvement of Water Supply to Bhubaneswar City" on Engineering, Procurement & Construction (EPC) Contract Including Operation & Maintenance for a Period of Five Years".**

The present water supply scheme for **Bhubaneswar City** has been planned to receive water from River Mahanadi with following broad provision:

- Detail Survey, Investigation, Soil Testing shall be done before execution of the Water Supply Project.

- **Construction of Intake arrangement** for lifting **130.00 MLD** water from river Mahanadi (Source) at **Mundali,** by constructing **"Double 'D' Type"** Intake well of **20 M** depth with **3.50 M** wide R.C.C./MS Foot Bridge including necessary Leading Channel, Sludge Dewatering Chamber etc all complete.

- Intake well Pump house shall be a double storied structure of minimum (**3.5+5.5**) **9.00 M** height over intake well. The Pump house shall be fitted with **EOT crane** of suitable capacity with lateral and transverse movement for lifting, lowering and shifting of pumps etc with cable trench & **1.50 M** wide walk-way all around. The bottom floor shall be Valve house & top floor shall be Pump House.

- Supply & laying of **1422.4 mm (OD)** size **S.W.M.S** (12mm thick) Pipe line (external PU Coating & internal Food Grade Epoxy Coating) about **800M** long as Raw Water Rising Main **from Intake** to Proposed **130.00 MLD** capacity **WTP** at **Naraj**.

- The raw water shall be lifted from the intake through installation of **4 Nos**. of **400 HP** capacity **VT Pump sets** (2w + 2s) with VFD.

- External & internal Power Supply for operation of Pump sets with installation of **4 Nos**. of **750 KVA 33/3.3** substation along with (HT & LT Transformer including 100% Stand-by) and drawl of required length of HT transmission line from available source to the **Intake Pump house**. Incomer **VCB 33KV** and Service Transformer **1 No** of **100** KVA **33/0.4** including 4 Nos of **3.3 Incomer indoor Panel** with **breaker, feeder, bus coupler, Battery bank charger** with HT Power to be provided for **Intake Pump house. One 33 KVA Substation** to be installed at **Intake Pump house.**

- **4(Four)** Nos. **650.00 KVA capacity (HT 3.3 KV grade) Silent DG set**s with NGR, NIS & AMF panel and **1(One)** Nos. **100.00 KVA capacity (0.415 Grade) Silent DG set**s with NGR, NIS & AMF panel shall be provided as back-up power supply for Pumping arrangement at **Intake Pump house.**

- **Construction of 130.00 MLD capacity Conventional Water Treatment Plant** at Mundali/Naraj with Cascade aerator, raw water channel, Flash mixer, Clarifloculator, Filter House with Back Wash arrangement, Clear Water Reservoir, Chemical House, Chemical dosing arrangement, Chlorine House, Chlorine dosing/Chlorination Arrangement with Gas Chlorinator, Chlorine Cylinders & Safety Devices, Clear Water Pump House, necessary By-pass arrangements, Administrative Block & Laboratory, installation of Electromagnetic flow meters, internal roads & drain, Road & yard lighting, Sludge Recycling & treatment unit, Under Ground Drainage, Waste Water Disposal System & On-site Sanitation at Treatment Plant site and arboriculture etc.

- The Clear water shall be supplied from CWR through installation of **6 Nos**. of **350 HP** capacity at WTP Pump house **Centrifugal Pump sets**.

- External & internal Power Supply for operation of Pump sets with installation of **6 Nos**. of **750** KVA **33/3.3** substation along with (HT & LT Transformer including 100% Stand-by) and drawl of required length of HT transmission line from available source to the **WTP Site**. Incomer **VCB 33KV** and Service Transformer **1 No** of **100** KVA **33/0.4** including **6 Nos** of **3.3 Incomer indoor Panel** with **breaker, feeder, bus coupler, Battery bank charger** with HT Power to be provided for **WTP Site. One 33 KVA Substation** to be installed at **WTP Site.**

- **6 (Six)** Nos. **650.00 KVA capacity (HT 3.3 Grade) Silent DG set**s with NGR, NIS & AMF panel **1(One)** Nos. **315.00 KVA capacity (0.415 Grade) Silent DG set**s with NGR, NIS & AMF panel shall be provided as back-up power supply for Pumping arrangement at **WTP Site.**

- Supply & laying of **1422.4 mm (OD)** size **S.W.M.S** (12mm thick) Pipe Line (external PU Coating & internal Food Grade Epoxy Coating) about **20200 M** long as Clear Water Conveying Main **from WTP** to Proposed **30.00 ML** capacity **MBR** at **Sikharchandi.**

- **Construction of 30.00 ML capacity RCC Double Chamber Master Balancing Reservoir (MBR)** with positive suction arrangement at Sikharachandi, Bhubaneswar

- The Clear water shall be supplied from **MBR** Pump house through installation of **4 Nos**. of **250 HP Centrifugal Pump sets at MBR** Pump house.

- External & internal Power Supply for operation of Pump sets with installation of **4 Nos**. of **500** KVA **33/3.3** ***substation*** along with (HT & LT Transformer including 100% Stand-by) and drawl of required length of HT transmission line from available source to the **MBR Site**. Incomer **VCB 33KV** and Service Transformer **1 No** of **100** KVA **33/0.4** including 4 Nos of **3.3 Incomer indoor Panel** with **breaker, feeder, bus coupler, Battery bank charger** with HT Power to be provided for **MBR Site.** ***One 33 KVA Substation*** to be installed at **MBR Site.**

- **4(Four)** Nos. **350.00 KVA capacity (HT 3.3 Grade) Silent DG set**s with NGR, NIS & AMF panel **1(One)** Nos. **100.00 KVA capacity (0.415 Grade) Silent DG set**s with NGR, NIS & AMF panel shall be provided as back-up power supply for Pumping arrangement of **MBR Site.**

- **Construction of 2 (Two) Nos 3.00 ML capacity RCC Elevated Storage Reservoir (ESR)** of required / designed staging height etc. all complete.

- Supply & Installation of **Butterfly Valve**, **Zero Velocity valve**, **Air Cushion Valve, Globe type surge anticipating Valve** and M.S Special as per requirement. Surge Protection Valve 2 Sets (Electronic & Fired) type.
- Construction of Compound Wall with Gate, Internal Road, Street light including site development for Intake, WTP & MBR site.

- Supply & Installation of **2 x 10 KL Underground Diesel Storage Reservoir** at WTP Campus and **1 x 10 KL Underground Diesel Storage Reservoir** each at Intake Point & MBR site respectively.

- SCADA based Automation system for Intake Well, WTP, MBR and ESR Site shall be made with individual PLC, Three-Phase UPS (1 W + 1S) at each location with Battery Bank.
-

Note: The above mentioned Scopes / Quantity written anywhere in the documents are indicative only. All ancillary items required to make the water supply system technically feasible & functional to be provided by the bidder within the bid amount.

It is intent of the Engineer-in-Charge to construct a facility to provide basic need of human being 'Water', using highest standards of construction and supply of material and equipment to enable a sustained reliable system for performance over next 30 years. The responsibility of the contract starts from the intake point of intake leading channel and ends at the consumer points included in the project area.

2.1 Scope of Work

2.1.1 The bidder before bidding shall visit the site at his own cost and shall satisfy himself with the nature and extent of the work involved, actual site conditions, and existing facilities. Shall collect any other information which may be required before submitting the tender. Any claim in this regard shall not be entertained.

2.1.2 The scope of work for the Water supply scheme covers surveys including Topographical survey, Geo-technical survey, raw water quality testing, design & detailed engineering of all components of the scheme, do the necessary changes as per site condition, develop detail drawing and getting approval from Engineer-in-Charge, supply of equipment and construction materials, testing at manufacturer's works, delivery up to site, erection, execution of works as per the work described under "Scope of Work" clause 16.0 or elsewhere in the tender and as per IS codes, OPWD specifications and detailed specifications attached hereto, final check-up, painting, testing, commissioning including hydraulic testing of all water retaining structures and pipes with fittings, valves, etc. as per relevant IS codes and relevant specification.

2.1.3 The work shall be carried out according to the design / drawings submitted by bidder and approved by Engineer-in-Charge. For building, facilities, systems, structures, etc., necessary layout and details are furnished with tender document. Any changes, if required, shall be done by the bidder keeping in view the scope, minimum specified requirement, the statuary and functional requirement and providing enough space and access for operation, use and maintenance. The bidder's work shall cover the complete requirement as per tender specification.

2.1.4 The work to be performed under the specification consists of providing all labours, supervision, materials, scaffolding, construction power, fuel, construction water, and construction equipment, testing equipment, tools and plants, supplies, transportation and all incidental items not shown or specified but necessary for successful completion of the work.

2.1.5 The nature of work generally involves site clearance, dismantling of existing above ground and underground structures, excavation in all types of soils, foundation preparation, dewatering and its disposal, backfilling, disposal of surplus excavated material, supply of all construction material and supply of all necessary plant machinery and equipment, etc., construction with the materials of specified quality, constructing drains, embedding, encasement of pipes, cleaning the site from all waste and surplus material after completion of work and other ancillary work as per specifications, as per drawings submitted by the contractor and approved by the Engineer-in-Charge.

2.1.6 Any items of work, either supply and / or erection of material / equipment which have not been specifically mentioned in the scope / specifications but are necessary for operation and guaranteed performance of the entire water supply scheme, and equipment offered shall be deemed to be included within the scope of this specifications and shall be provided by the bidder without any additional cost.

2.1.7 All material / equipment which have been mentioned and have not been specifically mentioned in the scope / specifications but are necessary for operation and guaranteed performance of the entire water supply scheme shall be any of the make mentioned in **Clause 7.16.iii, Annex-I (Schedule-D)**. Contractor shall have to obtain written approval of make of any item from Engineer-in-Charge before supply.

2.1.8 The scope of work also includes shifting of electrical/ telephone/ any other type of cable, electric poles, water, sewer or any other type of pipeline or any other facility. Any arrangement for crossing roads, drains, nallah including bypass arrangement and their restoration to the satisfaction of Engineer-in-Charge after completion of particular work also included in the “Scope of work”.

2.2 Services to be Provided by the Contractor

2.2.1 The contactor shall open a fully furnished site office with all necessary facilities having office equipment such as computer, printer, etc. A separate room shall be provided to the Engineer-in-Charge or its representative.

2.2.2 The Contractor will make necessary arrangement for construction power and construction water.

2.2.3 The Contractor shall make necessary arrangement for all the testing and inspection to be conducted in a manner as specified in the specifications and as per codes.

2.2.4 Transportation of all equipment / raw material / spares from manufacturers work to the project site, inclusive of all intermediate handling and unloading / storage at site and all taxes, etc.

2.2.5 Supply, erection as per manufacturers recommendations / specifications, inspection, testing, start up and running of the equipment during trial run / performance guarantee period at rated capacity and speed.

2.2.6 Deploying qualified and experienced staff for supervision of all erection and commissioning services. The Contractor shall also arrange for rectifying the defects during defect liability period.

2.2.7 During **defect liability period of two year** the contractor has to replace any equipment, component, etc. for manufacturing defect, malfunctioning and below

rated performance. He will make good any structure or part of it if found defective or becomes during functioning.

2.2.8 Application of the final paints and final finishing work shall be done by the Contractor after complete erection and testing, trial run but before handing over to the department.

2.2.9 The contractor shall also arrange technical experts of equipment from proprietary supplier as and when necessary, till the commissioning, trial run and performance guarantee period of the equipment.

2.2.10 Any survey/ leveling/ fixation of bench mark/ reference level required for detailed engineering of the any component of the scheme will be done by survey team deputed by contractor. The survey team will carry out the area survey and leveling of Intake, WTP, ESR compounds or wherever required as per the instruction of Engineer-in-Charge.

2.2.11 The detailed scope of work has been mentioned in clause no 16.0 of this chapter.

2.2.12 Nothing extra over the quoted price shall be paid to contractor on account of any financial implications of all the conditions and specifications. It will be treated that necessary financial provision are deemed to have been kept in the quoted price. Any contiguous item or any provision / requirement, if not included in the general specification and scope of work, special specification and detailed specification but necessary to be provided for the completion of the work and for its functional necessity, shall be provided at no extra cost above quoted price. The decision of the Engineer-in-Charge in such cases shall be final and biding on the contractor.

2.2.13 The time is the essence of this contract. The entire work described under "Scope of Work" clause 16.0 or elsewhere in the tender (Design, approval of design & drawings, execution and commissioning) is to be completed within a time frame of **24 (Twenty Four) calendar months from the date of issue of work order**.

3 Tender Drawings

The Tender drawings shall form the part of tender document. The contractor shall submit detail design and drawing of all component of the water supply scheme (except hydraulic design of rising mains and distribution network) for its sufficiency in all respect before taking up the construction work. The contractor can do addition, modification, alteration or detailing in the drawings as per the prevailing conditions and he has to take approval from Engineer-in-Charge. The structural stability throughout its working life lies with the contractor. The work has to be executed as per the construction drawings (latest revision) with additions, alterations and modifications made from time to time as required and approved by the Engineer-in-Charge and also according to any other drawing prepared by contractor progressively during the execution of the contract.

4 Test for Material/Workmanship

All tests required for all brought out materials as desired by the Engineer-in-Charge shall be carried out by the contractor as per relevant IS code and at his own cost in the presence of authorized representative of the Engineer-in-Charge.

5 Specifications

The detailed specifications, IS codes and OPWD specifications are intended for the general description of the work, quality and workmanship. All work is to be carried out according to the specifications. Wherever reference to the standard codes of practice etc. is made, they shall be taken as the latest edition of the same issued within one month before the date of submission of the Tender.

6 Layout and Levels

The layout and levels of all structures etc. shall be made by the contractor at his own cost from the general grid of the plot and bench marks given by the Engineer-in-Charge. Contractor shall provide all help in instruments, materials and men to the Engineer-in-Charge at no extra cost for checking the detailed layout and correctness of the layout and levels. However, the Contractor shall be solely responsible for correctness of layout and levels.

Permanent reference pillars shall be established by the contractor and under no circumstances shall the contractor remove or disturb any permanent/reference pillar/ benchmark without the approval of the Engineer-in-Charge. The contractor shall carefully maintain and protect all benchmarks and reference points and shall mark the layout of all his work by accurate reference to the benchmarks and reference points.

7 Construction Method

The bidder shall submit a pert chart along with this tender showing the time schedule for the overall constructions activities along with construction methodology. The construction method and mobilization of resources to be adopted by the contractor shall match with this time schedule and shall be approved by the Engineer-in-Charge. After approval of tender the contractor will submit his detailed schedule of work.

8 Quality Assurance Plan

A Quality Assurance plan giving details of necessary tests to be carried out on various materials for construction of work shall be submitted by the contractor for approval before start of the work. The Contractor shall be responsible for carrying out such tests. The contractor shall test the samples of all materials in presence of authorized representative of the Engineer-in-Charge at the specified frequencies as per relevant IS codes or elsewhere given in the tender document and keep proper record of all tests.

9 Testing of Materials

All arrangement shall be made by the contractor to provide testing requirement as specified in the specifications. For the tests for which, equipments required is not available with the contractor shall provide the same or will arrange the test to be done at a Government approved laboratory. No extra claim is admissible in this regard.

10 Approach Roads

The Contractor where required shall make his own arrangement for approach to the work site (including, burrow and disposal area) and for movement of men, machinery, other equipment etc. required for carrying out the work included under this contract. The contractor will also arrange for any land required for burrowing earth or disposal of any dispensable material.

11 Dealing with Water / Dewatering,

Bailing and Pumping out of subsoil water may have to be carried out during execution of work. The contractor's program and methods must be capable of dealing with rainfall / subsoil water. The contractor shall supply, install and operate his own temporary pumping equipments wherever required.

12 Prevention of pollution

12.1 Arrangement shall be made by the contractor to prevent Air Pollution and pollution in any stream, nallah or rivers. Arrangements for sprinkling of water in the

construction and burrow area to prevent any dust blowing also shall be done by the contractor. The contractor shall be solely responsible and liable for all damage caused by any pollution that may take place during the execution of the works, and he shall make arrangements as the Engineer-in-Charge may approve, for preventing pollution.

12.2 No separate payment shall be made for the pollution control measures.

13 Safety Measures

In respect of all labour directly or indirectly employed in the work for the performance of the contractor's part of this agreement, the contractor shall at his own expense arrange for the safety provision as per IS code framed from time to time and shall at his own expense provide for all facilities in connection therewith. In case the contractor fails to make the above arrangement Engineer-in-charge shall be at liberty to make arrangements and provide facilities as aforesaid and recover the cost incurred on his behalf from the contractor.

The contractor shall ensure the safety of men, material, machinery, existing structure and any other facilities. Since the work is to be done on road/lanes/by lanes, all necessary safety arrangements including proper barricading and lighting etc. shall be done by the contractor.

The Contractor shall be absolutely and solely responsible for any accident that may occur during the progress of the work and for injury or damage to the men, material, machinery, existing structure and any other facilities of any description whatsoever which may be caused by or result from the execution of work. The Contractor shall make good any damage due to accident or pay any claim arising out of accident and will indemnify the employer of expenses on account thereof. No separate payment shall be made for safety measures.

14 Equipments & Machinery.

The contractor shall have to use his own earth moving equipment's & concreting equipment such as dumpers, pocklains, dozers, batching & mixing plant vibrators etc. and any other machinery required for the entire scope of work including the work of excavation and conveyance of earth from the burrow areas to site and also shall have to use his own compaction machinery to compact the fill material such as vibratory /pneumatic rubber typed rollers, water tankers etc. A list of equipments/machinery to be deployed at site as per the requirement of the project schedule shall be submitted by the contractor within one week of award of work. All the equipments/machinery shall be kept in working condition by the contractor during the tenancy of the contract. Contractor will not move any equipment/machinery without written permission of Engineer-in-charge to any other work which is not under the scope of this work.

15 Storage and Handling of Materials

The protection all material and machinery from dirt, clay, rust, theft or damage at any stage of the project is the responsibility of the contractor and no claim will entertained in this regard.

15.1 **Reinforcement**

Reinforcement steel shall be stored in a manner that no damage/rusting is caused to the material.

15.2 **Cement**

The Cement shall be stored as per IS code and in a manner that no damage/setting is caused to the material.

15.3 **Coarse and Fine Aggregate**

Aggregates shall be stored on brick soling or an equivalent platform so that they do not come in contact with dirt, clay, grass or any other foreign substance at any stage. Aggregates of different sizes shall be kept in separate stacks. Aggregates from different sources shall be stacked separately, if so desired by the Engineer-in-Charge with proper care to prevent intermixing.

15.4 **Sand**

Sand shall be stored on brick soling or an equivalent platform so that they do not come in contact with dirt, clay, grass or any other foreign substance at any stage.

15.5 **Pipes**

Pipes shall be stored in stacks as per relevant IS codes.

15.6 **Electro-mechanical equipment**

A Go-down with roof and brick soling floor of sufficient size is to be constructed by the contractor for storage of equipment to protect from rust, damage, theft, etc. All electro-mechanical equipment shall be stored in the go-down.

15.7 All other material required for construction will be stored properly by the contractor.

16 Detailed scope of work

The work involves Civil, Mechanical, Electrical and Instrumentation, preparation of detail design and drawing, supply of labour, materials, equipment, fabrication, erection, construction, testing, commissioning, guaranteeing the performance of the proposed system. The work involve under these specifications is mainly related but not limited to the following:

16.1 The work shall be carried out according to the detailed specifications, IS codes and OPWD/CPHEEO/PHEO specifications. The design/drawings shall be submitted by the contractor and approved by Engineer-in-Charge. For building, facilities, systems, structures etc., necessary layout and details are to be developed by the bidder keeping in view the scope, minimum specified requirement, the statutory and functional requirement and providing enough space and access for operation, use and maintenance. The bidder’s work shall cover the complete requirement as per tender specification.

16.2 The Geo-technical investigation at Water Treatment Plant, Elevated Service Reservoirs, Underground Reservoirs & other RCC structures locations shall be carried out by the contractor for structural design of civil structures proposed in the compound or as required.

16.3 Preparation of work areas, clearing site, jungle clearance etc. in the entire area including dismantling and removing of any existing above ground and underground structures including existing roads, uprooting of all the trees, debris and vegetation and their disposal, shifting of pipes, cables, electrical poles etc. The dismantled and removed material shall be stacked/ disposed as per direction of Engineer in Charge. The bidders should visit the site prior to submission of bid and make himself conversant with the site conditions to estimate the dismantling/removing work. Shifting of electrical or any other type of cables, electric poles, water, sewer, gas or any other type of pipeline or any other facility, their restoration to the satisfaction of Engineer-in-Charge after completion of work.

Electrical Installation at Different Site.

Location	Pumping Unit	Transformer for Pumping Unit	Station Transformer	DG for Pumping Unit	DG for Ancillary Unit	Substation Building area in Sqm
1	2	3	4	5	6	7
Intake	**4 x 400 HP of 3.3KV Grade**	**4 x 750 KVA of 33/3.3KV Grade**	**100 KVA of 33/0.415 KV Grade**	**4 x 650 KVA 3.3 KV Grade**	**100 KVA 0.415KV Grade**	**100**
WTP	**6 x 350 HP of 3.3KV Grade**	**6 x 750 KVA of 33/3.3KV Grade**	**100 KVA of 33/0.415 KV Grade**	**6 x 650 KVA 3.3 KV Grade**	**315 KVA 0.415KV Grade**	**150**
MBR at Sikharchhandi	**4 x 250 HP of 3.3KV Grade**	**4 x 500 KVA of 33/3.3KV Grade**	**100 KVA of 33/0.415 KV Grade**	**4 x 350 KVA 3.3 KV Grade**	**100 KVA 0.415KV Grade**	**100**

- **i. Protection of all motors must be provided as per code of practice.**
- **Ii. All Transformer HT side shall have 33KV outdoor PCVCB's & LT Side shall have indoor VCB & C.R Panels including incomer, Bus-Coupler, Feeder, Capacitor bank etc. as per code of practice.**
- **Iii. Each site equipment earthing & Earth Grid shall be designed as per code of practice.**

16.4 **Intake Arrangement:**

The **130 MLD raw water** shall be lifted from **"Double 'D' Type" Intake well** to be constructed in river Mahanadi (Source) at Mundali through installation of **4 Nos**. **VT Pump sets with mechanical water seal** (2w + 2s). The External & internal Power Supply for operation of Pump sets with installation of **4 Nos**. of **750** KVA **33/3.3** substation along with (HT & LT Transformer including 100% Stand-by) are within the scope of this contract. The scope of work for intake arrangement shall consist of **three main** components with details as follows:

A.	**CIVIL ITEMS**
1	Allied structures at Intake site **Double 'D' Type"** Intake well of **20 M** depth with **3.50 M** wide R.C.C./MS Foot Bridge including necessary Leading Channel, Sludge Dewatering Chamber etc all complete. **Intake well Pump house is a double storied structure of minimum (3.5+5.5) 9.00 M height over intake well. Th pump house shall** be fitted with **EOT crane** of suitable capacity with lateral and transverse movement for lifting, lowering and shifting of pumps etc. with cable trench & **1.50 M** wide walk-way all around. The bottom floor of the structure shall be **Valve House** & top floor shall be **Pump House.**
a	Operator room with minimum area of 30 Sqm
b	Foot-way bridge (3.50 m wide MS/RCC with trestle structure) about 60 M. long
2	Electrical panel room with minimum area of 100Sqm with RCC Cable Trench
B	**MECHANICAL**

1	Installation of 4 Nos. of VT Pump with mechanical water seal for **1691 lps** with **70 m** head (2 W +2 S) with motor complete with installations of required
2	Control Panel & motor Control Centre with minimum area of 50 Sqm.
3	Supplying, fitting & fixing of Sluice Valves of 150 mm dia with approved make & quality with matching flanges, nuts, bolts & gaskets with proper alignment & support complete in all respect with all labour & material, T&P as per specification &direction of Engineer-In-Charge.
5	Supplying, fitting & fixing of Non-Return Valves with damper kit of 150mm dia with approved make & quality with matching flanges, nuts, bolts &gaskets with proper alignment &support complete in all respect with all labour & material, T&P as per specification &direction of Engineer-In-Charge.
6	Supply & erection of spring-loaded relief valve for controlling water hammer with Globe type Surge Anticipating Valve all-inclusive as per requirement
7	Supply, fitting and fixing of minimum 5.0 MT capacity EOT crane
C.	**ELECTRICALS**
1	Supply & laying of HT line from existing WTP upto transformer requirement of a length as per requirement
2	Supply & erection of 4 x 750 KVA substation with outdoor VCB (incomer) & outgoing indoor VCB at Panel Room.
3	Supply & Installation of protection device (VCB/ACB)
4	Supply & erection of control panel
5	Supply & erection of cabling arrangement
6	Energy Efficiency System
7	Earthing system as per IS/IEC-62305&NBC-2016 & IEC-62561
8	Provision for inspection charges @6% of total cost
9	Procurement and installation of 4 Nos. of 650 KVA Silent DG sets of 3.3KV including with NGR, NIS & AMF panel
	However, the external Electrification work has to be carried out as per the estimate and specifications of TPCODL and under the supervision of TPCODL authorities.
D.	**INSTRUMENTATION**
1	Pressure gauge dial type fitted and fixed with Snuber Cock
2	Full Bore Type Electro-Magnetic Flow Meters (for 1400mm size Pipe)
3	Instrumentation panel, interlock arrangement and SCADA system.

Details of pumps at intake near proposed WTP

Description	Type of Pump	Hours of Pumping	Capacity of Each Pump	Head of Each	No. of Working	No. of Standby

				Pump	Pump	Pump
Pumping of raw water to WTP	Vertical Turbine (4 x 400HP) 3.3 KV Grade	22 hours	1691 LPS	40 mwc	02	02

16.4 Raw Water Rising Main

a. Detailed engineering of raw water rising main, water hammer / surge protection system including allied works, thrust blocks, etc. as per CPHEEO manual. Raw water rising main has been designed for minimum **130 MLD capacity** (considering **22 hour** pumping).

b. Excavation of trenches in all kind of soils, including shoring and shuttering, wherever required, as per the approved alignment up to the depth to maintain minimum one meter earth cover over crown of the pipe for laying of pipes and fittings, including proper stacking of excavated soil/material, backfilling and disposal of surplus material.

c. Supply, laying & jointing of following raw water rising main pipes as per IS: 8329, Socket and Spigot joint and ISI marked rubber gasket conforming to IS: 5382 as shown in relevant drawings and detailed specifications.

Raw Water Rising Main: Laying **1422.4 mm (OD)** size **S.W.M.S** (12mm thick) Pipe Line about 800 M as Raw Water Conveying Main **from intake well** to Proposed **130 MLD** capacity WTP at **Naraj/Mundali.**

Total length	: 800 m (approx.)
Flow	: 130 MLD (considering 22 hours pumping)
Type	: **Spirally Welded M.S. Pipe confirming to IS: 8329**
Lining Internal	: Food grade epoxy coating not less than 406 micron thick
Lining External	: Polyurethane (PU) coating
Diameter (minimum)	: **1422.40** mm (OD)

d. Supply & laying of ISI marked Ductile Iron fittings (Tee, tail piece, bend etc.) of required sizes conforming to IS: 9523 with latest amendment.

e. Supply, laying & jointing Mild Steel Pipes conforming to IS: 3589 Fe410 grade pressure pipes of required diameter and quantity for nallah and other crossing and special bends, etc. as per detailed specifications.

f. Supply & erection of ISI marked double flanged Cast Iron sluice valves, scour valves, double acting kinetic air valves as per IS specification and Zero velocity valve confirming to relevant IS specification as per site requirement & as per instruction of Engineer-in-Charge.

g. Construction of thrust blocks of required size as per approved drawing at all bends and other necessary locations in the pipeline as per field requirement.

h. Construction of valve chambers as per approved drawing for all types of valves as per site requirement & as per instruction of Engineer-in-Charge.

i. Backfilling of the excavated trenches with selected excavated earth. Backfilling shall be done in layers of 150mm thickness and shall be watered and compacted as per detailed specifications.

j. Making all arrangements for laying of pipes and its stability for crossing of **Railway Crossing, Canal Crossing, NH Crossing, PWD Road Crossing** and small culverts/ nallah / drain / road / any other facility and their restoration with minimum disruption including making any by-pass arrangement and dismantling of all above

arrangement after completion and testing of work. At every crossing over, the pipeline will be supported through a suitable steel structure as per direction of Engineer-in-Charge.

k. Repair to damages caused during construction to any existing road, bridge, culvert, water supply line, sewerage line, drain, electricity cable & pole, gas pipeline and telephone line, etc. shall be reinstated as per the original specification and satisfaction of concerned authorities / Engineer-in-Charge.
l. Cutting of road surface for taking of pipeline at required depth will be done with making good to the damages by mending & repair to existing condition.
m. To provide inter-connections of raw water rising main with the intake chamber of existing WTP, including fixing of sluice valve to regulate the flow at existing WTP.
n. To connect the raw water rising main to the cascade aerator at the proposed WTP.
o. Testing and commissioning of raw water rising mains as per relevant IS code and to ensure minimum terminal head of 3.0m.

16.5 **Water Treatment Plant at Naraj, Bhubaneswar**

General Description

The WTP with all ancillary structures will be designed and constructed for **130 MLD** Capacity considering **22 Hrs of operation** basing on the intermediate design period. Maximum 3% water loss is permitted in the WTP.

Contractor has to design WTP including all associated works, CWR and Pump house and electrical sub-station, etc., considering the availability of land. Sufficient space shall be left for future expansion. Contractor shall design and fit all the works required for ultimate capacity in the available land accordingly.

The Water Treatment Plant is to be designed based on conventional treatment technology and rapid sand gravity filters. The contractor shall essentially follow the CPHEEO Manual, which is a guideline for the system design. However following the same concept does not relieve the bidder of his guaranteeing the performance of the plant including treated water quality.

16.5.1. Description of Work

A) Civil Works

(i) Construction of civil works for WTP and CWR and other services.
(ii) Supply and installation of all mechanical, electrical and instrumentation equipment.
(iii) Construction and equipping of testing laboratory for routine testing of water quality.
(iv) Instituting a Quality Control System during construction.
(v) Integration and tuning of the system.
(vi) Testing performance of the plant.
(vii) Trial running of the plant
(viii) Commissioning of the plant.
(ix) Remedying any defects during the Contract Period.
(x) Providing as-built drawings and operation and maintenance manuals for the completed facilities.
(xi) Providing Mandatory spare Parts for Mechanical, Electrical, Instrumental, Fire Fighting Instruments and specialized tools
(xii) Training Employer's Personnel in operation and maintenance.

The scope of work for the contract includes construction of all civil structures buildings and other building services for Water Treatment Plant, Clear water Tank and Clear water Pump house. The scope of construction of all civil structures buildings and other building services will be as per the specification, the GA of the tender document.

B) Electrical Works

(i) Supply, installation, testing and commissioning of Four pole structure at CWPS Premises along with lightning arrestor, disconnector, drop-out fuse, ACSR conductor, clamp and connectors, insulators, hardware, etc for terminating incoming 33kV overhead line coming from 33KV existing substation at existing WTP at Munduli as per drawings.

(ii) Supply, installation, testing and commissioning of Non segregated 500 A busduct with necessary hanging and fixing arrangement as per drawing and specification.

(iii) Supply, installation, testing and commissioning of the complete 3.3/L.T distribution panels such as CWPS PMCC, CWPS Auxiliary MCC, WTP and chemical house MCC, Lighting Panels, Feeder piller-1,2,3 etc at Clear Water pumping station as per drawing and specification.

(iv) Supply, installation, testing and commissioning of the complete cabling system including terminations (scope includes supply of gland, lug, etc.) as per technical specification and drawings.

(v) Supply, installation, testing and commissioning of the illumination system including lighting panels, lighting fixtures, internal road lighting, cables, cable terminations, wires, GI conduits, switches, receptacles etc. including all the necessary accessories as per layout drawings, Typical drawings and technical specification.

(vi) Supply, installation, testing and commissioning of earthing and lightning protection system with earth pits and connecting the pits to the earth grid and forming earth grid and all equipment such as six pole structure, Transformer, CWPS PMCC, CWPS auxiliary MCC, WTP and Chemical house MCC, etc connection to the grid including necessary clamps, nuts, bolts, etc all including welding, bolting and associated civil works as per layout diagram, Typical drawings and technical specification.

(vii) Supply, installation, testing and commissioning of bus connected Capacitor Banks with Automatic Power factor correction relay as per drawing and technical specification.

(viii) Earthing: Earthing for all installation shall be confirm IS/IEC-62305, NBC-2016 & IEC62561.

(ix) All structural members & RCC Slab shall be provided with Integrated Lightning Protection System confirming to IS/IEC-62305, NBC-2016 & IEC62561.

General

1. Laisoning with TCODL and OPTCL (Orissa Power transmission Company Ltd) for getting construction power supply, making new power supply agreement for the plant and getting final clearance from CEIG for all Electrical system .
2. Preparation and submission of ‘As built drawings’ and Operation & Maintenance manual.

C) MECHANICAL & INSTRUMENTATION & CONTROL WORKS (I & C Works)

The scope of these specifications shall include design, selection of equipment, supply, inspection & testing at manufacturer’s works, delivery to site, unloading and storage at site, erection and commissioning of the mechanical equipment and instruments as listed below & shown in drawing but not limited to that.

Brief scope of work for Mechanical works for WTP shall be as follows

(i) Horizontal Split Casing Centrifugal Pump for Clear Water pump of capacity 1480 m^3 /hr at 46 mwc with motor, valves, Dismantling joint, instruments, piping and accessories for supply to Munduli, Bhubaneswar town water distribution.
(ii) Horizontal Split Casing Centrifugal Pump for Backwashing of capacity 3300 m^3 /hr at 20 mwc with motor, valves, Dismantling joint, instruments, piping and accessories
(iii) Horizontal Split Casing Centrifugal Pump for Boosting pump for pre chlorination of capacity 7 m^3/hr at 40 mwc with motor, valves, Dismantling joint, instruments, piping and accessories
(iv) Horizontal Split Casing Centrifugal Pump for Boosting pump for post chlorination of capacity 4 m^3/hr at 40 mwc with motor, valves, Dismantling joint, instruments, piping and accessories
(v) Horizontal Split Casing Centrifugal Pump for service water pump of capacity 25 m^3/hr at 30 mwc with motor, valves, Dismantling joint, instruments, piping and accessories
(vi) Flash Mixer with necessary valves and pipe.
(vii) Clariflocculator with necessary valves and pipe.
(viii) Valves and piping for Rapid Dual Media filter.
(ix) Air blowers of capacity 2800 m3/hr and 0.35 kg/cm2 head with motor and all accessories for Gravity filter
(x) Alum dosing system Including Agitators, Dosing pumps (1000 LPH), valves instruments, piping and accessories
(xi) Lime dosing system Including Agitators, Dosing pumps (2000 LPH), valves instruments, piping and accessories
(xii) Poly electrolyte dosing system Including Agitators, Dosing pumps (1000 LPH), valves instruments, piping and accessories
(xiii) Chlorine Tonner for chlorination.
(xiv) 5 Ton EOT Crane
(xv) Exhaust Fans (3 phase)
(xvi) CO2 fire extinguishers (SS 316 grade)
(xvii) Chain Pulley Block with electric operated monorail incldingall accessories

Quantity and specification as per requirement and Mechanical specification

Brief scope of work for Instrumentation and Controls (I & C) shall be as follows –

Brief scope of work for Instrumentation and Controls (I & C) shall be as follows –

a) **4 Nos. Ultrasonic type** Level Measuring Instrument for the following:
    i. 2 nos. for two compartments of Intake Sump.
    ii. 2 nos. for compartments of clear water pumping station sump
b) **15 Nos. Level switches** for the following:
    i. 2 nos. for two compartments of Intake Sump for generating alarm and tripping signals
    ii. 2 nos. for two compartments of clear water pumping station reservoir for generating alarm and tripping signals
    iii. 3 Nos. On Alum solution preparation tanks for generating alarm and tripping signals
    iv. 3 Nos. On Lime solution preparation tanks for generating alarm and tripping signals.
    v. 3 Nos. On Polyelectrolyte solution preparation tanks for generating alarm

and tripping signals.

c) **15 Nos. Float and Board type** local level indicators for the reservoirs at the following sites -
   i. 2 nos. for two compartments of Intake Sump
   ii. 3 Nos. For Alum solution preparation tanks
   iii. 3 Nos. For Lime solution preparation tanks
   iv. 3 Nos. For Polyelectrolyte solution preparation tanks
   v. 2 Nos. For two compartments of clear water pumping station
   vi. 2 Nos. For two ESRs

d) **12 Nos. : Electromagnetic Flowmeters** for the following locations -
   i. 4 No. on each pump at intake pumping station discharge line (600 NB line size) + 1 No. on each pump at intake pumping station discharge line (1400 NB line size)
   ii. 1 No. recirculation line for service water to filters (80 NB line size)
   iii. 4 No. at outlet of clear water pumping station to Munduli, Bhubaneswar town (600 NB line size)
   vii. 2 Nos. 250mm in two ESRs

e) **1 No. Open channel flow measuring** system at outlet of cascade aerator

f) **25 Nos. IP 68 Pressure transmitters** for the following locations:
   i. 4 No. at intake pumping station discharge line
   ii. 5 No. at outlet of clear water pumping station to Munduli, Bhubaneswar town
   iii. 14 Nos. at various locations of rising main.
   iv. 2 Nos. at two ESRs level

g) **39 Nos. Pressure gauges at suction** and discharge of each pump common header for the following -
   i. 4 Nos. intake pumping station pumps
   ii. 1 No. on intake pumping station discharge header
   iii. 2 Nos. on WTP air blowers outlets.
   iv. 1 No. on WTP air blower discharge header
   v. 4 Nos. on suction and discharge of backwash pumps
   vi. 1 No. on common discharge of backwash pumps
   vii. 4 Nos. on suction and discharge of Service water pumps
   viii. 1 No. on common discharge of service water pumps
   ix. 4 Nos. on suction and discharge of pre-chlorination pumps
   x. 1 No. on common discharge of pre-chlorination pumps
   xi. 4 Nos. on suction and discharge of post-chlorination pumps
   xii. 1 No. on common discharge of post-chlorination pumps
   xiii. 8 Nos. on suction and discharge of Clear water pumps
   xiv. 1 No. on outlet of clear water pumping station to Munduli, Bhubaneswar City
   xv. 2 Nos. at two ESRs

h) **51 Nos.: Pressure switches at discharge** of each pump and 2 nos. (one for high pressure and one for low pressure) on common header for alarm / trip signals for following pumps -
   i. 3 Nos. intake pumping station.

ii. 4 Nos. on intake pumping station discharge header.
iii. 2 Nos. on WTP air blower's outlets.
iv. 2 No. on WTP air blower discharge header.
v. 4 Nos. on suction and discharge of backwash pumps.
vi. 2 Nos. on common discharge of backwash pumps.
vii. 4 Nos. on suction and discharge of Service water pumps.
viii. 2 Nos. on common discharge of service water pumps.
ix. 4 Nos. on suction and discharge of pre-chlorination pumps.
x. 2 Nos. on common discharge of pre-chlorination pumps.
xi. 4 Nos. on suction and discharge of post-chlorination pumps.
xii. 2 Nos. on common discharge of post-chlorination pumps.
xiii. 8 Nos. on suction and discharge of Clear water pumps.
xiv. 2 Nos. on outlet of clear water pumping station to Munduli, Bhubaneswar City.
xv. 2 Nos. at two ESRs

i) **5 No. Instrument control panel** with alarm annunciator and accessories for Intake pumping station.

j) 1 No. Instrument Control Panel with Alarm annunciator, PLC, PC based SCADA system with all associated hardware and software for monitoring and control of WTP.

k) 1 Nos. Instrument control panel with alarm annunciator and accessories at Sikharchandi in Bhubaneswar town.

l) 16 Nos. Filter Consoles and accessories for WTP rapid dual media filters.

m) Lot – Online water quality analyzer for PH, Turbidity, Chlorine for Raw and clear water including clarified water (Redundant), Laboratory equipment (pH, turbidity, residual chlorine meter, colorimeter etc)

n) 1 No. Portable Vibration meter.

o) 1 No. Portable Sound level meter.

p) 2 Nos. PLC Panel at two ESRs

Lot – Signal, FO and power supply cables for I & C system

Sl NO	DESCRIPTION	QUANTITY	UNITS
1	Ultrasonic type Level measuring system - (level sensor, transmitters, panel mounted indicator and accessories) for Intake and Clear Water Reservoir	4	Nos.
2	Conductivity type Level switches - (level sensor, controller unit and accessories)	15	Nos.
3	Float and board type Level indicators along with accessories	13	Nos.
4	Full bore electromagnetic flow meter with surge protection devices and accessories for following line sizes.	5	Nos.
A	700 NB	1	No.
B	80 NB	1	No.
C	600 NB	1	No.
D	1400 NB	1	No.
5	Parshall Flume type Flow measuring system using Ultrasonic level sensor, transmitter, panel mounted indicator & integrator and accessories	1	No.

6	Pressure measuring systems (Pressure, transmitters, panel mounted indicators and accessories)	17	Nos.
7	Pressure gauges and accessories	43	Nos.
8	Pressure switches and accessories	49	Nos.
9	Instrument control panel with alarm annunciator and accessories for Intake pumping station	1	Lot
10	Instrument control panel with Alarm annunciator, PLC and associated hardware and software for controlling and monitoring of pumping station and WTP	1	Lot
11	Instrument control panel with Alarm annunciator for controlling and monitoring of pumping station at Baliapanda	2	Lot
12	Instrument control panel with Alarm annunciator for various ESRs in Munduli,Bhubaneswar Town	13	Lot
13	Server based local SCADA system along with periphery(like printer, furniture etc)	1	Nos.
14	Filter console complete with all accessories for monitoring and control of filter equipments	4	Lot
15	Laboratory equipment (pH, turbidity, residual chlorine meter, colorimeter etc.)	1	Lot
16	Portable Vibration meter	1	Lot
17	Portable sound meter	1	Lot
18	Cables for I&C system – Power supply and signal cables	1	Lot
19	Any other items required for completion of the system (Bidder to provide description).	As required	

16.5.2 PROCESS PLANT REQUIREMENTS

16.5.2.1 RAW WATER QUALITY

The raw water is generally of low turbidity during the normal season but the turbidity shoots up to 2500 NTU for short duration in monsoon season. The quality of the water can undergo changes in the coming years. The general range of the turbidity is expected as below.

Maximum Turbidity	2500	NTU
Minimum Turbidity	0.9	NTU

The plant should be able to handle up to **2500 NTU** turbidity.

WATER QUALITY PARAMETERS:

Sr. No.	Parameters	Value
1	pH	7.73
2	Turbidity	20
3	Temperature	21.6
4	Colour	NA
5	Odour	NA

6	Total Alkalinity as CaCo3, mg/l	20
7	Total Hardness as CaCo3, mg/l	156
8	Calcium Hardness as CaCo3, mg/l	36
9	Magnesium hardness as CaCo3, mg/l	16
10	Chloride as Cl, mg/l	60
11	Sulphate as SO4 mg/l	16
12	Flouride, as F mg/l	0.2
13	Total Dissolved Solids mg/l	374
14	Residual Chlorine mg/l	NA
15	Iron mg/l	0.66

16.5.2.2 TREATMENT PLANT PERFORMANCE

The individual components of the plant will be design for the designed rated capacity. However all the interconnection channels, pipelines must have an additional capacity to allow 20% overloading (i.e. capable to hydraulically pass through additional 20% water). The treated water quality on the design flow rate shall be as defined below in the table for individual clarifiers, filters and the combined stream in the filter clear water channel and CWR.

Process guarantees

Turbidity of the effluent of the clarifiers	:	not more than 8 NTU
Suspended solids in the effluent of the clarifiers	:	not more than 8 mg/l
Total aluminum in the effluent of the clarifiers	:	not more than 0.5 mg/l
Minimum filter run period at any time of the year between successive backwashing	:	24 hours
minimum filter run during 90% of the year	:	36 hours
maximum backwash water during any period of 7 consecutive days at any season of the year	:	4 % of the raw water input
maximum backwash water during 90 % of the year	:	3% of the raw water input
Maximum water losses (filter backwash, de-sludging) in the treatment plant during a period of 7 consecutive days during monsoon period .	:	5 % of the raw water input

Treated Water Parameters

Turbidity (N.T.U.)	<1.0
Colour (Units on Platinum Cobalt Scale)	5.00
Taste and Odour	Unobjectionable
PH	7-8.5
residual chlorine content of the treated water, 30 minutes after the contact in the chlorination chamber.	0.35 -0.45 mg/l
Faecal coliforms number/100ml	0
Coliform organisms number/100ml	0

16.5.2.6 GENERAL REQUIREMENTS

The Scope of Work under this Contract includes the supply, construction, installation,

testing, trial run, and commissioning of the Water Treatment Plant and facilities and construction of Clear Water Reservoir and clear water pumping station (hereinafter referred to as "the Works"). The details of the work under this contract will be as per clause described below.

16**.5.**2.7. **COMPLETENESS OF THE OFFER***:*

The Contractor shall be fully responsible to ensure that the whole of the Works, including each individual component is constructed in a manner so that the plant as a whole operates as a fully integrated system which is capable of achieving the required output in an efficient and economical manner, and to include all plant, equipment and accessories required for the safe and satisfactory operation of the facilities. To achieve this, the Contractor shall ensure that each individual component performs in a manner which is complimentary to that of all other components. Any accessories which are not specifically mentioned in the specifications, but which are usual or necessary for completion of the Works and successful performance of the plant and facilities, shall be provided by the successful Bidder within the tendered cost. The Contractor shall, to the maximum extent practical and feasible, endeavor to standardize on the manufacture and supply of Plant and equipment so as to minimize the operation and maintenance requirements subject to clearance of all punch points.

16.5.2.8 **Trial Run of the System**:

After execution of the works the Contractor shall run the plant continuously 24 hours a day for a period of 30 days to demonstrate satisfactory performance to the Employer's Representative prior to taking over by the Employer. The cost towards the Contractor's Engineer and other operating personnel during the said period of trial run, along with cost of tools and spare parts, which are required for operation and maintenance of the Plant and equipment during the trial run period shall be borne by the Contractor and shall be included in Contract Price. In the event that the plant or any of the facilities do not satisfactorily achieve the required performance standards during this period, the trial run period shall be extended until such time as the Contractor has satisfactorily rectified any deficiencies as may be necessary to satisfy the performance requirements.

16.5.2.8 **Commissioning of the System**:

On completion of the Trial Run, commissioning of the Treatment Plant shall be done by the Contractor by operating the plant 24 hours continuously for a period of 60 days.

16.5.2.9 **Training of Employer's Personnel:**

The Contractor shall be responsible to provide practical training on all aspects of the operation, maintenance and routine repair of the Plant, equipment and facilities to all personnel selected by the Employer who will ultimately be responsible for the operation, maintenance and repair of the Plant and its facilities. For this purpose the Contractor shall provide a comprehensive training program for the Employers personnel during the entire period of the trial run and commissioning, and for as long thereafter as may be reasonably required to ensure that the designated personnel are adequately trained to take up their responsibilities.

16.6. Time for Completion:

The whole of the Work, including mobilization, reconnaissance, design, manufacturing, transportation, construction, installation, trial runs, testing and commissioning is to be completed within the scheduled Time for Completion as set out in the Appendix to Tender. The duration of the Trial Run and test period is 30 days and the Commissioning Period is 60 days; both periods are included within the scheduled time for completion. The physical completion of the plant and facilities shall be achieved before commissioning.

Commissioning of the plant will be deemed to be completed after the plant has been operated trouble free for 60 working days; any intervening breakdown period will not be considered as a part of this period.

16.6.1 Milestones:

The construction work shall start not later than 90 days from the date of issue of work order and shall end at the completion of 540 days from the date of issue of work order. The construction period shall include trial run of 30 days. The satisfactory commissioning of the plant shall be completed in 60 days from the date of completion of the construction work.

The tenderer shall submit a Bar chart showing construction schedule.

	Description of Milestones	**Time for Completion**
i)	Commencement of the Works	: 21 days
ii)	Mobilization to the site and establishment of field office and quality control laboratory.	: 90 days
iii)	Commencement of submission of design calculations, drawings and other documents	: 30 days
iv)	Completion of installation of Plant and equipment	: 90 days before the Time for Completion
v)	Completion of Trial Run of the Treatment Plant	: 60 days before the Time for Completion
vi)	Completion of Commissioning and Hand over to the Employer	: Time for Completion

16.7 GENERAL INFORMATION

The following site conditions shall generally apply:

- **Climate**

  Maximum Temperature: 130^{o} C
  Minimum Temperature: 10.6^{o} C
  Maximum Relative Humidity: 85%
  Minimum Relative Humidity: 49%
  Average Annual Rainfall: 1500 mm

- **Altitude**

  Munduli,Bhubaneswar: Average 18.8 m above MSL

- **Seismic Zone: III**

  Access

  Approach Road: National Highway No. 203A
  Nearest Airport: Bhubaneswar
  Nearest Railway station: Munduli, Bhubaneswar

8.8 SOIL INVESTIGATION REPORT

For structural design purposes, SBC at required depths and different locations below ground level at respective places for all units of the Water Treatment plant shall be found out by the agency through Govt/ Govt. approved laboratory confirming to relevant IS code. The soil test shall include bore log, SPT, UDS test, Tri-axial test, Vane shear test, core sample test, plate load test depending upon requirement of the structure. Before detailed engineering & design the contractor shall submit detailed soil test report to the Engineer-in-charge for approval of SBC to be adopted for structure design. Accordingly, the contractor has to design the structures. The maximum ground water table for design of WTP & ancillary structures shall be taken as 0.5 M below virgin ground level in worst

rainy season condition. In case further data would be necessary before or after submission of tender / during execution of the work, the tenderer / contractor shall collect the same of his own & at his cost.

Ignorance of any data shall not relieve the contractor of his obligation to complete & commission the work as per the provisions of the DTCN. Before detailed engineering & design the contractor shall submit detailed soil test report and all above information to the Engineer-in-Charge for approval of SBC and related all other design parameters to be adopted for structural design. Accordingly, the contractor has to design the structures.

While designing of the structures, it shall be ensured that the weight of the structure including foundation, water, over burden earth on foundation / slab / raft etc. as applicable shall be within the permissible limit of S.B.C. allowed by Department.

The proposed WTP of 130 MLD capacity (excluding Losses) considering 22 hours of pumping shall consist of the following units:

1. Cascade Aerator (No. of Unit-1) with stilling chamber
2. Raw Water Channel (No. of Unit-1, Overload-50%)
3. Flash Mixture Unit
4. Clariflocculator – 2 Units
5. Filter House with Rapid Gravity Filter units with pipe gallery including installation of Backwash Pump Sets, Air blowers & Motor Control Centre (MCC)
6. **600 cum** capacity separate Back Wash Reservoir with adequate staging along with Pipes, Valves, fittings etc all complete near filter house (to be supported with design).
7. Chemical House (2 floors) (Min.Floor area of each floor **600** sqm)
8. Chlorine house with Chlorinator arrangement (Min. Floor area of each floor **140** sqm)
9. Pump house (Min. Floor area-**460** sqm)
10. Filter house Annex building (Min. Floor area-**200** sqm)
11. Clear Water reservoir- **13 ML** Capacity-01 No
12. Office-cum-Lab building- (Double storied building of Min.Floor area **-150** Sqm)
13. Security Cabin / Watchman Room **-(** min. Floor area **-20 Sqm**)
14. Sludge recycling, treatment & disposal arrangement/unit inside WTP.
15. Internal Road of 500 mtr and Walk-way 500m
16. Internal drain 500 mtr.
17. Road & Yard lighting
18. All inter-connecting piping, sluice gates, valves and appurtenant
19. Glow Sign Board, Name Plate and Flow diagram etc.
20. External Drainage System 2500 mtr for disposal of waste water from WTP.
21. **Allied Structures**
    a. 1.50m wide CC walkway around all units of WTP
    b. Road & Yard lighting with pole mounted Led luminaries
    c. Internal Drainage
    d. Site Development
    e. Compound Wall with Gate (Intake:300m +WTP : 1000m+ MBR : 600m)
22. Instrumentation
    a. 1050 mm size Full bore type Electromagnetic Flow meter (for 1400 mm size pipe)

– 1 No.

b. Lab equipment Sets

23. SCADA based Automation system for complete Plant 100% Automation. It shall be integrated with Raw Water Pumping Station and MBR with armoured F.O. Cable.

16.5.2 Works to be performed:

i. The scope of work includes, but is not limited to design, detailed engineering, supply of material, construction, installation, testing & commissioning, and two year of defect liability period for all Civil, Mechanical, Electrical and Instrumentation Works for the WTP and all associated works including centering, shuttering, reinforcement, all piping arrangements, etc. as per detailed specifications.

ii. Conducting necessary investigations e.g. topographical survey, geotechnical survey, leveling etc., preparation of contour maps where ever necessary.

iii. Preparation of work area, clearing site, jungle clearance, etc., including dismantling and removing of any existing above ground and underground structures including existing roads, uprooting of all trees and vegetation and their disposal, shifting of pipes, cables, electrical poles, etc. and site dressing, leveling of the surrounding ground to final ground level, stacking and disposal of surplus material.

iv. Construction of **Chemical House (2 floors):** It shall be two storied RCC framed structure with doors, windows, ventilators etc. having minimum floor area of **600 sqm** per floor. Chemical storage area shall be provided at ground floor. Chemical tanks, dosing system shall also be accommodated at first floor. The chemical tanks shall be designed for ultimate capacity of the WTP. Water from back wash water reservoir (**600.00cum** capacity) shall be provided to chemical tanks. The RCC stairs shall be up to roof of the first floor and shall be provided with mumty. The construction of the building shall be as per detailed specification.

v. Construction of Clear Water Pump House: It is single storied building with RCC sunken base having minimum floor area of minimum **460.00 sqm** for achieving positive suction. However, the area of the building should be sufficient enough to accommodate 3 nos of pump sets and other mechanical equipment. It shall be RCC framed structure with doors, windows, ventilators etc. The construction of the building shall be as per detailed specification.

vi. The Filter House Annex building shall be RCC framed structure having minimum floor area of **200 sqm** & will be provided with an attached toilet.

vii. Construction of Office-cum-Laboratory Building: It is double storied building having minimum floor area of **150.00 sqm** in each floor. It shall be RCC framed structure with doors, windows, ventilators etc. It shall consist of office space, spare parts storage area and toilets. Potable water tank shall be provided on the roof. All sanitary fittings shall be installed in the toilets. RCC stairs along with mumty shall be provided to access the roof of the building. The construction of the building shall be as per detailed specification. The laboratory building should be furnished with all necessary equipment & chemicals & furniture's for water testing purpose as per CPHEEO manual comprising mainly of pH Meter, Turbidity Analyzer, Chlorometer, Jar Test Apparatus etc. as per direction Engineer-in-charge.

viii. Supply, erection and commissioning of 5.0 MT capacity electrically operated travelling crane (EOT) with monorail to lift the chemicals in chemical house. A cutout of adequate size in the roof of the ground floor at appropriate location shall be provided for lifting of chemicals in crane bucket from ground floor to first floor.

ix. Design, supply of material, construction of Paved Parking area for staff vehicles. Sufficient area for parking shall be provided for staff vehicles/departmental vehicles.

x. Safety equipment such as portable fire extinguisher of all types of adequate size and numbers including other safety equipment as required shall be provided in the Office-cum-laboratory Building, Chemical house and Scrubber for Chlorine House.

xi. Excavation up to the foundation in all kinds of soil including shoring and shuttering, wherever required, stacking of excavated material for all the units of the WTP.

xii. Backfilling of the foundations with selected excavated earth. Backfilling shall be done in layers of 150mm thickness and shall be watered and compacted as per detailed specifications.

xiii. Supply of all material and finishing of all buildings of WTP, like flooring, internal and external plastering, painting of 2 coats of weather coat on all exterior surfaces and 2 coats of oil bound distemper on all interior surfaces, including application of putties, primer, etc. to obtain smooth surfaces, roof treatment, rain water pipes, fixing & painting of doors and fixtures and windows, etc. as per the detailed specification.

xiv. All other units of WTP shall be painted with 2 coats of weather coat on exterior surface and 2 coats of epoxy paint on internal surfaces coming in contact with water.

xv. Automatic filter bed washing system should have HMI: Color, Panel mounted, touch screen type, alarm generation, trend generation, report generation, LOH & ROF meter, control cabling to acquater with 30 days data backup facility. HMI should control individual filter bed in auto mode. **Individual PLC also should have send data to centralized SCADA system which will be placed inside main control room**.

xvi. Main control room at WTP can control and operate all zonal pumping station, clear water pumping unit of WTP, Rapid Gravity filter bed operation, mixer & Scraper, Chemical dosing to raw water through metering pump, Chlorine dosing system, Online water quality analyzer for Turbidity, pH, BOD,COD & residual chlorine & power substation with EMS through Licensed SCADA software including data receiving to redundant server at control room and data transmission to NIC server at BBSR through dedicated static IP connection at NIC for data accusation & report generation.

16.5.2. A.Mechanical Units

a. Supply, installation, testing & commissioning of Horizontal centrifugal pumps as per Table with suitable motor for pumping water to zonal UGR and ESR of make mentioned in Clause 7.16.iii, Annex-I (Schedule-D) of the document, including air cooled A.T.S. Control Panel & Motor Controlled Centre (3 phase A.C. power supply 50Hz) etc. as per detailed specifications.

Details of pumps at CWPH near proposed WTP

Description	Type of Pump	Hours of Pumping	Capacity of Each Pump	Head of Each Pump	No. of Working Pump	No. of Standby Pump
Pumping for M B R at Sikharachandi	Horizontal Centrifugal (6 x 350HP) of 3.3 KV Grade	22 hours	1480 m^3/hr	46 Mtr	03	03

16.5.3. Power Supply at WTP

(i) As described at Clause 16.5.1 (B).

The external Electrification work has to be carried out as per the estimate and specifications of TPCODL and under the supervision of TPCODL authorities.

(ii) The scope includes all Design, installation, supervision, inspection charges etc including all incidental fees/ charges as per the estimate of concerned electrical authority is to be

deposited by the bidder excluding security deposit charges which will be borne by the department.

(iii) Execution of electrical works shall confirm to specifications as per Electrical Rules, Electricity Act-2003 and OERC guide line-2004.

(iv) Internal & External electrification of pump house including yard lighting &Industrial Exhaust fan.

(v) Intake, WTP & MBR at Sikharachandi shall have Sub-Station building at each site to accommodate indoor LT, VCB, DG,CR Panel for different feeders & Pump Control Panel i.e. VFD & AMF Pane.

(vi) Supply and construction of 230mm thick Fly ash brick masonry Boundary wall of 1.60m height above finished ground level with 25mm thick cement concrete coping and pillars at 2.5m interval around the WTP campus.

(vii) Supply and erection of decorative MS fabricated Gate (6.0M x 1.80M – 2 nos) at entry and exit point as per detailed specification and fixing it to the RCC columns.

(viii) Supply of all materials and construction of wastewater disposal system to dispose the wastewater generated from the toilets of Administrative and Laboratory building.

(ix) Potable water supply shall be provided within the WTP compound.

(x) Supply of all material and construction of open drainage system for WTP compound with brick masonry and its connection with nearest drain as per approved drawing.

(xi) Supply of material and construction of 1.5m wide PCC walkway to connect various units of WTP as per approved drawing.

(xii) Construction of bituminous approach road of required width and length inside the WTP compound, including supply of material as per detailed specification and joining it to the nearest road.

(xiii) Supply and plantation of saplings of different types in a properly designed landscaping.

(xiv) Supply of fluorescent Glow Sign Board captioned **"130 MLD Water Treatment Plant for Improvement of Water Supply to Bhubaneswar City"** with details in attractive colors with all fittings, etc. of appropriate size and fixing it at appropriate height at the entrance gate as per detailed specifications.

(xv) Guarantee the outlet quality parameters of the treated water for drinking purpose **as per IS:10500 with latest amendments**. The Guarantee of the treated water quality is irrespective of raw water quality. While designing the units of WTP the contractor shall keep this in mind.

(xvi) Supply of one number wall mounted board with **flow sheet** including details of all units, pumps, motors in attractive colors for mounting on the wall at appropriate height as per aesthetic requirement of the administrative building.

(xvii) The waste water generated from WTP is to be disposed of under gravity to the nearby natural nallah at a distance of 1500 mtr approximately by laying required size of RCC Hume Pipe with required Nos, of Man Hole Chambers. The minimum dia. of pipe line should not be less than 300mm.

ON-Line Analyzer:

(xviii) Continuous on-line analyzer for monitoring of raw water and treated water quality for Ph & Turbidity (with a range of 0 to 2000 NTU) and Ph, Turbidity (range 0 to 100 NTU) & residual chlorine respectively with BOD & COD analyzer. The system is to be tagged to PLC for real time data monitoring with local and remote operation. There shall be required capacity of battery backup system for Four hour.

(xix) The wall of chemical house shall be minimum **25cm** thick brick masonry. Chemical storage area shall be provided at ground floor. Chemical tanks, dosing system shall also be accommodated at first floor. The RCC stairs shall be up to roof of the first floor and shall

be provided with mumty. Suitable stair case, platforms etc shall be provided to have clear access to different units. The 2 nos. Alum and 2nos. lime tanks shall be provided & lined internally with **acid resistance tiles**. Floor and walls of chemical house shall be lined with **acid resistant tiles**. 2 No. 20 Cum capacity PAC storage tanks with dosing pumps 4 Nos.(2w+2s) with metering unit integrated to PLC for local and remote operation to regulate automatically the dosing of chemicals according to quantity and quality of raw water. The floor and dados shall be provided with chemical resistance tiles. The dosing pumps are linked with PLC for remote operation (change of flow and raw water quality) at the outlet valve of the solution preparation tank, the inlet and discharge of the dosing pumps are to be electrically actuated and there should be a level measuring system to measure the level in the tank.

16.6 **Clear Water Rising Mains:** Supply, laying, jointing of Spirally Welded M.S. Pipe confirming to IS: 8329 of **1422.4 mm (OD)** size **S.W.M.S** (12mm thick) Pipe Line from the Clear Water Reservoir of WTP to **30ML capacity** Master Balance Reservoirs (MBR) at Sikharachandi**.**

- C.W. Rising Main : 20200 M (approx.
- Flow : 130 MLD (considering 22 hours pumping) excluding losses
- Type : Spirally Welded M.S. Pipe confirming to IS: 8329
- Lining Internal : Food grade epoxy coating not less than 406 micron thick
- Lining External : Polyurethane (PU) coating
- Diameter (minimum) : **1422.40** mm (OD)

a. Supply, laying & jointing Mild Steel Pipes conforming to IS: 3589 Fe410 grade pressure pipes of required diameter and quantity for nallah and other crossing and special bends, etc. as per detailed specifications.

Note: The size & quantity shown in above table is indicative only. Contractor has to verify the same as per the design requirement and provide accordingly without any extra cost. Further, if the department provides any quantity of Pipe out of available quantity with department, the cost of same shall be deducted from the bill of contractor at the rate prevailing during issue of such material.

a. Supply & laying of ISI marked Ductile Iron fittings (Tee, tail piece, bend etc.) of required sizes conforming to IS: 9523 with latest amendment.
b. Supply, laying & jointing Mild Steel Pipes conforming to IS: 3589 Fe410 grade pressure pipes of required diameter and quantity for nallah and other crossing and special bends, etc. as per detailed specifications.
c. Supply & erection of ISI marked double flanged Cast Iron sluice valves, scour valves, double acting kinetic air valves as per IS specification and Zero velocity valve confirming to relevant IS specification as per site requirement & as per instruction of Engineer-in-Charge.
d. Construction of thrust blocks of required size as per approved drawing at all bends and other necessary locations in the pipeline as per actual requirement
e. Construction of valve chambers as per approved drawing for all types of valves as per site requirement & as per instruction of Engineer-in-Charge.
f. Backfilling of the excavated trenches with selected excavated earth. Backfilling shall be done in layers of 150mm thickness and shall be watered and compacted as per detailed specifications.

g. Making all arrangements for laying of pipes and its stability for crossing of **Railway Crossing, Canal Crossing, NH Crossing, PWD Road Crossing** and small culverts/ nallah / drain / road / any other facility and their restoration with minimum disruption including making any by-pass arrangement and dismantling of all above arrangement after completion and testing of work. At every crossing over, the pipeline will be supported through a suitable steel structure as per direction of Engineer-in-Charge.

h. Repair to damages caused during construction to any existing road, bridge, culvert, water supply line, sewerage line, drain, electricity cable & pole, gas pipeline and telephone line, etc. shall be reinstated as per the original specification and satisfaction of concerned authorities / Engineer-in-Charge.

i. Cutting of road surface for taking of pipeline at required depth will be done with making good to the damages by mending & repair to existing condition.

j. Testing and commissioning of clear water rising mains as per relevant IS code and to ensure minimum terminal head of 3.0m.

k. Supply and laying of ISI marked Ductile iron fittings (Tee, tail piece, bend etc.) of required sizes conforming to IS: 9523 with latest amendment as per site requirement & as per instruction of Engineer-in-Charge.

l. Supply and erection of ISI marked double flanged cast iron sluice valves, scour valve as per IS: 14846 PN 1.6 and double acting kinetic air valve as per IS: 14845 PN 1.6. as per site requirement & as per instruction of Engineer-in-Charge.

m. Excavation of trenches for laying of pipes and their refilling after completion of work in all kind of soil, including shoring and shuttering, wherever required as per the alignment up to the depth to maintain minimum one meter earth cover over crown of the pipe and fittings, including proper stacking of excavated soil/material and disposal of surplus material.

n. Supply of material and construction of thrust block of required size as per approved drawing at all bends provided in the pipeline as per site requirement & as per instruction of Engineer-in-Charge.

o. Supply of material and construction of valve chambers as per approved drawing for all types of valves as per site requirement & as per instruction of Engineer-in-Charge.

p. All work required for connection of clear water rising main with the proposed UGR .

q. Repair to damages caused during construction to any existing bridge, culvert, water supply line, sewerage line, drain, electricity cable, telephone line, etc. It shall be reinstated as per the original specification and satisfaction of Engineer-in-Charge.

r. **Cutting of road surface for taking of pipeline at required depth will be done with making good to the damages by mending & repair to existing condition**.

s. Testing & commissioning of the clear water rising mains as per relevant IS code.

Note:

i. Required numbers of Valves (Sluice Valve, NR Valve, Air Valves, Scour Valve etc., Including Chamber), Supporting Pillar for Nallah & drain crossing as per site requirement to be provided by the contractor without any extra cost for smooth functioning Potable Water Supply System.

ii. Making all arrangements for laying of pipes and its stability for crossing of Railway Crossing, Canal Crossing, NH Crossing, PWD Road Crossing and small culverts/

nallah / drain / road / any other facility and their restoration with minimum disruption including making any by-pass arrangement and dismantling of all above arrangement after completion and testing of work. At every crossing over, the pipeline will be supported through a suitable steel structure as per direction of Engineer-in-Charge.

Table 1.7:Details of Storage Reservoir & pumping system

Location	Capacity of MBR in ML	ESR		Capacity of Pump sets in HP (2w+2s)	Capacity of Transformer & Silent DG Sets in KVA
		Capacity in ML	Staging height in M (from FGL)		
Sikharachandi	30			4x250HP	4 x 500 KVA33/3.3 grade 4 x 350 KV of 3.3 Grade
Sikharachandi		3.00	40		
Sikharachandi		3.00	40		

A. Storage Reservoirs:

a. Design and detailed engineering, Supply of material, Construction, Testing and Commissioning of **30.00 ML capacity RCC Double Chamber Master Balancing Reservoir (MBR)**, including all piping arrangements, centering, shuttering, reinforcement etc. as per approved drawings at locations given in following table and as per the layout drawing provided.

b. Supplying fitting and fixing of ISI marked DI / CI pipes puddle collars and sluice valves of required size, including embedding in R.C.C. wall and / or floor of the MBR, wherever required.

c. Supply and erection of Mechanical Float type water level indicator at every underground reservoir.

d. Manholes with CI manhole cover; stainless steel access ladder, etc. shall be provided as per I.S. specification and approved drawing.

e. Backfilling with selected excavated earth and disposal of the surplus earth as per detailed specification.

f. Testing and commissioning of the Under Ground Reservoirs as per IS codes and detailed specification.

g. Supply of all material and painting of exposed surfaces of UGRs with two coats of weather coat, including application of putties, primer, etc. to obtain smooth surface.

h. Display of relevant data about Under Ground Reservoir at proper place as per direction of Engineer-in-Charge.

B. Pump House at Master Balancing Reservoir

a. Site clearance and removal of all trees, debris, above and underground structures etc., including stacking of the dismantled material and disposal of surplus material. Site dressing and leveling the surrounding ground to final ground level.

b. **MBR** located at Sikharachandi having Pump/store house of minimum **100.00 Sqm**. Carpet areas. However, the area of the building should be sufficient enough to accommodate 4 nos. of pump sets and other mechanical equipment. **The pump house should be built to achieve positive suction.**

c. Site clearance and removal of all trees, debris, above and underground structures etc. Stacking of dismantled material and disposal of surplus material. Site dressing and leveling the surrounding ground to the final ground level.
d. Excavation up to the foundation in all kinds of soil, including shoring and shuttering, wherever required, and stacking of excavated material as per direction of Engineer-in-Charge.

e. Excavation up to the foundation in all kind of soil, including shoring and shuttering, wherever required. Stacking of excavated material and disposal of surplus material.
f. Supply of material, Construction, Testing and Commissioning of Pump House including centering, shuttering, reinforcement, brick work, RCC roof slab etc. as per approved drawings at locations given in following table and as per the layout drawing provided.
g. Supply of all material and construction of all building, including finishing work, flooring, internal and external plastering, whitewashing, roof treatment, rain water pipes, fixing & painting of doors, windows & fixtures, etc. as per the detailed specification.
h. Supply of all material and painting of inside and outside of building as follows:
   (i) Inside-2 coats of oil bound distemper including application of putties, primer etc. to obtain smooth surface.
   (ii) Outside-2 coats of weather coat paint including application of putties, primer etc. to obtain smooth surface.
i. Backfilling of foundation with selected excavated earth and disposal of the surplus earth as per detailed specification.
j. Supply and installation of internal electrification work i.e. lighting, switches, fans and ventilation system, etc. of make mentioned in schedule of makes**.**
k. Supply, installation, commissioning & testing of Horizontal centrifugal pump set with suitable **V.F.D Control** panel (3 phase A.C. power supply 50Hz) of approved make, for aforesaid capacities of Pump Sets. Piping work at zonal pumping stations as per the instruction of Engineer-in-Charge. The capacity of pump sets and staging height of ESR mentioned in the table above is the minimum requirement. Suitable Motor control panel, capacitor bank, ATS control panel & APFC panel including EMS, all other accessories including PLC panel with SCADA, HMI for local and remote operation along with the required size of incoming & out going cables with a spare one shall be installed. The EMS with licensed soft ware is to be tagged to available WATCO server at NIC, Bhubaneswar. **Contractor has to verify the same and provide accordingly without any extra cost.**
j. Supply and fixing of pipes (delivery, overflow, common header, etc. up to ESR), valves (Sluice valve with motor operated actuator, Non-Return Valve, Foot Valve etc.), and dismantling joints of make mentioned in Clause 7.16.iii, Annex-I (Schedule-D), pipe support, thrust block as per the system requirement.
k. Supply and installation of Pressure gauges of make mentioned in in Clause 7.16.iii, Annex-I (Schedule-D)**,** one each on delivery sides of the pumps and one on the common header with two way stop cork.
l. Supply and painting of structural steel pipe supports, pipes and other equipment as per detailed specification.
m. All work for electric supply connection from **33 KV** sub-station including connection charges, supply and laying of underground cable including its jointing.
n. Supply, construction & Erection of 3-phase 3-wired 33 KV power supply HT line of approximately **1000 mtr** shall be drawn with 150x150x6mm R/S joist- 13mtr long pole along with 100 mmsq. AAAC conductor and where ever road crossing, guarding shall be provided. Each pole should be supported with anti-climbing devices and danger boards as well as individual earthings. Where ever the line passes adjacent to jungle, bushes,

overhead insulated conductor to be provided. Each span should be of 50mtr having horizontal configuration.

o. Supply, installation, testing and commissioning of 33/3.3 KV sub-station, comprising of 2x250 KVA transformer, 4 pole structure with D.P. structure, AB switch, HG Fuse, outdoor distribution panel, lightening arrester, required nos. of earthing, transformer panel with Circuit Breakers with 2x500 KVA industrial grade Silent DG set including AMF pannel to complete the system in totality, A.T.S. control panel &**Motor Control Centre** (3 phase A.C. power supply 50 Hz), push buttons, power and control cables etc. to complete the system in totality as per detailed specification as per detailed specification.

p. Execution of Electrical works should be conforming to specifications as per Electricity rules, Electricity Act-2003 and OERC guide lines – 2004

q. Supplying, laying and jointing cable between the transformer and main LT Distribution Board any of make mentioned in schedule of makes.

r. Supplying, installation, making connection and testing of LT panel board with LMCCB suitable for transformer of make mentioned in schedule of makes.

s. Supply, laying, jointing and testing of cables between the main LT Distribution Board (main LTDB) and all the required equipment, illumination, ventilation, plug-sockets, etc. of any of make mentioned in schedule of makes.

t. Supply, laying, jointing and testing of earthing for all installations as per IS: 3043. The earthing shall cover all the motor, control panel, control post, cable racks, illumination and ventilation etc. The size of G.I. strips to be used for earthing for different equipment shall be suitably selected and shall be subjected to the approval of the Engineer-in-Charge and shall meet the stipulation of the Indian Electricity Rules and Regulations to the satisfaction of State Government Electricity Inspector.

- **The scope includes all supervision, inspection charges etc including all incidental fees/ charges as per the estimate of concerned electrical authority is to be deposited by the bidder excluding security deposit charges which will be borne by the department.**

- **The external Electrification work has to be carried out as per the estimate and specifications of TPCODL and under the supervision of TPCODL authorities.**

C. Elevated Service Reservoirs (ESRs)

a. Two Nos **3.0ML capacity ESRs** will be constructed near proposed MBR Site.

b. Site clearance and removal of all trees, debris, above and underground structures etc. Stacking of dismantled material and disposal of surplus material. Site dressing and leveling the surrounding ground to the final ground level.

c. Excavation in foundation in all kinds of soil, including shoring and shuttering wherever required. Stacking of excavated material and disposal of surplus material.

d. Design and detailed engineering, Supply of material, Construction of **R.C.C. M-30 Intze type staged ESRs with circular column/shaft** of various capacities and staging heights along with stairs and all piping arrangements, including centering, shuttering, reinforcement and brick work, etc., including its testing and commissioning as per approved drawing, at locations given in above table and as per the layout drawing provided.

e. Backfilling of foundation with selected excavated earth and disposal of the surplus earth as per detailed specification.

f. Design, Supply, laying, jointing and fixing of DI-K-9 double flanged pipes (inlet, outlet, overflow and scour, etc.), specials and valves of required size including embedding puddle collar in RCC floor of the reservoir, wherever necessary, excavation of trench for laying of pipe line, construction of valve chamber, testing and commissioning of pipe line. The overflow and scour pipeline is to be extended up to nearest drain.

g. Supply, erection and testing of Mechanical Float type water level indicator to indicate the water level in the ESR and Bulk water meter/Flow meter (Electromagnetic type) at the outlet of ESR.

h. Manholes with CI cover, stainless steel access ladder for inside of tank and another fixed type MS ladder on outside wall of tank and railing, etc. as per approved drawing.

i. Construction of required number and size of valve chambers as per approved drawing.

j. Supply and fixing of one number lightening arrester on top of dome of Elevated Service Reservoir as per relevant IS code.

k. Supply of all material and painting of exposed surfaces of ESRs with two coats of weather coat paint, including application of putties, primer, etc. to obtain smooth surface.

l. Supply of fluorescent Glow Sign Board captioned **"Bhubaneswar Waterworks"** in attractive colours with all fittings etc. of appropriate size and fixing it at appropriate height at the entrance gate as approved by the WATCO Authority.

D. **Any item or any provision/requirement if not included in this section, but is necessary to be provided for the completion of the project and for its functional necessity, the same shall be provided by the contractor. No extra payment shall be admissible on this account**.

17. CHANGE OF SCOPE

The length of Pipe lines and capacity of different structures of Civil, Mechanical and electrical installations specified hereinabove shall be treated as an approximate assessment. The actual lengths and capacity as required on the basis of detailed investigations shall be determined by the Contractor in accordance with the Specifications and Standards. Any variations in the lengths specified in this Schedule-B shall not constitute a Change of Scope, save and except any variations in the length arising out of a Change of Scope expressly undertaken in accordance with the provisions of Article 13.

18. <u>Operation & Maintenance:</u>

On issue of provisional completion certificate, the Operation & Maintenance of the project are to be under taken by the Executing Agency for a period of **5 (Five) years** with supply of manpower, chemicals, consumables & other repair & maintenance works including spare parts, if any. The energy charges shall be paid by the Department directly to the concerned electrical authority. Any defects/discrepancies noticed in civil, mechanical and electrical works has to be attended promptly. It is to be ensured that the quantity, quality of water and minimum residual head at the consumers end has to be maintained by the Executing Agency as per CPHEEO standard. Daily test of water samples is to be carried out by the Executing Agency. It should be ensured that the quality of clear water must satisfy the permissible limit as per CPHEEO standard. The entire project needs to be operated upto **22 Hours per day**.

19. **Works to be performed for Operation & Maintenance:**

19.1 **Raw water collection and Storage**

i) Monitoring of inflows, Drawls, Quality of Raw Water shall be assessed.

ii) It should be ensured that sufficient water level is maintained in order to ensure drawl of required quantity of water.

Source & Intakes

i) Monitoring of inflows, Drawls, Quality of Raw Water shall be assessed.
ii) It should be ensured that sufficient water level is maintained at Head works in order to ensure drawal of required quantity water into intake works.
iii) All damages to structural components of intake works particularly during flood should be promptly repaired.
iv) All raw water holding structures such as leading channel, intake well should be desilted during and immediately after monsoon to remove settled silt.
v) A schedule of painting of steel and other structural parts of the intake works should be prepared and followed.
vi) All intake strainers shall be cleaned at frequent intervals particularly during monsoon to prevent entry of floating materials.

19.2 Transmission systems

The transmission mains would include raw/treated water pumping as well as gravity mains from source to treatment works, treatment works to clear water reservoirs in the distribution systems.

A) All pipes

i) Sufficient stock of spare pipes and specials and jointing materials should be maintained for replacement of damaged ones.
ii) Performance of Sluice valves, air valves, expansion joints, etc. shall be monitored regularly.
iii) Regular Leak detection surveys should be undertaken particularly for bursting of pipes and leaky joints.
iv) A detailed record of break downs and leaks observed and repaired should be maintained section-wise so that more vulnerable lengths could be identified and special measures to repair / replace them could be undertaking.
v) A regular schedule of inspection and attendance to all valves including air and scour valves should be drawn up and the same followed scrupulously. Specials attention should be given to air valves.

B) M.S. Pipes laid above ground

i. Pipes should be painted at least once in five years to prevent corrosion.
ii. Appurtenances such as sluice valves, air valves, expansion joints, roller should be checked, cleaned at least twice a year and worn-out parts replaced. The cleaning and lubrication of rollers should also be done twice a year, preferably pre and post monsoon.
iii. Expansion joints should be inspected every month.
iv. The catch drains provided for the portion of water mains laid in cutting should be cleaned before on set of monsoon so that no water accumulates in the cutting portion, resulting in uplift pressure on pipes.

19.3. Water Treatment Plant

The person in charge of the maintenance and operation of water treatment plants should have a thorough knowledge of the functions of the several units under his control should be a position to bring to the notice of the concerned Engineer-in-charge any faults in design and execution giving rise to problems during the course of operation and rectify them immediately.

The maintenance programme should observe the following general rules.

a) Keep a set of plans giving details of the several units and indicting the layout and position of all pipe lines and appurtenances.
b) Establish a systematic plan of daily operations.
c) Establish a routine schedule for inspection of machinery and lubrication and maintain records thereof. Instructions for lubrication, the type of lubricant suggested and the frequency of lubrication should be drawn out.
d) Main data and record of each piece of equipment giving details of cleaning and replacement of worn parts and other data of importance such as unusual incidents on faulty operating conditions.
e) Keep a record of analysis of water collected at various points from the source to the distribution system and observation on the effect of such quality on the several units of operation.

19.3.1 Chemical Feeding Unit

i) Annual Painting alum tanks by anti-corrosive paints.
ii) Cleaning of V notch weirs and floats
iii) Keeping adequate Spares for mixing unit
iv) Inspect Jar test facilities

19.3.2 Rapid mix unit and Flocculation unit

i) Periodical painting with weather proof paint.
ii) Annual Overhauling and repainting a month or two prior to monsoon.
iii) Free of chokage of sludge lines
iv) Periodical cleaning of channels

19.3.4 Rapid Gravity Filters

i) Daily Check for water quality at various stages, chemical dose, washing of filters, adequate depth of water over filter media, performance of filter regarding output and back washing.
ii) Note the readings regarding:
Quantity of water received, wasted, filtered water produced, water consumed for back wash, pressure gauge reading at blower, rate of filtration
iii) Performance of blower
iv) Uniform washing of bed by air and water
v) Check the surface of filter media for cracks, incrustation of media, mud balls slime growths, sand boils, bumping of filter beds, air binding, inadequate media on filter beds.
vi) Status of functioning of Instrumentation, Valves, Blowers, gauges etc.
vii) Check for corrosion of all underwater equipments

19.3.6 MAINTENANCE AND REPAIRS OF ELECTRICAL EQUIPMENT

i) CONSUMABLES
Adequate stock of lubricating oil and transformer oil should be maintained.
ii) REPLACEMENT SPARES
To avoid downtime, stock of fast moving spares and of spares likely to be damaged by short circuit should be maintained. A set of recommended spares for two years of trouble free operation should be kept.

19.3.7 TOOLS AND TEST EQUIPMENTS

Tools such as crimping tools, soldering, brazing and usual electrical tools should be available.

19.3.8 PREVENTIVE MAINTENANCE

As preventive maintenance, a schedule for the maintenance of the equipments shall be followed. The schedule covers recommendations for checks and remedial actions, to be observed at different periodicities such as daily, monthly, quarterly, semi-annually, annually and bi-annually.

19.3.8.1 DAILY

(i) For Motors
  (a) Check bearing temperatures
  (b) Check for any undue noise or vibration

(ii) For panel, circuit-breaker, starter;
  (a) Check the phase-indicating lamps
  (b) Note readings for voltage, current, frequency etc
  (c) Note energy meter readings

(iii) For transformer substation
  (a) Note voltage and current readings

19.3.8.2 Monthly

(i) For motor: nothing special other than the daily checks

(ii) For panel, circuit-breaker, starter
  (a) Examine contacts of relay and circuit breaker. Clean, if necessary.
  (b) Check setting of cover-current relay, no volt coil and tripping mechanism and oil in the dashpot relay.

(iii) **For transformer substation**
  (a) Check the level of the transformer oil
  (b) Check that the operation of the GOD is okay.
  (c) Check contacts of GOD and of over-current (OC) relay
  (d) Check temperatures of the oil and windings
  (e) Clean radiators to be free of dust and scales
  (f) Pour 3 to 4 buckets of water in each earth-pit

19.3.8.3 Quarterly

(i) <u>For motor:</u>

(a) Blow away dust and clean any splashing of oil or grease

(b) Check wear of slip ring and bushes, smoothen contact-faces or replace, if necessary. Check spring-tension. Check bush-setting for proper contact on the slip-ring.

(c) Check cable connections and terminals and insulation of the cable near the lugs, clean all contacts, if insulation is damaged by overheating investigate and rectify. All contacts should be fully tight.

(ii) <u>For panel, circuit-breaker, starter, etc.</u>

(a) Check fixed and moving contacts of the circuit breakers/ switches. Check and smoothen contacts with fine glass-paper or file.

(b) Check condition and quantity of oil / liquid in circuit-breaker, auto-transformer starter and rotor-controller.

(iii) <u>For transformer substation:</u>

(a) Check condition of the H.T. bushing.

(b) Check the condition of the dehydrating breather and replace the silica-gel charge, if necessary. Reactivate old charge for reuse.

19.3.8.4 Semi-Annual

(i) <u>For motor</u>
  (a) Check condition of oil or grease and replace if necessary. While greasing avoid excessive greasing.
  (b) Test insulation by megger.

(ii) <u>For panel, etc</u>

Check for corrosion and take remedial measures. Check by megger the insulation-resistance of switches, bus-bar, starter-terminals, auto-transformer, etc for phase-to-earth and phase-to-phase, resistance.

(iii) <u>For transformer substation,</u>

(a) Check dia-electric strength and acid-test of transformer oil and filter, if necessary.
(b) Test insulation by megger
(c) Check continuity for proper earth connections.

19.3.8.5 Annual

(i) <u>For motors</u>

(a) Examine bearings for flaws, clean and replace if necessary
(b) Check end-play of bearings and reset by lock nuts, wherever provided.

(ii) <u>For panel, etc</u>

(a) All indicating meters should be calibrated

(iii) <u>For transformer substation</u>

(a) Check resistance of earth pit/earth electrode

19.3.8.6 Bi-Annual

(i) For motor: Same as Annual
(ii) For panel, etc. Same as Annual
(iii) For transformer substation
(a) Complete examination including internal connections, core and windings.

19.4 TROUBLE SHOOTING FOR ELECTRICAL EQUIPMENT

Trouble-shooting comprises detecting the trouble, diagnosing the cause and taking remedial action. Detection of the trouble is prompted by noticing the symptoms. The trouble shooting details are hence outlined hereunder for various symptoms.

19.4.1 MOTOR GETS OVERHEATED

(i) Check whether voltage is too high or too low. Change tapping of transformer, if HT supply is availed. Otherwise approach Power supply authorities for correction of the supply voltage.
(ii) Check whether air ventilation passage of motor is blocked. Clean the passage.
(iii) Check whether the motor bearings are properly lubricated or damaged. Replace the damaged bearings and provide proper lubrication.
(iv) Check whether the cable terminals at the motor are loose. Tighten the terminals.

19.4.2 MOTOR GETS OVER LOADED: (DRAWING MORE THAN THE RATED CURRENT AT THE RATED VOLTAGE)

i) Check any excessive rubbing in the pump or any clogging of the impeller passages.
ii) Check whether characteristics of pump (i.e. the related driven equipment) are of the overloading type.
iii) Check for any vortices in the sump
iv) Check that there is no short-circuiting or single-phasing.
v) Check whether any foreign matter has entered the air-gap, causing obstruction to the smooth running of the motor.

19.4.3 STARTER / BREAKER TRIPS

(i) Check whether the relay is set properly. Correct, the setting, if necessary
(ii) Tripping can also occur, if motor is drawing more than the rated current, for which details are mentioned above.

(iii) Oil in dashpot may be either inadequate or of flow viscosity
(iv) Check that there are no loose connections
(v) Check whether the time setting of star delta or auto transformer starter is proper.

19.4.4 VIBRATION IN MOTOR

(i) Check for structural rigidity of supporting frame and foundation
(ii) Check alignment of pump and motor
(iii) Check that the nuts on foundation bolts are tight
(iv) Check if rotor has an imbalance
(v) Check the resonance from supporting structure or foundation or from critical speed of rotor or from vibration of adjoining equipment.

19.4.5 CABLES GET OVER-HEATED

(i) Check whether the cable is undersized. Change the cable or provide another cable in parallel.
(ii) Check for loose termination or joint. Fasten the termination and make proper joint
(iii) Check whether only a few strands of the cable are inserted in the lug. Insert all strand using a new lug, if necessary.

19.5 Pumps:

Pumps should be operated only within the recommended range on the H-Q characteristics of the pump.

The maintenance schedule should enlist items to be attended daily, semi annually, annually as follows:

19.5.1 Daily Checks:

A log book should be maintained to record covering the following items; such as;

a. Timing of pump running
b. Observe for leakages through stuffing box
c. Bearing temperature
d. Any undue noise or vibration
e. Readings of pressure, voltage and current

19.5.2 Half Yearly checks

i) Free movement of the gland of stuffing box
ii) Cleaning and oiling of gland bolts
iii) Inspection of the gland packing and repacking, if necessary.
iv) Alignment of pump and drive
v) Cleaning of oil/grease lubricated bearings and replenishing fresh oil and grease.

19.5.3 Annual Checks :

a. Clean and examine all bearings for flows
b. Examine shaft sleeves for wear or scour
c. Check clearance at wearing ring
d. Check impeller hubs and vane tips for pitting or erosion
e. Calibration of all instruments and flow meters
f. Check performance of pump Q, H, KW and efficiency
g. Check for availability of required tools
h. Check for availability of lubricants and other consumables such as gland packing, bolts etc.

i. Check for repair facilities such as pullers, clamps, machinery, welding set, grinder, blower, drilling machine etc.
j. Records to be kept on the Operations.
k. Stock of fast moving recommended spares for two years of trouble free operation shall be kept.

19.6 Clear Water and Underground/ Elevated Service Reservoir

i) Check for proper operation of valves, functioning of Water level indicators, lighting arrestor, functioning /cleaning of ventilators; to guard against mosquito breeding and bird dropping.
ii) Check for corrosion of Manhole covers; inter connecting pipes, ladder and railings and replace, if required.
iii) Cleaning of reservoirs shall be under taken at least once in a year.
iv) Roofing shall be periodically checked to ensure no leakages are there.
v) Check for any structural damages/leakages through the structure of reservoirs and interconnecting pipes, valves etc.. Structural damages and leakage should be promptly repaired.
vi) Check for any possibilities of pollution of the water stored in the reservoir
vii) Check for the availability of consumables, spares and tools
viii) General cleanliness in around the reservoirs should be maintained.

19.7 Checks to be carried out in the distribution system :

i) Check for leakages in pipes, valves, appurtenances, gland, bolts etc. Shall be made at regular intervals.
ii) Inspect for any possibilities of pollution of water in the distribution system.
iii) Adequate spares for valves and pipes and jointing materials shall be kept.
iv) Special inspection of pipe lines through marshy or high water table areas, crossing across waste channels, pipes etc. and in the vicinity of sewers shall be carried out at regular interval.
v) A regular programme of leak detection of entire distribution system shall be made at least once in three years. Leaks and damages detected shall be promptly required.
vi) Preparation of water budget for each zone served by one reservoir shall be made.
vii) Recording of number of connections given, Status of bulk metering and consumer Metering number of meters out of order, quantity of inflows and outflows shall be made.
viii) Identification and disconnection of unauthorised connections if any shall be made.
ix) Monthly water tariff bills generated should be served to the consumers.

19.8 Control of quality of water:

The physical, chemical and bacteriological tests of water samples need to be carried out at frequent intervals as per direction of Engineer-in-charge at source, WTP and distribution system.

19.9 **Taste & Odour control:**

It shall be made as per CPHEEO Manual.

SCHEDULE – C
(See Clause 2.1)

PROJECT FACILITIES

DELETED

SCHEDULE – D
(See Clause 2.1)

SPECIFICATIONS AND STANDARDS

1 Construction

The Contractor shall comply with the Specifications and Standards set forth in Annex-I of this Schedule-D for construction of the Water Supply Project.

2 Design Standards

The Water Supply Project shall conform to design requirements set out in the following documents:
[CPHEEO manual on Water Supply and relevant I.S. Specification & Standards]

3.1 TECHNICAL SPECIFICATIONS & DESIGN CRITERIA

3.1.1 Design Standards

The Water Treatment Plant shall be designed conforming to state-of the art technology & practice to produce and maintain output water quality hygienically safe and palatable in an economical manner. The output quality of water shall conform to physical and chemical standards stipulated in the manual on Water Supply and Treatment (latest edition) published by Central Public Health & Environmental Engineering Organization and Indian Standard Code of Practice. The entire Treatment Plant shall be designed to work on gravity flow principle without need of any additional pumping. Basic design guide lines given below are indicative only and however, in order to achieve designed parameters for drinking water, Tenderer, if feels necessary, may assume & offer better data of his own and suggest suitable layout for the plant. The capacity of WTP will be **130 Million Liters per Day (MLD)** exclusive of all losses for an operating period of **22 hrs** and quality management system should follow **ISO 9001:2015** specification**.**

[CPHEEO manual on Water Supply and relevant I.S. Specification & Standards]

3.1.2 Specifications and Standards for Construction

All the structure shall be designed conforming to state-of the art technology & practice to produce and maintain output water quality hygienically safe and palatable in an economical manner. The output quality of water shall conform to physical and chemical standards stipulated in the manual on Water Supply and Treatment (latest edition) published by Central Public Health & Environmental Engineering Organisation and Indian Standard Code of Practice. Similarly, the RCC Intake Well, RCC Under Ground Reservoir, RCC E.S.R. and W.T.P. shall be designed based on the latest concepts & principles enumerated in the standard text books conforming to latest **BIS Code.**

The entire Treatment Plant shall be designed to work on gravity flow principle without need of any additional pumping. Basic design guide lines given below are indicative only and however, in order to achieve designed parameters for drinking water, Tenderer, if feels necessary, may assume & offer better data of his own and suggest suitable layout for the plant. The capacity of WTP shall be **130 Million Litres per Day (MLD)** exclusive of all losses for an operating period of **22 hrs**.

3.2. Design, Construction, testing & commissioning of **Double 'D' Type" Intake well** of 20 M depth with 3.50 M wide R.C.C./MS Foot Bridge (upto 60 Mtr length) with cable trench & 1.50 M wide walk-way all around including necessary Leading Channel, Sludge Dewatering Chamber etc all complete. **Intake well Pump house** shall be a double storied structure of minimum **(3.5+5.5) 9.00 M** height over intake well. The pump house shall be fitted with EOT crane of suitable capacity with lateral and transverse movement for lifting, lowering and shifting of pumps etc. The bottom floor of the structure shall be Valve House & top floor shall be Pump House.

A. **Intake Well with Pump House**

The construction shall be of RCC M-30 grade concrete with required scope & specification having mentioned in related parts of the tender schedule. There shall be a RCC/MS footway bridge having suitable foundation system as per design requirement connecting river bank to intake well in complete shape. Required information for structural design shall have to be collected by the contractor from competent Government Departments at his own cost and risk.

i) The top of the slab over intake well shall be minimum 2.0 mtr. above the HFL. The total depth of intake well may vary as per site condition up to 20 m & as per the requirement of detailed design satisfying all design parameter based on actual field data & hydraulic parameters. The thickness of the wall shall not be less than 500 mm.

ii) There shall be one RCC slab to be provided at 2.00 mtr above the HFL which shall be the floor of the pump house. This RCC slab over the intake well shall be of 250 mm thickness minimum and there shall be necessary opening for installation of polder Pump Sets and accessing to the Intake well.

iii) There shall be an RCC cantilever slab of 1.00 mtr width around the intake well at the RCC slab level.

iv) A stainless steel ladder and CI step irons shall be provided till bottom of the well inside the Intake well.

v) There shall be a framed structure Pump House of size **(12.00 M x 8.00M)** with **(3.5+5.5) 9.00 M** height above the Intake well/ Shaft with cantilever beams and slab structure.

- The bottom floor of the structure shall be fitted with Valves, Manifolds etc. named as Valve House.
- The top floor shall be shall be fitted with Pumps named as Pump House.

vi) There shall be required size of rectangular holes (Four numbers minimum) to be provided on the wall of the Intake well at different levels to draw water in different conditions with sliding gates with telescopic shaft and wheel arrangement suitable to be operated at the floor of the pump house.

vii) There shall be a provision for suitably lifting arrangement including installation of **5.00 MT** capacity EOT Crane for lifting & lowering of Pump sets, column pipe etc.

viii) There shall be one door of 2.00 mtr width and 2.40 mtr height with collapsible gate and 3 nos of windows of size 1.20 x 1.20 mtr with M.S Grill & Aluminium frame and double panelled pre laminated board.

ix) There shall be internal electrification for all electrical instrument with provision of 450 mm dia wall fan – 2 nos, 450 mm dia Exhaust fan -2 nos and suitable nos light fittings for interior light and 3 nos of weather proof street light around the pump house for exterior and yard lighting.

x) Appropriate Earthing arrangement for all the pump house as per IS 3043-1966 shall be provided.

xi) 800 mm height 32 mm GI post with two row of 15 mm GI handrails shall be provided at the edge of the cantilever slab.

B. R.C.C. / M.S. Foot-Bridge .

There shall be a RCC / MS footway bridge having suitable foundation system as per design requirement connecting river bank with the intake well in complete shape.

(i) The Foot Bridge shall be of **3.50 M** width and of required length (about **60.00 M** long).

(ii) There shall be sufficient nos of R.C.C. Column structure with R.C.C. walk-way and SS handrails / R.C.C. Column structure with M.S. walkway and M.S. handrails having joist arrangement.

In case of M.S. walkway, the Foot Bridge shall comprise required size of ISMB, ISMC, ISA and chequered plate of 10mm thick confirming to I.S. Specification and shall be bolted / welded to the columns properly.

Water Treatment Plant Layout

WTP Capacity : 130 ML in 22 Hours excluding Plant losses

3% of Plant capacity shall be considered in design towards plant losses.

Due consideration should be given to the following factors while deciding for positions of various plant units. A site plan is enclosed at relevant **Volume** for drawal of layout plan of the Water Treatment Plant considering the following aspects.

i) Geometry of the available land.
ii) Topography.
iii) Soil and foundation conditions.
iv) Inlet & outlet pipes.
v) Plant hydraulic: preferably with straight flow paths between units to minimize head loss & provide symmetry for flow splits.
vi) Transportation access.
vii) Site drainage.
viii) Accessibility to operating personal.
ix) Reliability & economy in operation & maintenance.
x) Aesthetics.

9.5.1 **Plant Hydraulics:**

Plant shall be designed to permit **Gravity Flow** from the **Cascade Aerator** up to the proposed **13 Million Litre** capacity **Clear Water Reservoir**.

(a) Cascade Aerator: The Cascade Aerator shall be a reinforced concrete structure .with

surface shall be finished with smooth plaster in CM 1:3 and then painted with anti-corrosive paint.

The cascade aerator shall have following details.

Number of Units	:	**1 (one) circular**
Head Required	:	**1.5 M**
Space required	:	0.03 m^2/ m^3/hr.
Number of steps	:	5 Nos. finished with Glazed tile.
Battery Limit	:	**15.00M.** from the center of Cascade fitted with all valves & fittings.
Core Pipe	:	***1422.40(OD)mm dia Spirally welded M.S. Pipe*** with outer PU Coating & inside food grade epoxy lining.
Launder design capacity	:	50% over loading.
Channel flow velocity	:	**0.7 m/sec**
Tread Width of steps	:	Shall not be less than 1.75 times of 'Rise'
Walk way		All round 1.0M width with S.S. Hand railing

(b) Raw Water Channel: The channel shall start from the Cascade aerator and will end up to the Filter House. The channel shall be constructed in R.C.C. For access, a 0.9 m wide walkway shall be provided at top of the channel, along its full length.

The alum and lime solutions shall be injected into the channel to ensure a thorough mixing. The chlorine solution shall be injected by bottom mounted diffuser disks or PE pipes.

For pre-chlorination, required dose of chlorine solution average 3 mg/l and maximum 5 mg/l shall be injected by PE pipes to the diffuser disks or pipes.

Along the length of the channel, a flume shall be provided to measure the quantity of raw water. An Ultrasonic type open channel flow measuring system shall be provided at the flume to measure only the rate of flow. The flow rate measured by this flow meter along with integrated flow shall be displayed on the Annunciator panel. The flume should be designed according to the recommendations of IS 14371:1996. All components of the flow meter shall be of non-corrosive material. The discharge shall also be displayed in the control area/ Office room. In addition, there shall be an integrator to display the total production.

The Raw Water Channel shall have following details

Number of Units	:	Minimum 1 (one) number
Type of unit	:	Rectangular RCC channel with operating platform of 1 mtr. Wide with S.S. Hand railing.
Capacity of Unit	:	To accommodate up to **50%** (fifty percent) overload with minimum **free board** of **0.35 m** & with catwalk along length of channel with Stainless steel hand railing.
Type of Flow meter	:	**Ultrasonic open channel flow measuring system with Mechanical flow meter**
Flow measurement		Suitable for measurement of flow within a range of **2000Cum/Hr to 4500 Cum/Hr**. Measuring accuracy: +/- 2%

		Necessary straight length of the raw water channel upstream and downstream of the Flow Measuring device and access to the channel shall be provided.
Channel flow velocity	:	**0.7 m/sec**
Stilling Basin		1 number in between Raw water Channel
Stilling Basin detention		**60 Sec**

(b1) Distribution Chamber:

Number of Units	:	Minimum 1 (one) number of required size
Type of unit	:	Rectangular/Square RCC Chamber with operating platform of 1 mtr. wide with S.S. Hand railing.
Free Board	:	Same as Raw Water Channel

(c) Rapid Mixing Unit (Flash Mixer): The Flash Mixers shall be of reinforced concrete. The inlet to from flash mixers shall be provided with manually operated sluice gates. The free board shall be at least 30 cm. The flash mixer shall be equipped with an impeller type high speed mixer. The driving motor of suitable capacity and other accessories shall be totally enclosed but easily accessible for maintenance. The shaft with the impeller shall be freely suspended from the driving gear mounted on a platform on top of the chamber. Thrust or guide bearing shall be located above the liquid level. The impeller shall be of stainless steel-316. The outlet of the flash mixer shall lead directly to the clariflocculator. The pipes shall be flanged CI material. The chamber of flash mixer shall be connected to the drainage system by means of a gate valve.

A walkway with hand railing shall be provided around the top of the flash mixer and shall be accessible from the ground level by a staircase.

Material of construction
Shaft - SS 431
Paddles - MS
Drain Valve - Manually operated
Drive motors to be provided with local push button control also.

The Flash Mixer shall have following details

Type	:	Mechanical-Turbine / Propeller type. The shaft & propeller shall be of Stainless Steel.
Number of Units & Shape	:	**2 (Two) Nos.** Circular
Detention time	:	60 sec.
Power	:	1 to 3 W/ m^3 of flow /hr.
Shaft Speed of Propeller	:	> 100 RPM.
Free Board	:	300 mm (minimum)
Tangential velocity at tip of blade	:	More than 3.0 M/S
H / D ratio	:	2.5 : 1
Impeller dia to tank dia :	:	0.30 : 1
Outlet pipe to Clariflocculator Velocity		0.8 m/sec

Motor with suitable reduction gear box shall be provided for the tank. One number of spare motor of same capacity shall be provided. They shall be placed over suitable RCC/Steel supporting arrangement on top of the tank.

Vertical strip of baffles, projecting $^1/_{10}{}^{th}$ to $^1/_{12}{}^{th}$ of the tank width, shall be provided at

minimum 4 places from the wall of tank to reduce vortex. Walking platform of 900mm wide shall be provided all-round the Flash Mixer at top of the wall with 800mm height Stainless steel Hand railing. Suitable supporting arrangement shall be made at top of wall level for placement of mechanical/electrical mixing devices. Motor, reduction gear, cabling, mixing arrangement, etc. shall be provided in complete shape as required for smooth functioning of the units.

All other scopes including electrical, mechanical, P&I etc. required for completion of the unit and for smooth functioning in all respect automatically cover under contract without any extra payment.

Other Criteria shall follow latest Manual on Water Supply & Treatment by CPHEEO, Government of India.

(d) Clariflocculators:

Circular Clariflocculator shall have central Flocculator for coagulation and flocculation and peripheral Clarifier shall be constructed. No. of Clariflocculators shall be **two (2)** suitable for clarification and treatment to suit to raw water quality of worst rainy season condition.
The Clarifier shall have a peripheral weir with vertically adjustable V-notch SS 316 weir blades for the uniform surface withdrawal of the clarified water. The blades shall be fixed with stainless steel anchors, nuts and washers. The flocculation zone and the sedimentation zone shall be separated by a circular isolation wall. All inlets, outlets passages of water shall be designed and arranged for a steady and uniform flow without undue turbulence to avoid disintegration. The freeboard shall be at least 30 cm.

A bridge with peripheral on-board drive with steel wheels traveling on the steel billets on the peripheral wall will be provided with:

- central platform for the installation of the stirrers and their drives and for the local control panel;
- paddle stirrers/agitators for slow mixing of the incoming raw water in the central unit;
- A radial scraper system with bottom scraper blades, suspended on the bridge.
- The hydraulic equipment is:
- the inlet pipe from the distribution chamber feeding into the central flocculation part;
- sludge outlet pipe with an electrically driven valve for intermittent operation according to an adjustable timer;
- a drain pipe with manually operated gate valve for the complete emptying of the unit;
- discharge pipe from the sludge outlet and the drainage outlet to the adjoining nallah
- A constant bleeding arrangement for desludging pipe shall be provided to enable observation of the sludge quality.
- A discharge pipe/channel from the peripheral collecting channel to the main channel leading to the filters.

The electrical equipment is:

- incoming cable with slip ring contacts for the on-board power supply and the supply of all motors;
- on-board panel for all operations of the unit with connections to the main control room for indication of the status of the unit components;

- adjustable drives for the flocculator stirrers;
- adjustable drive for the bridge;
- emergency stop buttons at the centre and at the outer side of the bridge;
- lighting.

The access to the bridge shall be possible from the peripheral walkway of width not less than 90 cm with a railing. The sludge withdrawal valve shall be of electrically operated type. The frequency of the sludge valve will be adjusted manually through push buttons according to the raw water inflow.

i. Rotating Scraper Bridge and accessories

a. The scrapers, flocculator blades and the rotating/ bridge supplied by the Contractor shall generally be manufactured in steel, painted and protected. All steel members of the bridge shall be painted; hand rails shall be galvanized.

ii. Rotating bridge structure

a. The rotating bridge structure shall incorporate a walkway having a minimum effective width of 90 cms which shall be surfaced with M.S. chequered plates, painted black. The bridge shall be designed to take its own dead weight together with uniformly distributed loading of 250 kg/m² over the full span and width of the walkway bridge and a moving point load of 500 kg. Maximum deflection of the bridge under the specified loading shall not exceed 1/360th of the span. The positive camber shall be kept initially to compensate for the maximum deflection under dead weight and superimposed loads.

b. The bridge shall be so braced as to limit lateral deflection to less than 80 mm measured at mid span under a full load condition.

c. The central part of the bridge shall be large enough for the installation of the flocculator systems and the control panel.

iii. The bridge shall have hand railing to both sides forming an enclosure at the center in between. The finished height of the railing shall be 1 m above the walkway. Toe guards shall be provided and secured around the bridge walkway which shall not be less than 100 mm high and 5 mm thick.

1. Bridge support and end carriage:

The bridge structure shall be supported at the center of the clariflocculator by means of cast iron bearing assembly of the slewing ring type and incorporating trunnion type mountings to accommodate vertical undulations of the traction wheels at the peripheral wall of the tank. The central bearing assembly shall be adequately lubricated and all grease points shall be extended to a battery plate mounted at the convenient point above the walkway. Oil fills and drain points, where applicable shall be extended to provide a convenient access for filling and draining the system. Catch drains shall be provided under all oil and grease points to prevent spillage from reaching the water surface.

2. The wheel carriage assembly shall be suitably proportioned to provide adequate stability to the rotating bridge structure, whilst providing the suitable base for the motors, gear box, driving and idling wheels, shafts and bearings. The wheels shall be plain without flanges. They shall travel on steel billets. The tolerance of the wheels shall be such that a de-railing cannot occur due to some misalignment. The size and design of wheels and carriage shall be calculated to transmit optimum tractive effort relative to the proportions of the scraper without producing wheel spin when the wheel path is subject to the climatic conditions.

iv. Drive

a. The bridge drive shall comprise of either (a) motor with reduction gear a chain sprocket or (b) a geared motor. The assembly shall be rigidly mounted and shall be adequately rated for continuous service in a water treatment works environment.

b. All lubrication points and all necessary provisions shall be made for routine maintenance and for prevention of oil and grease spillage. A deflector shall be provided and fitted to the leading edge of the driving carriage. It shall be angled at 45° and arranged to be adjustable to within 3 mm of the perimeter rail such that material coming in the way of free passage of the wheel shall be deflected.

v. Blades and fixtures

a. Scrapers shall be suspended and arranged to give continuous and progressive scraping of the entire floor of the Clariflocculator and the swept area of the successive blades shall overlap. The configuration of blades shall be designed to carry sludge and deposited suspended solids from the periphery of the tank and deposit it efficiently in the withdrawal hopper/sludge pocket.

b. The number and length of individual blades shall be designed by the Contractor, but the depth shall not be less than 300 mm and the thickness not less than 6 mm. Renewable fabric reinforced rubber wearing strips of cross section not less than 12 mm x 100 mm shall be fitted to each blade to provide a continuous contact surface which is adjustable for wear. The material shall have hardness not greater than 40 and be manufactured from well proven compound.

c. Backing strips shall be fitted to give support to the fixing of the rubber wearing strips and the assembly shall be secured by means of Galvanised bolts. Appropriate washers shall be fitted beneath all bolt heads and nuts. The top connections shall permit the blades to follow slight undulations in the tank floor. The bottom connections shall allow the blades to maintain contact with the floor throughout its length, while accommodating slight variations in the radial plane of the tank floor.

vi. Flocculation zone

The central driven flocculator shall consist of MS flocculator paddles, fixed to a SS 431 shaft with guide bearings and guide brackets suitable for under water use. The paddle area shall be at least 10% of the sectional area of the flocculator zone. The drive mechanism consists motor with reduction gear.

vii. Motors, starters and control

a. The electrical supply to bridge or flocculator driving motors shall be taken through a multi ring and slip-ring collector unit mounted in a fully water proof enclosure. The unit shall be fitted at the center of rotation of each bridge and shall be complete with all necessary support brackets, anti-rotation device. A suitable means of lubrication shall be provided.

b. The slip ring assembly shall be mounted above the top level of the tank walls. Sufficient rings shall be included to cover the motor supply and any ancillary circuits. Bridge drive and flocculator motors shall be of squirrel cage type, protected and shall be rated 25% above design duty.

c. All cables shall be connected to a termination box at the wall of the Clariflocculator. From there cables are connected to the main control panel

d. The bridge drive and the flocculator shall be controlled from an outdoor panel installed in the central part of the bridge. The drive status indicating lamps shall be provided on the Main Control Panel.

All other scopes including electrical, mechanical, P&I etc. required for completion of the unit and for smooth functioning in all respect automatically cover under contract without any extra payment.

(i) **Circular Flocculator shall have following details :**

No. of Flocculator	:	**2 (two) circular**
Type of Mixing	:	Mechanical Paddles type vertical shaft with Stainless Steel Shaft and paddles 8mm thickness minimum with required nut & bolts.
Inlet arrangement	:	suitable dia D.I.K-9 pipe as per design with Velocity 0.8m/sec from Bottom of Flash Mixture to bottom of central shaft duly laid below the floor slab of the Clariflocculator with required concrete encasing.
Detention period	:	30 minutes
Velocity gradient	:	40/Sec.
Total Area of Paddle	:	15% of Cross sectional area of the Tank.
Side water depth	:	3.75 mtr (Max)
Peripheral Velocity of blades	:	0.40 m/sec
Velocity of flow below partition wall	:	0.25 m/minute
Free board	:	0.30 m (min)
Sludge removal pipe	:	Suitable dia D.I.K-9 pipe (Minimum 300mm dia.) as per design for drain embedded in concrete below the tank portion. Control Valve shall be provided in the Sludge removal pipe at suitable location. Limit of contract upto the nearest drainage manhole.
Dislodging arrangement	:	Sludge is to be withdrawn continuously from the bottom of the basin under hydrostatic head through sludge discharge pipe.
Sludge pit	:	Circular Sludge pit as per design around the central shaft of Clariflocculator shall be provided with sludge removal arrangement.
No of driving unit	:	Two sets in each unit
Paddle rpm of mixing paddles	:	3 to 4

(ii) **Circular Clarifier / Settling Tank:**

No. of Units	:	**2 (two)**
Detention period	:	3.00 hr
Entrance Velocity to tank	:	0.25 m/minute.
Surface Loading	:	30 m^3/ m^2/ day. (Maximum)
Weir loading	:	300 m^3/m/day (Max.) designed to take 50 % overload.
Side Water Depth	:	3.75m (Max)
Free Board	:	0.30m (min)
Slope of Bottom	:	8%
Clear distance between tip of scarper and tank wall	:	Not exceeding 15cm.
Scarper Velocity	:	One revolution in 40 min. with Tip velocity of scarper is less than 0.3m/min.

Outlet Structure	:	Effluent launder with "V" Notches / Sub merge Orifice
Settled water turbidity	:	Not more than 15 NTU.
The **Partition Wall** of Clariflocculator	:	Minimum 150mm thick R.C.C.

The channel carrying clarified water from each Clariflocculator shall meet at a common point from where it shall run through a common channel and join to filter feed channel of RGF. The by-pass channel from common distribution box shall join at said common point.

Motor and reduction gear for mixing devices of flocculator and rotating foot way bridge/ scrappers, mixing devices and arrangements, underground power cabling, current collector, central bearing on central shaft, scrapper driving system, scrappers for de-sludging, MS foot way bridge with S.S. hand rail and floor MS Chequrred plate of 3 mm thick minimum, driving rail on top of wall etc., and all other related items required for completion and smooth functioning of Clariflocculator shall be provided based on required design.

M.S. Fabricated revolving Foot Bridge of **1200mm** wide(min) with S.S. Guard rail at both side, spanning between Outer wall of Clarifier, central shaft and overhang portion beyond central shaft up to required length for accommodating scarper arrangement, flocculator mixing arrangement and motor reduction gear of appropriate design approved by the department shall be provided. Walking plat form of 1000mm wide shall be provided all round the Clariflocculator at top of the wall projecting beyond wall with 800mm height Stainless steel Hand railing. The **Central Shaft** shall be designed accordingly.

Bypass of the Clariflocculator; collecting channel; Overflow:

The clariflocculators shall be bypassed by connecting the channel from the cascade aerator to the channel leading to the filters. The bypass can be used during periods of good raw water quality with minimum of turbidity and suspended solids for direct loading of the filters. There will be a manually operated bypass wall gate.

Other Criteria shall follow Manual on Water Supply & Treatment by CPHEEO, Government of India.

All other scopes including electrical, mechanical, P&I etc. required for completion of the unit and for smooth functioning in all respect automatically cover under contract without any extra payment.

(e) Valve chamber of Clariflocculator:
The R.C.C valve chamber with roof slab of required size should be provided.

(f) Filter House:

i. General

The filters shall be open type, constructed in reinforced concrete and its superstructure shall be reinforced concrete framed structure with in filled brick walls of specified thickness. The filters shall be symmetrically arranged on either side of the central gallery.

Every filter shall have walkways all around at the top. The clear width of walkways shall be minimum 900mm with G.I. hand railing and appropriate draining arrangement. All

walkways crossing the filters shall be provided with coloured cement chequered tiles. Two reinforced concrete stairs 1.5 m wide shall be provided on either side of the filter battery to access walkways at the centre of the filter gallery. The suspended floor used to support filter media shall be of cast in situ reinforced concrete and shall be designed for all necessary loads. The top slab of filter inlet channels and walkways shall be designed to cater for the loads during erection or loading of filter media.

a. The filter beds shall be supplied raw water from a main channel coming from the clariflocculators. The filters shall be of declining rate of flow type. All filters shall be identical in internal dimensions. The top level of the filters is so maintained as to avoid overflow in the filter area. The filters shall be open to sky. The gate shall be used for the isolation of a filter in case of backwash or maintenance. It shall be electrically operated from the filter control consoles.

b. The water level on the filter bed during filtration shall not be controlled. It will serve as the indicator for the filter loss. The filter influent shall enter below low water level of filters. Filters shall be cleaned when the water has reached that upper level.

c. Filtration shall be by gravity, downwards through a bed of filter sand supported by a layer of suitably graded filter gravel. The filter sand shall consist of hard, durable grains of silica and shall have a specific gravity of not less than 2.5. All grains of sand shall preferably be water worn. The filter gravel shall consist of hard; preferably rounded stones with an average specific gravity not less than 2.5, shall be free from clay, sand, loam and organic in Munduli, Bhubaneswar ties of any kind and shall not disintegrate with the action of water and backwashing. The supporting media depths shall be such as to ensure adequate and uniform distribution of wash water and air after leaving the orifices with the minimum risk of mixing sand with the gravel of the supporting media.

d. The filter media (sand and gravel) shall conform to IS: 8419 (part I) amended up to date. The sand media shall have an effective size ranging between 0.45 and 0.7 mm and a uniformity coefficient of 1.3 to 1.7. Filter sand when immersed in 40% hydrochloric acid for 24 hours, the soluble matter shall not be more than 5% by weight. It shall not contain more than 1.5% of calcium and magnesium calculated as $CaCO_3$. Ignition loss should not exceed 0.7% of the weight. The solubility of supporting gravels in 40% hydrochloric acid after 24 hours shall not exceed 10% for 10 mm or larger size gravel and 5% for smaller than 10 mm size.

e. All filter media shall be supplied in polythene bags. Suitable care should be taken to protect the media from spillage or contamination. Storage on site shall only be in an approved area, well drained and free of mud and silt. The filter media shall be carefully placed in the filter beds and shall not be dropped or dumped or machine handled so as to be detrimental to the floor media, nozzles or sealant. etc.

f. It shall be deemed that the Contractor has investigated all potential sources and verified that sufficient quantities of satisfactory filter sand can be obtained, packed and stored on site.

g. The **under-drain system** shall be a pipe grid type consisting a central pipe/channel with lateral system of PE pipes having perforations or nozzles. The laterals will have staggered orifices for water on the underside of the pipe. Air orifices will be at the topmost point in the pipe laterals. The holes drilled in the pipes shall be properly bushed. Alternatively,

nozzles shall be provided in the pipes for collecting filtered water and also for discharging air for scouring the filter media and water for backwashing. The under-drain system shall be designed to provide uniform draw-off of filtered water and uniform distribution of wash water and air over the whole area of the filter. Particular provisions have to be made for the handling of the high air velocities at the inlet zone of the manifold. Before filling the supporting layers and the sand of the filter beds the whole under-drain system shall be thoroughly cleaned and tested for equal distribution of water.

h. Each filter shall have central and lateral wash water troughs which shall be connected with adequate slope to the wash water outlet to prevent deposits of silt. They shall allow an equal withdrawal of the wash water during backwashing the filter. The filter backwash water shall ultimately be discharged to nearby nallah/waterbodies

i. **The filter house shall comprise** of **16 nos. twin bed rapid sand gravity filters** suitably arranged on both side of the operation pipe gallery. The rapid sand gravity filters shall be of Constant Rate Filtration type achieved by influent flow splitting. RCC framed structure roof shall be provided over the filter beds & operation gallery at a height of 4.15 M measured from top of filter bed wall.

   The filters shall be backwashed through **actuator operated valves** located on the operating platform on attaining allowable maximum head loss.

   The filter house shall have an annex building with RCC roof of minimum of **200m^2** floor area to house the backwash filling pumps, Air blowers, MCC, & control panels, the operators working area & furniture etc.

   The filter operating floor should be designed for maximum convenience to the operating personnel including ease of maintenance & provision of facilities to place & replace filtering materials, for accommodating the hand wheels for manual operation of valves etc. The provisions made for operating floor shall be clearly shown in the offer along with proper justification. There shall be adequate access from the operating floor to the pipe gallery. The width of the operating platform shall not be less than **2.00 mtr**.

   The pipe gallery should offer adequate space for convenience of inspection and for removal of faulty equipment. It should be possible to remove any individual valve without the disassembly of large amount of piping. Ample points of access should further more be provided for ease in handling of heavy pieces of equipment. The designer should use his ingenuity to develop an arrangement of piping that satisfies all functional requirements & ensures easy of maintenance & operation. The width of the pipe gallery shall not be less than **6.00 mtr.** All cares must be exercised to obtain water tight joints & connections. Some leakage of water which may be expected in the pipe gallery shall have to be disposed of by providing conceal floor drains with S/S grated openings/screens with sump & pump sets of required capacity with all piping and valves and mechanical and electrical accessories to discharge the collected drainage. **A bypass arrangement should be design to connect central manifold to wash water gutter**. Walkways of **1000 mm wide** shall be a provided around the filter beds & wherever necessary for easy access & operation & maintenance.

   There shall be a filtered water sump with all piping and valves, manholes, access ladder etc. in the filter house/close to filter house of designed capacity for pumping to the backwash water reservoir.

(g) Filter House shall be fully covered with RCC roof.

(i) **General Design Criteria:**

Number of Units	:	16 nos. twin bed with covered RCC Roof.
Type of filter	:	**Conventional type rapid gravity sand filters of Constant rate filtration type.**
Size ratio	:	1.25 to 1.33 for each single bed.
Media	:	Filter sand over graded gravel.
Average rate of filtration	:	**4.80 m^3/m^2/hour**
Effective size of sand	:	0.50 mm (0.45 to 0.6 mm)
Uniformity co-efficient of sand	:	>1.3 & < 1.6
Depth of sand	:	**0.75 m** (filter sand should conform to IS 8419 Part-I : 1977)
Depth of standing water	:	1.50 M (minimum)
Free board	:	0.50 m above water level.
Filter gravel size	:	50 mm at bottom to 2 to 5 mm at top conforming to IS: 8419 (part-I) 1977.
Depth of filter gravel not less than	:	0.50 m
Filter bed under drainage system	:	Shall confirm CPHEEO Mannual
No. of beds to be washed at a time in backwash	:	One twin bed

Other Criteria shall follow the latest Manual on Water Supply & Treatment by CPHEEO, Government of India.

All other scopes including electrical, mechanical, P&I etc. required for completion of the unit and for smooth functioning in all respect automatically cover under contract without any extra payment.

(i) **Filter operation gallery and pipe gallery:**

a. Each filter shall be provided with necessary electrically driven valves/gates having control through push buttons provided on the filter operating console. The valves shall have provision for manual override to cater for power failure. **List of valves/gates to be provided is given below**:

Filtered water outlet valves (electrical.)
Backwash water inlet valves (electrical.)
Backwash air inlet valves (electrical.)
Backwash water outlet (electrical.)
Raw water inlet gate (electrical.)

The valves shall be connected to pipe branches coming out of the filter box. These outlet and inlet pipes shall be provided with proper wall ducts without any leakage.

The electrically driven valves and the inlet gates shall be operated from individual control consoles positioned adjacent to each filter in the operation gallery with visibility to the

respective filter bed. **These consoles shall allow for the following control functions (-c) and indicators (-i):**

- -c Operation of the inlet gate and the valves (open, close)
- -i indication of the status of the gate and the valves (opened, closed, actuator motor fault)
- -c Operation of the air blowers (on, off, trip)
- -i Signal lamp with acoustic signal if the water level in filter bed has reached the top level and the backwash cycle has to be started
- -i Indication of adequate water level in the backwash reservoir (yes, no)

b. The washing cycle of the filter shall be controlled manually, step by step. Before backwashing, the filter water level has to be lowered to its minimum in order to avoid wastage,

c. The pipe gallery shall have the following piping arrangement**:**

- backwash water pipe with connection to each filter
- air pipe with connection to each filter

The filtered water pipe of each filter shall be connected to a small chamber to the central filtered water channel. The completely covered channel leads to the chlorination chamber.

The filter gallery and console shall be covered. In the pipe gallery easy access to all valves and drives, cables etc. has to be ensured. If required, walkways and ladders shall be provided.

(h) **Filter Backwash**

The filters shall be backwashed with **water and air according to a cycle prescribed by the Contractor**. The back wash interval shall not be less than 24 hours under normal conditions. The backwashing of the filters shall be carried out using a horizontal split casing centrifugal pumps (1W+1S) along with suitable induction motor coupled suitable for operating on 415V 50c/s frequency supply.

(i) **Backwash pumps**

The contractor shall provide horizontal split casing centrifugal pumps (1W+1S) along with suitable induction motor coupled suitable for operating on **415V 50c/s** frequency supply. The system shall be complete with suction pipe from the sump in the clear water channel, sluice valve in the suction, delivery pipe with spring loaded non-return valve and sluice-valve. The delivery pipe shall be connected to the individual filter beds with isolation valves. The system shall include the following:

- pipes and manually operated sluice valves for the suction and delivery pipes;
- electrically actuated automatically operated, valves for delivery pipes;
- pressure gauges with stop cock at suction and delivery of the pumps;
- spring loaded non return valves in the delivery pipes;
- mechanical water level indicator of the sump;
- low level switch in the sump for automatic stop of the pumps;
- Velocity in suction, delivery and pumping main shall be limited to 2.5 m /sec.

Blowers

The blowers for the air delivery for scour of the filter beds have to be provided and blower capacity shall be adequate for both beds of twin bed system and for single bed in case of single bed system. Each unit shall be provided with a suction air filter and silencer, pressure relief valve and delivery non-return valve. A non-return valve shall be provided on common air main to each battery of filter. The air pipe to the filter shall be laid with an apex above the maximum water level of the filters and a vacuum breaker at the point to avoid backflow and siphoning of water. Pressure gauges with stop cock at the pressure side of the compressors shall also be provided.

The air piping connecting the blowers to the filters shall be laid on the ring main principle. There shall be a provision for the release of air from the system at the end of the scour before backwash commences.

Design Parameters:

Configuration	1W+1S
Vol. of free air	600 to 900 l./min/sq. m.
Air pressure at under drain	0.35 Kg./sq cm.
Speed	< 1000 rpm
Air velocity in pipe and valves	< 25 m./sec.
Noise level	< 85 DB

(J) Service Water pumps

The contractor shall provide horizontal split casing centrifugal pumps (1W+1S) along with suitable induction motor coupled suitable for operating on 415V 50c/s frequency supply. The system shall be complete with suction pipe from the sump in the clear water channel, valves in the suction, delivery pipe with spring loaded non-return valve and sluice-valve. The delivery pipe shall be connected to all the dosing tanks and the relevant service water connections. The system shall include the following:

- pipes and manually operated valves for the suction and delivery pipes;
- pressure gauges with stop cock at suction and delivery of the pumps;
- spring loaded non return valves in the delivery pipes;
- low level switch in the sump for automatic stop of the pumps;
- Velocity in suction, delivery and pumping main shall be limited to 2.5 m /sec.

(iii) **Inlet and Outlet Control Arrangements:**

The inlet and outlet control arrangements of filters shall be designed for **50 (Fifty) percent** overload.

(iii) **Filter Feed:**

The inlet flow to the filters shall be evenly distributed along the length of the filter battery through reinforced concrete settled water common influent channel with a suitable arrangement of piping and weir to enable the incoming flow to be automatically divided between the total number of filters and to allow for common constant rate of filtration through all the filter beds. The feed channels shall be appropriately dimensioned to keep

turbulence and velocities within the required limits which shall not in any case exceed **0.60mtr/sec.** The channels and associated chamber floor shall be given slope towards the drains and drainage valves. They, if necessary, shall be fitted with steps or step irons for internal access.

(iv) **Filter Media and Charging:**

Before providing filter media and filter bottom, the contractor must provide three sets of samples each containing 10 kg of filter sand and graded gravels for examination and keeping them at site for visual verification of actual verification of quality through random sampling. The filter media and gravel should be brought to site in clean containers at least two months before the same are laid in the filter box. The contractor shall prepare the grain size distribution curve by taking representative samples from the stock filter sand to show that the d_{10} and Uniformity Coefficient values conform to the DTCN Provisions. Following installation and satisfactory testing of all the filter floors, when the engineer-in-charge is satisfied that the installations are complete; the contractor will be given written permission to commence filling the filters.

The filter media shall be carefully placed and not charged by dropping dumping, machine handling or any other method which in the opinion of the Engineer-in-charge will be detrimental to the floor media, nozzles, drains, laterals etc.

Following the initial charging, the filters shall be washed by the contractor. Filter beds, designed for expansion during cleaning, shall be skimmed prior to disinfection and the commissioning of the works.

(v) **Filter Bottom and Under-drainage System:**

The under drainage system shall be carefully designed to collect the filtered water and to distribute the wash water in such a fashion that all portions of the bed should perform nearly the same amount of work and when washed, receive nearly the same amount of cleaning. Since the rate of backwash is several times higher than the rate of filtration, the former shall be the governing factor in the hydraulic design of the under-drainage system.

The underdrainage system shall consist of central manifold of concrete/Cast Iron with perforated laterals. The laterals shall be of un-plasticized PVC conforming to relevant ISS. All other accessories of under drainage system shall conform to relevant ISS and shall be provided in complete shape required for smooth functioning.

The contractor may follow the guidelines given at section **7.6.3.9** of Manual on Water Supply & Treatment by CPHEEO, Govt. of India or any standard text book by authors of National & International repute / Codes of Practice **(IS/BS/AWWA/EU)** for design of manifold with perforated lateral under-drainage system. But the outcome of the design findings in any case shall have to be checked for uniformity of distribution of wash water in the laterals of the under-drainage through established hydraulic design without which the design shall not be accepted.

Water washing shall be done by drawing water from a Back Wash Water Reservoir of minimum **600 m^3** capacity located separately located on separate staging over close to filter house. The height of the backwash tank shall be decided from consideration of backwash head requirement. The backwash head shall have to be precisely calculated by considering the static head requirement at the inlet to the filter plus the dynamic head loss

occurring in the piping & specials, valves, inlet & entry losses, control equipment & appurtenances, under drainage system, gravel media, head required for fluidization of filter bed etc. Thumb rule provision from manual on water supply & treatment or any other text book shall not be accepted. The back wash tank shall be completed with all piping and valve arrangement, auxiliaries required for its completeness.

The wash water trough should be constructed not more than **2.00 m** apart and the same should be capable of discharging the waste water freely into the gullet. The bottom surface of the trough should be 5 cm above the expanded bed level while back washing. In total filter house and annex building shall be completed to the relevant civil, electrical, mechanical, instrumentation, piping and valve arrangements, Internal & External electrification required for completeness and smooth functioning of the Unit and annex building with required pumps, motors, blowers water & air wash system.

(a) **Back Wash Water Reservoir:**

The overhead back wash water tank of minimum **600 m^3** capacity with adequate staging located separately located on separate staging close to filter house shall be provided. The backwash water tank shall serve following purposes:

1. for back washing of one twin filter bed at a time.
2. for the laboratory for all tests likely to be conducted.
3. for the toilets for flushing and bathing purposes.
4. for chlorination.
5. For Chemical house requirement

The backwash tank shall be filled using filling pumps from filtered water sump of required capacity. The backwash tank shall be complete with all pipings (inlet, outlet, overflow, scour etc.) & valves required for meeting the above purposes, water level indicator etc. all complete. Over flow pipeline shall be connection to surface water drainage channel and scour line shall be connected to the underground plant waste drainage line. Piping shall be of D.I K-9 & valves PN_1. The sizes shall be as per design requirement.

The **wash water pumps** shall be of adequate capacity for filling the wash water tank in **2 hrs** time & with 100% standby (wash water pump & motor).

All other scopes including electrical, mechanical, P&I etc. required for completion of the unit and for smooth functioning in all respect automatically cover under contract without any extra payment.

(vii) **PUMPS & MOTORS: (For loading of back wash tank):**

1. **Scope of Work:**

The scope of work of the Contractor shall include design, engineering, preparation of drawings, supply, laying, erection, insulation, termination, testing, trial-run & commissioning of complete electrics, cable work, illumination, ventilation, including trench/duct making, civil & structural work etc. on turnkey basis. The scope of work of the contractor shall include complete electrical & cable work between the main LT Distribution Board (main LTDB) outlets to all the equipment, illumination, ventilation, plug-sockets etc. The pumping set shall be installed for the purpose of filling of back wash over head tank.

2. **Technical Specifications:**

(a) **Medium Voltage A.C. Motors:**

i) All A.C Medium voltage squirrel cage induction motors shall be designed, manufactured and tested in accordance with the requirements. All AC induction motors shall fully conform **to IS:325-1996.**

ii) The TEFC induction motors shall be designed for the maximum ambient temperature of 55^0C. The relative humidity (RH) can be upto the maximum of 100%. But the maximum ambient temperature and 100% relative humidity both may not occur simultaneously.

iii) The Motors shall be designed for an over load capacity of 115% of rated capacity for frequent operations.

iv) The insulation class of motors shall be B/F and degree of protection to be provided by the enclosure shall be IP 55 in accordance with IS:4691-2004. Degree of protection provided by enclosure for rotating electrical machinery.

v) The motors shall be designed for Direct-On-Line (D.O.L.) starting at full voltage with starting current generally not more than 600% of rated full load current and a minimum pull out torque of 250% of rated torque of full voltage.

vi) The motor body shall have two separate earthing terminals for earthing in compliance with Indian Electricity Rules.

(b) **Motor Control Centre (MCC):**

1) Two motor control centers, one in chemical house control room & one in filter House control room shall be provided.

2) The motor control centre (MCC) shall be designed, manufactured and tested in accordance with the requirements. The control of individual motors shall be suitably designed. It shall have load break isolator, fuses, electromagnetic contactor and thermal over load relays etc.

3) The MCC shall be sheet steel enclosed, floor mounted, free standing type and fully draw out type. The thickness of sheet steel used shall be 2.0 mm minimum.

4) The degree of protection provided by the enclosure shall be IP-52 as per IS:2147. Durable gaskets shall be provided for all doors and covers. The MCC shall be able to withstand a rated symmetrical fault level of 40KA for 1 second.

5) The main horizontal and vertical bus-bars shall be designed and supported to withstand the thermal and dynamic stresses corresponding to the above fault level.

6) The outgoing functional units shall be designed such that the components and wiring can withstand the stresses arising out of a bolted short circuit at the outgoing terminals till such time that the short circuit protective devices (SCPD) clears the fault. The protection shall be type 'C' of Clause No.2.1 of **IS:8544(Part-I**) 1971.

7) The short circuit protection shall be graded that a fault occurring in any outgoing branch circuit is cleared by the SCPD in the faulted branch without affecting the other outgoing branch circuits.

8) MCC shall be assembled by suitable combination of panels arranged side by side and shall be easily extensible on either side.

9) MCC shall be front wired.

10) The MCC shall have uniform height and preferably uniform depth also, throughout its entire length.
11) The cable entry shall be from bottom only, detachable ground plates of minimum 2.5 mm thick shall be provided.
12) The control transformer shall be housed in a non draw out module in one of a separate bottom compartment.
13) The MCC shall be provided with indicating instruments along with selector switches.
14) The MCC shall be provided with **'DANGER'** name plates in accordance with IS:2551-1982 and IS:8923-1978.
15) The bus-bars shall be of electrical grade aluminum and shall be so selected that the total operating temperature does not exceed 85^{o} C. The control bus shall be of suitable rating.
16) Clearances between phase buses shall not be less than 25 mm.
17) Power connections shall be done by single core 1100V grade PVC insulated copper cables and control wiring by 1100 V grade PVC wires with minimum 2.5 mm^2 copper conductor.
18) All power and control terminals shall be properly separated and suitably identified.
19) All sheet steel work shall undergo a process of degreasing, pickling in acid, cold rinsing and phosphatizing and then sprayed with a corrosive resistant primer followed by stove enameling, two coats of final painting shall be given with the opaline green finish as per shade 275 of IS:5.
20) Continuous earth bus shall be provided for the full length of the MCC running at the bottom with an earthing terminal at each end.
21) Mode of starting shall be Direct-On-Line system. Protection safety measures shall be taken to comply with statutory regulations and the design shall generally confirm to IS:8623 (Part-I) 1993.

(c) **Control Board :**

i) The Control Board shall be of sheet steel clad, floor mounting type, free standing design. The thickness of sheet steel shall be 2.00 mm minimum. The enclosure shall be dust and vermin proof with rubber gasketing conforming to IS:8623. The bottom of the control Board shall have removable cover plate to facilitate drilling of holes for cable entry as required during installation.
ii) The control Board shall be provided with push buttons, selector switches, indicating lamps, indicating instruments. The control board shall also be provided with audio visual annunciation facilities. The measuring instruments for indicating voltage and currents shall be provided. The emergency push buttons with mushroom head for all pumps shall be provided for any emergency off operation. This shall be non key type with mushroom head snapped push button with latch and twist release. A standard colour code shall be used.
iii) The control board shall be properly earthed.
iv) The control board shall be wired with a minimum of 1.5 sqmm. PVC insulated copper cables. All outgoing connections shall be brought out to terminal blocks. All terminals shall be covered with ferrules having engraved numbers.

v) Protection safety measures shall be taken to comply with statutory regulation and the design shall generally conform to IS:8623 (Part-I) 1993.

(d) **Cables :**

i) The multi core 1.1 KV grade power and control cables shall be included under the scope of supplying, lying and terminating of power/ control cables.

ii) **Power Cables** : The 1.1 KV grade power cables shall be PVC insulated, PVC sheathed armored, aluminum conductor. The minimum size of each core power cable shall be 6 sqmm. The power cables shall conform to IS:1554 (Part-I) 2005.

iii) **Control cables** : The multi core 1.1 KV grade control cables shall be PVC insulated, PVC sheathed armored, copper conductor. The minimum size of each core shall be 2.5 sqmm. The control cables shall conform to IS:1554 (Part-I) 2005.

(e) **Cable Laying :**

i) All the precautions, customaries in modern code of practices shall be observed with while laying of cables. Latest ISS, code of practices shall be followed for laying of cables. The underground cables for 1.1 KV grade for power/control shall be laid at a depth of 800 mm and after laying of cables the excavated earth trenches shall be back filled wherever required.

ii) When cables cross existing cables, water main and sewers the, cables shall be laid at least 300 mm below existing cable or water mains. Where the cables have to cross deep drains, the crossing shall be covered by fixing protective RCC pipe across the drain.

iii) All 1.1 KV grade power and control cables run on cable trays/racks shall be laid touching each other but shall be in one layer only.

iv) Cables of different voltages shall generally be laid on separate trays, where this is not possible; cables may be installed on the same trays with suitable barriers. At least 20 percent space on each tray shall be kept reserved for future installation.

v) Cables laid on vertical tray shall be clamped to the rangs at regular intervals using PVC cable strips, also cables entering or leaving cable trays shall be adequately supported or protected.

vi) Cable trays shall be provided with sheet steel covers.

vii) In the main plant buildings, sub-stations, control room etc. power and control cables shall be generally be taken on cable trays laid in tunnels, concrete trenches, cable cellars/ basements or along building structure, walls ceilings etc. Cables routed from tunnels/ trenches, the cables shall be taken to embedded/ exposed rigid steel conduits or flexible conduit unless directly terminated to the equipment located above the tunnel/ basement/ trenches.

viii) Cable for lighting installation shall generally be run on buildings, structures, ceilings, walls etc. provided in concealed PVC conduits conforming to relevant ISS.

ix) The RCC pipe protection for cables shall be provided for crossing the roads.

x) All cable entry openings for the equipment shall be sealed and made vermin proof.

(f) **Cable trays/Racks :**

i) The cable trays/ racks shall be designed, fabricated, supplied and installed suitably. The racks shall be fabricated ladder type made of MS angles and flats/rods. These shall be properly painted. The racks shall be of standard width of 300 mm or 600 mm suitable wherever required & shall be flush with walls etc. i.e. conceal type.

ii) The vertical and horizontal supports for the cable racks shall be fabricated steel sections/rods. The spacing of cable trays supports shall be to suit the loading of the racks but shall not exceed 1500 mm vertical spacing between the two racks & not less than 300 mm.

iii) All 1.1 KV grade power and control cables run on racks shall be laid touching each other but shall be in one layer only.

iv) Cables of different voltages shall generally be laid on separate trays, where this is not possible; cables may be laid on the same racks with suitable barriers. At least 20% space on each rack shall be kept reserved for future installation. All LT cable and control cables laid on trays/racks should have identification tags at every 5 meters of length.

v) All cable trays shall be protected by sheet steel covers duly bolted/screwed.

(g) **Earthing :**

Earthing for all installations shall confirming to **IS/IEC:62305, NBC–2016 and IEC:62561.** Accordingly, **'**Earthing' for all installations shall be included in the scope. The earthings shall include all the motor control center control post, cable racks, and illumination and ventilation installations. The material used for earthings purpose for different equipment shall be suitably selected and shall be subjected to approval of the Department and shall meet the stipulation of the Indian Electricity Rules and Regulations to the satisfaction of State Government Electricity Inspector.

(h) **Filter Piping and Valves:**

Typical range of velocities to be used for design is given below and are applicable for the channels, pipes etc for which the velocity has not been mentioned specifically. The contractor should avoid taking the maximum extreme value unless under specific conditions when commercial diameters of pipes are not available.

SN	CONDUIT	VELOCITIES M/S
01.	Influent	0.6 to 1.83
02.	Effluent	0.91 to 1.83
03.	Wash water from elevated tank	2.0 to 3.0
04.	Drain from filter	2.4 to 3.6

Flanged DI pipes of appropriate class conforming to relevant ISS shall be used. The connection pipe from Filter House to proposed **13 ML capacity** Clear Water Reservoir & Piping for filter house and operation gallery shall be of **D.I K-9 Pipe**. The filter house shall be complete with all related electrical items, internal electrification, piping & valve arrangements for water & air wash, internal electrifications & all other related piping & instrumentation.

All other scopes including electrical, mechanical, P&I etc. required for completion of the unit and for smooth functioning in all respect automatically cover under contract without any extra payment.

(h) Chemical House:

i) **General**

The chemical house comprising of facilities for storage of chemicals (PAC)/Alum, chemical handling, solution preparation & dosing for PAC/Alum etc. shall be suitably designed for all chemicals required for the water treatment purpose. The complete chemical house shall be in one building which also includes space for Sixty days storage of alum, lime and polyelectrolyte.

The chemical house **shall have two floors.** The ground floor shall be used for storage of chemicals while the upper floor for housing the solution tanks, dosing facilities, MCC room & operating platform. Ground floor area is equal to first floor area. Suitable staircases, platforms etc. shall be provided to have clear access to different units. The building is supplied with process water. The chemical house shall have sufficient space for unloading of the chemicals.

The MCC room shall accommodate the control panels of mixing devices of chemical tanks, & other electrical facilities & also the operators operating area & furniture's. There shall be RCC stairs of **1.0 m** wide for access to the 1st floor of standard rise & suitably located.

The area at GF & FF each shall not be less than **600m²**.

ii) **Facilities to Handle the following Chemicals for Coagulation & Flocculation:**
PAC dosing arrangement:

For PAC dosing, the PAC will be pumped to a agitation tank of SS 316 construction design for **required size with 0.30 mt** free board. Agitator is provided with an impeller consisting of 4 bladed axial flow type located at one third of chamber depth (above floor level). The drive shaft and turbine blade shall be manufactured for high corrosion resistive material, The mixing speed shall be 100 RPM. The driving motor shall be connected to the shaft through a direct coupled worm reduction gear box reducing the speed from either 970 or 1400 RPM The shaft shall be detachable above water level by means of steel coupling with stainless steel bolt motor shall be of appropriate rating, the drive is mounted on MS fabricated base frame as per specification.

The Alum tanks shall be lined internally with acid resistant tiles or bricks. Areas around the building shall be paved. Floors and walls shall be lined with acid resistant tiles or other acid and abrasion resistant tiles. The external appearance of Chemical house shall blend well with that of the other plant buildings. A covered overhead service water tank shall be provided on the roof level of building.

The Chemical storage house shall have space for storing of (60) Sixty day's storage of Alum and lime and shall be of RCC framed structure. Wall of Chemical storage house shall be minimum 230 mm thick brick masonry. It shall be covered at top with RCC slab. Finishes to be provided in Chemical storage house are enclosed in TABLE A of clause1.21.3.

The dosing plant must fulfill the following criteria for the raw water treatment capacity

Dosing plant capacity:

Medium	max. dose	Solution	Dosing Rate m3/h	Solution tanks
Alum	50 mg/l	10%	1300 l/h	3
Lime	25 mg/l	2%	3250 l/h	3
Polyelectrolyte	0.5 mg/l	0.1	650 l/h	3
Chlorine (pre-chl.)	3 mg/l		1+1 working and one standby total 3Nos	
Chlorine (post-chl.)	1.5 mg/l			

i. **Alum, Lime and Polyelectrolyte solution dosing**

The dosing of Lime, Alum and Polyelectrolyte shall be carried using the pumps of capacities as indicated in the table above. The diameter of the pipes in the chemical plant and to the injection points shall be a reasonable compromise between a sufficiently wide diameter to prevent clogging and a satisfactory high flow velocity to prevent deposits.

ii. Tanks and agitators

The alum solution tanks shall be of reinforced concrete lined internally with acid resistant glazed tiles laid in suitable cement mortar to resist corrosion by the alum solution where as the dosing tanks for the lime and polyelectrolyte shall be of reinforced concrete and then painted with anti-corrosive paint. There shall be suitable platforms on top of the tank for mounting of the agitators. Another platform or walkway shall be provided along the front of the tanks for easy inspection and maintenance. Strainer troughs of stainless steel 316 shall be provided for the dissolution of alum sulphate bricks. The freeboard shall be 300 mm. Each solution mixing tank shall be provided with electrical agitators. They shall be of paddle type. The driving motor of suitable capacity including reduction gear and other accessories shall be provided for rotating the agitator at a speed between 30 to 50 rpm. The fan cooled driving motor and reduction gear shall be totally enclosed but easily accessible for maintenance. The sweep area of paddle shall cover a minimum of 25% of the tank area. The shaft shall be freely suspended from the driving gear mounted on top of the tank. Thrust or guide bearing shall be located above the liquid level. The shaft of the agitator and the paddles shall be of stainless steel-431. The speed reduction gear assembly shall be of nickel hardened steel and oil immersed. A local push button control shall be provided for the motor of the auxiliary tank.

All other scopes including electrical, mechanical, P&I etc. required for completion of the unit and for smooth functioning in all respect automatically cover under contract without any extra payment.

iii) Chlorination:

Chlorine storage:

The chlorine storage shed shall be provided in the ground floor of the chemical house as per IS 10553 provisions. Its area shall be open to the sides of the building. It shall be large enough to take 1 month storage of 900 kg chlorine drums, the chlorine drums shall be placed on concrete supports with two steel rollers each for easy rotating of the drums.

Each tonner shall be provided with pressure gauge and isolating valve. A loading and unloading bay of 4 m width shall be provided at the entrance of the area.

a. The open area is protected with a steel bar fencing of 2 m height. There will be an entrance with gate to unload and load the chlorine gas drums. The handling of the chlorine drums will be made with an electrically driven hoist and trolley of a capacity of 3,000 kg, capable to lift and move the chlorine drums. The hoist shall have an automatic brake. It shall have a safety type hook and a suitable drum lifting beam and an in-built weighing device with a dial indicator. The latter shall be calibrated in a manner to indicate the net weight of the chlorine gas, without the weight of the drums and the other dead weight. The vertical and the horizontal movement of the hoist shall be controlled from a panel mounted at the wall of the handling bay or from a pendant mounted on the hoist, near the weight indicator.

ii. **Neutralization of cl2 through Scruber of Capacity 900Kg.**:

iii. **Chlorinators:**

- Vacuum type chlorinators shall be installed in a separate chlorinator room. The room shall have space to install **4 nos chlorinators of capacity 10Kg/Hr**. The room shall be reasonably gas tight and shall be provided with a ventilation system delivering into the open space of the chlorine storage area. A set of continuously running fans shall exchange the air three times per hour. Emergency fans shall exchange it 20 times per hour. The doors of the room shall open outward.
- The process water for chlorine solution shall be drawn from clear water tank.
- The chlorinators shall be adjustable within a range of 1:10 according to the chlorine requirements. The tolerance of adjustment is not more then +/- 4%. Pressure gauges, indicating chlorine gas pressure and injector pressure shall be mounted on the front of the chlorinator and calibrated in metric units.
- An injector module to suit the capacity of the chlorinator shall be provided with each chlorinator. A spring diaphragm check valves (to close injector suction part when the injector is not operating) a ball check valve or both shall be incorporated in the injector to prevent the back flow of water from the injector into the chlorinator. The flow of the injectors shall be controlled with the help of Rota meter. A booster pump shall be provided to increase the pressure to the required level.
- All parts of the chlorinators, the injector and its accessories shall be of suitable material resistant to the chlorine (silver, silver plated Hastelloy C, PVC, Teflon, Borosilicate glass, ebonite lined cast iron).
- The chlorinators and their injectors shall be with suitable mounting brackets with anchor bolts. All connections, valves and other parts of the chlorinators shall be easily accessible for cleaning, maintenance and repairs. Pipe connections shall be flexible.
- The complete chlorinator and injector units shall be piped, and pre-tested as a system with all necessary valves, inlet connections, gauges and orifice control.

iv. **Operation water and booster pumps for the chlorinators**

The water supply shall be made from the internal system. The pressure shall be boosted by four centrifugal booster pumps (**2 for pre and 2 for post chlorination**) to be installed in the pump room, adjoining to the backwash pumps.

Two pumps shall be supplied with isolating valves and the pressure gauges on delivery and valves by pass with pressure release valve from delivery to suction for each pump. The pumps shall be directly coupled to drive motor. The pump set shall be mounted on a base plate.

v. **Chlorine and solution pipes:**

a. The gas and water piping system shall be designed according to the chlorine and injection water flows and the design hydraulic/pressure conditions. The pipes shall be laid as straight as possible on the shortest route from the drums to the chlorinators. They shall be fixed on well supported trays / brackets and adequately sloped to allow for drainage. All steel supports shall be heavily painted in chlorinated rubber paint.

b. The connections of the chlorine gas pipes to the cylinders and the chlorinators shall be coiled for flexibility during operation and maintenance. Each connection shall have a valve, a solenoid valve and a pressure gauge. All pipes and valves of the connection shall be placed out of the reach of gas cylinders hanging on the hook during manipulation. Not more than 4 gas drums shall be connected to a common withdrawal header.

Pipe material for the chlorine dosing plant

Medium	Construction material	Test pressure
Chlorine gas	Soft seamless copper tube with compressed fittings	25 kg/cm²
Injector water	PE pipes	10 kg/cm²
Chlorine solution	PE pipes and fittings,	10 kg/cm²

c. After installation, the chlorine gas piping system shall be cleaned and dried. After drying, the system shall be pressurized with dry air up to the test pressure and tested for leaks by application of soapy water to the outside of all joints and connections. Leaking joints shall be repaired, and only when all joints are made leak proof chlorine gas shall be gradually introduced and the system shall again be tested for leaks.

d. The pipes for water and chlorine solution shall be tested with water with the respective test pressure.

Colour code for pipes

All visible pipes in the different units of the plant shall be painted according to a distinct **Colour code.**

Raw water	**Dark Green**	Air	**Yellow**
Settled/filtered water	**Light Green**	Sludge, Sludge water	**Brown**

Treated potable water	**Light Blue**	Chlorine solution	**Red**
Backwash water	**Blue**	Alum,	**Pink**

All roof terraces shall be accessible for inspection via a small staircase.

Chlorine House:

i) The chlorinators shall be housed in the Chlorinator room of minimum **120 m^2** floor area for Pre Clorination and **120 m^2** floor area for Post Chlorination.

a. **Chlorine store :**

i) The chlorine store including the chlorinator room shall be of minimum 2 x **(20+120) 140m^2** floor areas & shall be separately located close to the filter house for storage of **minimum 5 nos**. of toners & two nos. of **Gas Chlorinators**. The chlorine toners shall be kept at **1.80 mtr. C/C** apart & shall move on trunions. The loading and unloading of toners shall be made to and from the truck respectively in the loading bay inside the storage area. Monorail system shall be provided inside the chlorine storage room so that loading & unloading of chlorine cylinder can be done inside the room. Height of the roof above plinth level shall be minimum **5.0mtr** or as per requirement whichever is more.

ii) The contractor shall supply at his cost **five numbers** of full chlorine toners with necessary certificates. Each toner shall have a normal capacity of **0.9 ton liquid chlorine** available above one bar pressure. These shall be of standard Indian manufacturer without fusible plugs. Each drum shall be fitted with ringed or removable protective valve cap. The drums shall be painted yellow with back concave ends and shall have the words 'liquid chlorine' with the gross and net weight stenciled on the side in Kg. The toner size, its length and diameter along with the weight of liquid chlorine, which it can contain, shall be clearly mentioned.

iii) Provision shall be made for manually operated hoist of **3 ton** capacity running on monorail system for handling of chlorine cylinders. The monorail shall have an operational design capacity of at least **3 tons** and shall be provided with safety type of hook, a drum lifting beam etc. The drum lifting beam shall have a central lifting eye, rotating swivel and hinged steel hooks designed to accurately and safely hold the ends. The contractor shall arrange the layout, the store ceiling height and the elevation of the gantry arrangements to permit any drum to be lifted from any cradle for transfer to any location of the loading vehicle. All drum positions shall be served by the monorail gantry and the clearance shall be such as to enable the drums to be loaded in a standard vehicle with at least 700 mm clearance between the drum in transit and the top of any drums already in position on the vehicle.

iv) **Chlorine Gas Detector:**

i. Two numbers of chlorine gas detector with alarm facility of reputed make to be approved by Department shall be provided. One will be in the chlorinator room & the other chlorine store.

ii. Two numbers of self-contained breathing apparatus, with a full-face piece and a cylinder of air or oxygen carried on the body or with a canister that produces oxygen chemically, shall be provided.

iii. Neutralization pit of required size shall be provided close to Chlorine house.
iv. One no. of **Emergency kit** of approved make to handle leakage shall be provided.
v. One number of **first aid kit** shall be provided.
vi. One number of **Steel Almirah** of approved make and design suitable for storage of accessories shall be provided.

v) **Ventilation requirements:**

The contractor shall provide forced ventilation system in the chlorine store & chlorinator room conforming to the Govt. of India safety rules, provisions of National Safety Council, **IS:4379-1967**, other relevant IS codes of practices and Manuals Governing the storage & use of chlorine gas. The forced ventilation system shall be capable to vent even traces of leaked chlorine gas to the atmosphere. The ventilation system shall be manually controlled from external switches outside the rooms at each doorway. Any damage to personnel, property etc. due to mis-handling/ inadequacies in handling facilities shall be the total responsibility of the contractor. The tenderer shall clearly outline/specify in their offer about the facilities provided by them for storage and handling of chlorine gas and chlorinators.

The Chemical House, Chlorine store, Office building, Pump house, etc., shall be completed in all respect based on specification provide in tender schedule and for all other items standard PWD & electrical specification of Government shall be followed. The chlorine store & related units shall be complete with all related mechanical, electrical & instrumentation, piping & valve arrangements for smooth functioning of system.

All Structural Members and RCC Slab shall be provided with Integrated Lightening Protection System confirming to IS/IEC-62305, NBC-2016 & IEC-62561.

All other scopes including electrical, mechanical, P&I etc. required for completion of the unit and for smooth functioning in all respect automatically cover under contract without any extra payment.

(I) Chlorine contact tank

The chlorine contact tank should be of RCC of size not less than 7.50mtr length x 5.00mtr width x 2.00 mtr SWD with free board of 0.30 mtr. The detention time should not be less than 10 minutes.

(J) Security Cabin / Watchman Room

Of size **4.00mtr x 4.00mtr x 3.00mtr** height with one toilet 2 x 2 M having RCC frame structure to be constructed near entrance of the WTP.

(K) Internal Road

All the internal roads of the WTP should be unreinforced plain cement concrete pavement of M-30 grade of 200mm thickness over a prepared sub base of cement concrete (1:3:6) of 150mm thickness for 4.00 mtr wide road. Pathway as required with cast in situ paver block in cement concrete M20 shall be provided.

(L) Interconnecting Channel

All inter connecting channel constructed with cement concrete M30 with 20mm downgraded CBHG chips over RCC column of appropriate size including finishing smooth to the proper gradient.

(M) Clear Water Under Ground Reservoir:

Shape : Rectangular Shape with two compartments.
Capacity : **13 Million ltr – 1 no.**

The filtered water will be collected in the **13 ML capacity** Clear water Under Ground Reservoir. Clear water reservoir shall have rectangular shape with two compartments. All pipe work, gates, valves etc. for isolation of each compartment. The responsibility of water tightness, structural stability shall be of contractor. The Clear Water reservoirs shall be complete with all required piping & valves on the inlet & outlet side, overflow and scour pipes and 100 mm dia C.I. air vent pipe with cowl etc.

The scope includes:

- Design, Construction, testing and commissioning of **13 ML capacity** Circular domed / flat roof.
- Under Ground Reservoir with inlet, overflow and outlet piping and valves of required dia as per design.
- One set of Ultrasonic & Mechanical type (Float Type) Water / Liquid level indicators of Krohne / MEI /reputed make shall be provided for **RCC reservoir**
- Manhole two nos. 600 mm dia, Stainless Steel Access ladders etc, shall be provided as per detailed specification for **RCC reservoir**
- The contractor shall provide a masonry drain with outfall structure etc. for disposal of overflow water by gravity to the proposed drainage system.
- RCC grade – M-30 for all components.

All other scopes including electrical, mechanical, P&I etc. required for completion of the unit and for smooth functioning in all respect automatically cover under contract without any extra payment.

(N) Pump house

The pump house should be constructed at proper level above HFL as well as providing **positive suction of the pump sets**. The pump house shall be of RCC frame structure with R.C.C. roof slab of 150mm thick with RCC M-25 having minimum floor area of **460 Sqm and** wall shall be of fly ash brick with cement mortar (1:6), provision for MS girder with monorail system of (minimum) **5.00MT capacity EOT**, floor should be of 25mm thick A.S. flooring over 0.075m thick cement concrete (1:2:4) using 12mm size CBHG chips and under layer should be 100mm thick P.C.C (1:3:6) using 40mm size CBHG metal, along with provision for construction of platform for fitting fixing of pump sets and M.S rolling shutters, windows, ventilators, painting both inside and outside, internal electrification etc. all complete .

(O) Administrative building -cum-Testing Laboratory:

A double storied building having floor area of **150 m^2 in each floor.**

The floor area of the office building & testing laboratory shall be **150 m^2**. The furniture shall include - (1) Sink base unit (2) Drawer base units (3) Drawer base unit for 6 paddle stirrer (4) Shelf box unit for general work space (5) Refrigerator (6) Office desk with file space (7) Chair. The sink shall be of size 30 inch x 18 inch x 10 inch and in addition a water tap of CP material shall be provided.

The laboratory furniture shall be of plywood construction resistance to acid & water of highest quality material and workmanship. The size of the plywood shall be of 12mm thickness for doors, drawers etc. and not less than 19mm for table tops fixed on wooden construction of adequate thickness. The contractor shall provide handles, locking systems and all other fixtures. The firm shall furnish catalogues from several reputed laboratory manufactures with detailed specification for the laboratory furniture.

The laboratory shall be furnished with equipment & glass wares as listed below, for testing of the following parameters - (i) optimum doses of coagulant (ii) turbidity (iii) pH (iv) Residual chlorine (v) Alkalinity (vi) Iron, (vii) hardness and viii) Dissolved Oxygen. The **pH meter and turbidity** measuring instruments shall also be of portable type. All type of chemicals required for conducting routine tests during trial run of the WTP, shall be provided by the firm at his cost.

List of Laboratory Equipments,Chemicals & Glass Wares:

1.	pH Meter (0 – 14)	1no.
2.	Nephlo Turbidity Meter (0 – 3000 NTU)	1no
3.	Test Kit to measure Residual Chlorine (0–10 PPM)	1no
4.	Flocculator	1no
5.	Coloroscope with chlorine dose 0 to 2 ppm	1no
6.	Borosil Make Measuring Cylinder 100ml,250ml	2nos.
7.	Borosil Make wash bottle 1000ML	3nos.
8.	Borosil Make Conical Flask 500ML	6nos.
9.	Borosil Make Conical Flask 250ML	1no
10.	Borosil Make Beaker 500ML	5nos.
11.	Borosil Make Beaker 250ML	5nos.
12.	Borosil Make Beaker 100ML	8nos.
13.	Borosil Make Burette 100ML.	4nos.
14.	Borosil Make Pipette (10ml, 5ml)	5nos. each.
15.	Borosil Make Test Tube (Standard size) - 20ml	12nos.
16.	Burette Stand	2nos.
17	Reagent bottle (125 ml, 500ml)	5nos. each.
18	Sample bottle 2.5ltr capacity	10 nos
19	Thermometer $-10^0$to 50^0c	1 no

20	PH Strips (25 to 10.5 range)	1 doz
21	Hydramine sulphate	50gm
22	Hexamethylene telamine	500gm
23	Orthotolidine	1 bottle
24	EDTA Solution	500 ml
25	Ammonium Chloride	250gm
26	Magnesium Sulphate	250 gm
27	Calcium Carbonate	500gm
28	Sulphuric Acid	250ml
29	Sodium Carbonate	500gm
30	Phinophthline	100ml
31	Methlic Orange	100ml

All other scopes including electrical, mechanical, P&I etc. required for completion of the unit and for smooth functioning in all respect automatically cover under contract without any extra payment.

(P) Sludge recycling, treatment & disposal unit inside WTP:

The **Sludge recycling, treatment & disposal unit** shall consist of Sludge Collection Tank of 40.00M dia (min), with all Piping arrangement for receiving sludge from Filter House, Back Wash recycling Sump, Sludge thickener including all required units as per the design requirement. Necessary pumping system to be provided for pumping of recycled water.

All other scopes including electrical, mechanical, P&I etc. required for completion of the unit and for smooth functioning in all respect automatically cover under contract without any extra payment.

iii. Machineries and pump sets (where it has not mentioned specifically)

a) Flash Mixture

Flash Mixture mechanism consisting of TEFC squirrel cage induction motor of appropriate HP with S/S shaft, S/S impellor, reduction gear mechanism, support spanning with paddles, guide bearings, etc. as per design.

b) Clariflocculator

Clarifier Scrapper Bridge spanning radial wall of clariflocculator made of welded and bolted MS section. The scrapper arm with scrapper blade being suspended top of the bridge which includes rubber scrapper with supporting MS shaft bolted with S/S nut bolt. Floculator suspended from the clarifier bridge with MSA Shaft guided in under water guides, MS paddles and scrapers as per design. Floculator driving arrangement consisting of suitable bevelled gear, reduction gear and 1HP TEFC electric motor- 4 nos. Driving mechanism of clariflocculator bridge consisting of

required capacity of electric motor, reduction gear and chain spocket transmission to driving wheel and idle wheel mounted on suitable trolley- 2 nos. Central bearing consisting of special bearings to take care of axial & radial thrust housed in CI housing with auto aligning system. Steel rail for peripheral wall. Special current collector for transmission of electric current through overhead / under ground cable for different motors. The specification may change as per design with prior intimation with authority.

c) Chemical House

i) **PAC Dosing system**(2 sets- one working and one stand by)- PAC dosing system consisting of agitator design for 1x1x1m liquid depth with 0.3mtr free board.

ii) **Chlorination plant** : (2 sets- one working and one stand by)- Chlorination plant of capacity 4kg/Hr consisting of vacuum regulator, injector assembly, differential pressure regulator, chlorine pressure gauge, chlorine flow meter (Rota meter), Chlorine rate control valve, interconnecting removable type pipe of PVC with ceiling rubber O rings, cylinder connecting valve with clamp to connect copper coil and tonner, live stop valve with auto gas off.900 kg capacity filled tonner with necessary explosive department certificate, EOT Crane – single girder type fully motorised crane with electrically operated hoist with monorail beam, locking arrangement, limit switch, pendant push button, starter panel, etc.

d) Filter House

2 sets of Twin Lobe air blower (one working & one stand by) having capacity 1600cum/ Hr coupling with motor of required capacity with all arrangements.

e) Pump sets

Supplying, fitting, fixing, testing & commissioning of following submersible pump sets with allied equipment (Working +Stand by for each as per design requirement) as per relevant IS Specification suitable for 3 phase, 415 volt, 50 Hz, AC Supply having TEFC Enclosure with class F insulation and IP 68 protection, operated at 1500 RPM.

i) Back wash water tank :- Height- As per design requirement

Supplying, fitting, fixing, testing & commissioning of following Horizental split casing centrifugal pump sets with allied equipments -2 nos (1W+1S for each) as per relevant IS Specification and make : Kirloskar / Jyoti/ Worthington / WILLO /KSB capable of common base plate coupled with SPDP Eff1 induction motor , rating of motor 10% more BHP than that of pump ,suitable for 3 phase, 415 volt, 50 Hz, AC Supply operated at 1500 rpm. with suction & delivery piping arrangements with required size S.Valves, N.R.Valves and all other accessories.

ii) Form WTP to raising main- Q-10550 Lpm, H-10M

f) Main Power Distribution Panel (MCP)

i) For WTP to raising main

Floor mounted cubical LT Motor Control Panel board fabricated with M.S. sheet of 18 SWG, dust and vermin proof and Panel should be painted with one coat of red oxide paint and two coats of Enamel paint. Consisting of proper power distribution 4 pole suitable Amper copper busbar, 1 no. incoming feeder of MCCB and 2nos. outgoing

feeder MCCB for pump sets [MCCB make: L&T/ABB/Siemens/Schnieder], 2 no. MCB for lighting and other utility loads, 2 nos. Suitable Fully automatic star delta starter (make: - L&T/ Jyoti /Siemens/Schnieder) suitabale for above H.P. switch disconnected isolator (TPN) rated (200A-414V) selector switches, Voltmeters, Ampere meters ,indicator lamps etc. all complete with internal wiring, protection units/relays and capacitor blanks of proper KVAR for power Factor control.

ii) Power wiring

a) Power wiring with required 35 Sq mm 3.5 core 1.1KV grade LT copper Cables XLPE/PVC insulated, armored cable from Transformers to MCP, laying, jointing and making proper termination etc. all complete.

b) Power wiring as per requirement from MCP to motor, including laying on wall or on floor as where required, jointing and making proper terminations etc. all complete.

III) Chain pulley block

3T Triple spur type chain pulley block suitable as below with 6m lift complete with load chain suitable for above lift, tested to 50% over load as per IS 3832.

IV) External & Internal lighting of pump house

External & internal lighting by doing wiring and installing lumenaries e.g. suitable Wattage LED light fittings with standard lumen in pump house, Campus and fitting and fixing of required numbers of exhaust fans in pump houses for proper ventilation.

The contractor shall get the above installations inspected by the concerned authority and shall bear the required Inspection charges. However the Department shall deposit the supervision charges and Security Deposit etc., to the TPSODL.

(q) Underground Drainage & Waste Disposal System & On-site Sanitation at Treatment Plant Site:

The contractor shall provide open drainage system with RCC M-25 with cement plaster (1:3) including punning to inside & exposed surface for carrying rain water/ roof top drainage/ surface run-off for its disposal. The drain is to be designed accordingly. Graded weep holes shall be provided at suitable intervals along the drain.
The contractor shall provide RCC slabs of required thickness over the open drain wherever necessary. Any CD works if required shall have to be constructed by the contractor.

The contractor shall provide close conduit under drainage system with RCC NP2 S/S Hume pipe of designed dia with manhole duly spaced not exceeding 15 M etc. for carrying the processed water from Chemical House, Filter House, Sedimentation Tank & Clariflocculator etc. Both the surface drainage system and under drainage system shall meet at a suitable location at the **Master Man Hole** from where it shall be connected to the nearest existing drain to the proposed WTP site by close conduit system with required numbers of Manhole and outfall structure to allow gravity/pumping under pressure discharge under all conditions. The close conduit under drainage system is to be designed accordingly. Final disposal point shall be as will be shown by the Engineer-in-charge of work based on actual field requirement. For smooth disposal of waste generated till the outfall point, ancillary structures & items likes waste water RCC sump, pumping main,

motor & pumps with pump house etc. if required based on actual field condition & direction of engineering-in-charge of work automatically covers under the scope of contract.

The contractor shall submit the necessary drainage layout plan for disposal of rain water & waste water as well as showing the position of manholes, invert levels etc. along with the layout & hydraulic profile plan for approval by Department.

Ancillary Works

i. Roadways

A road network shall be provided for connecting the various units of plant i.e. main entrance, chlorine tonner shed, coagulant storage house, chemical house, etc. to link with the main roads. All roads shall be minimum 3.75 m width. Strom water drainage system shall be constructed along the roads so as to prevent standing water in the plant area.

ii. Site Drainage

The contractor shall provide systems for storm water drainage, foul drainage and process drainage.

iii. Boundary Wall

The Boundary wall shall be provided all around the WTP campus.

(r) Design & Construction of Boundary wall

Boundary wall shall be RCC framed structure with 25cm thick Fly-ash Brick Masonry filler wall (1:4) with 16mm thick cement plaster of 1:6 cement mortar, **M-20** grade RCC Column structure at max 3m interval with Plinth Beam. Top of the wall shall be provided with 40mm thick PCC (1:2:4) layer. Depth of foundation of Boundary wall shall be minimum 1.00M. **R.C.C. Column** for the Gate Opening shall be of 0.38m x 0.38m size & 1.60m high of **M-25** grade structure. The depth of foundation of the R.C.C. Column with isolated footing shall be minimum 1.00m below the ground level. Supply, erection of 2 leafed MS Fabricated gate of size 6.0 M x 1.80 M height as per the detailed specification and fixing it to the RCC Column. The both side of the compound wall should be painted with two coats of weather coat paint over one coat of primer. Construction joints in boundary wall shall be provided at suitable interval as per the direction of Engineer-in Charge.

(s) Illumination and Ventilation:

i) The Scope for illumination & ventilation covers the complete lighting system both interior & exterior lighting of all the units of the treatment plant, road & yard lighting along with ventilation for chemical house, filter house, testing laboratory all complete. The contractor shall provide the **Energy efficient illumination with auto ON & OFF system (Light Sensitive Sensor) for total WTP Complex, Pump House, B.W.T. area, yard & ground lighting**.

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

a) Light fittings complete with accessories for all buildings interior & exterior lighting and yard lighting including road lighting facilities.

b) Main lighting distribution board along with sub distribution boards to be suitably located.
c) 10 Amps. and 20 Amps., 240 V switch socket outlets
d) Ceiling fans for all manned rooms.
e) Exhaust fans as required.

ii) **Requirements of lighting fixtures/lamps***:*

a. Illumination level in different area shall be as per recommended level of illumination for industrial area/special area conforming to IS codes/ Electrical Engineering Hand Books. The illumination level for particular areas, illumination for interior/exterior luminaries and their minimum mounting heights above floor area shall be based on recommended electrical engineering hand books/ Indian Standards Code of Practice & Specification.

b. Inside the filter house, chemical house etc., indoor type high bay fluorescent luminaries shall be designed for water vapours protection. Illumination intensity shall be suitably designed as per recommended illumination lux, nos. of fixtures and wattage of fluorescent lights selected.

c. Outside area near Cascade aerator, Rapid mixing unit, Clariflocculator, chemical house, filter house, etc. outdoor flood light type with metal halide lamps of 150watt similar LED to M/NVC-52 model of Phillips shall be provided. The luminaries shall be designed for the protection of high humidity. The lux of lighting system shall be designed as per recommended illumination lux.

d. Inside of office & laboratory building shall be provided with fluorescent luminaries similar to TCS 31/218 Phillips make with fluorescent lamps. Number of luminaries shall be suitably designed as per recommended illumination lux.

e. Yard lighting using GI, tubular poles single/double arm and energy saving lighting devices i**.e.** LED units shall be provided. The height of the pole shall be at least 20 feet **(6.0** m**)** and diameter not less than 100 mm and shall be of the heavy duty type**.** The poles shall be provided with S**.**S**.** bracket suitable for installation of LED lamp. The poles and brackets shall be adequately painted with anti-corrosive paints and enamel paints to protect against corrosion**.**

f. Adequate and proper arrangements shall be made to make cable connection running inside the poles up to the LED point fixed on the bracket**.** All cable connections shall be provided with proper sealing against water leakage inside the pole**.**

g. The LED bulb shall not be less than 70 watt per pole and only white LED shall be used**.**

h. The location of LED posts shall be approved by the Engineer-in-charge before execution**.**

(iii) **Lighting Fixtures (Indoor luminaries**)**:**

A) Fluorescent lighting fixtures for interior illumination of all structures except office & laboratory building :

Fluorescent lighting fixtures shall have the following main features:

a) Vitreous enameled reflector, CRCA sheet steel channel.
b) Copper wound polyester filled low loss ballast.
c) Two pins neon starter
d) Capacitor for power factor improvement.

e) Two nos. fluorescent troposphere tube light in each fixture.

B) **Fluorescent fixtures for office & laboratory building:**

i) Housing made of CRCA sheet steel stove enameled white inside & brown or white outside. The ends of the luminaries are provided with a decorative finish click fix lamp holders.

ii) All other accessories such as copper wound polyester filled ballast, starters, starter holders, power factor improvement capacitors are mounted on a gear tray. All accessories are pre-wired upto the terminal block.

iii) A specially designed aluminium reflector system for obtaining a high optical efficiency & a widespread bat wing type of light distribution. This reflector is fixed to the housing by a clip on mechanism & can be hinged to the housing during maintenance.

C) **Street Lighting fixtures**:

(Make shall be of Philips/ Bajaj/ Crompton greaves)

The Energy efficient street lighting fittings with LED lamps shall have the following features :

a) End mounting cantilever type moisture proof fixture.

b) Street lighting fixtures for road lighting shall be provided with 90 W LED integrated type fittings on steel tubular poles of 6m height (from finished ground level) and 1.5m out reach. The spacing between poles shall be suitably designed.

D) **MCB lighting distribution Boards:**

The lighting distribution boards shall have the following features:

a) The lighting distribution board shall be sheet steel enclosed wall/column mounting type. The thickness of sheet steel used shall be **2.0 mm** minimum.

b) The degree of protection shall be IP-51.

c) The power supply shall be 415/230 V, 3-phase, 4-wire, 50 Hz. AC neutral solidly earthed system. All components of LDB shall be capable to withstand a symmetrical short circuit level of 28 MVA (40 KA) for 1 sec.

d) The lighting distribution board shall be provided with miniature Circuit breaker (MCB) for outgoing circuits. The bus bars shall be of EC grade aluminum alloy equivalent to E:63401-WP (E-91E) conforming to IS:5082-1998.

e) 415V, TPN combination fuse switch shall be provided for the lighting distribution board. The ratings shall suitably be designed as per load requirements.

f) The MCB distribution board shall be properly grounded.

(E) **10/20A Socket Outlet:**

The socket outlets shall have the following features :

i) Die cast metal housing with porcelain/mol amine body for heavy body operation.

ii) Interlocked plug pin with die cast metal body and silvered pins.

iii) 110V, 3 pins (phase, neutral and earth) 10/20 Amps. rating.

iv) 230V, 3 pins, (phase, neutral & earth 10/20 Amps.
v) Self-closing shutter on sockets.

(F) **Point Wiring:**

i) The type of wiring shall be done as per requirement at different locations.
ii) Neutral conductor for each sub circuit shall be taken separately and terminated in a junction box. Terminal block from where neutral conductor for each point shall be taken separately.
iii) Junction Boxes for the point wiring shall be of malleable casting with threaded conduit entry and fixed terminal slip.
iv) All wirings shall be in PVC conduit & of conceal type with junction boxes, switch board flush with wall.

(G) **Ventilation:**

- A suitable ventilation system shall be provided considering the required amount of fresh air. The number of air changes per hour for particular locations shall be considered as per IS codes/ Hand books.
- The office building shall be suitably ventilated as per required norms. There shall be ceiling fans of 48 inches blade size in different manned rooms with all electrical & mechanical accessories all complete as given below.
    1) Filter house control room : 1no.
    2) Office & laboratory : 4 nos. in different rooms
- Heavy duty exhaust fans with louver/ shutters shall be provided wherever required. The fans shall be painted for anti corrosion/ acidic effect.

(H) **Earthing:**

Complete earthing of all the electrical installations as per **IS: 3043-1987** shall be included. The earthing shall include all the equipments for illumination/ventilations including lighting main distribution board and sub distribution board. All light fittings and exhaust fans shall also be properly earthed.

The sizes of G.I. strips used for earthing equipments shall be suitably designed

.

(u) **Miscellaneous items like Brass nameplate, Flow sheet Boards, Glow Sign Boards etc:**

i) The name of the plant shall be embossed in Oriya (Oriya version of **130 MLD Water Treatment Plant, Naraj, Bhubaneswar**) in polished brass letters (of appropriate letter size) duly fixed on the wall/ projected beyond the wall at appropriate height as per aesthetic requirement.
ii) The contractor shall provide a fluorescent glow Board with all fittings etc. of appropriate size showing the **treatment flow sheet** and allied structures in attractive colours and fix it on MS angle columns at appropriate height and location. The contractor shall also provide one number of wall mounted boards with flow sheets in attractive colours for mounting on the wall of the control room.
iii) The contractor shall provide a fluorescent **Glow Sign Board** captioned "**Naraj, Bhubaneswar Waterworks**" with all fittings etc. of appropriate

size in attractive colours and fix it at appropriate height at the entrance gate.

(v) **Process Sampling Points:**

The contractor shall provide sampling points generously throughout the works to permit proper and adequate monitoring of the treatment process, chemical solutions, chemical dosing and the works performance. Hand samples shall be made available from at least the following points:

1. Incoming raw water and pre-chlorinated raw water.
2. Coagulated water.
3. Flocculated water.
4. Settled water before supply to the filter.
5. Filtered water from each filter.
6. Filtered water prior to chlorination.
7. Filtered water immediately after chlorination.
8. Final treated water before supply to distribution system.
9. PAC dosing tanks.

Hand sampling shall (as appropriate) be by piped supply to conveniently positioned taps. The contractor shall ensure that the arrangements permit ready access to all the required sample points and hand holds are appropriately provided for the sampling throughout the work. Sample pipe work shall be in non-corrosive materials and each sample arranged to enable a 1 ltr. sample to be taken within 5 seconds. Sample taps shall be of Brass and generally about 1 mtr. above floor or access level and be identified by an adjacent wall mounted notice 30 mm x 150 mm (block lettering on a white background)

w) **Beautification of WTP campus by Arboriculture & Horticulture**:

I. The selected area for WTP, MBR & ESR site shall have to bring to suitable condition by cutting, filling, brush cutting & cleaning.

II. The agency shall have the provision of digging holes in all kinds of soil and refilling the same with the excavated earth mixed with manure or sludge in the ratio of 2:1 by volume (2 parts of stacked volume of earth after reduction by 20% : 1 part of stacked volume of manure after reduction by 8 %) flooding with water, dressing including removal of rubbish and surplus earth if any with all leads and lifts (cost of manure, sludge etc.).

III. Spreading of dump manure and/or good earth in required thickness as per direction of office in-charge.

IV. Mixing earth and manure in the required proportion specified as directed by the Officer-in-charge.

V. Supplying and stacking at site dump manure from approved source including carriage.

VI. Planting of following varieties of trees to cover all the specific locations as per the directions of Engineer-in-Charge.

a) Cocos Nucifera (Coconut)– (4’0” height).

b) Bottle Brush (Yellow) – (6’0” height)

c) Foxtml Plam – (10’0” height)

d) Bauhinia Blakeana– (6’0” height)

e) Mini Ixora (New)– (1’0” height)

f) Manilkara Zaputa (Chiku)– (6’height).

g) Variegated Lilly– (0’9” height).
h) Mini Allmanda – (1’0” height).
i) Acalypha – (1’0” height).
j) Variegated Tager– (1’6” height).
k) F. Blaki (Topiary)– (3’0” height).
l) F. Prestige (Topiary)– (3’0” height).
m) F. Starlight– (3’0” height).
n) Juniper Africana – (3’0” height).
o) Amrapalli Mango – (5’0” height).
p) Collisman Polandi – (3’0” height).
q) Ixora Dafic – (2’0” height).

VII. Application of the pesticide such as 2-4 D Sodium salt/glyphoctparaquat 5ml per liter of water over vegetation area (wildly grown, unwanted wild bushes) two applications at an interval of 15 days.

VIII. Turfing with grass selection No 1 grass including water and Maintenance of the lawn for 60 days or more till the grass forms a thick lawn, free form weeds and fit for mowing including supply of good earth of required quantity as per the site condition and to achieve adequate height for drainage.

IX. Anti-termite treatment of lawn area through premises 30.50% I P. One liter premise diluted in 499 liters water and applying solution @ 1.00 liter solution per sqm lawn or bed area. (two application including cost of chemical) and as per direction of Officer-in-charge.

X. Required quantity of good earth for the entire landscaping area to achieve adequate elevation for aesthetic as well as drainage purposes shall be brought and spread. Unsuitable earth shall be removed from the site if required.

A sprinkler system consisting of water sprinkler set and associated accessories with delivery pipe of length about **40** m shall be provided at regular intervals in the periphery of the landscaping area for proper watering and maintenance of the garden and plants.

9.6 Instrumentations:

The scope of work for the contractor shall include the following instrumentations. The Instrumentation shall be of latest technology and best of their kind used in Water Works. The contractor shall furnish **2-3 makes** with copies of catalogues along with his tender documents that he intends to supply under this scope of work and same shall form a part of contract. The instrument shall be suitable for indication in MKS/ SI Units and the respective dials shall be calibrated and printed accordingly.

The electromagnetic full bore type bulk flow meter shall be of reputed make having MID approved and CE marked confirming ISO specification.

Pressure gauges shall be preferably ‘**Dial’** type with min. 200 mm dia. Dial. The range for the pressure gauges shall be 2 times the normal working pressure of the pipe line. The pressure gauge shall be mounted in vertical position with a three-way cock. It shall have the scales in metric system.

All other Instrumentations mentioned elsewhere in this Agreement shall have to be provided in addition to the above. Besides, any instrumentation which is not indicated

above but shall be required for completeness of a system shall have to be provided by the contractor without any extra claim.

	Location		**Instruments**
i.	Treatment Plant control	1.	Mechanical Meter (rate of raw water in flow to Treatment plant.)
ii.	Filter House Local	1.	Loss of head indicator-dial type for each filter bed
		2.	Rate of filtration indicator-dial Type for each filter bed
iii.	Overhead tank	1.	Water Level Indicator of mechanical type
			Wash water overhead tank
iv.	Testing Laboratory	1.	Turbidity meter (electronic) 0-3,000 NTU
	(Local / Portable)	2.	PH Meter (electronic) 0-14 (range)
	(one set each)	3.	D.O meter (electronic)
		4.	Jar Test Apparatus
v.	Flow meter	1.	Electromagnetic flow meter

All other Instrumentations mentioned elsewhere in this DTCN shall have to be provided in addition to the above. Besides, any instrumentation which is not indicated above but shall be required for completeness of a system shall have to be provided by the contractor without any extra claim.

9.7 MOTORS & PUMPS

(A) SCOPE & SPECIFICATION OF CENTRIFUGAL PUMPS

Supply of reputed make wide voltage range motors suitable to be coupled with pump having capable of discharging (i) CWR to Back Wash tank (ii) CWR to MBR (iii) MBR to ESR at different locations including supply of suitable size of M.S. channel base plate installed in required R.C.C. foundation, making suction & delivery arrangement, testing at site & supply of control panel of reputed make with all accessories such as current sensing, over load relay single phase preventor, over and under voltage cut out etc. confirming to relevant I.S. specification. Separate suitable capacitor bank to each pump set and motor protection relay for each motor separately to be provided for protection of motor. The pump should be coupled with suitable capacity 3 phase motor to operate in A.C. power supply ranging 360 volt to 440 volt in the frequency 50 Hz in a common base plate. The contractor has to submit detailed design, drawing, layout plan of all pumping units showing therein all the piping arrangements at different pump houses including design of RCC foundation for various pumps as per the relevant IS specifications for approval before installation of pumps.

(I) **PUMP:**

(a) The pump shall confirm to relevant IS specification with latest amendments thereof. The Centrifugal Pumps will be of horizontal split casing with high efficiency **(energy efficient pumping system**) and ensure satisfactory performance and having suction and delivery arrangement suitable for inlet and outlet connection of pipe of suitable nominal bore size.

(b) ASSEMBLY OF PUMP SET.

(i) **CASING:** - The casing shall be made of cast iron grade FG-260 of IS:210 with latest revision and shall be of such construction as to be capable to withstand a hydrostatic test pressure of 1.5 times shut of pressure and two times the duty pressure which is higher.

(ii) **IMPELLER:** - The impeller shall made from bronze grade LTB-2 of IS:318 with revision and shall be dynamically balance as per VD 12060 class 6.3 at 1200 Rpm. Against manufacture defect along with any other un-machined rotating parts as proper balancing equipment.

(iii) **SHAFT:** - The shafts shall be made of high tensile steel confirming to IS:1570) (part V/45 CB as per I.S.-5517) and accurately ground all over. It shall be of sufficient size as to be capable of transmitting the required power over the entire range.

(iv) **WEARING RINGS, STUFFING BOX, IMPELLER AND SHAFT SLEEVES: -** There shall be made of bronze AST-410 as Grade-II of IS:318 latest revision. Pump should be fitted with double warning ring. One is fitted in casing and another is behind the impeller. The impeller should preferably be provided with balancing hold not with back vanes.

(v) **GASKETS, SEATS AND PACKING:** -These shall confirm to those specification in IS:5120 with latest revision and the pump should be fitted with the pack grease lubricated bearing.

(vi) **COUPLING:** - The pump shall be directly coupled with the electric motor through spacer /pin type coupling of reputed make so that both the rotating parts function as one unit without casing nay loss.

(vii) **NAME PLATE:** - The pump shall have a name plate (Specification plate) including

1. Manufacturer's names of recognized trade mark.
2. Type / Model and Serial Number of pumping.
3. Speed.
4. Total head/Rate of flow/Best efficiency point with power input.
5. Range of head and corresponding rates of flow.

(c) PUMP TESTING:

a. The overall efficiency of the pump set shall not be less than 75%

b. The overall efficiency of the pump shall be guaranteed at specified point of rating only and the discharge shall be guaranteed for the range of head between minus 25% & plus 10% of the specific head. The Firm should furnish the guaranteed discharge at these head. There should not be stiff rise and fall in head vrs. Discharge curve and discharge vrs. overall efficacy curve.

c. The firm must furnish the curves authenticated by the manufacture to enable the purchaser to judge the performance of the pump set.

i) Head Vrs. Discharge Curve

ii) Discharge Vrs. Pump efficiency curve

iii) Discharge Vrs. Pump input at pump shaft curve.

(II) **MOTOR:**

a) The Motor shall be rated for continuous duty, ambient temperature of 50^{o} Celsius. The relative humidity can be up to the maximum of 100% Motor shall be suitable for 3 phase electric power supply wide range voltage 415 Volt 10% $H_{Z.}$ It should be designated for an over load capacity of 115% of rated capacity of pump set for frequent operation. Motor should be of

reputed company make and manufactured fully confirming to IS:325 with latest version efficiency of motor should not be less than 85%.

(b) **ASSEMBLY OF MOTOR**

i) **WINDING:** - The winding should be enamelled copper / strip with 'F' type insulation and winding are braced to prevent soil deformation due to stress caused by surges.

ii) **CORE:** -The core should be made from low loss; high permeability; varnish insulated electrical grade sheet steel and stamping are hydraulically pressed than clamped to form a rigid structure.

iii) **SHAFT:** - Shaft shall be made from high carbon steel of cross section adequate enough to provide strength and rigidity to minimize the deflection and vibration.

iv) **BEARING:** - Bearing and grease lubricated anti-friction bearing coupling should have 90% survival life of a minimum of 10,000 working hour for drive transmission direct through flexible coupling.

v) **EARTHING STUD:** - The motor body shall have two separate earthings stud for earthings in compliance with I.E. Rules.

vi) **BASE FRAME:** - The base should be made out of M.S. Channels confirming to IS:226 grade with foundation Nut & Bolt.

(III) **CONTROL PANNEL:**

i) **CONSTRUCTION:** - Equipment shall be fabricated out of 2mm for C.R.C.A. sheet having non-compartmentalized type. Provision for cable entry at bottom and all terminals of the equipment shall be accessible from front.

ii) **WIRING: -** All power wiring to be done with copper wire having good insulation to with stand against 660 Volt of different colour or of black colour with phase marking at both ends. All the control wiring shall be done with 1.5 mm^2 Flexible wire of Red colour with phase marking at both the ends.

iii) Painting shall be done with stoving primer and stoving finish of approved colour

iv) Individual Panel Board for Individual pump set and one main control panel board to be provided.

v) Suitable earthings as per relevant IS/ Electrical Specifications to be provided to protect electrical installations.

IV) AUTO TRANSFORMER CONTROL PANEL (ATS)

Features :

- Electro mechanic Control Panel Auto Transformer Start
- Power Supply 3~50Hz, 380 - 415V AC (+/- 10%)
- Short Circuit and Over Current protection (MCB/MCCB)
- Overload protection
- Phase failure protection

- Air cooled Auto Transformer with 60%, 70% & 80% tapings
- Water level controller with dry run protection
- Contactors with thermal overload relay resettable
- Electronic timer with master timer
- Control Fuse
- Volt meter, Ammeter, Indicating lamps (R, Y, B, trip)
- Dust proof metal enclosure IP 44 with high quality finishing

(V) **CIRCUIT CONFIGURATION**:

System Voltage	:	415 $\pm$ 10% 3 phase 50 H_z
Utilization Category	:	AC 3 phase as per IS:8544-1
Coil Voltage	:	415 $\pm$ 10% Volts
Power	:	Suitable for above motor.
Back up protection	:	H.R.C. Fuse Link
Isolator	:	reputed make
Contactor	:	Star/delta/Main Contract of reputed make.
S.P.P.	:	Reputed make.
Over load relay	:	Reputed make of suitable range. Phase including lamp of different colour of reputed company make.
Volt meter	:	Suitable Volt meter Volt meter selector switch of reputed company make.
Ampere Meter	:	Suitable Amp meter C.T. operated of C.T. suitable Ratio of reputed make. Capacitor: - Suitable of reputed make.

(VI) Necessary priming arrangement to be made for priming at each pumping stations by constructing one no. 1000 ltr. capacity R.C.C./PVC, O.H. Tank including supply / fitting of required G.I. pipes/ fittings / F.W. vales etc all complete as per requirement at site and direction of Engineer-in-charge.

9.8. VERTICAL TURBINE PUMP SET (At Intake Point)

a) Technical Description

i) **BOWL**

Made of close-grained cast iron. Houses bronze bowl bearing S.S. impeller shaft & impeller shaft & impeller. Has hydraulically profiled guide vanes for higher efficiency.

ii) **IMPELLER**

Made Stain Less Steel (SS-410), Single suction, Enclosed or semi-enclosed type. Dynamically balanced clamped by draw-out type collect and locknut to stainless still shaft.

iii. DISCHARGE CASE

Made of close grained cast iron. House bronze bearing. Guided water flow into column assembly. The discharge case in oil lubricated turbine pumps has intermediate bearing, lantern ring, asbestos-plated yarn seal (gland packing) and discharge case bearing for line shaft tube. Prevents water from entering the line shaft tube as the high pressure water is bypassed through relief ports in the lantern ring. The discharge case in water lubricated turbine pumps has a sand collar which prevents entry of sand into the discharge case bearing.

iv. LUBRICATION

For oil lubricated turbine pumps, manual lubricator or autocratic electric oil lubricator available. Separate pre-lubricating tank is available for water lubricated turbine pump.

i) **SUCTION CASE**

Made of closed grained case-iron-Houses bronze bearing and sand collar which prevents entry of sand into suction case bearing guides flow of water into the eye of the lowest impeller.

ii) **CASING PIPE/LINE SHAFT TUBE**

Made of steel. Concentrically threaded for line shaft bronze bearing provided at intervals of 1.5 m.

iii) **COLUMN PIPE**

Made of steel. Concentrically threaded as per Indian standards.

iv) **LINE SHAFT**

Made of high carbon steel. Concentrically threaded at both ends. The line shaft on oil lubricated pumps rotates in bronze bearing fitted at 1.5m. intervals. The line shaft in water lubricated pumps has a stainless steel sleeve which rotates in cut less rubber bearing fitted in C.I. bearing retainer (spider).

v) **DISCHARGE HEAD**

Robust construction. Has an integral smooth discharge elbow. In water lubricated pumps, the discharge head houses a stuffing box and gland nut. In oil lubricated pumps, it houses a tension nipple and gland nut. Standard discharge outlet flange is drilled as per IS specification.

vi) **PRE-LUBRICATION**

For water lubricated turbine pumps, pre lubrication tank and pipe connections with rock available for pre-lubrication of pump shaft, bush bearing and stuffing box before staring the pumps.

vii) **VERTICAL TURBINE PUMPS** with special material of construction can be supplied against specific requirement.

9.9 SPECIAL CONDITIONS AND TECHNICAL SPECIFICATION FOR EXTERNAL /INTERNAL ELECTRICAL INSTALLATIONS WORK:

i) **General Requirement**

The installations shall generally be carried out in conformity with the requirements of Indian Electricity Act 1910 as emended up to date and Indian Electricity Rules, 1956 framed there under, the relevant regulations of the Electric Supply Authority concerned and also with the specifications laid down in the Indian Standard IS:732/1963 “Code of Practice (Revised) for Electrical Wiring Installations (System Voltage nor exceeding 650-V)”. The work shall be executed as per the National Electrical Code and if any item is not covered there under or there is any doubt, the specification approved by the Engineer-in-Charge will be final and binding.

<u>Ambient Conditions:</u>

All Electrical installations and equipment shall be suitable to work in following ambient conditions.

Maximum temperature	:	50 degree Celsius
Relative humidity	:	100%
In the vicinity of	:	Rayagada

System Conditions:

The Electrical installation and equipment shall be suitable for operation in the following system conditions.

Supply voltage	:	415 volts ±10%
Supply frequency	:	50Hz ±5%
Number of phases	:	Three

ii) **Scope:**

a. Materials

All the materials, fittings, appliances used in electrical installations shall conform to Indian Standard Specifications wherever these exist. A list of approved materials is attached in Annexure-I. Materials not included in the list as well as any particular made not included in the list should be approved by the Consultant or Engineer-in-Charge before use. All required materials covered under this specification shall be supplied and installed by the contract complete in all respect except in cases where it is clearly mentioned otherwise. The materials and accessories required for completing the work will form part of the work although they have not been specified separately.

Selection of Materials and installation work shall be such as to simplify operation, inspection, maintenance and testing. The work shall include all reasonable pre-cautions and provision for safety of operation and maintenance personnel.

b. Standard:

Unless otherwise specified, all materials covered under this specification shall be designed, manufactured, tested and installed in conformity with the latest Indian Standard specifications. In case such Indian Standard Specifications are not published equivalent British Standard Specifications shall be followed. All equipment shall confirm to latest Indian Electricity Rules, PWD and Local / State laws or bye-laws as regards to safety, earthing and other essential provisions specified therein.

All equipment and materials selected shall also be supplied and installed taking into consideration the Factories Act, Fire Regulations and Local laws or bye-laws. All light fittings and equipment selected shall be of well tied out design. All materials used in the assembly of fittings and their accessories shall be of high quality and manufactured in accordance with the best modern practice.

All the materials supplied by the contractor according to the contract conditions will be subject to inspection and approval by the consultant or / and Engineer-in-charge or their authorized representative from time to time. The contractor shall extend all required facilities for such inspection free of cost. At the time of inspection, the inspecting officer shall have full liberty to reject any such material, which does not confirm to specifications or the requirements. The owner shall not entertain any claim for the rejected materials. The contractor shall remove all rejected materials from the site at his own cost.

The owner shall not accept any surplus materials procured by the contractor.

The contractor will be responsible to get electrical installations inspected by the Electrical Inspector of the State Govt. and to obtain the statutory clearance for

energisation. The owner will reimburse the necessary inspection fees on production of documentary evidences.

The contractor should possess valid electrical contract license and labour license issued by the appropriate statutory authority of the State Govt. during the execution of the Contract.

The contractor shall be registered with provident fund Department for engagement of Labourers / Employees.

c) Inspection & Approval

The contractor shall put up samples of all major items for inspection and testing the consultant and or Engineer-in-Charge for which the contractor shall furnish minimum 10 days clear notice in advance to enable them to depute their Inspecting Officer. Similar procedure shall be adopted for the approval of samples of minor materials / accessories to be used for the work.

iii. **LIST OF APPROVED MAKE**

	MATERIAL DESCRIPTION	MAKE OF MATERIALS
1	Non-Metallic conduit & accessories	Berlia /Uniflow /Sudhakar
2	Switch, socket, Holder, Ceiling Rose etc.	Anchor /Cona
3	PVC Insulated wires	Finolex/ KDK/ Rajanigandha/ Anchor/ NICCO/ L&T / Havells
4	Bakelite sheets	Hylam /Formica
5	PVC Insulated cables (ISI Mark only)	NICCO/ Finolex/ Crystal/ Fort Gloster/ Poly Cab
6	Cable lugs	Dowells/ Ismal/ Clipon
7	Cable joining Kits	M. Seal
8	Switchgears viz., Isolator Switches, SFU, Starter, change over switch, HRC fuse holder etc.	Siemens / L&T
9	MCB RCCB & Associated Distribution Board	HPL/ Havells/ Standard /Indo Asian
10	MCCB	Seimens/ L&T/ ABB/ Legrand
11	Instrument viz colmeter etc	AE/IMP/ Meco/ Cosmo
12	Selector Switch	Kaycee/ Saltzer
13	Timer /Time switch	L&T/ Hanger/ Legrand
14	Energy Meter	GEC/ Capital Jaipur
15	LT Distribution Board(Fabricated)	ESS/ Technocrat/ Utkal
16	Kit Kats	BPC/ Anchor
17	HRC Fuses	Siemens/ L&T
18	CTs & PTs	AE/ Kappa/ Eastern Switchgear
19	Metal Clad plug Socket	Crompton/ Havells
20	Fluorescent Fixtures	Philips/ Crompton/ Bajaj/ PAC
21	HPSV/HPMV/LPSV Luminaries & PL/SL Lamp Luminaries /LED luminaries	Philips/ Crompton /Bajaj
22	Incandescent lamp Luminaries	Decon/ Philips/ Crompton/ Bajaj
23	Lamps (HPSV/HPMV/LPSV/Fluorescent. Incandescent	Philips/ Bajaj/ Crompton/ Sylvania

24	Ceiling Fans	Crompton/ Khaitan/ Usha/ Bajaj/ Polar/ Orient/ Ortem/ Almonard
25	Exhaust Fan	Almonard/ Crompton/ Khaitan
26	Call Bell & Buzzers	Anchor/ Cona/ Rider
27	Electronic Regulator & Dimmer	Anchor/ Cona/ Rider
28	Adhesive & Insulating Tapes	Streel grip
29	G.I Pipes	TATA/ Jindal/ Prakash
30	Transformer	Alfa/ OTPL/ OEU/ Bright
31	A.B Switch	S&S/ Motison/ Odisha Electrum /Sigma
32	H.G Fuse	S&S/ Motison/ Odisha Electrum /Sigma
33	Lightening Arrestor	Oblum/ WS/ IGE

iv. **Power Supply:**

Standard voltage shall be as follows :

i) 415V (± 6%, 3-Ph, 4-wire, 50 (± 5%) Hz AC available line for A.C. motors and illumination/Ventilation.

ii) 230V, 1-ph, 50Hz. AC for control power and lighting.

9.10.4. Components of Automation System

a) Industrial grade - To be used by the operator to view the data acquired and allow the operator to control and improve optimization.
b) Programmable Logic Controllers: To control the outputs based on the inputs being monitored in the required sequential steps and it also communicates with the personal computers.
c) Modems: To transfer data from Water treatment plant site,
d) Training programme for automation & calibration system for 120 days for 10 departmental engineers.

9.10.4.1 SCADA Software

The standard SCADA software need to be installed in application servers at the plant site, but they should be capable of controlling and monitoring the various instruments. The data acquired from the PLC should be displayed in the SCADA screen and the logs of each site station measurement should be transferable using data export to data base processing software like Oracle, Microsoft Excel, etc. It should also support internet connectivity for data transfer.

7.24.2 SCADA Security Level

In order to prevent misuse and to restrict access to a site station measurement there should be privileges to the various users of the SCADA. Typically, there are three levels, which are (1) Operator Level, (2) Assistant Executive Engineer Level and (3) Executive Engineer Level.

7.24.3 PLC Security Level

The PLC communication port should have a configurable access level for its security. The minimum access levels are described in the following sub-section. These access levels are required to control read and write access to that port. Hence, once all the PLC ports are configured with these varying access levels depending on the requirement, then it becomes secure against unauthorized usage. It can be re-configured only after unlocking the PLC

common port.

7.24.4 Minimum Access Levels of Programming and Configuration Interface

The interface shall have the minimum varying levels of user access that can be configured by the system controller. They are:

a) Unlimited Access: This will allow the user to read and write all PLC configuration parameters such as local, network and system registers, Hardware input and output registers, event logs and logic programs.
b) Access without configuration: This will allow reading and writing of all PLC configuration parameters except system registers and ladder logic.
c) Access limited to only reading the PLC parameters
d) Access limited to PLC port configuration.

7.24.5 SCADA User Interface

The SCADA system shall permit the user to access displays via printing device and/or soft key menus with a choice of function keys, cursor, control keys or any key on the keyboard. The system shall support operator access to multiple displays at one time, including split screens where the operator may view more than one process area at a time and permit pop-up displays.

The operator shall be able to have access to context sensitive help at any time during operation of the system. The operator shall be able to access multiple data sources/items with a single tag name.

7.24.6 Command/Control Functions

The system shall allow the user to control a specific set point or to adjust a set of points depending on the operating limits. Control of individual set points shall be enabled based upon a user's security level.

7.24.7 Display Capability

The system shall allow the user to view animated graphics for process templates including valves, meters, etc. The system shall support the capability for the operator to view scanned images and be possible to animate these images.

7.24.8 Text Description

The system shall support use of true-type scale able fonts that may be scaled according to the desired size of the text. The fonts shall be loaded by the operating system.

Text shall be able to blink based upon any user definable condition occurring in the system such as an alarm on a particular set point.

7.24.9 Alarm Capabilities

i) Alarm Display Capability

The system shall support alarm display capability on the display. Current alarms shall be available as an alarm summary object and a chronological summary of alarms shall be available.

It shall be possible to inform the operator of an alarm condition via an audible tone, a pop-up display or any combination of animation types on the screen.

Alarm acknowledgement may be performed on all alarms, alarms in a single group, and alarms in a collection of groups in defined in alarm group hierarchy or on a point-by-point basis.

iii) **Alarm File Capability**

Alarms shall be logged to a file for future viewing or review of alarm history data. The user shall have the capability to review the file for cause and event analysis. The alarms that are logged shall be configurable from a choice of the parameters listed during configuration.

iii) Alarm Printing Capability

Alarms shall be allowed to be printed and the format shall be configurable and made up of any of the parameters listed during configuration.

9.22 Sound Engineering Practice to be followed

The civil work shall have to be executed according to relevant IS code and OPWD specification and detailed specification but if at any point these IS code/OPWD specifications are silent, then work can be executed according to sound engineering practices after obtaining written approval of Engineer-in-Charge.

Annex – I
(Schedule-D)

Specifications and Standards for Construction

1. Specifications and Standards

All Materials, works and construction operations shall conform to the relevant I.S. Specifications and Standards of CPHEEO manual on Water Supply published by MoUD, Government of India. Where the specification for a work is not given, Good Industry Practice shall be adopted to the satisfaction of the Authority's Engineer.

2. TECHNICAL SPECIFICATION & DESIGN CRITERIA

2.1 TECHNICAL SPECIFICATION:

All the structure shall be designed conforming to state-of the art technology& practice to produce and maintain output water quality hygienically safe and palatable in an economical manner. The output quality of water shall conform to physical and chemical standards stipulated in the manual on Water Supply and Treatment (latest edition) published by Central Public Health & Environmental Engineering Organisation (CPHEEO) and Indian Standard Code of Practice. Similarly, the RCC Intake Well, RCC Under Ground Reservoir, RCC E.S.R. and W.T.P. shall be designed based on the latest concepts & principles enumerated in the standard text books conforming to latest **BIS Code.**

2.2. General Specification of Materials:

1. Specification of MS Pipes

i) The **MS pipes** of **100 & 150 mm** dia shall confirm to IS:1239 & MS pipe of 200 mm dia. and above shall confirm to **IS:3589** (latest revision). **Wall Thickness of pipe shall be 12 mm for 1200mm dia to 900mm dia., 10mm thickness for above 800mm up to 600 mm dia. and 8 mm wall thickness for pipes above 300mm up to 600 mm dia. and 7 mm below 300 mm dia. The above wall thickness will be adopted in case the same is not specifically mentioned against the particular pipe line. PU coating is required for external protection of MS pipes. However internal coating shall be food grade epoxy coating not less than 406 micron & external coating shall be polyurethane coating.**

At welded joints there shall be Heat shrink sleeves need to be done at site as per specification.

The MS pipes required for the work confirming to relevant IS specification and meeting the standard prescribed shall be from any reputed manufacturer.

ii) **Specification for Ductile Iron (DI) Pipes and Fittings:**

The DI pipes should be centrifugally cast (spun) and suitable for push on Rubber gasket joints and confirm to IS:8329 (latest revision).

The Ductile Iron pipe fittings shall be all socketed suitable for rubber gasket joints and should confirm to IS:9523 (Latest revision).

The outer surface of the pipes and fittings shall be zinc coated with bitumen coating over it, and the inside surface of the pipes and fittings are to be lined with cement mortar as per IS:1196 (latest revision). The lined surface shall be painted with one coat of bituminous paint.

The inside lining and outside coatings shall be done in factory by the pipe

manufacturer.

The pipes shall be supplied in standard lengths of 4.00, 5.00, 5.50, and 6.00 meters. The pipes should have socket and spigot ends; the sockets ends should be suitably rounded and chamfered; and fittings should have all socket ends.

iii) **Zinc Coating-**

Zinc coating shall comply with ISO:8179 and shall be applied as a spray coating. The mass of sprayed metal shall not be less than 130gm/ m2 as described in clause5.2 of ISO :8179.

vi) **Bitumen Coating –**

The Bitumen coating shall be as per appendix C of IS:8329. It shall be of either coal tar or asphaltic base with a minimum thickness of 0.1mm. The finished coating shall be continuous, smooth, neither brittle when cold nor sticky when hot, and strongly adhere to the surface of pipes and fittings.

v) **Specification for rubber gaskets for DI pipe joints.**

The Rubber gaskets shall be manufactured from EPDM/SBR rubber and should confirm to IS:5382. The rubber gaskets should also be supplied by the manufacturer of the pipes. They should preferably be manufactured by the manufacturer of pipes. In case they are not, it shall be the responsibility of the manufacturer of pipes to have them manufactured from a suitable manufacturer under its own supervision and have it tested at his/ subcontractor's premises as per the contract. The pipe manufacturer will however be responsible for the compatibility and quality of the products.

vi) **Flanged joints-**

Flanged joints if any shall confirm to the Clause 6.2 of IS:8329 for PN 10 flanges. The pipe supply shall also include rubber gaskets for each flange. Flanged joints shall comply with dimensions and drilling details in IS:8329 for PN 10 Flanges.

2.3 Specification of Valve:

Generally, pressure designation shall not be less than **PN 1.6. Valves** should have integral flanges drilled as specified in relevant IS specifications. Rubber used in valves shall be Ethylene Propylene Diane Monomer (EPDM) or Styrene Butadiene Rubber (SBR).It shall comply with the requirements of Appendix B of BS:5155 or of IS Specifications, be suitable for making a long term flexible seals, and be resistant to anything causing deterioration of the flexible seal.

2.4 Specification for Cement:

Cement shall be O.P.C. confirming to IS: 8112/1989 PPC confirming to IS:1489 or PSC confirming to relevant IS specification. Minimum grade of cement shall be 43 and should be of reputed manufactures like OCL, Ultratech or ACC.

Each bag should bear IS certification mark and should contain 50kg cement net. Any bag found torn or damaged or having contents less than 50kg or sewed manually shall not be accepted and will have to be removed from site. Cement factory should have its own clinker making arrangement as per relevant IS Code. Cement manufactured in mini cement plants shall not be accepted.

2.5 Specification for Reinforcement steel:

Reinforcement steel shall be high yield strength deformed (HYSD) bars (CTD) or TMT plain rolled bars conforming to IS: 1786 (latest revision) Minimum Grade of Steel shall be Fe-415 preferably Fe-500 manufactured by reputed manufacturers like SAIL/RINL/ TATA/Jindal/ Shyam steel. The steel reinforcement shall be corrosion resistant.

2.6 Specification for Structural Steel:

Structural steel should confirm to IS: As & when required, the steel/cement & other building materials will be tested by Department at the cost of contractor to ensure proper quality as per relevant IS specification.

2.7 **Specification for Aggregates required for Construction of Civil structures**:

Regarding quality and size of aggregates for concrete works the Indian Standard Code of practice for Plain & Reinforced concrete for general building construction shall be followed.

Aggregates shall consist of naturally occurring stones (crushed or uncrushed), gravel and sand. They shall be chemically inert, strong, hard, clean, durable against weathering, of limited porosity, free from clay film, dust, silt, organic impurities and deleterious materials, and confirm to Is:383.

Aggregates such as slag, crushed over burnt bricks, bloated clay ash, sintered fly ash and tiles shall not be used. Granite, trap, quartzite and rock of similar characteristics are suitable for breaking in to coarse aggregates

Aggregates containing reactive materials shall be used only after tests conclusively prove that there will not be any adverse effect on strength, durability and finish, including long term effect,on the concrete.

The maximum size of Coarse aggregate shall be as stated in the drawing but in no case greater than ¼ of the minimum thickness of the member.

The Fineness Modulus (FM) of sand shall neither be less than 2.2 nor more than 3.2

2.8 **Specification of Water for construction work**:

Water to be used for construction works shall confirm to IS:456. Potable water are generally satisfactory. Water containing any excess of acid, alkali, sugar or salt shall not be used.

2.9 **Admixtures for concrete work** :

Normally no admixtures shall be used for concrete work. However if the Authority/Authority's Engineer approves the use of admixtures for accelerating, retarding, water reducing, and air entraining purposes, the admixtures should confirm to IS:9103 and should be used as per manufacturer's instruction only. An admixture's suitability and effectiveness shall be verified by trial mixes with the other materials used in the works. If two or more admixtures are to be used simultaneously in the same concrete mix, their interaction shall be checked and trial mixes done to ensure their compatibility. There should also be no increase in risk of corrosion of the reinforcements or other embedment.

Calcium chloride shall not used for accelerating set of cement for any concrete work containing reinforcement or embedded steel parts.

2.10 Samples and Tests :

All materials used for the works shall be tested before use. Manufacturer's test certificate shall be furnished for each batch of cement and steel, and when directed by the Authority /Authority's Engineer samples shall also be tested by the contractor in a laboratory approved by the Authority. Sampling and testing shall be done as per IS:2386 under the supervision of the Authority's Engineer. Water to be used shall be tested to comply with requirements of IS:456. The Contractor shall have to make all arrangements at his own cost for water fit for construction purpose and also water for drinking purpose.

The Contractor shall furnish manufacturer's test certificate and technical literature for any admixture proposed for use. If directed, the admixture shall be tested at an approved laboratory.

All testing charges including sampling, conveyance, packaging etc shall be borne by the contractor. For routine quality control tests (eg. Cube tests, sieve analysis etc), the Contractor shall establish a well-equipped Field laboratory or deal with a laboratory subject to prior approval of the Authoty/ Authority's Engineer.

All tests required as per specification/IS codes and directed by the authority/ Authority's Engineer shall have to be done by the Contractor at his own cost and in the presence of Authority's Engineer.

3 Specification for Construction Works:

3.1 Laying & Jointing of pipes.

3.1a Transportation of pipes to site.

Pipes are to be carried to site through trucks loaded in such a way that they are secured, and no movement should take place on the vehicle during transit, and pipes are not damaged during handling. When using mechanical handling equipments, it is necessary to employ sufficient personnel to carry out the operation efficiently with safety. The pipes should be lifted smoothly without any jerking motion and pipe movement should be controlled by use of guide ropes in order to prevent damage caused by pipe bumping together or against surrounding objects.

3.1b **Stacking of pipes.**

Pipes being taken to a stock ground for storage and held pending further distribution shall be arranged in to a stack. The first layer of pipe should be laid on a firm foundation consisting of solid timbers set level on the ground. Subsequent layers should be placed according to the method of square or any other method of stacking. Care should be taken so that the pipes do not rest on their sockets.

3.1c **Inspection of the pipes.**

Pipes are to be inspected at site to see if any damage to the pipe, including lining or outside coating has occurred during transportation and handling. Damages if any shall be made good up to the satisfaction of the Authority's Engineer before laying.

A copy of the certificate and factory test reports from the recognized bodies preferably **CIPET/ PDIL / RITES Ltd.,** should be obtained from the manufacturer or supplier and to be shown to the Authority's Engineer if he so desires. If desired by the Authority/ Authority's Engineer, inspection to factory to witness the testing of pipes shall be arranged by the contractor at his own cost.

3.1d **Site Preparation.**

Preliminary work required to be done before the laying of pipes include, fixing the alignment of pipe line, pegging out, cleaning and disposal of all shrubs, grasses, large and small bushes, hedges fences, gates, portions of old masonry, boulders and debris from the route. The alignment fixed in the field is to be got approved by the Authority's Engineer.

3.1e **Excavation & Preparation of Trench**

The excavation of trenches may be carried out manually or by mechanical means. The width of trench at bottom between the faces of trench wall (or faces of sheeting's if any) shall be such as to provide not less than 200mm clearance on either side of pipe except when rock excavation is involved. Trenches shall be of such extra width, when required, as will permit the convenient placing of timber supports, strutting and planking, and handling specials.

Special considerations should be given to the depth of the trench. The depth should provide a Minimum cover of 1100mm when laid along side or across the roads. For cross

country laying the cover above the crown of the pipe may be 900mm. It may be necessary to increase the depth of excavation to cross surface drains.

When crossing the National High ways, State High ways and Railway tracks and River embankments, the guide line of respective authorities for minimum cover depths will govern the excavation.

The beds of trench shall be filled with 150mm thick river sand to allow a level surface for the pipe barrel and bell rest on ground. Firmly. All surface materials, which in the opinion of the Authority's Engineer are suitable for use in restoring the surface, shall be kept separate from the general excavated material as directed by the Authority's Engineer.

Care should be taken to avoid spoil banks causing an accumulation of water. All other excavated material shall be stacked in such a manner that will not endanger the work men and it will avoid obstructing foot paths, roads and drive ways. Care should be taken to avoid spoil banks causing an accumulation of water. Utility controls shall be left on obstructed

3.1f **Laying & Jointing of Pipes**.

Laying of pipes should be done as per IS:12288, Pipes shall be lowered in to the trench with tackle suitable for weight of the pipe. For smaller size up to 250mm nominal bore, the pipes may be lowered by ropes but for heavier pipes either a well-designed set of shear legs or a mobile crane should be used. All construction debris should be cleared from the inside of the pipe either before or after a joint is made. The jointing of pipes should be flexible push on rubber ring joints in case of socket joints. Before jointing, the inside of the socket and outside of the spigot shall be cleaned and wire brushed to a distance 150 - 225mm Gaskets shall be wiped clean and inspected for damages if any. When lifting gears are used to place the pipes in trench, it should also be used to assist in centralizing the spigot in the socket When laying is not in progress, a temporary end plug should be securely fitted to the open end of the pipeline. When pipes are to be lain laid in high water table locations care should be taken to prevent floatation of the pipes by holding down the pipe by either partial refilling of the trenches or by temporary strutting wherever needed. On gradients of 1:15or steeper, precaution should be taken to ensure that the spigot of the pipe being laid does not move in to or out of the socket of the laid pipe during the jointing operation.

3.1g Pipe Supports and Thrust Blocks When pipes are laid above ground, the pipes are to be laid on saddles or rocker supports as Specified by the Authority's Engineer. Each pipe shall be supported within a support positioned behind the socket of the pipe. The pipe should be fixed to the supports such that such that the axial movement due to expansion or contraction is taken up at individual joints on the pipe line.

Thrust Blocks are to be provided at each bend, tees and tappers to resist the thrusts developed by the internal pressure due to the fluid flowing through the pipes.

3.2 **Fitting and Fixing of Valves**

3.2.1 **Sluice Valves**-

Sluice valves will be used on the pipe lines as Isolation Valves to isolate the pipe section during repair and maintenance, and with a Tee branch as scour valves for draining out the water from the pipe section to facilitate repair works. Tentative locations of these valves have been shown on the Longitudinal Section of the pipe mains. However exact locations are to be determined at site at the time of detailed Engineering and execution at site. Sluice valve are to be provided along the pipe line at suitable intervals to serve as Isolation valve And at valley portion these are to be installed as Scour valves. Dismantling joints shall be installed with the valves to facilitate replacement of damaged valves.

3.2.2 **Air Valves**

Air valves should be DI tamper proof double orifice kinetic air valve fitted with isolation valves as size of Air valves should not be less than $1/8^{th}$ of nominal bore of the pipe. The Air valves shall be fitted at every peak and at suitable intervals in straight reaches. The tentative location of Air valves have been shown in longitudinal section of the mains. However, the locations and no. of Air valves may change during detailed engineering and as per the direction of the Authority's Engineer at site.

3.2.3 **Construction of Valve Chambers**

All the valves are to be enclosed in chambers. The valve chamber in Raw water rising main and clear water rising main shall be of RCC chamber and in all other pipe lines the valve Chambers should be brick masonry chambers with removable precast RCC roof slabs. Drain pipes shall be provided at the bottom of the chambers to drain out the leakage water from valves.

The contractor is to provide the drawing for approval by the Authority/ Authority's Engineer.

3.2.4. Pipe bedding to provide a firm bed for laying of pipes, sand filling of 150mm thick shall be provided at the trench bottom and compacted properly before laying of pipes. The sand may be river sand free from clay and stony materials.

3.3 **Hydrostatic Testing of Pipeline.**

After the pipe line is laid and jointed testing shall be done for

- Mechanical soundness and leak tightness of pipe and fittings
- Leak tightness of joints, and
- Soundness of any construction work in particular Thrust blocks and Anchor blocks.

Hydrostatic Testing is to be carried out as per IS12288.

The completed pipe line should be tested first in sections and then the whole length. When the joints are left uncovered until after testing, sufficient back filling material shall be put over the Centre of each pipe to prevent movement under the test pressure. Each section should be properly sealed off properly with special stop ends secured by adequate temporary anchors.

The Test Pressure to be applied should not be less than any of the following

a. The maximum sustained operating pressure

b. The maximum static pressure + 0.5 N/mm^2

c. The maximum sustained operating pressure (or the maximum static pressure) + Maximum calculated Surge pressure

The test pressure should be measured at the lowest point of the section under the point of the section under the test, or alternately an allowance should be made for the static head between the lowest point and the point of measurement. If the test is not satisfactory, the fault should be and found out and rectified immediately as per the direction of Authority's Engineer. After all the sections have been joined together on completion of section testing, a test on the complete pipe line should be carried out.

3.4 **Backfilling of Trenches**

Backfilling of trenches shall be done with approved backfilling materials free from boulders, sharp objects, and rubbish. The backfilled material should be well watered and consolidated to 90% of maximum dry density at optimum moisture content. Proper care should be taken to see that pipe level and alignment are not disturbed. In raw water & clear water rising main passing under small drains, culverts, NH crossing should be embedded with cement concrete of grade not less than M20 grade.

3.5 **Dewatering the trenches**.

In high ground water level conditions, dewatering of trenches may be necessary to facilitate excavation as well as laying & jointing of pipes and construction of valve chambers etc. Reference should be made to the boring data in this regard.

Ground water as well as surface water shall be controlled to the extent that excavation and pipe installation can proceed in the specified manner and such that the trench bottom is not disturbed to the detriment of the pipe installation. Trench water shall not be permitted to enter the inside of the pipes being installed.

The necessary pumps, well points, or other suitable (subject to the approval of the Authority's Engineer) equipment shall be employed to keep excavation free of water. Caution shall be exercised to make sure that foundations in proximity to pipe trench excavation are not adversely affected by the excavation or dewatering process. Discharge from pumps, well points, or other dewatering equipments shall be located and controlled so that loss, damage, nuisance or injury to the public does not result.

3.6 **Shoring & Shuttering**

The sides of the excavations should be timbered and supported in such a way as is necessary to secure these from falling in, and the shoring shall be maintained inposition as long as necessary. The contractor shall be responsible for the proper design of the shoring to be approved by the Authority's Engineer to hold the sides of the excavation in position and ensure safety of persons and properties etc. The shoring shall be removed as directed after the items for which it is required are completed. Suitable barricading should be provided for safety purpose.

3.7 **Connection to Pump header, Inlet and outlets to the UGR and existing ESR, and existing pipe line**.

Connection to inlet & outlets of UGR, OGR, Pump header and existing pipe lines wherever necessary unless otherwise specified are within the scope of work and need to be done as directed by the Authority's Engineer. Wherever necessary for connecting to old existing pipelines, Mechanical joints should be used.

3.8.1 **Crossing/Laying of Raw Water Rising Main along/across the NH.**

The Rising Main/Distribution pipe line is to be laid along the road. On completion of cutting the asphalt road/concrete road along/across the NH for laying of Rising Main/Distribution pipe line the MS pipe with required width and making good to the damage over the compacted granular material with 100mm thick PCC(M-10) followed by 250 mm thick PCC (M-20) for length as per scope of work in the Draft Agreement of respective project. The detailed drawing for crossing and laying of pipeline along the NH are provided as below.

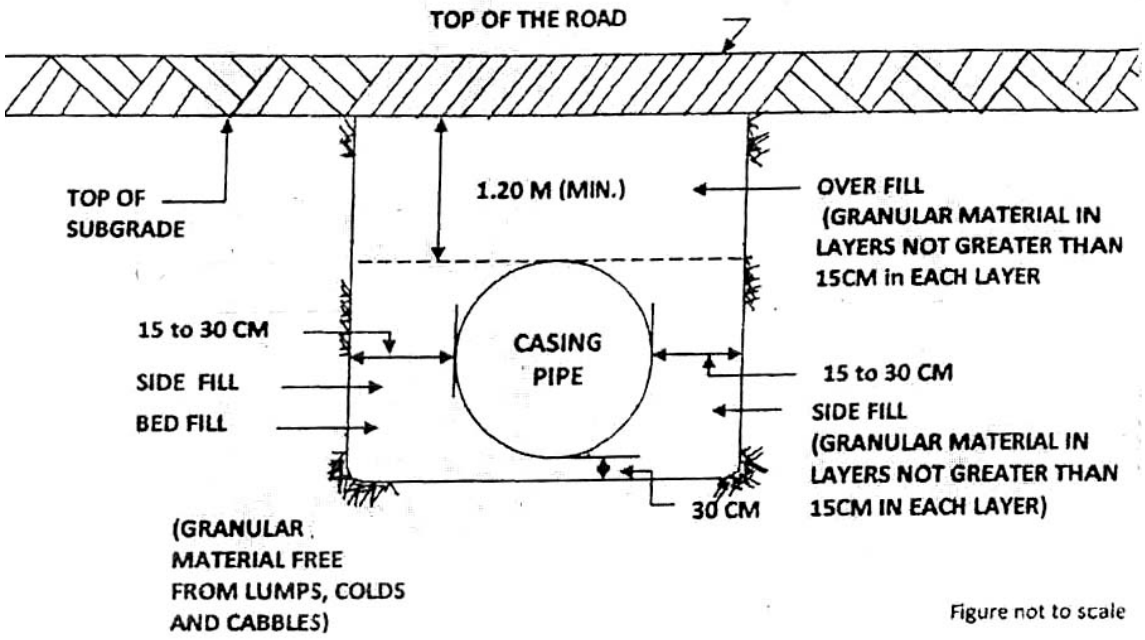

FIGURE-1 INSTALLATION OF CASING PIPE FOR CROSSING THE ROAD

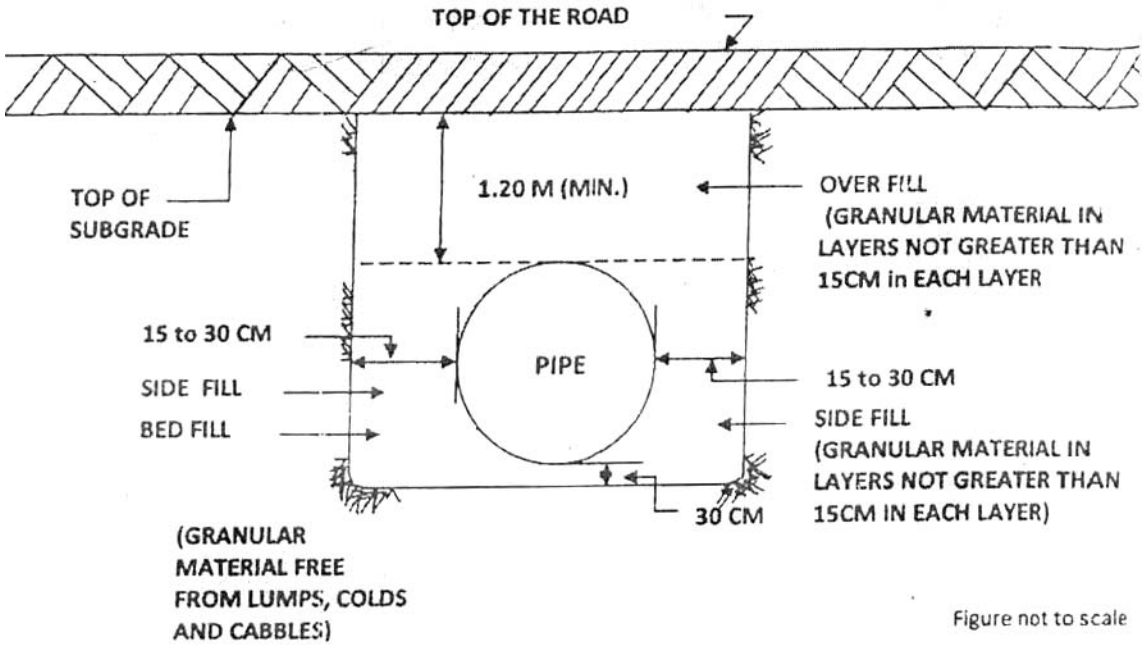

FIGURE-2 INSTALLATION OF PIPE FOR ALONG THE ROAD

4 Concrete Works

4.1 General

Concrete grade shall be as designated in the drawings and specified for the respective structures and their parts. In concrete grade M15, M20, M25 etc. the numbers ie., 15,20,25 etc., represent the specified characteristic compressive strength of 150mm cube at 28 days, expressed in N/sq.mm as per IS:456.

4.2 **Design Mix Concrete:**

For Design Mix concrete, the mix shall be designed 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 be in addition to such that it is cohesive and does not segregate and should result in a dense and durable concrete and also capable of giving the finish as specified. The Contractor shall exercise great care while designing the concrete mix and executing the works to achieve the desired result.

It will be the Contractor's sole responsibility to adopt appropriate normal mix proportions to yield the specified strength. The minimum cement content for Design Mix Concrete shall be as per Appendix-A of IS:456 or as given blow whichever is higher.

Grade of Concrete	Minimum Cement Content in Kg/Cum. Of Concrete
M15	260
M20	300
M25	320
M30	340
M35	360

The contractor shall submit the details of the source of all materials and the proposed quantities of each ingredient per cubic meter of fully compacted concrete. The Contractor shall then make trial mixes for each class of concrete using the same contractor's equipment and the same material as are proposed for the permanent works. He shall furnish to the Authority's Engineer at least 30 days before concreting operations, a statement of proportions proposed to be used for the various concrete mix ascertained on 150mm cubes as per IS:516 shall comply with the requirements of IS:456.

7days & 28days Compressive strength of different grades of concrete are as given below.

Serial No.	Grade of Concrete	Minimum Compressive Strength at 7 days (in N/mm^2)	Minimum Compressive Strength at 28 days (in N/mm^2)
1	M15	10.0	15.0
2	M20	13.5	20.0
3	M25	17.0	25.0
4	M30	20.0	30.0
5	M35	23.5	35.0
6	M40	27.0	40.0

The Contractor shall give 24 hours notice of such trials to enable the Authority's Engineer to attend for each trial mix, three separate and consecutive batches of concrete shall be made by the contractor and the specimens shall be tested at 7 days and 28 days (9 specimens for 7 days and 9 specimens for 28 days). For 7 days test the acceptance criteria shall be 70% of the corresponding target mean strength.

The contractor shall not commence concreting in the permanent works until the details of trial mixes and test results for each class of concrete have been submitted to and approved by the Authority's Engineer.

Unless otherwise specified, only medium graded fine aggregates shall be used for the concrete

A trial mix design will be approved by the Authority's Engineer with respect to strength if the average compressive strength of the nine specimens each at 7 days and 28 days is more than the specified target mean strength appropriate to the grade of concrete.

The contractor shall not alter the approved mix proportions nor the approved source of supply of any of the ingredients without having previously obtained the approval of the Authority's Engineer.

During production, the authority/ Authority's Engineer may require trial mixes to be made before a substantial change is made in the materials or in the proportion of the materials to be used.

A range of slumps which shall generally be used for various types of construction unless otherwise instructed by the Authority's Engineer is given below.

Structure/Member	Maximum Slump (in mm)	Minimum Slump (in mm)
Reinforced foundation walls and footings	75	40
Slabs, Beams and reinforced walls.	100	40

4.3 **Batching and Mixing of Concrete:**

It is expected that batching plants of suitable capacity shall be used. The contractor shall submit monthly program of concrete works to the approval of the Authority/ Authoritys' Engineer. Proportions of aggregates and cement, as determined by the concrete mix design, shall be preferably by weight. These proportions shall be maintained during subsequent concrete batching by means of weigh batchers capable of controlling the weights within one percent of the desired value.

Based on the adopted nominal mixes, aggregates may be measured by volume. However cement shall be by weight only.

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. Water cement ratio specified for use by the Authority/s Engineer shall be maintained. Each time the work stops, the mixer shall be cleaned, and while recommencing, the first batch shall have 10% additional cement to allow for sticking in the drum.

Arrangement should be made by the contractor to have the cubes tested in an approved laboratory or in field laboratory with prior consent of the Authority/ Authority's Engineer. Sampling and testing of strength and workability of concrete shall be as per IS:1199, IS:516 and IS:456

4.4 **Formwork:**

Formwork shall be all inclusive and shall consist of but limited to shores, bracings, sides of footings, walls, beams and columns, and bottom of slabs etc.

The design and engineering of form work as well as its construction shall be the responsibility of the contractor. However, if so desired by the Authority's Engineer, the drawings and calculations for the design of the form work shall be submitted to the Authority's Engineer for approval. Formworks shall be designed to fulfill the following requirements.

1. 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.
2. Made of suitable materials
3. Capable of providing concrete of the correct shape and surface finish with the specified tolerance limit.
4. Capable of withstanding without deflection the worst combination of self-weight, reinforcement and concrete weight, all loads and dynamic effects arising from construction and compacting activities, wind and weather forces.
5. Capable of easily striking without shock, disturbance or damage to the concrete.

6. Capable of accommodating design temporary openings where necessary for these purposes and to facilitate.

The form work shall be made of steel joists between form work and formwork and between form work and structure all be sufficiently tight to prevent loss of slurry from concrete, using sealed if necessary.

The faces of form work coming in contact with concrete shall be cleaned and two coats of approved mold oil applied before fixing reinforcement. All rubbish, particularly chippings, shavings, saw dust, 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.

Forms intended for reuse shall be treated with care. Forms that have deteriorated shall not be used. Before reuse, all forms shall be thoroughly scraped, cleaned, holes suitably plugged, and joints repaired. The contractor shall equip himself with enough shuttering to allow for wastage so as to complete the job in time.

Permanent form work shall be checked 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.

Wire ties passing through beams and walls shall not be allowed. In their place bolts passing through sleeves shall be used. Form work spacers left in situ shall not impair the desired appearance or durability of the structure by causing spacing, rust staining or allowing the passage of moisture.

All corners and angles exposed in the finished structure shall have chamfers or fillets of 20mmX 20mm size, unless otherwise stated on the drawings or elsewhere.

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

The contractor shall provide adequate props carried down to a firm bearing without overloading any of the structures.

The shuttering for beams and slabs shall be so erected that the side shuttering of beams can be removed without disturbing the bottom shuttering. If the shuttering for a wall is erected for the full height of the wall, one side shall be built up in sections as placing of concrete proceeds or windows left for placing concrete from the side to limit the drop of concrete to 1.0m or as approved by the Authority's Engineer. The contractor shall temporarily and securely fix items to be cast (embedment/inserts) in a manner that will not hinder the striking of forms or permit loss of grout.

Form work showing excessive distortion, during any stage of construction, shall be repositioned and strengthened. Placed concrete affected by faulty form work, shall be entirely removed and form work corrected prior to placement of new concrete.

Before concrete is actually placed in position, the inside of the form work shall be cleaned and mold oil applied, inserts and reinforcements shall be correctly positioned and securely held, necessary openings, pockets etc., provided.

All arrangements-form work, equipments and proposed procedure, shall be approved by the Authority's Engineer.

4.4.1 **Formwork Striking time-**

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

- Development of adequate concrete strength.
- Permissible deflection at time of striking form work

- 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

Under normal circumstances (where temperature are above 20^0C) forms may be struck after expiry of the time period given in IS:456 unless approved otherwise by the authority's Engineer. For Portland Pozzolana/slag cement the stripping time shall be suitably modified as approved by the Authority's Engineer. 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 resist surface damage and any stresses arising during the construction period.

4.5 **Finish**

The formwork for concrete works shall be such as to give the surface finish Type F1as specified below. The contractor shall make good any unavoidable defects as approved consistent with type of concrete and finish specified: defects due to bad workmanship (e.g. damaged or misaligned forms, defective or poorly compacted concrete) will not be accepted. The contractor shall construct the formwork using the correct material and to meet the requirement of the design and drawing to produce finish concrete to required dimensions, plumb planes and finishes as per standard specification.

Surface Finish Type F1

The main requirement is that of dense, well compacted concrete. No treatment is required except repair of defective areas, filling all form tie holes and cleaning up of loose or adhering debris.

4.6 **Tolerances**

4.6.1 Variation from plumb, from specified batter or from curved surfaces of all structures

1. In 2.5m :10mm
2. In 5m :15mm
3. In 10m or more :25mm
4. In buried construction : Twice the above amounts

4.6.2 Variation from Level or Grade indicated in drawing of slab, beams, soffits and visible arches

1. In 2.5m :5mm
2. In 7.5m : 10mm
3. In buried construction : Twice the above amounts.

4.6.3 variation in Cross-sectional dimensions of columns, beams, buttresses, and similar members

1. Minus :5mm
2. Plus : 10mm

4.6.4 Variation in thickness of slabs, walls, arch sections and similar members

1. Minus :5mm
2. Plus : 10mm

4.6.5 Footing for columns, piers, walls, buttresses and similar structures

1. variation in dimensions in plan;

a). Minus : 10mm

b). Plus : 50mm

2. Displacement or eccentricity : 2%footing width in the direction of misplacement but not more than 50mm.
3. Reduction in thickness : 5% of specified thickness subject to a maximum of 50mm.

4.6.6 Tolerance in fixing anchor bolts, or embedded parts

1. Anchor bolts without sleeves ;1.5mm in plan
2. Anchor bolts with sleeves :5mm for bolts up to 28mm dia and 3mm for bolts 32mm and above
3. Embeded parts : 5mm in all directions.

4.7 **Transporting, Placing and Compacting Concrete**.

Concrete should be transported from the mixing plant to pouring site 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. To avoid segregation, concrete shall not be re handled or caused to flow. For locations where direct placement is not possible and in narrow forms the contractor shall provide suitable drops through “Elephant trucks”. Concrete should not be dropped from a height of more than 1.0m.Concrete shall not be placed in flowing water. Under water, concrete shall be placed in position by Tremies 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 shall ensure the following.

- Continuously between construction joints and predetermined abutments.
- Without disturbance to forms or reinforcement
- Without disturbance to pipes, ducts, fixings, and the like to be cast in. Ensure that such items are securely fixed, and that concrete cannot enter open ends of pipes and conduits etc.
- Without dropping in a manner that could cause segregation or shock.
  In deep pours, only when the concrete and form work is designed for this purpose, and by using suitable chutes or pipes.
  Refraining from placing 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 excavation, with draw the linings progressively as concrete is placed.
- If placed directly on to hard core 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.

Concrete shall normally be compacted in its final position within thirty minutes of leaving the mixer. 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 in to all corners of the formwork. Immersion vibrators for compaction of concrete shall be electrically operated and vibrator needles shall be of 60mm size only. Immersion vibrators shall be inserted vertically at points not more than 450mm apart and withdrawn slowly till air bubbles cease to come to the surface, leaving no voids. When placing concrete in layers advancing horizontally, care should 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, form work and finished surfaces after start of initial set.

Concrete may be conveyed and placed by mechanically operated equipments after getting the complete procedure approved by the Authority’s Engineer. 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 should be taken to avoid stoppage in work once pumping has started.

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 wall 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 on approved by the Authority's Engineer. Concrete shall be protected against damage until final acceptance.

4.8 **Curing :**

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

1. Premature drying out, particularly by solar radiation and wind
2. Leaching out by rain and flowing water
3. High internal thermal gradients
4. Vibration and impact which may disrupt the concrete and interfere with its bond to the reinforcement.

The finished concrete shall be protected from direct exposure to the sun for the first three days after being laid. On the day the concrete is laid, generally no watering can be done, but moist condition have to be maintained and water shall be lightly sprinkled on the surface as soon as it is hard enough to stand this. On the next day it shall be more freely sprinkled with water and kept thoroughly wet by being covered with gunny bags or other suitable materials and kept constantly wet. It shall be inundated and kept under water for at least 7 days. Surfaces where ponding is impracticable shall be covered with very weight gunny bags. Curing with water will be continued till the concrete is at least 10 days old. Shocks to the concrete by throwing materials over it or excessive walking over it shall be avoided for at least 7 days.

During the curing period, it shall be particularly seen that all exposed surfaces are kept thoroughly moist and not allowed to dry out. Verticals or inclined surfaces from which side forms have been removed and also soffits from which centering has been removed shall be given special attention in this respect by sprinkling with water or keeping covered with wet gunny bags as may be most suitable.

All concrete, unless approved otherwise by the Authority's Engineer, shall be cured by use of continuous sprays or ponded water or continuously saturated coverings of sacking, canvas, hessian, or other absorbent material for the period of complete hydration with a minimum of 7 days. The quality of curing water shall be the same as that used for mixing.

Where a curing membrane is approved by the Authority's Engineer to be used, the same shall be of anon-wax base and shall not impair the concrete finish in any manner. The curing compound to be used shall be approved by the Authority's Engineer 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.

4.9 **Construction Joints :**

Construction joints shall be provided as shown in the drawings or as approved by the Authority's Engineer. 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 the Authority's Engineer.

Any excess water or laitance shall be removed from surface of joints after the concrete is deposited and before it has set. When resuming work on the hardened concrete surface of the joint. It shall be thoroughly cleaned, roughened and all lattices removed. The surface shall be swept clean with wire brushes thoroughly wetted and treated with a thin layer of cement mortar consisting of equal volume of sand and cement and fresh concreting will start.

As soon as the exposed concrete has sufficiently hardened, the surface of the joint shall be water jetted or brushed with stiff brush to expose the larger aggregates without being disturbed. Alternatively, if the preparation is not satisfactory, or proper joint preparation is not possible due to inclement weather, the contractor shall thoroughly remove the laitance of hardened concrete by mechanical chipping after seven days of concrete work at his own cost. Before placing fresh concrete against a construction joint, all loose material shall be removed and the surface sluiced with water until it is perfectly clean, there after all ponded water should be removed.

When concreting is to be resumed on surface which has not fully hardened, all lattices 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 150mm thickness shall be placed and well rammed against the old work. There after work shall proceed in the normal way.

4.10. **Concreting records:**

A written record of the concrete works shall be made each day by the contractor and kept available for inspection by the Authority's Engineer. The diary shall contain notes and record of:

1. The names of the contractor's engineer who are responsible for the different phases of the concrete work and also the names of their assistants.
2. The temperature of air, water, cement, aggregate, together with the air humidity and type of weather.
3. Deliveries to the site of concrete materials (quantity, brand of concrete, materials etc).
4. Inspection carried out, tests performed etc. and their results.
5. Times of commencement and completion of different parts of the concrete works and times of erection and striking of.

4.11 **Acceptance by the Engineer**

The decision of the Authority's Engineer as to acceptability or otherwise of any concrete work shall be final and binding on the contractor.

For works not accepted, the Authority's engineer may review and decide whether remedial measures are feasible so as to render the work acceptable. The Authority's Engineer shall in that case direct the contractor to undertake and execute the remedial measures. These shall be expeditiously and effectively implemented by the contractor. Nothing extra is to be paid to the contractor for executing the remedial measures.

4.12 **Repair and Replacement of Unsatisfactory Concrete**.

Immediately after the shuttering is removed, all the defective areas such as honey- combed surfaces, rough patches, and holes left by form bolts etc. shall be inspected by the Authority's Engineer who may permit patching of the defective areas or reject the concrete work.

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

Rejected concrete shall be removed and replaced by the contractor at no additional cost to

the Authority.

For patching of defective areas all loose materials shall be removed and the surface shall be prepared as approved by the Authority's Engineer. This work is to be done by the contractor at his own cost.

Bonding between hardened and fresh concrete shall be done either by placing cement mortar or by applying epoxy. The decision of the Authority's Engineer as to the method of repair to be adopted shall be final and binding on the contractor. 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 approved by the Authority's Engineer. The cost involved on this will be borne by the contractor.

5. Reinforcement Workmanship :

Reinforcing bars supplied bent or coils shall be straightened cold without damage.All bars shall be accurately bent gradually and according to the sizes and shapes as shown in drawings / schedules to be prepared by the contractor. Re bending or straightening incorrectly shall not be done without approval of the Authority's Engineer

Reinforcements shall be accurately fixed and maintained firmly in the correct position by the use of blocks, spacers, chairs, binding wire etc to prevent displacement during placing and compaction of concrete. The tied in place reinforcement shall be approved by the Authority's Engineer prior to concrete placement. Spacers shall be of such materials and designs as will be durable, not lead to corrosion of the reinforcement and not cause spalling of the concrete cover. Binding wire shall be 16 gauge soft annealed wire. Ends of the binding wire shall be bent away from the concrete surface, and in no case encroach in to the concrete cover.

4 **Brick work :**

Bricks to be used for brick work shall preferably be Kiln Burnt clay bricks confirming to IS:1077. In case of non availability of KB clay bricks, Fly Ash bricks may be used on approval of the Authority/ Authority's Engineer. The compressive strength of bricks shall not be less than 75kg/cm^2. The bricks shall be sound, hard and homo generous in texture. The specification of cement mortar for brick work shall be as specified in the approved design and drawings of the respective structures.

6.1. **Preparation of Cement mortar**

The proportion of cement to sand of cement mortar to be used in brick work or plastering works shall be as specified in the approved drawings.

The cement to be used shall be OPC or PPC confirming to relevant Indian Standard Specification.

The sand shall be free from clay, shale, loam, alkali, and organic matters, and shall be sound, clean, and durable particles. The sand samples shall be approved by the Authority's Engineer before use.

For preparing cement mortar, the ingredients shall be mixed thoroughly in dry condition. Water shall then be added and mixing continued to give a uniform mix of required consistency. Prepared cement mortar should be used within 25 minutes of mixing. Mortar left unused in the specified period shall be rejected.

The contractor shall arrange tests on mortar samples if required by the Authority's Engineer

6.2 **Construction of Brick masonry**.

Laying of brick masonry shall confirm to IS:2212 (latest revision).

All bricks shall be thoroughly soaked in clean water for at least one hour immediately

before being laid. Bricks work of 230mm thick and over shall be laid in English Bond unless otherwise specified. 115 thick brick work shall be laid with stretchers. Before laying bricks, a layer of mortar shall be spread over the full width of suitable length of the lower course. Each brick shall be pressed in to the mortar and shoved in to final position so as to embed the brick fully in mortar. Bricks shall be laid with frogs uppermost.

All brickwork shall be plumb and square unless otherwise shown on drawing and true to dimensions shown. Vertical joints in alternate courses shall come directly one over the other and be in line. Horizontal courses shall be leveled. The thickness of brick courses shall be kept uniform. For walls of thickness greater than 230mm both faces shall be kept in vertical planes unless otherwise specified. All interconnected brick works shall be carried out at nearly one level (so that there is uniform distribution of pressure on the supporting structure) and no portion of the work shall be left more than one course lower than the adjacent work.

Bricks shall be so laid that all joints are well filled with mortar. The thickness of joints shall not be less than 6mm and not more than 10mm. The face joints shall be raked to a minimum depth of 12mm by raking tools daily during the progress of work when the mortar is still green, so as to provide a proper key for the plastering to be done. The face of brick work shall be cleaned daily and all mortar droppings removed. The surface of each course shall be thoroughly cleaned of all dirt before another course is laid on top. If mortar in the lower course has begun to set, the joints shall be raked out to a depth of 12mm before another course is laid.

6. **Cement Plastering**.

Both faces of brick work masonry walls are to be plastered with cement mortar as specified in the drawing. All joints in masonry brick work shall be raked to a depth of 12mm with hooked tool made for the purpose when the mortar is still green and in any case within 48 hours of laying. The surface shall be washed with fresh clean water free from all dirt, loose material, grease etc., and thoroughly wetted for 6 hours before plastering work is commenced. Concrete surfaces to be rendered will however be kept dry. The wall should not be too wet but only damp at the time of plastering. The damping shall be uniform to get uniform bond between the plaster and the wall. Cement shall be mixed thoroughly in dry condition and then just enough water added to maintain a workable consistency. The quality of water, sand and cement shall be as per relevant IS. The mortar thus mixed shall be used immediately and in no case shall the mortar be allowed to remain for more than 25 minutes after mixing with water. Curing of plaster shall be started as soon as the applied plaster has hardened enough so as not to be damaged. Curing shall be done by continuously applying water in a fine spray and shall be carried out for at least 7 days unless otherwise specified.

7 .1 **Testing of water tightness shall be conducted as per relevant IS Codes**.

1. Machine mix shall be used in concrete work for all structure. Design mix of concrete will be preferred. Vibrator of appropriate type shall be used for compaction of concrete.
2. All the structures are to be designed as permanent type and shall have aesthetic elevation.
3. Form work shall be of steel plates and frame, sound seasoned timber or any approved materials as decided by Engineer-in-charge to be used for the centering and shuttering of the structures.
4. Painting of all steel / MS structure to be done as per approved quality of enamel paint over a coat of primer.

5. All electrical work / earthings including wiring of pump & other buildings etc. to be done as per relevant I.S. specification and Indian Electrical Rules. Single phase wiring shall be done for lighting purpose & three phase wiring shall be done for running pump motors, W.T.P. & wherever necessary.
6. All the valves are to conform with relevant IS specification and of reputed make.
7. The surplus earth and debris should be lifted after completion of work and proper levelling of site as directed by Engineer-in-charge without any extra claim.

7.2. **General Conditions:**

2. Cement shall not be less than O.P.C.-43 grade/PPC/PSC-53 grade of reputed manufactures confirming to relevant IS Specification.
3. Reinforcement to confirm Fe-500 and I.S. specification (SAIL/RINL/ TATA/Jindal Steel/Shyam Steel).
4. As & when required, the steel/cement & other building materials will be tested by Department at the cost of contractor to ensure proper quality as per IS specification.
5. Testing of water tightness shall be conducted as per relevant IS Codes.
6. Machine mix shall be used in concrete work for all structure. Design mix of concrete will be preferred. Vibrator of appropriate type shall be used for compaction of concrete.
7. All the structures are to be designed as permanent type and shall have aesthetic elevation.
8. Form work shall be of steel plates and frame, sound seasoned timber or any approved materials as decided by Engineer-in-charge to be used for the centering and shuttering of the structures.
9. Painting of all steel / MS structure to be done as per approved quality of enamel paint over a coat of primer.
10. All electrical work / earthings including wiring of pump & other buildings etc. to be done as per relevant I.S. specification and Indian Electrical Rules. Single phase wiring shall be done for lighting purpose & three phase wiring shall be done for running pump motors, W.T.P. & wherever necessary.
11. All the valves are to conform with relevant IS specification and of reputed make.
12. The surplus earth and debris should be lifted after completion of work and proper leveling of site as directed by Engineer-in-charge without any extra claim.
13. Pumps and motors to be of reputed and approved make.
14. All the work including supply of materials to be executed as per relevant IS specification and direction of Engineer-in-charge.
15. Foundation of all structure including supply of materials shall be designed depending on Ground water table / subsoil condition. In no case the Depth of foundation below virgin soil shall be less than 1 mtr. at respective places.
16. All equipment, accessories, auxiliaries, piping, electrics, instruments, installations, construction, buildings etc. including all mechanical, electrical & civil engineering works covered under the scope of work of contractor shall be subjected to inspection & testing by the Department for its material, quality, workmanship and the performance. The contractor shall arrange and carryout all such inspection, testing, trial run etc. and demonstrate in presence of the Engineer-in-charge of the Department.
17. The cost of such inspection, testing, trial run, demonstration etc. shall be borne by the contractor. All responsibility of such inspection, testing, trial run, demonstration etc. and any damage/loss that may cause directly or indirectly shall exclusively rest with the contractor.

18. Such inspection, testing, trial run, demonstration etc. shall, however, not relieve the contractor of their liability for replacing/rectifying any defects, which may subsequently appear or be detected during erection and guarantee period.
19. All equipment, sub-assembly and components, auxiliaries and accessories shall be tested at manufacturer's workshop/site in accordance with relevant Indian Standards/International Standards. The contractor shall furnish all test certificates etc. related to the quality of all the materials to the Department along with the delivery of the materials at site without which no payment shall be released. However, such test certificates, quality assurance certificate shall not relieve the contractor of it's obligation to replace forth with any instrument/materials found defective during tests at works / trial running period/guarantee period.
20. Testing for performance of equipment shall be carried out and be checked with the approved parameters and performance characteristic curves for the purpose of acceptance.
21. **Electrical equipments/installation:** All the Electrical equipments/ installations shall be energy efficient and confirm to star rated/BEE as applicable. **The Electrical Power Factor should not be less than 1.**
22. Reinforced cement concrete **Grade M-30** in all members in contact with water and members close to water like roof slab/dome etc.
22. **Design Criteria and Specification for Water retaining structures**: All the RCC Water Retaining structures shall be designed as per IS456-2000 and IS: 3370 -2009. The structural design shall be done by **Working Stress Method**. The concrete grade for the water retaining members shall be M30. The steel used for reinforcement shall be Corrosion resistance high yield strength deformed bars confirming to IS:1786 (with latest revision).
24. **Design Criteria and specification for RCC Structures :** Concrete structures should be designed as per IS:456 -2000 **using Limit State Method of design**. For RCC works the Grade of concrete shall not be less than M20 Machine mix shall be used in concrete works of the structures. Vibrators of appropriate type shall be used for compaction of the concrete. The contractor shall give at his own cost concrete cubes to the department made from fresh concrete prepared for the work taken as per IS:1199 cured for 7 days and 28 days for testing by

7.3. Procurement, Inspection & Testing of MS / DI pipes and fittings:

1) The successful bidder shall source all ISI Marked Ductile Iron Pipes & Fittings from;
   a) The manufacturer who has not been blacklisted by any Govt./Govt. Undertaking for supply of DI Pipes in India and
   b) The manufacturer is having valid BIS License for marking ISI Mark on their products for at least 5 (five) years and
   c) The manufacturer's DI Pipes and Fittings are in satisfactory performance in Indian Projects for at least three years.
      - The D.I. pipes are to be inspected by the quality assurance wing of CIPET/ PDIL / RITES Ltd., and the consignment are to be embossed with the CIPET/ PDIL / RITES Ltd., inspection mark.
      - The materials without CIPET/ PDIL/ RITES Ltd., inspection and without CIPET/ PDIL/ RITES Ltd., shall not be accepted. All the materials should also be ISI Marked.
      - The DI pipe should confirm IS:8329:2000& its subsequent amendments and DI Fittings should confirm IS:9523:2000 and its subsequent amendments, if any.

2) The successful bidder is also to purchase materials necessary for execution of work contract from local SSI Units & MS Enterprises having valid rate contract & ISI Mark if materials are found suitable for the work.

3) **Laying of different diameter D.I. and M.S. pipe lines at different places in the project area**

i. Excavation of foundation in all kinds of soil including rocks of any kind shoring, shuttering and dewatering where ever required, site dressing and leveling the pipeline trenches. The minimum width of the pipeline trench shall not be less than (d + 40cm) and minimum depth of the trench shall not be less than (d + 90cm) in any case. But in case of raw water rising main to be laid from Intake well to WTP the width of trench shall not be less than (d+60cm) and the depth of trench shall be (d+150cm) where d is the diameter of pipe in cm.

ii) Supplying all materials labour T&P and construction of Brick masonry (i) Sluice Valve Chamber (ii) Air Valve Chamber including earth work in excavation in all types of soil, Providing minimum 15cm thick PCC (1:3:6), Brick work in Cement Mortar (1:4) using KB brick of size 25x12x8cm size having crushing strength not less than 75kg/sqcm, Cement plastering in Cement Mortar (1:4) at inside surface, 12 mm thick cement flush pointing (1:3) at the outside surface, and providing RCC top slab of 100mm. thick (minimum) using M-20 cement concrete in RCC as per the PWD/ PH and relevant IS specification and direction of the Engineer-in-charge and as per the tender schedule**.**

v) Supplying all materials, labour and T&P for laying of MS ERW/SAW pipeline including fabrication work at site for the canal crossing, culvert crossings, drain crossing or at low level lands including making bends/ offsets where ever required as per site condition. The MS pipes to be used are from reputed manufacture confirming to relevant IS specification. Internal & external lining shall be of food grade epoxy coating not less than 406micron.

Application of Epoxy Coating

a) Coating shall be applied when

i) When the pipe surface temperature shall be at least 3°C above dew point temperature.

ii) The temperature of mixed coating material and the pipe at the time of application shall not be lower than 10°C or greater that 50°C.

a) Material preparation shall be in accordance with manufacturer's recommendations.

Internal Lining :

Internal surface of the pipe should be coated with one coat of two-part epoxy primer with not less than 30-micron DFT (dry film thickness) followed by two part **food grade polyamide cured solvent less epoxy**. The minimum dry film thickness (DFT) of internal lining shall be 400 micron. The epoxy coating should offer highest resistance to cathodic disbandment and provide excellent adhesion to steel. The manufacturer should have the certificate issued in support of portable water service for tests of pH, turbidity, total hardness, chloride nitrate, iron, arsenic &fluoride as per IS 10500 :2003.

External Coating :

External surface of the pipe and specials to be painted with one coat of two part chemically cured polyurethane primer of min 30 micron dry film thickness followed by three or maximum four coats of two part **solvent free**

polyurethane provide a high build coating of dry film thickness of 1000 micron including primer coat. Polyurethane coating should have good resistance to ultraviolet degradation along with corrosion resistance. PU coating should provide hard yet flexible, with very low water absorption with outstanding adhesion as well as impact and abrasion resistance.

Solvent less PU system are to be used eliminating solvent health hazards.

Internal lining and external coating should be carried out at site by Paint Manufacturer as during transportation coating will get damaged. Moreover, the joints will fail as quality of coating on pipe and joint will be different.

4. General Requirement:

I) The work shall conform to the following documents / specifications (latest revision or as specified).

a) SSPC SP 10 / NACE 2 / Sa2½	Near White Blast Cleaning
b) SSPC PA 2	Measurement of dry film Coating Thickness with magnetic gauges.
c) ASTM D 4541	Method for pull off strength using portable Adhesion Tester.
d) NACE RP 0274 – 2004	High-Voltage Electrical Inspection of Pipeline Coatings
e) NACE SP 0188 – 2006	Discontinuity (Holiday) Testing of New Protective Coatings on Conductive Substrates
f) NACE RP 0169 – 2002	Control of External Corrosion on Underground or Submerged Metallic Piping Systems
g) AWWA C 210 – 2007	Liquid-Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines.
h) IS 3589 : 2001 Annexure B	Steel Pipes for Water and Sewage Specification.
i) AWWA C222-2000	Polyurethane Coating for the Interior and Exterior of Steel Water Pipe and Fittings.
j) IS 13213 : 2000	Polyurethane Full Gloss Enamel (Two pack)
k) IS 10221 : 2008	Coating and wrapping of underground mild steel pipelines.
l) BIS DOC : CHD 20 (1938) P	Solvent less Liquid Epoxy System for interior & exterior of Steel Water Pipeline.

II) The steel surface preparation prior to actual commencement of coating shall conform to SSPC SP 10 / NACE 2 /Sa2½ (near white metal) with sand blasting.

III) The contractor shall submit a detailed written description in the form of a manual covering coating equipment, procedures, materials inspection test, and repair etc. to Owner's Engineer In Charge's approval.

IV) The contractor shall also provide copies of test reports from NABL approved laboratory (like National Test House, Kolkata) evidencing that materials (paint / primer) shall conform to the technical specification.

V) The contractor shall also provide certificates from coating manufacturer quoting batch numbers, date of manufacture and shelf life etc. the contractor shall also provide Manufacturing Quality Plan (MQP) and field Quality Plan (FQP) before supply of material and starting of work.

VI) The coating shall be applied either by coating / paint manufacturer or by their authorized applicator. The authorized applicator should have been trained by and certified by manufacturer and shall possesses the necessary specialized equipment, trained crew and experience in spraying epoxy coating.

VII) Applied coating shall be tested for dry film thickness, holiday (electrical inspection for continuity) and adhesion asper relevant standard such as SSPC PA 2, NACE RP 0274 and ASTM D 4541.

VIII) The material may be heated if necessary and applied by airless spray / plural component spray system

5. COATING PROCEDURE AND APPLICATION

Surface Preparation :

Pipe shall be blast cleaned by sand. The cleanliness achieved prior to application shall be in accordance with the requirement of SSPC SP 10 / NACE 2 / Sa2½ of ISO 8501 (near white metal)

a) The blast pattern or profile depth shall be 40 to 100 micron and shall be measured by dial micrometer.

b) Before sand blasting is started or during blasting or coating, temperature of the pipe surface should be more than 3°C above dew point temperature. Blast cleaned surface should be primed within 4 hours and shall be protected from rainfall or surface moisture and shall not be allowed to flash rust. If the rust occurs, the surface again to be prepared by sand blasting or wire brushing.

c) Application of epoxy coating system :

The epoxy coating system shall be applied as per recommendation of the manufacturer and shall be applied by airless spray / plural component spray machine. For more than one coat, the second shall apply with the time limits as recommended by the manufacturer.

Application of PU Coating

a) PU coating shall be applied when the pipe surface temperature atleast 3°C above dew point temperature (when R.H is more than 85%).

b) Material preparation and application shall be done as per manufacturer recommendation and shall be applied by plural component machine.

TEST REQUIREMENTS :

a) **Measurement of dry film thickness**

Measurement of dry film thickness of coating: Coating thickness shall be in the range of ±20% and as per SSPC PA 2.

i) **Apparatus / Instrument**: The instrument used for dry film thickness may be Type 1 pull of gauges or Type 2 electronic gauges.

ii) **Procedures:**

ii.a) No. of measurements: For 100 square feet (9.29 square meters), five (5) spots per test area (each spot is 3.8 cm) in diameter. Three gauge readings per spot (average becomes the spot measurement).

ii.b) If the structure is less than 300 square feet, each 100 square feet should be measured.

ii.c) If the structure is between 300 and 1000 sq ft, select 3 random 100 square feet test areas and measure.

ii.d) For structure exceeding 1000 square feet, select 3 random 100 square feet testing areas for the first 1000 sq ft and select 1 random 100 square feet testing area for each additional 1000 square feet

ii.e) Coating thickness Tolerance: Individual reading taken to get a representative measurement for the spot are unrestricted (usually low or high readings are discarded). Spot measurements (the average of 3gauge readings) must be within 80% of the minimum thickness and 120% of the maximum thickness. Area measurement must be within specified range.

b) Electrical Inspection (Holiday) Test :

i) All the coated / lined pipes shall be tested with an approved high voltage holiday detector preferably equipped with an audio visual signaling device to indicate any faults, holes, breaks or conductive particles in the protective coating.

ii) The applied output voltage of holiday detector shall have a spark discharge of thickness equal to at least twice the thickness of the coating to assure adequate inspection voltage and compensate for any variation in coating thickness. The electrode shall be passed over the coated surface at approximately half the spark discharge distance from the coated surface only one time at the rate of approximately 10 to 20m/min. The edge effect shall be ignored. Excessive voltage shall be avoided as it tends to induce holiday in the coated surface thereby giving erroneous readings.

iii) While selecting test voltages, consideration should be given to the tolerance on coating thickness and voltage should be selected on the basis of maximum coating thickness likely to be encountered during testing of a particular pipe. The testing voltage shall be calculated by using following formula. (as per NACE 0274 : 2004) Testing Voltage V = 7900 _T ± 10 percent where T is the average coating thickness in mm.

iv) Any audio visual sound or spark leads to indicate pinhole, break or conductive particle.

c) Adhesion Pull off Test :

After holiday the coated surface is subjected to adhesion pull off test as per ASTM D 4541.

i) Apparatus / Instrument : Adhesion tester consists of three basic components : A hand wheel, a black column containing a dragging indicator pin and scale in the middle and a base containing three legs and a pulling “Jaw” at the bottom and also dollies.

ii) Prepare the test surface : Once test area is selected, test area shall be free of grease, oil, dirt, water. The area should be flat surfaces and large enough to accommodate the specified number of replicate test.

iii) Prepare Dolly (Test Pull Stub) : The dolly is a round, two sided aluminium fixture. Both sides of the dolly looks same, however, one side sloped on top

surface while flat on bottom surface. As the surface of the dolly is polished aluminium, roughen the same using a coarse sand paper.

iv) Select an adhesive : Use araldite, a 100% solid epoxy adhesive. This adhesive requires at least 24 hours at room temperature to cure.

v) Attach the dolly to the surface.

v.a) Using a wooden stick, apply an even layer of adhesive to the entire contact surface area of the dolly.

v.b) Carefully remove the excessive adhesive by using a cotton swab. Allow the adhesive to fully cure before performing the adhesion test.

v.c) Attach the dolly to the coated surface and gently push downward to displace any excessive adhesive.

v.d) Push the dolly inward against the surface, then apply tape across the head of the dolly.

vi) Determine whether scoring is required

vi.a) No standard including ASTM does not recommend any tape of scoring around the base of dolly prior to testing. Scoring may produce tiny factures in the coating or may generate friction heat, which can change the properties of coating and result in lower adhesion values.

vii) Perform the Adhesion Test

vii.a) Attach the adhesion tester to the dolly by rotating the hand wheel counter clockwise to lower the jaw of the device.

vii.b) Slide the jaw completely under the head of the dolly. Position the three legs of the instruments so that they are sitting flat on the coated surface.

vii.c) Slide the dragging indicator pin on the black column to zero by pushing it downward.

vii.d) firmly hold the base of the instrument in one hand and rotate the hand wheel clockwise to raise the jaw of the device that is attached to the head of the dolly. The dragging indicator pin will move upward on the black column as the force is increased and will hold the reading. Apply the tension using a moderate speed. Continue to increase the tension on the head of the dolly until (a) the minimum PSI/MPa/Kg/cm² required by project specification is exceeded and the test is discontinued, (b) the maximum PSI/MPa/Kg/cm² of adhesion tester has been achieved and dolly is still attached, (c) The force applied by the adhesion tester causes the dolly to dislodge.vii. e) Read the scale and record the adhesion value. The black column near the middle of the adhesion tester contains two scales and a dragging indicator pin in between. Right scale is PSI and left scale is MPa. The dragging indicator pin will hold the reading until push back to zero. When achieve the end point of test, read the scale across the bottom of the dragging pin.

d) Coating Repair

i) Defective Coating : Coating shall be repaired in accordance with the following subsections.

ii) Surface Preparation : Accessible areas of pipe requiring coating repairs shall be cleaned to remove debris and damaged coating using surface grinders or other means. The adjacent coating shall be feathered by sanding, grinding or other method. Accumulated debris shall be removed by blowing with contaminant free air or wiping with clean rags. Areas not accessible for coating repair such as interior surfaces of small diameter pipe shall be reprocessed and recoated.

iii) Coating Application : The coating system shall be applied to the prepared areas in accordance with procedure.

iv) Repair Inspection : Repaired portion shall be electrically inspected using a holiday detector.

e) Welded Field Joints

i) Preparation : The weld joints shall be cleaned so as to be free from mud, oil, grease, welding flux, weld spatter and other foreign contaminants. The cleaned metal surfaces of the weld joint shall then be abraded using rotary abrading pads or emery paper. The adjacent liquid Epoxy / PU coating shall be feathered by abrading the coating surface for a distance of 25 mm.

ii) Electrical Inspection : After curing the coating system applied to the welding joints shall be holiday tested. Any holidays indicated by the detector shall be marked with chalk to identify the area of repair.

1. The contractor shall cut the asphalt / metalled / concrete road during laying of pipe line and same should be repaired after laying and testing of pipe line to its original condition.

2. Other Criteria shall follow Manual on Water Supply and Treatment by CPHEEO, Government of India.

7.4.a All concrete works for water retaining as well as the supporting structures shall be executed, tested as per IS 456, 1978, IS 3370 (Part-I) 1965 and IS3370 (Part-II) 1965.

7.5. **Design Criteria and specification for RCC Structures.**

Concrete structures should be designed as per IS:456 -2000 using limit state method of design. For RCC works the Grade of concrete shall not be less than M20 Machine mix shall be used in concrete works of the structures. Vibrators of appropriate type shall be used for compaction of the concrete. The contractor shall give at his own cost concrete cubes to the department made from fresh concrete prepared for the work taken as per IS:1199 cured for 7 days and 28 days for testing by the department at any recognized/Govt. testing laboratory, and the testing charges shall be borne by the contractor. Besides the above arrangements, contractor shall also carry out such tests as required by the department at regular intervals at his own cost. Samples shall be taken from the concrete prepared for use in the following components of the structure. The concrete mix design shall be prepared in a Govt. Laboratory recommended by the Authority at the cost of the Contractor and design mix test report shall be submitted to the Authority/ Authority's Engineer for approval before starting the work.

i) Foundation
ii) Each lift of supporting structure (column/shaft)
iii) Supporting beams / Floor beams / Tie beams /Bracings.
iv) Floor
v) Each lift of the wall.
vi) Roof slab.
vii) Any other portion of the structure as desired by the Engineer-in-charge.

In the event of deviation from the desired strength, the contractor shall dismantle the defective parts of the construction and make good the same at his own cost and no extra payment will be made by the department for the same.

7.5.1 All pipes, valves & fittings required, shall be of best quality confirming to relevant IS specifications which shall be provided by the contractor at his own cost as per P.H. specification and direction of Engineer-in-charge.

7.5.2 The safe bearing capacity of the soil is to be ascertained before preparation of drawing & designs for construction of CWR, ESR, UGR, Each component of WTP, all types of buildings and Intake Well etc.

7.5.3 The contractor shall submit the design & drawing in a phased manner after one month of issue of LoI and complete the same for the whole project within three months. Two sets of design calculation and drawings to the Authority's Engineer. The design and drawings shall be scrutinized and preliminary approval will be communicated by the competent authority.

7.5.4 On receipt of preliminary approval, the contractor shall furnish within fifteen days, ten sets of clearly typed design calculations and drawings for final approval and communication to all concerned.

7.6 **Soil Investigation Report:**

For structural design purposes, Geotechnical investigation shall be conducted and SBC shall be found out at required depths at locations of Intake well, each unit of WTP,UGRs, ESRs, Pump houses, Bridge structures and other important structures by the contractor confirming to relevant IS Code, through the Government approved agencies. The soil test shall include bore log, SPT, UDS test, Tri-axial test, Vane shear test, core sample test, plate load test depending upon requirement of the structural design of the structures. Before detailed engineering & design of the structures the contractor shall submit detailed soil test report along with calculation of SBC to the Authority's Engineer for approval of SBC to be adopted for structural design. On approval of the SBC the contractor shall design the structure considering the recommended SBC. In case further data would be necessary before or after submission of tender / during execution of the work, the tenderer / contractor shall collect the same of his own & at his cost. Ignorance of any data shall not relieve the contractor of his obligation to complete & commission the work as per the provisions of the Agreement. For detail structural design of the intake well and bridges, the contractor has to collect all the required hydraulic & flow parameters of the river/water way where the intake well and bridge structures are to be constructed, from the Water Resources Department, and other data as will be required from the concerned departments, at his own cost and risk & shall submit to the Authority's Engineer for approval. Then based on the approved data the agency has to prepare detail design & drawing of Intake well and bridge structures.

While designing of the structures, it shall be ensured that the weight of the structure including foundation, water, over burden earth on foundation / slab / raft etc. as applicable shall be within the permissible limit of S.B.C. allowed by the Authority's Engineer.

7.6.1 **Design Criteria and Specification for Water retaining structures**

All the RCC Water Retaining structures shall be designed as per IS456-2000 and IS: 3370 -2009. The structural design shall be done by working stress method. The concrete grade for the water retaining members shall be M30. The steel used for reinforcement shall be Corrosion resistance high yield strength deformed bars confirming to IS:1786 (with latest revision)

i. Capacity of the reservoir shall be the volume of water stored between the full supply level and the invert of the outlet pipe. Due allowance shall be made for plastering the inside surface of the wall and floor, while calculating the net capacity of the reservoir.

ii. The elevated RCC reservoir shall be with RCC shaft /column bracing staging and cylindrical container. The container and column shall beproportioned properly so as to give architecturally good aesthetic view.

iii. Free board shall be minimum 350 mm.

iv. Minimum dead storage of 150 mm shall be provided at the bottom of the reservoir.

v. Design shall be based on accepted norms and methods of design and the provision contained in the latest versions of IS: 456, IS:3370, IS:1893, IS:875 and all other relevant codes etc. No age factor shall be allowed in the design of the structure.

vi. Plain cement concrete of grade M-10 thickness, not less than 100 mm shall be provided below the footings/ foundation.

vii. The minimum thickness of the structure numbers shall be as follows:

a) Wall of reservoir

i)	Up to 4 m water depth	: 185 mm
ii)	Up to 5 m water depth	: 200 mm
iii)	Up to 6 m water depth	: 215 mm

b) Floor of the reservoir in container : 200 mm

c) load bearing shaft of elevated reservoir : 150 mm

d) Top Roof slab if designed as shell : 100 mm

e) Top Roof slab flat : 125 mm

viii. For the RCC column of the ESR minimum diameter of the column shall be 400 mm.

ix) Grade of RC concrete: RCC M-30 for water retaining members & RCC M-25 grade for all other components of ESR (foundation to top of ESR).

x) The design calculations and drawing shall be worked out in either metric or in S.I. unit.

xi) The water retaining component/ member including member subject to condensation like Roof Slab shall be designed as un-cracked section with M-30 grade concrete.

xii) The minimum depth of foundation of elevated reservoir shall be 1.80 m below the virgin ground level.

For access into the over head reservoir there shall be RCC stair case with RCC landings at suitable intervals. The width of the stair and landing shall not be less than 800 mm. The stairs shall be provided with MS railings of approved design for a minimum height at 800 mm with two rows of horizontal runners at each side holding the vertical posts. There shall be either a central access inside the tank or a catwalk with suitable guard rails all around. In both the cases access to the roof & inside bed of the reservoir shall be provided. Inlet & outlet pipe shall be as per pump motor & field requirement. Overflow pipe dia shall be more than inlet dia. 100mm dia wash out pipe. Each pipeline shall be provided with required puddle collars, expansion joint, duck foot bend, DI/DF valves, valve chambers etc., as required for completeness. The limit of contract of each pipeline for ESR is up to foundation trench from outer face of staging shaft/column.

xiii) The roof of the overhead reservoir shall be provided with hand rail at the edges

by means of Stainless-Steel posts and railings for a minimum height of 800 mm with two rows of horizontal runners holding the vertical posts.

xiv) The overhead reservoir shall be provided with suitable ventilation arrangement at the roof. The openings of the ventilators shall be protected with mosquito proof wire net of copper wire net of copper wire mesh.

xv) One lightening arrestor shall be provided on the roof of the elevated reservoir as per IS:2309. The same shall be suitable earthed with aluminum tape conductor as per I.S. specifications.

xvi) Two Nos. of C.I. lockable hinge type manhole covers of minimum 600mm dia. with frame shall be provided on the roof of the elevated reservoir.

xvii) All RCC works shall be finished perfectly smooth at his own cost the inside surface of walls and floors shall be rendered with 20mm thick cement plaster (1:3) after necessary surface cleaning.

xviii) All exposed faces of the concrete shall be given two coats of weather coat paint of approved quality over a coat of primer. All expose iron works outside the reservoir shall be painted with two coats of approved synthetic enamel paint over a coat of primer. All expose iron works inside the reservoir shall be painted with two coats of approved anticorrosive paint over a coat of priming.

xix) The Engineer-in-charge or his authorised representative shall have the right to inspect and test the materials collected by the contractor for use in the work. The materials not confirming to relevant specification shall be rejected and the contractor shall have to replace the defective materials immediately.

xx) The Authority's Engineer shall have the authority to reject or accept any or all the works and materials and to direct the contractor to stop the work if the work is not taken up to the specification. The Engineer-in-charge shall also have authority to suspend a part or whole of the above and no claim whatsoever on this account made by the contractor shall be entertained. In case of any dispute, the decision of the **Engineer-in-Chief, P.H. (Urban), Odisha, Bhubaneswar** shall be final and binding.

xxi) All design shall be submitted in the form of booklet in complete shape along with relevant drawing and in a presentable manner neatly typewritten/ computer printed in A4 size bond paper.

xxii) All design calculation/ findings shall be supported with illustrative drawings in form of plan section etc., as applicable which shall form a part of design book let.

xxiii) All reference made in the design shall be indicated in reference chapter of the design booklet on demand, the contractor shall furnish reference materials to the department to facilitate checking of design.

xxiv) All drawings shall be with black line on which tracing paper in metric scale in size 560 mm x 810 mm and shall be title cross reference and fully explanatory with the contractors name date seal and signature on it. Each drawing shall contain the title at the bottom of the right hand corner. Alternatively the contractor may submit computer aided drawings drawn in different colours confirming to other specifications as described above.

xxv) In case of computer aided design the firm shall also additionally submit the soft copy containing the software and the design to the department to facilitate the checking of the design. Contractor shall also furnish the design calculation through manual method if demanded by the department.

7.7 Design Basis:

i) All design shall be based on the best modern practices enumerated in the standard text book/ reference books and hand books by author of international and national repute, reference books like the Manual on Water Supply and Treatment by CPHEEO. Government of India, latest Indian Standard code of practice and specification norm fixed by Pollution Control Board and state/ central Electricity Authority shall also be followed whenever required. In case of any contradiction the decision of the Authority of the department or his representative shall be final.

ii) For computer aided design the contractor shall use only widely accepted standard software of international/ national repute.

iii) Thumb rule design based on the contractor's own experience / substandard books and literature/ substandard software shall be out rightly rejected.

iv) Size of pipes, fittings and valves will be as per design requirement for individual reservoirs. The pipes should be double flanged Cast Iron Class-B or DI Class K-9.

7.8 **Civil Works:**

a) **General**:

i) All the building and structures shall be of permanent type. The Treatment Plant buildings shall have good aesthetic and imposing elevation and architecture with the grounds attractively landscaped and well maintained. Reinforced cement concrete fins, decorative "**Arch type**" windows, boxes, pebble dash/ rough cast plaster, grills etc. may be proposed to elevate the look.

ii) Sufficient consideration shall be given for the design of the buildings for **aesthetic look.** Ordinary configurations without aesthetic shall not be accepted.

iii) Foundations for all the buildings and structures of Treatment Plant Complex shall be designed depending on Ground water table, sub-soil condition and bearing capacity of soil. In no case the depth of foundation below the virgin soil shall be less than **1.0 mtr**.

iv) Provision of pressure relief valves/earthen overburden for countering full or part of uplift pressure shall not be allowed.

b) **Constructional Features:**

The Water treatment Plant is of 130 MLD capacity

(i) Clear Water Reservoir / OGR:

(a) The Clear Water Reservoir/ OGRs shall be of RCC Construction, Circular/ rectangular shape with domed roof/flat roof having column beam supporting arrangement.

(b) The concrete used for RCC work shall be M-30 grade.

(c) The PCC below the base raft shall be of M10 Grade, the minimum thickness of PCC being 100mm.

(d) The height of top of ring beam shall be as per design requirement.

(e) The capacity of the reservoir shall be the volume of the water stored between the invert level of overflow pipe and the dead storage level. Due allowance shall be made for plastering inside surface of the wall and floor while calculating the net capacity of reservoir.

(f) Free board shall be minimum 500 mm in case of flat roof and 400 mm in case of domed roof.

(g) A dead storage of not less than 100mm depth to be provided for the reservoir.

(h) The design shall be based on accepted norms and methods of design and provisions contained in latest version of IS-456, IS-3370, IS-875 and IS-1893.

(i) There shall be RCC stair case and SS hand railing & landings for access to the roof of USR from GL. Similarly, SS ladder shall be provided inside the tank for access into the tank.

(j) 2 Nos. of C.I. lockable hinge type Man Hole covers of minimum 600mm diameter with frame shall be provided on the roof of the tank.

(k) Ventilators of adequate size with mosquito proof wire net shall be provided on top of the tank

(l) The UGRs shall be provided with all necessary piping, valves & interconnections etc.

(m) The base raft shall be designed for full uplift pressure considering water table at Ground Level (GL). No overburden on roof top of any kind (earthen, masonry, or in any other form) or Pressure Relief Valves at base slab to counter a part or full up lift pressure shall be allowed.

(n) Inlet, outlet, over flow & washout pipeline shall be as per design requirements. The pipes shall be double flanged pipes of CI Class-B or DI K-9.

(o) Minimum depth of foundation shall be 1.00 m measured from lowest natural ground level(NGL).

(p) Inside surface shall be plastered with 20mm thick cement mortar in proportion not less than 1:3 (1cement: 3 sand) and the surface shall be rendered smooth with neat cement punning.

ii) **Pump Houses :**

a) The pump houses shall be with RCC framed structure with 250mm thick brick filler walls. Sufficient doors & windows shall be provided in the building. The foundation for pumps and motors shall be designed for machine foundation in accordance with relevant I.S. specifications. The floor shall be suitably sloped and drains provided to let out any leakage water so as to keep the floor dry. The floor of panel room and utility spaces shall be 150mm higher than the pump floor.

b) Floorings of the Pump Houses shall be of RCC sunken floor for complete positive suction arrangement with Ceramic Tile of Johnson or equivalent Make of approved colour. The walls of the Pump Houses shall be provided with white glazed tiles up to **2.0mtr** height from the finished floor level. Entrance Step shall be finished with **Mirror Polished Granite**type Flooring. All other items including electrical shall be standard PWD/Electrical specification unless otherwise mentioned specifically elsewhere.

iii) **Boundary Wall:**

Boundary wall shall be of Brick Masonry in CM (1:4) .The brick used for the purpose shall be good quality KB Clay bricks or Fly Ash bricks the compressive strength of which shall not be less than 35kg/$cm^{2.}$ thick Both side surfaces of the walls shall be plastered with 16mm thick CM(1:6).**M-20**grade RCC Column & Plinth Beam structure. Topof thewall shall be providedwith40mmthickPCC(1:2:4)layer. Depth of foundationofBoundary wall shall be minimum 1.00M.**R.C.C.Column**fortheGateOpeningshallbeof 0.38m x0.38m size&2.0m high of **M-20**gradestructure.Thedepthof foundationoftheR.C.C.Columnwithisolatedfootingshallbeminimum1.00m below the ground level. The both side of the compound wall should be

painted with two coats of weather coat paint over one coat of primer. Construction joints in boundary wall shall be provided at suitable interval as per the direction of Engineer-in-Charge.

7.9. **General for all Buildings & Structures:**

a) All tanks for alum & lime, aerator, Rapid mixing unit, flocculation, sedimentation, filtration units, elevated water tank etc., backwash tank and all channels carrying raw, coagulated, settled or filtered waters shall be of M**30**grade and shall be designed as water retaining tanks without considering any age factor. All the water retaining structures shall be tested for water tightness before installing the equipment, media etc. All channels of the Water Treatment Plant shall be cladded with white glazed ceramic tile of approved make. Required type of foundation as required with respect to actual soil condition& soil parameters, SBC , position of maximum subsoil water table in worst rainy season condition shall be provided for the units of WTP, Intake well, UGR, ESR, footway bridge, buildings and other structures as per actual design requirements satisfying the requirements of books of reputed authors & IS codes.

b) Minimum free board (FB) of 150mm shall be provided for channels unless specified separately and the Filter Boxes in which case it shall be 500 mm.

c) All channels, launders, conduits etc. shall be designed for 50% overload.

d) No age factor shall be allowed in the design of the structures.

e) The plinth level of all the buildings shall be **0.75 m** above the general ground formation level unless otherwise specified.

f) The room height (between finished floor level and ceiling) of the office and laboratory building, Pump house shall be not less than **3.60 mtr.**

g) Plain cement concrete of grade **M10** of thickness not less than **100 mm** shall be provided below the RCC floor slab and the footings and foundation unless otherwise specified specifically.

h) Mechanical type water level indicator shall be provided in reservoirs. All other related items required for completeness of the reservoirs for smooth functioning shall be provided.

i) In case of Overhead tank with shaft staging there shall be an entrance door at plinth level and ventilators at suitable locations shall be provided. The plinth shall be provided with suitable flooring over a base course.

j) All Iron works shall be painted with two coats of approved anticorrosive synthetic enamel paint over a coat of primer. All wood works shall be painted with two coats of approved paint over a coat of primer.

k) All External surfaces shall be painted with two coats of Weather proof acrylic emulsion paint of approved colour over a coat of primer. The Engineer-in-charge shall approve the computerized colour code prior to application of paint.

l) The specification of **building works** shall be as below:

i) Brick work:

Bricks should conform to IS 1077. First class KB Bricks in cement mortar (1:4) in foundation and plinth. All non-load bearing outer walls shall be minimum 250 mm thick & inside partition walls shall be minimum 125 mm thick. First class KB bricks in cement mortar (1:6) in superstructure. The thickness of plaster shall not be more than 20 mm for outside face & 15 mm for the inside face.

ii) Plastering :

All brick works with 16 mm thick cement mortar in 1:6 & all RCC exposed surfaces & roof ceilings except for the Water retaining structures shall be with 12mm thick cement mortar in 1:4(1cement : 3 sand) unless specifically mentioned.

iii) PCC :

Minimum 100mm thick **M-10 PCC(1:3:6)** under RCC foundation and flooring.

iv) Painting / Colouring over Plastering:

All External surfaces shall be painted with two coats of Weather proof acrylic emulsion paint of approved colour over a coat of primer. All internal surfaces of all the buildings/Room shall be given with two coats of distemper paint over a coat of primer. Ceiling of all round of building shall be painted with two coats of white distemper over a coat of primer.

v) Flooring :

Level of flooring shall be 0.75m above the virgin soil at respective structures. There shall be sand filling between the virgin soil & the floor. The flooring shall be of ceramic tile(stain less) flooring except pump house where the flooring shall be done as AS flooring. The dado in all types of flooring shall be of 0.3mtr height.

m) The contractor shall provide necessary sun shades/Chajja etc. wherever necessary.

n) The contractor shall provide ramp with gentle scope to the buildings wherever required.

o) Plinth protection for a width of 1.00 m around all the buildings shall be provided. It shall be C.C. checkered floor over 100 mm PCC.

p) All roofs shall be provided with grading plaster of 25 mm thick in 1:4 cement plasters with required grading for drainage. There shall be drainage pipes of 110 mm PVC pipes with all fixtures and specials extending up to the surface drain for disposal of rainwater. The number of pipes shall be as per the roof drainage plan to be approved by the Department. A DPC coarse in 1:2:4 concrete shall be provided at plinth level for a thickness of 40mm for all buildings.

q) There shall be parapet walls of 250 mm brick masonry up to 600 mm height above the roof of all buildings.

r) Expansion joints shall be provided in exposed pipelines as per standard practice & in conformity with relevant IS Specification.

i) In the event of any deviation from the desired strength, the contractor shall dismantle the defective parts of the construction and make good the same at his own cost. All the building materials including steel rods shall be tested in recognized testing laboratory to be selected by Department at the cost of the contractor. Any material found defective/not to specification shall be replaced forth with by the contractor without any extra financial implication.

ii) All reinforcement shall be checked and recorded prior to concreting by the Engineer-in-charge or his representative and the contractor shall countersign this. Entire concreting work shall be done in the presence of an officer not below the rank of Assistant Engineer, The contractor shall, therefore, give notice of at least two days to the Engineer-in-charge or his representative so that the works can be checked by him or his authorised representative.

iii)1. The form work shall be of steel plates of steel frame, sound and seasoned timber or of any approved materials, having sufficient strength to hold the concrete and withstand ramming and vibrations. If timber shuttering is used it shall be constructed in such a way that none of the concrete grout leaks away and shall be such as to leave a clean smooth surface not requiring further plastering. The surface of all forms in contact with concrete shall be clean, rigid, tight and smooth. Before a piece of work on formwork is concreted, the formwork shall be cleaned of all mortar, shavings, concrete from previous work and all other dirt. It shall then be covered with thin coat of Mobil oil.

2. The joints in the form work shall be arranged in a regular pattern.
3. Shuttering shall be provided to concrete faces where the slope exceeds 1: 2½.
4. The stripping time of all form work shall be in accordance with recommendations contained in **IS:456**.

s) **Concrete face work:**

- The exposed faces of concrete shall be true to line have smooth surface and without roughness occurring between successive sections of shuttering. In removal of forms, minor uneven surface defects shall be picked out to such a depth, refilled and properly replaced with such class concrete as necessary. All pin holes shall be plugged.
- The surface of non shuttered faces of concrete shall be finished with a wooden float to give a finish equal to that of the rubbed down shuttered faces. The top faces of slabs not intended to be surfaced shall be leveled and floated to a smooth finish.

t) **Embedment and Anchorages**:

All the embedment and anchorages shall be provided by the contractor and shall be rigidly fastened. Anchor bolts and other anchorages or inserts shall be set to template and /or firmly secured in position.

u) **Grouting** :

Nominal minimum strength of grouting concrete shall be 40 N/mm^2 or such other values as may be shown on the approved drawings. The nominal maximum size of aggregate for grouting concrete shall be 10 mm.

In case ‘Dry’ concrete or mortar is used, slump shall not exceed 6 mm.

If ‘Wet’ expanding concrete or mortar is used, slump shall be at least **125mm** or more but not exceeding 225 mm. An expanding grouting admixture shall be of approved type and in accordance with the manufacturer’s instruction.

v) **Doors/Window/Ventilators/Grills :**

1. There shall be adequate nos. of doors & windows in all the buildings/structures.
2. The area of openings shall not be less than 25% of floor area.
3. All windows shall be with aluminum frame & 5 mm thick reinforced glass panels provided with all related aluminum hardware fittings. The shutters shall be of sliding type in two folds.

4. All doors except for those specified separately shall be with aluminum frame & 12mm thick pre laminated plywood panels provided with all related aluminum hardware fittings.
5. There shall be adequate nos. of ventilators of size 750mm x 300 mm fitted with decorative RCC Jally.
6. There shall be a **3 mtr**. wide **2.4 mt**r. height rolling MS shutter of standard thickness with all hardware fittings suitably located to facilitate conveyance of chemical bags in to the storage area. There shall be an additional outside door for general thoroughfare.
7. There shall be MS grills of member thickness not less than 5 mm of decorative designs fitted to all the windows of the office & laboratory building, chemical storage area for safety. Similarly, the Grill Gate to be fixed to the boundary wall shall be approved design and of 2.0m. height.
8. The panels of all external doors, toilets, filter house shall be of waterproof pre-laminated plywood shutter of minimum 12 mm thickness. For chemical house, the panels should be of chemical resistant materials.
9. The specifications of aluminum frames for doors & windows shall be as per relevant ISS & suitable from aesthetic point of view to be approved by Department.
10. All other materials used in doors & windows shall conform to relevant ISS & to be approved by Department.
11. The fixing of doors & windows shall conform to relevant ISS.

7.10 Steel & Structural Fabrication:

i) Method and Material for construction:

Steel structures shall generally be of welded construction. Structural steel shall conform to IS:226 or IS:2062 as required from design considerations. In welded construction plates up-to and including 20 mm thickness and rolled section shall be of grade St.42 conforming to IS:226. Plates above 20 mm thickness, where welding is employed shall be of steel grade St.42 conforming to IS:2062. Electrodes, bolts, nuts, washers etc. shall conform to relevant Indian Standards. Only tested materials shall be used and all test certificates are to be submitted by the Contractor.

ii) Fabrication:

The fabrication of structures shall be carried out as per relevant India Standards and also according to latest practices. Steel structures shall be fabricated to suit transport requirement and minimum site work.

All steel structural works shall be subjected to inspection by the engineer-in-charge.

All permissible tolerance in workmanship shall be as perIS:7215.

iii) Erection:

The erection shall be carried out as per relevant Indian Standards. The minimum tolerance for alignment and level of the steel work shall be + 3 mm on any part of the structure. The structure shall not be out of plumb by more than 10 mm. These tolerances shall apply to all parts of the structure.

iv) Painting:

- ❖ All the steel works shall be painted.
- ❖ Painting operation and paint schedules shall be as per IS:1477 (part-II).
- ❖ All steel structural other than in chemical house shall receive one coat of red oxide zinc chromate primer conforming to IS:2239 after fabrication and

one coat of the same primer after erection. Steel structures in chemical house shall receive acid / alkali resistant epoxy-based primer.

- ❖ Priming coat shall be followed by two coats of painting by approved quality colour shade paints. Steel structure in chemical house shall be painted with acid/alkali resistant epoxy-based paint.
- ❖ Before starting actual painting operation, the members to be painted shall be thoroughly cleaned of all dirt, grease, rust, scales etc.

v) **Walkway work:**

- The walkway shall be paved with Chequered tile and of 1 mtr wide and constructed with the following specification.
- The base shall consist of 150mm thick sand layer & above 100mm thick PCC layer, paved with Chequered tile of approved design uniformly jointed by 1:4 mixed cement mortar.

vi) **Disposal of Surplus Earth & Debris after construction:**

The surplus left over earth and debris after completion of erection work and leveling the site shall be transported and dumped in areas as directed by the Department's Engineer without any extra claim.

7.11. **Piping & Valves:**

Specifications for C.I. pipe	IS:1536-1989 Class-A flanged and Tested.
Specifications for C.I. fittings	IS:1538-1976 (part-1 to 24) tested.
Type of joint	Flange Joint.
Code of practice for laying	IS:3114
Test pressure	1.5 times the working pressure subject to minimum 1.0 kg/cm^2 for 24 hrs.
Specifications for D.I. pipe K-9	Socket & Spigot ended Centrifugally Cast (Spun) Ductile Iron (K-9) Pressure Pipes for water main and distribution line of different sizes conforming to I.S: 8329/2000 and subsequent amendments, in standard lengths suitable for Rubber Gasket ('Push-on' flexible joint) jointing with inside cement mortar lining and with an external bituminous coating and duly ISI marked.
Specifications for D.I. pipe K-7	Socket & Spigot ended Centrifugally Cast (Spun) Ductile Iron (K-7) Pressure Pipes for water main and distribution line of different sizes conforming to IS 8329/2000 & subsequent amendments, in standard lengths suitable for Rubber Gasket ('Push-on' flexible joint) jointing with inside cement mortar lining and with an external bituminous coating and duly ISI marked.
MS pipe work :	
Specifications	The MS pipes of 100 & 150 mm dia shall confirm to IS:1239 & MS pipe of 200 mm dia. and above shall confirm to**IS:3589** (latest revision).

Wall Thickness	Not less than 6 mm upto 300 mm dia Not less than 8 mm above 300mm up to 600 mm dia. Not less than 10 mm above 600mm up to 800 mm dia. Not less than 12 mm above 800mm dia.
In-lining & out coating	The internal Cement Mortar lining as per **IS11906/1986**& external 3 LPE **(three layer of poly ethylene**) coating as per DIN standard for MS pipes of 700mm dia and above. At welded joints there shall be Heat shrink sleeves need to be done at site as per specification. The internal and external lining shall be of food grade epoxy coating not less than 406 micron for MS pipes below 700 mm dia.
Laying	IS:5822/1986
Flange thickness	As per relevant ISS
PVC pipes & fittings	For internal water supply/sewerage : Relevant ISS.
DI pipes & fitting & their laying	As per IS:8329/2000, IS:9523/1980 & IS:12288/1987
Pump Delivery sluice valves & scour valves.	Double flanged sluice valves, Rising spindle, Rating : PN 1.6 (16 kg/cm^2) or as per requirement whichever is more. IS:14846(latest Version), Body: CI Spindle: SS, AISI –410
Non-return valves	Double flanged swing check type, rating : PN 1.6 (16 kg/cm^2) or as per requirement whichever is more. IS: 5312, Body: CI, Disc : CI, Spindle: SS, AISI –410.
Throttle valve/ Control valve	Butterfly valves (Rating 16 kg/cm^2) suitable rating BS: 5155, AWWA : C-504, Body : CI Disc: CI, Spindle :SS AISI-410.
Specification for pipe	IS:1239 (Part-I) G.I. Screw/Socket end tested (Heavy)
Specification for fittings	IS:1239 (Part-II), GI, Screw end tested.
Valves, stop cocks, bib cocks	IS:778, Gun Metal Construction, screwed.
Pillar Cocks/Taps	IS 1795/ 1982 Chromium Plated.
Specification & material for chemical dosing pipe.	IS : 4985/2000 UPVC.
Specification & material for chemical scour/ drain pipe	IS : 3006 chemically resistant stoneware
Valves	Teflon, Double flanged Diaphragm type.
Regulating throttle valve	S.S. Slim seal type butterfly valves.

7.12. **Technical Requirement:**

All the valves shall confirm to relevant **BIS/BS/AWWA** and bear such embossed certification mark.

Valves, wherever required, shall be provided with extended spindle (AISI-410 material) and head stock so that hand wheels can be provided at 1.2 m level for manual operation. Sluice valves of sizes more than 400NB shall be provided with bypass arrangement and shall be gear operated.

All valves for water supply & air applications shall be CI (IS:210, FG:220) body with 13%

Chrome-steel (AISI-410) spindle and seat & seat ring made of gun metal. All valves for chemical & corrosive application shall be Teflon body & internals.

The valves shall be double flanged body with 'raised-face' flanges and drilling to conform IS: 1538.

RCC Valve chambers/CI surface box as required shall be provided for the valves with CI lockable manhole of standard size.

Suitable Thrust blocks/anchor blocks shall be provided at bends and other locations where unbalanced forces may develop under normal operation, during power failures, during reverse flow or during testing of pipe line that tend to cause movements in the pipe line.
Valves of size NB 300 and above shall be installed with a dismantling joint or short-piece in the pipe line to facilitate easy replacement.

On completion of erection, trial-run and testing all the pipelines, valves and fittings shall be cleaned thoroughly and painted with 2 coats of enamel paint over by 1 coat of primer. The colour code shall conform to Department's norms for identification of raw water/ clear water/ spent water/ wash water/ air etc. The flow direction shall also be stenciled on the pipe lines.

The scope of work for the tender includes entire piping work & valves of all types as per actual requirement at site for the completeness of the project. Any variation in piping work & valves shall be borne by the contractor and shall not be entertained for extra payment.

7.13. **Instrumentations:**

The scope of work for the contractor shall include the following instrumentations. The Instrumentation shall be of latest technology and best of their kind used in Water Works. They should be dust and moisture proof suitable for the environment in which they are installed. Where hinged covers are necessary, they shall be provided with lock. The contractor shall furnish **2-3 makes** as per approved make list with copies of catalogues along with his tender documents that he intends to supply under this scope of work and same shall form a part of contract. The instrument shall be suitable for indication in MKS Units and the respective dials shall be calibrated and printed accordingly.
All instruments, gauge and meters shall be approved by the Authority's Engineer before use in the works.

a) The electromagnetic full-bore type bulk flow meter shall be of approved make list having MID approved and CE marked confirming ISO specification.

b) Pressure gauges and Meters shall be preferably '**Dial'** type with min. 100 mm dia. Dial. The dials shall be white with black scales and lettering not subject to fading. Scales shall be of such material that no peeling or discoloration will take place with age under humid condition. The range for the pressure gauges shall be 2 times the normal working pressure of the pipe line. The pressure gauge shall be mounted in vertical position with a three-way cock. It shall have the scales in metric system.

c) Motor Ammeters shall be capable of withstanding the starting current and shall have a compressed overload scale.

d) All other Instrumentations mentioned elsewhere in this Agreement shall have tobe provided in addition to the above. Besides, any instrumentation which is not indicated above but shall be required for completeness of a system shall have to be provided by the contractor without any extra claim.

7.14. MOTORS & PUMPS

2.14.(A)Scope & Specification for Vertical turbine Pumps

The Vertical Turbine Pumps shall be installed at Raw water intake to pump raw water to water treatment plants. The Pumps shall be self-water lubricated and suitable for pumping raw water from river.

The pumps shall be capable of developing the required bowl head at rated capacity for continuous operation. Pump shall be suitable for withstanding reverse rotation due to back flow of water without mechanical damage to any component of the pump. Pumps of a particular category shall be identical and shall be suitable for parallel operation. Components of identical pumps shall be interchangeable.

The noise level shall not exceed 85dBA measured at 1.86m from the out line of the pump set.

Total head capacity curve shall be continuously rising towards shut-off, with highest at shut-off. The critical speed of the pump shall not be less than 130% of the normal operating speed of the pump. The impeller adjustment shall be such that the impellers run free in any installed condition despite extension of the line shaft (caused by hydraulic down-thrust), the weight of shafting and weight of the impellers.

a) Technical Description

i) Bowl assembly

Shall be made of close-grained cast iron. Houses bronze bowl bearing S.S. impeller shaft & impeller shaft & impeller. Has hydraulically profiled guide vanes for higher efficiency.

The bowls shall be cast free from blow holes, sand holes and other detrimental defects, shall be equipped with replaceable wearing rings on suction side of enclosed impellers. Liquid passage shall be smooth finished and enameled. The bowls shall contain bushes to serve as bearings for the impeller shaft.

The suction bell shall be designed for smooth inflow of water with minimum losses.

ii) Impeller

Shall be made of CF8/ CF8 M Stain Less Steel (SS-410), Single suction, Enclosed or semi-enclosed type. Dynamically balanced clamped by draw-out type collect and locknut to stainless still shaft.

iii) Discharge Case

Shall be made of close-grained cast iron. House bronze bearing. Guide water flow into column assembly. The discharge case should have a sand collar which will prevent entry of sand into the discharge case bearing.

iv) Lubrication

The Pump should be self-water lubricated. A pre-lubrication connection with all accessories shall be provided to wet the bearings. The selection of material for such bearing shall suit the quality of water to be pumped and the suspension length.

If shaft enclosing tube is not provided, the shaft bearings shall be lubricated by the liquid being pumped.

v) Suction Case

Shall be made of closed grained cast iron, house bronze bearing and sand collar which shall prevent entry of sand into suction case bearing, guide flow of water

into the eye of the lowest impeller.

vi) Casing Pipe Shaft Tube

Shall be made of steel. Concentrically threaded for line shaft bronze bearing

vii)Column Assembly

The Column assembly shall consist of the column pipe to convey the liquid transferred from the bowl assembly to head assembly and shaft assembly. If shaft enclosing tube is used for the line shaft, bearing shall be supported from shaft enclosing tube. If shaft enclosing tube is not used, the line shaft bearing shall be supported from the column pipe.

Shall be made of steel. Concentrically threaded as per Indian standards.

viii)Line Shaft

The Line Shaft shall be made of high carbon steel. Concentrically threaded at both ends. The line shaft should have a stainless-steel sleeve which should rotate in cut less rubber bearing fitted in C.I. bearing retainer (spider).

The shaft shall be straight within 0.125mm for 3m length total dial indicator reading. The maximum allowable error in the axial alignment of the thread axis with the axis of the shaft shall be 0.05mm in 150mm.

The shaft shall be furnished with interchangeable sections. The bushing faces of the shaft be machined square to the shaft axis and the shaft ends shall be chamfered on the edges,

Couplings shall be designed with safety factor of 1.5 times the shaft safety factor and shall have threads to tighten during pump operation.

ix) Discharge Head

Shall be of robust construction, and should have an integral smooth discharge elbow. The discharge head should house a stuffing box and renewable bushing. The discharge elbow should be designed to directly connect to the discharge pipe without a reducer/expander. Standard discharge outlet flange shall be drilled as per IS specification.

It should have a base frame from which the column shaft assembly is suspended. A tube tension plate shall be installed on the discharge head to tighten up the shaft tbue (incase a shaft tube is provided)for the purpose of aligning the shaft.The pump shall be complete with base plate and foundation bolts.

7.15(B) Specification for Centrifugal pumps

These Pumps will be installed in Clear water reservoir at WTP and also at Zonal Pump houses in the distribution system to pump clear water

The pumps should be coupled with suitable capacity 3 phase motor to operate in A.C. power supply ranging 360 volt to 440 volt in the frequency 50 Hz in a common base plate. The contractor has to submit detailed design, drawing, layout plan of all pumping units showing therein all the piping arrangements at different pump houses including design of RCC foundation for various pumps as per the relevant IS specifications for approval before installation of pumps.

Pumps of particular category shall be identical and shall be suitable for parallel operation with equal load division. Components of identical pumps shall be interchangeable

The pump shall confirm to relevant IS specification with latest amendments thereof. The Pumps will be of horizontal split casing with high efficiency (minimum efficiency) 75% and ensure satisfactory performance and having suction and delivery arrangement suitable for inlet and outlet connection of pipe of suitable nominal bore size. The critical speed of the pump shall not be less than 130% of the normal operating speed of the pump

Flow rate versus head curve shall have a stable and continuously rising characteristics

towards the shutoff head. Besides the actual flow rate versus head curve, curves for minimum and maximum impeller diameters shall also be shown.

The design of pumps shall be such that no thrust is transferred to the driving motor, and where necessary a thrust bearing shall be provided. The combined thrust and journal bearing shall be capable of carrying at least 10% more than the calculated design load and shall be capable of reversed rotation as 130% of full speed. All Micnell bearing shall be fitted with an oil level gauge and a dial type thermometer complete with adjustable alarm and cut-out contacts.

Pumps shall be provided complete with all fixing bolts, nuts and washers. Non return valves of the non-slam, quick closing type and isolating valves shall be fitted to the pump delivery branches and an isolating valve to the suction branch with dismantling joints. Automatic float type air valves with cocks in the highest part of the casing or head bend to assist priming shall be fitted. Automatic air valves shall be fitted with pipes to convey leakage back to drains. The system shall be designed to provide for positive suction for the pumps. Each pump shall be provided with suction and delivery pressure gauges.

(b) Assembly of pump set.

(i) **Casing:** - The casing shall be made of cast iron grade FG-260 of IS:210 with latest revision and shall be of such construction as to be capable to withstand a hydrostatic test pressure of 1.5 times shut of pressure and two times the duty pressure which is higher.

Pump casing shall be provided with drain and vent connection with plugged or valve connection.

(ii) **Impeller:** - The impeller shall made from bronze of grade OLTB -2 as per IS:318 with revision and shall be dynamically balanced as per VD 12060 class 6.3 at 1200 rpm. t.The impeller shall preferably be provided with balancing hold nut with back vanes.

(ii) **Shaft:** - The shafts shall be made of high tensile steel confirming to IS:1570) (part V/45 CB as per I.S.-5517) and accurately ground all over. It shall be of sufficient size as to be capable of transmitting the required power over the entire range.

The pump shaft shall be provided with renewable type casing ring. Pumps having more than 1000m^3/hr capacity shall be provided with impeller ring in addition to casing ring.

(iii) **Wearing ring, Stuffing Box, Impeller and Shaft Sleeves, and Bearings -** There shall be made of bronze AST-410 as Grade-II of IS:318 latest revision. Pump should be fitted with double wearing rings. One is to be fitted in casing and another behind the impeller. Stuffing boxes shall be designed for easy adjustment and replacement of the packing material**.** Alternatively, split mechanical seals may be provided.

(iv) Bearings shall be oil lubricated or grease lubricated and shall have a life of 40,000 hours of working. In case of oil lubricated bearing, constant oil leveller with magnetic drain plug shall be provided.

(v) **Gaskets, Seats and Packing:** -These shall confirm to the specification laid down in IS:5120 (latest revision) and the pump should be fitted with the pack grease lubricated bearing.

(vi) **Coupling:** - The pump shall be directly coupled with the electric motor through spacer /pin type coupling of reputed make so that both the rotating parts function as one unit without casing.

(vii) **Name Plate:** - The pump shall have a name plate (Specification plate) including

6. Manufacturer's names of recognized trade mark.
7. Type / Model and Serial Number of pumping.
8. Speed.
9. Total head/Rate of flow / Best efficiency point with power input.
10. Range of head and corresponding rates of flow.

(c) Pump Testing:

d. The overall efficiency of the pump set shall not be less than 75%

e. The overall efficiency of the pump shall be guaranteed at specified point of rating only and the discharge shall be guaranteed for the range of head between minus 25% & plus 10% of the specific head. The Firm should furnish the guaranteed discharge at these head. There should not be stiff rise and fall in head vrs. Discharge curve and discharge vrs. overall efficacy curve.

f. The firm must furnish the curves authenticated by the manufacture to enable the purchaser to judge the performance of the pump set.

i) Head Vrs. Discharge Curve
ii) Discharge Vrs. Pump efficiency curve
iii) Discharge Vrs. Pump input at pump shaft curve.

(II) **MOTOR:**

a) The Motor shall be of reputed make, and should be energy efficient confirming to the latest version of IS:325 and IS:12615 or equivalent international standards and shall be of TEFC enclosure, rated for continuous duty, ambient temperature of 50^{o} Celsius. The relative humidity can be up to the maximum of 100% Motor shall be suitable for 3 phase electric power supply wide range voltage,3.3kV, 415 Volt 10% $H_{z.}$It should be designated for an over load capacity of 115% of rated capacity of pump set for frequent operation. Motor efficiency should not be less than 85%.

The motors shall be suitable for DOL/ Star-Delta/ Soft Starters.

The Starting current of motor shall not exceed 200% of rated full load current for Star/Delta starting and 600% of rated full load current for DOL starting, under any circumstances.

Motors shall be capable of starting and accelerating the load with the applicable method of starting, without exceeding acceptable winding temperature, when the supply voltage is in the range 85% of the rated motor voltage.

Motor shall be designed to withstand 120% of rated speed for two minutes without any mechanical damage, in either direction of rotation.

(b) **ASSEMBLY OF MOTOR**

i) **Winding:** - The winding should be enameled copper / strip with 'F' type insulation and winding are braced to prevent soil deformation due to stress caused by surges.

ii) **Core:** -The core should be made from low loss; high permeability; varnish insulated electrical grade sheet steel and stamping are hydraulically pressed than clamped to form a rigid structure.

ii) **Shaft:** - Shaft shall be made from high carbon steel of cross section adequate enough to provide strength and rigidity to minimize the deflection and vibration.

iii) **Bearing:** - Bearing and grease lubricated anti-friction bearing coupling should have 90% survival life of a minimum of 10,000 working hour for drive transmission direct through flexible coupling.

v) **Earthing stud:** - The motor body shall have two separate earthings stud for earthings in compliance with I.E. Rules.

vi) **BASE FRAME:** - The base should be made out of Cast Iron or M.S. Channels confirming to IS:226 grade with foundation Nut & Bolt.

(III) **CONTROL PANNEL:**

i) **Construction** - Equipment shall be fabricated out of 2mm for C.R.C.A. sheet having non-compartmentalized type. Provision for cable entry at bottom and all terminals of the equipment shall be accessible from front/back.

ii) **Wiring: -** All power wiring to be done with copper wire having good insulation to with stand against 660 Volt of different colour or of black colour with phase marking at both ends. All the control wiring shall be done with 1.5 mm^2 Flexible wire of Red colour with phase marking at both the ends.

iii) Painting shall be done with stoving primer and stoving finish of approved colour.

iv) Individual Panel Board for Individual pump set and one main control panel board to be provided.

v) Suitable earthings as per relevant IS/ Electrical Specifications to be provided to protect electrical installations.

(IV) **CIRCUIT CONFIGURATION**:

System Voltage	:	415 $\pm$ 10% 3 phase 50 H_z
Utilization Category	:	AC 3 phase as per IS:8544-1
Coil Voltage	:	415 $\pm$ 10% Volts
Power	:	Suitable for above motor.
Back up protection	:	H.R.C. Fuse Link
Isolator	:	reputed make
Contactor	:	Star/delta/Main Contract of reputed make.
S.P.P.	:	Reputed make.
Over load relay	:	Reputed make of suitable range.
		Phase including lamp of different colour of reputed company make.
Volt meter	:	Suitable Volt meter with Volt meter selector switch of reputed make.
Ampere Meter	:	Suitable Amp meter C.T. operated of C.T. suitable Ratio of reputed make. Capacitor: - Suitable & reputed make.

(V) Necessary priming arrangement to be made for priming at each pumping stations by constructing one no. 1000 ltr. capacity R.C.C./PVC, O.H. Tank including supply / fitting of required G.I. pipes/ fittings / F.W. vales etc all complete as per requirement at site and direction of Engineer-in-charge.

b. **AUTO TRANSFORMER CONTROL PANEL (ATS)**

Features :

• Electro mechanic Control Panel Auto Transformer Start

• Power Supply 3~50Hz, 380~415V AC+/- 10%
• Short Circuit and Over Current protection (MCB/MCCB)
• Overload protection
• Phase failure protection
• Air cooled Auto Transformer with 60%, 70% & 80% tappings
• Water level controller with dry run protection
• Contactors with thermal overload relay resetable
• Electronic timer with master timer
• Control Fuse
• Volt meter, Ammeter, Indicating lamps (R,Y,B, trip)
• Dust proof metal enclosure IP 44 with high quality finishing

c. VFD (Variable frequency drive) details -

Output frequency – 50 or 60 HZ
Over load capacity – 110% - 60 Seconds
Main Circuit – Three phase
Control / Fan circuit – 400-50 HZ / 440 Volt 60 HZ / other options.
Permissible fluctuation – Voltage $\pm$ 10% frequency $\pm$ 5%
Inpute power factor / generate capacity – fundamental wave power factor of approx. pf=1.0 regenerative capacity = 80%
Control method – Sensorless vector control, vector control with sensor, or V/f control + multi level PWM
Frequency accuracy - $\pm$ 0.5% for maximum output frequency
Load torque characteristic – Variable torque load, constant torque load.
Acceleration / declaration time – 0.1 to 3270 seconds, individual setting possible
Primary control function – Soft stall (Programmable speed reduction for fans & pumps during periods of overload),Ride-through control during instantaneous power failures, break point acceleration /declaration function, specific frequency evasion function, continuous operation function during speed reference loss, total run time display function.
Transmission (option) – Device Net, ProfiBus-DP, ModBus – RTU, TC-net I/O, CC-Link
Display – LCD display (240 x 64 dots.) 4 LED indicators (READY, RUN, ALARM /FAULT, Discharge Check).
Push bottons – NAVIGATION Key, Control Key, operation, stop , fault reset, interlock (drive run inhibit)
Input transformer – Class H, dry type, TM drive-MVe2 dedicated specification (external option available)
Ambient temperature – 0 to 40^0 C (Higher temperatures with derating)

7.16. SPECIAL CONDITIONS AND TECHNICAL SPECIFICATION FOR EXTERNAL ELECTRICAL INSTALLATIONS WORK:

i) **General Requirement**

The installations shall generally be carried out in conformity with the requirements of Indian Electricity Act 1910 as emended up to date and Indian Electricity Rules, 1956 framed there under, the relevant regulations of the Electric Supply Authority concerned and also with the specifications laid down in the Indian Standard IS:732/1963 “Code of Practice (Revised) for Electrical Wiring Installations (System Voltage nor exceeding 650-V)”. The work shall be executed as per the National Electrical Code and if any item is not covered there under or there is any doubt, the specification approved by the Engineer-in-Charge will be final and binding.

Ambient Conditions:

All Electrical installations and equipment shall be suitable to work in following ambient conditions.

Maximum temperature	:	50 degree Celsius
Relative humidity	:	100%
In the vicinity of	:	**Rairangpur, Anandpur & Vyasanagar**

System Conditions:

The Electrical installation and equipment shall be suitable for operation in the following system conditions.

Supply voltage	:	415 volts ±10%
Supply frequency	:	50Hz ±5%
Number of phases	:	Three

ii) **Scope:**

a) **Materials**

All the materials, fittings, appliances used in electrical installations shall conform to Indian Standard Specifications wherever these exist. A list of approved materials is attached in Annexure-I. Materials not included in the list as well as any particular make not included in the list should be approved by the Authority's Engineer before use. All required materials covered under this specification shall be supplied and installed by the contractor complete in all respect except in cases where it is clearly mentioned otherwise. The materials and accessories required for completing the work will form part of the work although they have not been specified separately.

Selection of Materials and installation work shall be such as to simplify operation, inspection, maintenance and testing. The work shall include all reasonable pre-cautions and provision for safety of operation and maintenance personnel.

b) **Standard:**

Unless otherwise specified, all materials covered under this specification shall be designed, manufactured, tested and installed in conformity with the latest Indian Standard specifications. In case such Indian Standard Specifications are not published equivalent British Standard Specifications shall be followed. All equipment shall confirm to latest Indian Electricity Rules, PWD and Local / State laws or bye-laws as regards to safety, earthing and other essential provisions specified therein.

All equipment and materials selected shall also be supplied and installed taking into consideration the Factories Act, Fire Regulations and Local laws or bye-laws. All light fittings and equipment selected shall be of well tied out design. All materials used in the assembly of fittings and their accessories shall be of high quality and manufactured in accordance with the best modern practice.

All the materials supplied by the contractor according to the contract conditions will be subject to inspection and approval by the consultant or / and Engineer-in-charge or their authorized representative from time to time. The contractor shall extend all required facilities for such inspection free of

cost. At the time of inspection, the inspecting officer shall have full liberty to reject any such material, which does not confirm to specifications or the requirements. The owner shall not entertain any claim for the rejected materials. The contractor shall remove all rejected materials from the site at his own cost.

The owner shall not accept any surplus materials procured by the contractor.

The contractor will be responsible to get electrical installations inspected by the Electrical Inspector of the State Govt. and to obtain the statutory clearance for energisation. The owner will reimburse the necessary inspection fees on production of documentary evidences.

The contractor should possess valid electrical contract license and labour license issued by the appropriate statutory authority of the State Govt. during the execution of the Contract.

The contractor shall be registered with provident fund Department for engagement of Labourers / Employees.

c) **Inspection & Approval**

The contractor shall put up samples of all major items for inspection and testing by the consultant and or Engineer-in-Charge for which the contractor shall furnish minimum 10 days clear notice in advance to enable them to depute their Inspecting Officer. Similar procedure shall be adopted for the approval of samples of minor materials / accessories to be used for the work.

iii. List of Approved Make

List of Approved Make		
SL No	**Material/ Equipment**	**Make**
1	Cement	OCL, ACC, Ultra Tech
2	Steel Reinforcement	SAIL, TATA, RINL, JINDAL STEEL, SHYAM STEEL
3	Mild Steel Pipes	ERW / SAW pipes from any manufacturer conforming to relevant IS & required specification as per Agreement.
4	Stainless Steel Pipes	Jindal, Prakash, Remi
5	Ductile Iron (DI) Pipes	Any make of DI pipe which is conforming to relevant IS & requirements as per Agreement Clause No.7.3(a) of Annexure-I (Schedule-D)
6	G I Pipes	Tata,Jindal
7	UPVC Pipes	IS marked
8	HDPE Pipes	IS marked
9	C I Sluice Valves	Kirloskar,IVI, Fouress,
10	Butterfly Valve	Audco, Kirloskar, IVI,IVC
11	Tamper ProofKinetic Air Valves	VAG,Audco
12	Non Return Valves	VAG, Kirloskar
13	Pressure Release Valves	VAG, Dorrot, Bermad
14	Expansion Joints	Reliable
15	Centrifugal Pumps	Kirloskar / Mather & Platt / Voltas / Greaves/KSB/WPIL/Grundfos/Willow/Xylom
16	Vertical turbine pumps	Kirloskar, Mather & Platt, Greaves, KSB, Voltas, WPIL
17	Electric Motors for Pumps	Siemens, Kirloskar, Crompton greaves, Bhar Bijlee, ABB, TMEC
18	Chain Pulley Blocks/EOT Hoist	Indef, Hercules hoists Ltd, W.H.Brady&Co. Ltd.,
19	Pressure Gauges	H. Guru,Budon tube,Gluck,Waree,Oricol
20	Liquid level Indicator	Krohne, MEI
21	Elecrto Magnetic Flow Meter	Krohne Marshal, Batliboi, Rota Instrumentation, Honeywell, E&H, Forbes marshal
22	Parshal Flume	Reliable
23	Chlorinator	Chloro Control, PenWaltt, Siemens
24	Electrical motors	Siemens, Kirloskar, Crompton greaves,BharBijlee,ABB, TMEC
25	Switch Gear Panel	
a)	HT Switch Gear	ABB, Siemens
b)	LT SwitchGear,MCC	L&T, Siemens, ABB, Schneder Electric India ltd
26	Power Transformer	
a)	Oil filled Transformer	CGL, VOLTAMP, Kirloskar, Alstom
b)	Dry type Transformer	VOLTAMP,CGL
27	DC Distribution board,MLDB,SLDB, Lighting panel	M K Engineers, Siemens, Legend
28	CT/PT	Pragati,Kappa, Power Gear
29	Indoor Isolator	Driescher Panicker, A bond strand pvt. Ltd

30	Local Control panel / Local Push Button Station	Intelec, Control & Schematics, Power switch Gear, Universal Electric.
31	Cables	Polycab, Universal cables, KEI Industries
32	Instrumentation cables	Parmount cables, Cords cables Inndystries, Delton Cables.
33	Online UPS	Emerson Network Power Pvt. Ltd, DB Power, HI-Rel, Phoenix Contact
34	Lighting Fittings	Philips, Bajaj, Crompton, Havels,
35	Lighting Transformer	Voltamp, Truvolt, TransO India, Indcoil
36	VFD	Siemens, L&T, ABB, Gujrat Hirel,Rockwell Automation, TMEIC
37	Battery & Charger	Siemens, L&T, BCH
a)	Lead –Acid battery	AMCO,EXIDE,AMRA RAJA,TATA,Power zone, Phoenix Contact
b)	Battery Charger	CHHABI,AMAR RAJA,HBL
38	Contactor & Oil Relay	Siemens,L&T,BCH
39	Control Switches,Selector switches	Areva,Kaycee,Siemens,L&T,Teknic
40	Push Buttons	Siemens,Schneider, ESSEN
41	Terminal Box	Phoenix Contact, ELMEX, WAGO
42	MCB	ABB,Siemens,Legrand, Schneider
43	Hooters	Kheraj,Tullu,Waves elctronics
44	Plug & Sockets	BCH, Shakti Electricals, CycloElectric,Kaypee Electricals
45	Earthing Materials	RK Smelting Enter prise,Industrial perforation,India Electrical syndicate
46	HT Termination & Jointing Kits	3M,Raychem, Densons
47	Cable Trays	R K smelting Enterprise,Indiana Cable trays,Technofab.Industrial Perforations
48	Level indicator	Bradbury Instrument,EIP Bulk controls, Sapcon,Levecon
49	Protective Relays	ABB,Siemens, Schneider
50	Interposing Relays	Areva,L&T,OMRON,Jyoti,Phoenix Contact
51	Ammeter,Voltmeter	Automatic Electric, Meco,IMP,Reshab Instruments
52	Transducers	Phoenix Contact, Siemens,ABB, P&F
53	Outdoor Isolator with earth Switch	ABB,OBLUM ,ELPRO,Hwelm Industries, DriescherPanicker,PEI,Sterling Isolator
54	Lighening arrester	CGL.ELPRO,OBLUM, WS Insulator
55	Capacitors	CGL,Madhev, Meher, Universal cables

56	Insulators	Jaysree, Modern, WS Insulators, Allied Ceramic
57	Motor Contactors	BCH, L&T, Siemens, Schneider
58	Relays	ABB, L&T,Schneider
59	Switch & Fuses	GE,L&T, Siemens,Bussmann
60	Instrument & Meters	Universal ElectricsLtd,Automatic Electric Ltd,
61	Local Push buttons & Indication lamps	Meco instruments, Industrial Motors,Forbes Marshal
62	Ceiling fans	Crompton, Orient,Usha,Khaitan,Bajaj
63	Exhaust Fans	Crompton, GE,Bajaj
64	Lighting Fixtures	Cromton,Philips,Wipro,Bajaj
65	Diesel Generators	Kohler,caterpillar,Cumins,Jack son,Kirloskar
66	Level switch	E&H,Nivo Control, P&F,SBEM,
67	Level Transmitter	E&H, Forbrs Marshal
68	Actuator	Auma, L&T,Rotork
69	PLC	Siemens, Phoenix contact, Honywell, Schneider, confirming to IP-20 with ambient operational temperatura 55oC.
70	SCADA Software	Siemens, Phoenix contact, Honywell, Schneider, confirming to IP-20 with ambient operational temperatura 55oC.
71	Optical Fibre Cable	Phoenix Contact,Molex,Finolex
72	Optical Fibre connectors	Phoenix Contact,Molex
73	Ethernet Switch (Industrial)	Phoenix Contact,Hirchmann,Siemens
74	Blower	K-international, Everest, Swam
75	Sanitary Ware	Parryware,Neycer,hindware
76	sanitary Fittings	Jaquar,ESS
77	All Furniture	Godrej, Durian
78	Paints,Distemper	Johnson Nicholson, Asian paints, Berger paints
79	laboratory Instruments	Polymetron, Zellweger analytic, Hach
80	Laboratory Glass wares	Borosil
81	Online analyzer	HACH, E&H, Siemens, ABB
82	Energy Meter with MODBUS port	Schneider, Phoenix Contact, SELEC
83	Gear Box	Greaves
84	Metering Pump / Dosing pump	Eureka Forbes, Prominent, Grundfoss
85	MCC, VFD & Instrument Panel / Enclosure	Rittal, ELDON, Hoffman
86	Operator console / Control desk	Rittal, ELDON, Hoffman
87	Panel cooling unit / panel AC	Rittal, Warner folly
88	Industrial PC	Phoenix Contact, Siemens, Rockwell
89	Industrial touchscreen HMI	Phoenix Contact, Siemens, Rockwell
90	Dot Matrix Pinter	EPSON,TVS
91	Laser printer	HP,Canon,EPSON
92	Differential float control valves	Bermad, Doret, VAG
93	Altitude pilot control valves	Bermad, Doret, VAG
94	Make of panel	Rittal, Hensel, Pyrotech, Bartekke confirming to IP 65.
95	Other Electrical & Mechanical	In case of absence of approved make list, the

	Accessories :	bidder is to propose & obtain approval of proposed vendors from the Authority before purchasing the materials.

iv. **Power Supply:**

Standard voltage shall be as follows :

iv) 3.3 KV for HT motors with VFD panel, Battery Bank with panel having control circuit etc.

v) 415V (± 6%, 3-Ph, 4-wire, 50 (± 5%) Hz AC available line for A.C. motors and illumination/Ventilation.

ii) 230V, 1-ph, 50Hz. AC for control power and lighting.

7.17. **Inspection, Testing, Trial-Run, Guarantee Test, Operation & Maintenance Manual, Completion Drawings, Guarantee & Acceptance:**

(i) **General:**

- All equipment, accessories, auxiliaries, piping, electrics, instruments, installations, construction, buildings etc. including all mechanical, electrical & civil engineering works covered under the scope of work of contractor shall be subjected to inspection & testing by the Department for its material, quality, workmanship and the performance. The contractor shall arrange and carry-out all such inspections, testing, trial-run etc. and demonstrate in presence of the Engineer-in-Charge of the Department.

- The cost of such inspection, testing, trial-run, demonstration etc. shall be borne by the contractor. All responsibility of such inspection, testing, trial-run, demonstration etc. and any damage/loss that may cause directly or indirectly shall exclusively rest with the contractor.
- Such inspection, testing, trial-run, demonstration etc. shall, however, not relieve the contractor of their liability for replacing/ rectifying any defects which may subsequently appear or be detected during erection and guarantee period.

- Copies of certificates for materials test, hardness, balancing test along with other routine shop's quality assurance tests shall be furnished by the contractor prior to carrying out of the inspection and testing.

(ii) **Tests at works:**

- All equipment, sub-assembly and components, auxiliaries and accessories shall be tested at manufacturer's works in accordance with relevant Indian Standards/International Standards. The contractor shall furnish all test certificates etc. related to the quality of all the materials to the Department along with the delivery of the materials at site without which no payment shall be released. However, such test certificates, quality assurance certificates shall not relieve the contractor of it's obligation to replace forth with any instrument/materials found defective during tests at works/ trial running period/ guarantee period.
- Testing for performance of equipment shall be carried out and be checked with the approved parameters and performance characteristic curves for the purpose of acceptance.

(iii) **Tests at Site:**

- On completion of erection, all equipment, accessories, auxiliaries, pipings, electrics, controls, instruments etc. covered under the scope of work of the contractor shall be tested to demonstrate their smooth operation and proper

functioning. All instruments, gauges, interlocks etc. shall be for calibration and for proper functioning during the test. All testing requirements specified elsewhere in this specification and mentioned in relevant Indian standard/ International Standards shall be carried out by the contractor. All defective items or any defects observed during the test shall be replaced and/ or rectified by the contractor and test shall be repeated.

- All the water retaining structures shall be tested for **water tightness** as per relevant IS code of practice before starting of Trial run.
- The contractor shall also carry out at site, any tests, which may be required by the State/ Central Government, State Pollution Control & prevention Board and/or any other Statutory Body.

(iv) **Trial Run & Hydraulic testing:**

- On completion of erection and testing at site the Tenderer shall carry out trial-run & hydraulic testing of all individual items one after another. The duration of trial run & hydraulic testing for individual items shall be not less than 24 hours in continuous operation. On satisfactory performance of individual items, trial-run & hydraulic testing of composite units, one after another and then of complete 'Installation' shall be carried out. The duration of each trial run' for each composite unit shall not be less than 48 (forty eight) hours continuous operation, and the duration of trial run for complete 'Installation' shall not be less than ninety six (96) hours continuous operation. All defective items or any defect is observed during trial run shall be replaced and/or rectified by the Tenderer.
- The detailed schedule of trial-run and procedure shall be furnished by the Contractor to be approved by Department. Proper record shall be maintained by the contractor for all such testings and trial run.

(v) **Performance Guarantee Test:**

- On satisfactory completion of trial run the complete 'Installation' shall be tested for demonstration of guaranteed performance. The duration for such **'Performance Guarantee Test' shall not be less than continuous twenty days (480 hours).**
  The performance guarantee test by the Contractor shall demonstrate satisfactory operation of all individual items, equipment, controls, instruments, electrics, auxiliaries & accessories, and piping etc.

(vi) **Operating Log Sheets:**

Record Books of operating log sheets shall be handed over by the contractor to the Engineer-in-charge in an approved form before the completion of the trial run period.

(vii) **Completion Drawings:**

A set of approved process, hydraulic, structural, mechanical, electrical, equipment drawings basing on the actual execution of the plant shall be handed over by the contractor to the Authority/ Authority's Engineer before completion of trial run and performance guarantee test. The record drawings shall be prepared on best quality polyester tracing papers. One set of Soft copies of the drawings shall also be provided along with the hard copy.

(viii) **Penalty for non submission of completion drawings (As built Drawings):**

A penalty @ **0.3 % of 10 %** meant for **"inspection, testing, trial-run, guarantee test, training, operation & maintenance manual, completion drawings, guarantee & acceptance"** ~~per day~~ shall be imposed per ~~each~~ day of non

submission of the manual & completion drawings beyond 7 days of date of completion of successful performance guarantee test up to a maximum ceiling of 2% of the 10% meant for the aforesaid item, after which 1% of ISD shall also be forfeited.

ix) **On completion of construction:**

The contractor shall clear all the left over surplus earth, bricks, boulders, debris, scrap, temporary structures etc. from the construction site and present the entire premises in a neat and tidy manner. All units, equipment, tanks, reservoirs, pipelines etc. shall be cleaned thoroughly and disinfection shall be done. **On completion of finishing work, colour wash & painting work, the contractor shall provide name plates on the main units and shall stencil in bold letters the equipment code nos. & direction of flow on all the units, equipment, pipelines, valves etc.** The code nos. scheme shall be worked out in consultation with the Department.

x) Acceptance of Project:

On completion of **successful testing, trial running, satisfactory performance** guarantee test, successful training, submission of Manual, operating log sheets and completion drawings, the 'Installation' shall be accepted by the Department.

EOT Cranes :

The Cranes shall be electrically operated, bridge type complete with all accessories including down shop conductor, crane rails and fixtures and shall confirm to IS:3177

The crane should consist of bridge girders on which a wheeled trolley is to run. The bridge trucks and trolley frames shall be fabricated from structural steel .Access walkway with safe hand railing as is required along the full span length of the bridge girder shall be provided. Steel to be used shall be tested quality confirming to ASTM A36, except that, plates more than 20mm thick shall confirm to BS:4360.The bridge shall be designed to carry safely the loads specified in IS:807 and IS:800. All antifriction bearings for bridge and trolley track wheels, gear boxes and bottom sheaves on hook shall be lubricated manually by hand operated grease pump through respective grease nipples.

Wheels and structural frame of the wheel mounting of the end carriage shall be designed so as to ensure that the crane remains square and prevent skewness. Bridge and trolley track wheels shall be of forged steel and shall be double flange type. The crane rails shall be manufactured from wear resistant austenitic manganese steel. Walkways shall be at least 500mm clear inside width with a 6mm thick non-skid steel plate surface. Steel rail stops to prevent rails from creeping and trolley from running off the bridge. The hook shall be solid forged, heat treated alloy or carbon steel for the duty service. They shall have swivels and operate on ball thrust bearings with hardened races. The lifting hooks shall comply with requirements of BS:2903/BS:3017 and shall have a safety latch to prevent rope coming off the hook.

7.18 The following Special Specifications are applicable for construction and commissioning of water supply scheme and other structures and shall be treated as part and partial of the clauses of contract, conditions of contract, general specifications and special conditions and scope of work and all are to be read together, unless otherwise specified.

7.19 Sound Engineering Practice to be followed

The work shall have to be executed according to relevant IS code and OPWD specification and detailed specification but if at any point these IS code/OPWD specifications are silent, then work can be executed according to sound engineering practices after obtaining written approval of Engineer-in-Charge.

7.20Providing and Fixing M.S. Gate

All compound walls shall be provided and fixed with M.S. gate of Fe 410 grade according to the design to be submitted by the contractor and approved by the Authority's Engineer. Weight of MS gate should not be less than 40 kg per sqm. The height of the gate will not be less than the height of boundary wall and fabrication shall be done aesthetically to suit the surroundings. The width of the gate will be 4 m approximately or more as decided by the Authority's Engineer.

7.21Providing and Fixing of Rolling Shutters

All pump houses shall be provided with M.S. rolling shutters of standard thickness and manufactured conforming to the requirements specified in IS: 6248 (latest revision).

The type of rolling shutter shall be self-coiling type (manual), gear operated type (mechanical). Rolling shutters shall be suitable for operation from both inside and outside with the crank handle or chain gear operating mechanism duly considering the size of wall/column.

Rolling shutters shall be supplied duly considering the type, specified clear width/height of the opening and the location of fixing as indicated in the drawings prepared by the Contractor and duly approved by the Authority's Engineer.

Shutters shall be made of cold rolled steel strips built up of interlocking laths 75 mm width between rolling centre formed. The thickness of the steel strip shall not be less than 0.90 mm for shutters up to 3.50m width and not less than 1.20 mm for shutters above 3.50 m width. Each lath section shall be continuous single piece without any welded joint.

The guide channels should be prepared out of mild steel sheets of thickness not less than 3.15 mm shall be of either rolled, pressed or built up construction. The channel shall be of size as stipulated in IS: 6248 for various clear widths of the shutters.

Hood covers shall be of mild steel sheets not less than 0.90 mm thick and of approved shape.
Rolling shutters shall be provided with a central hasp and staple safety device in addition to one pair of lever locks and sliding locks at the ends.

All component parts of the steel rolling shutter (excepting springs and insides of guide channels) shall be applied with one coat of zinc chrome primer conformity to IS: 2074 at the shop before supply. These surfaces shall be given an additional coat of primer after erection at the site along with the number of coats and type of finish paint as specified in the respective items of works prepared by the Contractor and duly approved by the Authority's Engineer

Guide channels shall be installed truly plumb at the specified location. Bracket plate shall be rigidly fixed with necessary bolts and holdfasts. Workmanship of erection shall ensure

strength and rigidity of rolling shutter for trouble free and smooth operation to the full satisfaction of the Authority's Engineer.

7.21.a Painting of Rolling Shutters, M.S. Grill, M.S. Gate G.I. Pipe Railing, Cast Iron and other Steel Work etc.

All items mentioned above shall be painted with 3 coats of superior quality, synthetic enamel paint of approved shade and quality prior to which priming coat after rubbing and removal of rust shall be provided.

7.21.b Water Proof Treatment over the Roof

Roof of all the buildings shall be provided with integral cement based waterproofing treatment as per OPWD specifications, after surface preparation.

7.21.c C.C. Gola and Khurras over the Roof

Roof of all the buildings shall be provided with C.C. Gola of 75 mm x 75 mm in 1:2:4 mix along the parapet walls as per OPWD specifications. Similarly, C.C. Khurra of 45 cm x 45 cm in 1:2:4 and 5 cm thick shall be provided over the roofs where rainwater pipes are to be fixed as per OPWD specifications.

7.21.d PVC Rain Water Pipe

For draining rain water from all roofs, PVC rain water pipes of not less than 100 mm dia from roof to plinth protection level shall be provided. The number of places shall be as per drawing submitted by the contractor and approved by the Authority's Engineer.

7.22. Exhaust Fans:

Exhaust fans shall comply with IS:2312. And should have ISI Marking

Fan blades shall be of mild steel? Cast aluminum of an airfoil design mounted on stream lined hub. It shall be properly balanced so as to avoid noise and vibration. The blades and blade carriers shall be securely fixed so that they do not loosen.

7.22.a Fire Extinguishers:

The Fire extinguishers shall be portable of 5kg capacity and shall of Carbon dioxide type . They shall confirm to requirements of NFPA 12 and shall be UL/ FM approved.

7.23 Site Clearance

Before the commissioning the site shall be cleared of all left over materials, temporary hutments and debris etc.

7.24 Components of Automation System

e) Industrial grade - To be used by the operator to view the data acquired and allow the operator to control and improve optimization.
f) Programmable Logic Controllers: To control the outputs based on the inputs being monitored in the required sequential steps and it also communicates with the personal computers.
g) Modems: To transfer data from Water treatment plant site,
h) Training programme for automation & calibration system for 120 days for 10 departmental engineers.

7.24.1 SCADA Software

The standard SCADA software need to be installed in application servers at the plant site, but they should be capable of controlling and monitoring the various instruments. The data

acquired from the PLC should be displayed in the SCADA screen and the logs of each site station measurement should be transferable using data export to data base processing software like Oracle, Microsoft Excel, etc. It should also support internet connectivity for data transfer.

7.24.2 SCADA Security Level

In order to prevent misuse and to restrict access to a site station measurement there should be privileges to the various users of the SCADA. Typically, there are three levels, which are (1) Operator Level, (2) Assistant Executive Engineer Level and (3) Executive Engineer Level.

7.24.3 PLC Security Level

The PLC communication port should have a configurable access level for its security. The minimum access levels are described in the following sub-section. These access levels are required to control read and write access to that port. Hence, once all the PLC ports are configured with these varying access levels depending on the requirement, then it becomes secure against unauthorized usage. It can be re-configured only after unlocking the PLC common port.

7.24.4 Minimum Access Levels of Programming and Configuration Interface

The interface shall have the minimum varying levels of user access that can be configured by the system controller. They are:

e) Unlimited Access: This will allow the user to read and write all PLC configuration parameters such as local, network and system registers, Hardware input and output registers, event logs and logic programs.
f) Access without configuration: This will allow reading and writing of all PLC configuration parameters except system registers and ladder logic.
g) Access limited to only reading the PLC parameters
h) Access limited to PLC port configuration.

7.24.5 SCADA User Interface

The SCADA system shall permit the user to access displays via printing device and/or soft key menus with a choice of function keys, cursor, control keys or any key on the keyboard. The system shall support operator access to multiple displays at one time, including split screens where the operator may view more than one process area at a time and permit pop-up displays.

The operator shall be able to have access to context sensitive help at any time during operation of the system. The operator shall be able to access multiple data sources/items with a single tag name.

7.24.6 Command/Control Functions

The system shall allow the user to control a specific set point or to adjust a set of points depending on the operating limits. Control of individual set points shall be enabled based upon a user's security level.

7.24.7 Display Capability

The system shall allow the user to view animated graphics for process templates including valves, meters, etc. The system shall support the capability for the operator to view scanned images and be possible to animate these images.

7.24.8 Text Description

The system shall support use of true-type scale able fonts that may be scaled according to the desired size of the text. The fonts shall be loaded by the operating system.

Text shall be able to blink based upon any user definable condition occurring in the system such as an alarm on a particular set point.

7.24.9 Alarm Capabilities

i) Alarm Display Capability

The system shall support alarm display capability on the display. Current alarms shall be available as an alarm summary object and a chronological summary of alarms shall be available.

It shall be possible to inform the operator of an alarm condition via an audible tone, a pop-up display or any combination of animation types on the screen.

Alarm acknowledgement may be performed on all alarms, alarms in a single group, and alarms in a collection of groups in defined in alarm group hierarchy or on a point-by-point basis.

vi) **Alarm File Capability**

Alarms shall be logged to a file for future viewing or review of alarm history data. The user shall have the capability to review the file for cause and event analysis. The alarms that are logged shall be configurable from a choice of the parameters listed during configuration.

iii) Alarm Printing Capability

Alarms shall be allowed to be printed and the format shall be configurable and made up of any of the parameters listed during configuration.

7.24.10 Specification for Automation of the water supply system

I Zonal Pumping stations

A **Zonal Pumping station with 2 Nos. of pumping unit.**

1 Supply, installation,Testing & commissioning of PLC system with minimum features as follows:

PLC: PLC should have Ethernet TCP/IP and MODBUS RTU/Profibus port. The PLC can be easiliy extendable with additional IO cards in future. The PLC software should support all 5 languages as per IEC 61131-3, The ambient operating temperature shall be 55 deg C. Minimum no. of IOs should be DI-64 ; DO- 32 ; AI-16 ; AO-8 ;Modbus- 4 channels. Suitable fuse terminal should be used in all DI & DO. Intermediate relay should be considered for all DOs. Power supply to the PLC should be redundant type with suitable diode oring module. Enclosure should be neatly wired and with adequate space for ease of maintenance in future. Front & rear access may also be considered if required.

HMI: 12", TFT Color, Panel mounted, touchscreen type, alarm generation, trend generation, report generation with 30 days data back up facility.

Networking: Networking component should consists of required ethernet components along with Fiber Optic & accessories to establish communication between each zone and main WTP. Fiber optic should be Single Mode 9/125, 6 core type, suitable for more than 20KM data transmission without any repeater. Whole network infrasrtucture should have

proper security system and firewall in each and every location.
EMS: All energy meter should read Current, Voltage, Power, energy and any other parameters required for EMS. EMS should calculate pump running hours, total energy consumption etc. Data from EMS shall be displayed on the HMI in the PLC panel.

2 Supply ,installation ,Testing & commissioning of Pressure trans mitter with minimum features as follows:
Pressure Transmitter:
Measuring Principle : Hydrostatic
Characteristic : Digital transmitter with capacitive sensor and ceramic membrane
Supply voltage : 4...20mA
Reference Accuracy : Standard: 0.05%
Platinum: up to 0.025%
Process temperature : -20°C...150°C
Ambient temperature : -40°C...85°C
Measuring cell : 100mbar...40bar or (1.5psi...600psi)

3 Supply ,installation ,Testing & commissioning of ultrasonic level transmitter with minimum features as follows:Ultrasonic Level Transmitter:
Measuring Principle : Ultrasonic
Supply / Communication : 2/4-wire, PROFIBUS PA
Accuracy : +/- 2 mm or +/- 0,2 % of set measuring range
Ambient temperature : -40 °C ... 80 °C
Process temperature : -40 °C ... 80 °C
Main wetted parts : PVDF
Process connection : G / NPT 2"
Blocking distance : 0.35 m (1.15 ft)
Max. measurement distance : 8 m (26 ft)
Communication : 4 ... 20 mA

4 Supply of PLC enclosure of following specification;
Profile : 16 fold in a single steel construction
Painting : triple anti-corresion, nano-ceramic surface treatment with dip coat priming and textured power coating ral-7035.which help to protect rust & corrosion. Protection : ip 55.
Mounting plate : 3mm zinc plated.Front door : 2mm.Side panel : 1.5mm. Gasket : polyurethene. Door : hinged door
Door designed : 130 degree hinged door. Looking arrangment : comfort handle with security lock

5 Supply, installation ,Testing & commissioning of Online UPS (minimum 1 KVA with 1 Hour Backup) with following Specifications:
Rack mounted. Hot swapable battary replacement. Doubble Conversion technology. Battery Type: VRLA (Dry - Maintenance Free).
Monitoring of battery health thru PLC

6 Limit switch for Differntial control valve and configured to PLC

7 Armoured Screened instrumentation cable - 2 Pair

8 Cable Gland

9 GI Coated Cable Tray

10 HDPE Conduit pipe

11 Chemical Earthing - 3 pit system

B Zonal Pumping station with 3 nos of pumping unit

1 Supply, installation, Testing & commissioning of PLC system with minimum features as follows:

PLC: PLC should have Ethernet TCP/IP and MODBUS RTU/Profibus port. The PLC can be easiliy extendable with additional IO cards in future. The PLC software should support all 5 languages as per IEC 61131-3, The ambient operating temperature shall be 55 deg C. Minimum no. of IOs should be DI-64 ; DO- 32 ; AI-16 ; AO-8 ;Modbus- 4 channels. Suitable fuse terminal should be used in all DI & DO. Intermediate relay should be considered for all DOs. Power supply to the PLC should be redundant type with suitable diode oring module. Enclosure should be neatly wired and with adequate space for ease of maintenance in future. Front & rear access may also be considered if required.

HMI: 12", TFT Color, Panel mounted, touchscreen type, alarm generation, trend generation, report generation with 30 days data back up facility.

Networking: Networking component should consists of required ethernet components along with Fiber Optic & accessories to establish communication between each zone and main WTP. Fiber optic should be Single Mode 9/125, 6 core type, suitable for more than 20KM data transmission without any repeater. Whole network infrasrtucture should have proper security system and firewall in each and every location.

EMS: All energy meter should read Current, Voltage, Power, energy and any other parameters required for EMS. EMS should calculate pump running hours, total energy consumption etc. Data from EMS shall be displayed on the HMI in the PLC panel

2 Supply ,installation ,Testing & commissioning of Pressure trans mitter with minimum features as follows:
Pressure Transmitter:
Measuring Principle : Hydrostatic
Characteristic : Digital transmitter with capacitive sensor and ceramic membrane
Supply voltage : 4...20mA
Reference Accuracy : Standard: 0.05%
Platinum: up to 0.025%
Process temperature : -20°C...150°C
Ambient temperature : -40°C...85°C
Measuring cell : 100mbar...40bar or (1.5psi...600psi)

3 Supply ,installation ,Testing & commissioning of ultrasonic level transmitter with minimum features as follows:Ultrasonic Level Transmitter:
Measuring Principle : Ultrasonic
Supply / Communication : 2/4-wire, PROFIBUS PA
Accuracy : +/- 2 mm or +/- 0,2 % of set measuring range
Ambient temperature : -40 °C ... 80 °C
Process temperature : -40 °C ... 80 °C
Main wetted parts : PVDF
Process connection : G / NPT 2"
Blocking distance : 0.35 m (1.15 ft)
Max. measurement distance : 8 m (26 ft)
Communication : 4 ... 20 mA

4	Supply of PLC enclosure of following specification; Profile : 16 fold in a single steel construction Painting : triple anti-corresion, nano-ceramic surface treatment with dipcoat priming and textured power coating ral-7035.which help to protect rust &corrosion.Protection : ip 55. Mounting plate : 3mm zinc plated.Front door : 2mm.Side panel : 1.5mm. Gasket : polyurethene. Door : hinged door Door designed : 130 degree hinged door. Looking arrangment : comfort handle with security lock
5	Supply ,installation ,Testing & commissioning of Online UPS (minimum 1 KVA with 1 Hour Backup) with following Specifications: Rack mounted. Hot swapablebattary replacement. Doubble Conversion technology.Battery Type: VRLA (Dry - Maintenance Free). Monitoring of battery health thru PLC
6	Limit switch for Differntial control valve and configured to PLC
7	Armoured Screened instrumentation cable - 2 Pair
8	Cable Gland
9	GI Coated Cable Tray
10	HDPE Conduit pipe
11	Chemical Earthing - 3 pit system

II	**Intake Area**
1	Supply, installation, Testing & commissioning of PLC system with minimum features as follows: PLC: PLC should have Ethernet TCP/IP and MODBUS RTU/Profibus port. The PLC can be easiliy extendable with additional IO cards in future. The PLC software should support all 5 languages as per IEC 61131-3, The ambient operating temperature shall be 55 deg C. Minimum no. of IOs should be DI-64 ; DO- 32 ; AI-16 ; AO-8 ;Modbus- 4 channels. Suitable fuse terminal should be used in all DI & DO. Intermediate relay should be considered for all DOs. Power supply to the PLC should be redundant type with suitable diode oring module. Enclosure should be neatly wired and with adequate space for ease of maintenance in future. Front & rear access may also be considered if required. HMI: 12", TFT Color, Panel mounted, touchscreen type, alarm generation, trend generation, report generation with 30 days data back up facility. Networking: Networking component should consists of required ethernet components along with Fiber Optic & accessories to establish communication between each zone and main WTP. Fiber optic should be Single Mode 9/125, 6 core type, suitable for more than 50KM data transmission without any repeater. Whole network infrasrtucture should have proper security system and firewall in each and every location. EMS: All energy meter should read Current, Voltage, Power, energy and any other parameters required for EMS. EMS should calculate pump running hours, total energy consumption etc. Data from EMS shall be displayed on the HMI in the PLC panel

2 Supply ,installation ,Testing & commissioning of Pressure trans mitter with minimum features as follows:
Pressure Transmitter:
Measuring Principle : Hydrostatic
Characteristic : Digital transmitter with capacitive sensor and ceramic membrane
Supply voltage : 4...20mA
Reference Accuracy : Standard: 0.05%
Platinum: up to 0.025%
Process temperature : -20°C...150°C
Ambient temperature : -40°C...85°C
Measuring cell : 100mbar...40bar or (1.5psi...600psi)

3 Supply ,installation ,Testing & commissioning of ultrasonic level transmitter with minimum features as follows:Ultrasonic Level Transmitter:
Measuring Principle : Ultrasonic
Supply / Communication : 2/4-wire, PROFIBUS PA
Accuracy : +/- 2 mm or +/- 0,2 % of set measuring range
Ambient temperature : -40 °C ... 80 °C
Process temperature : -40 °C ... 80 °C
Main wetted parts : PVDF
Process connection : G / NPT 2"
Blocking distance : 0.35 m (1.15 ft)
Max. measurement distance : 8 m (26 ft)
Communication : 4 ... 20 mA

4 Supply of PLC enclosure of following specification;
Profile : 16 fold in a single steel construction
Painting : triple anti-corresion, nano-ceramic surface treatment with dipcoat priming and textured power coating ral-7035.which help to protect rust &corrosion.Protection : ip 55.
Mounting plate : 3mm zinc plated.Front door : 2mm.Side panel : 1.5mm. Gasket : polyurethene. Door : hinged door
Door designed : 130 degree hinged door. Looking arrangment : comfort handle with security lock

5 Supply ,installation ,Testing & commissioning of Online UPS (minimum 1 KVA with 1 Hour Backup) with following Specifications:
Rack mounted. Hot swapablebattary replacement. Doubble Conversion technology.Battery Type: VRLA (Dry - Maintenance Free).
Monitoring of battery health thru PLC

6 Limit switch for Differntial control valve and configured to PLC

7 Armoured Screened instrumentation cable - 2 Pair

8 Cable Gland

9 GI Coated Cable Tray

10 HDPE Conduit pipe

11 Chemical Earthing - 3 pit system

III Water Treatment Plant

A Raw water & Chemical dosing

1 Supply ,installation ,Testing & commissioning of PLC system with minimum features as follows:

PLC: PLC should have Ethernet TCP/IP. The PLC can be easiliy extendable with additional IO cards in future. The PLC software should support all 5 languages as per IEC

61131-3, The ambient operating temperature shall be 55 deg C. Minimum no. of IOs should be DI-128 ; DO- 64 ; AI-24 ; AO-8 .Suitable fuse terminal should be used in all DI & DO. Intermediate relay should be considered for all DOs. Power supply to the PLC should be redundant type with suitable diode oring module. The PLC should be neatly wired up inside the operator console. Operator console also should have push button & lamps for manual operation in case of failure of PLC. Front & rear access may also be considered if required.

HMI: 12", TFT Color, Panel mounted, touchscreen type, alarm generation, trend generation, report generation with 30 days data back up facility. HMI should control individual filter bed in auto mode. Individual PLC also should have send data to centralized SCADA system which will be placed inside main control room.

3 Supply ,installation ,Testing & commissioning of ultrasonic level transmitter with minimum features as follows:Ultrasonic Level Transmitter:
Measuring Principle : Ultrasonic
Supply / Communication : 2/4-wire, PROFIBUS PA
Accuracy : +/- 2 mm or +/- 0,2 % of set measuring range
Ambient temperature : -40 °C ... 80 °C
Process temperature : -40 °C ... 80 °C
Main wetted parts : PVDF
Process connection : G / NPT 2"
Blocking distance : 0.35 m (1.15 ft)
Max. measurement distance : 8 m (26 ft)
Communication : 4 ... 20 mA

4 Supply of PLC enclosure of following specification;
Profile : 16 fold in a single steel construction
Painting : triple anti-corresion, nano-ceramic surface treatment with dipcoat priming and textured power coating ral-7035.which help to protect rust &corrosion. Protection : IP 55.
Mounting plate : 3mm zinc plated.Front door : 2mm.Side panel : 1.5mm. Gasket : polyurethene. Door : hinged door
Door designed : 130 degree hinged door. Looking arrangment : comfort handle with security lock

5 Supply ,installation ,Testing & commissioning of Online UPS (minimum 1 KVA with 1 Hour Backup) with following Specifications:
Rack mounted. Hot swapablebattary replacement. Doubble Conversion technology.Battery Type: VRLA (Dry - Maintenance Free).
Monitoring of battery health thru PLC

6 31/2 core aluminium power cable (2.5sqm)

7 Armoured Screened instrumentation cable - 2 Pair

8 Cable Gland

9 GI Coated Cable Tray

10 Chemical Earthing - 3 pit system

B Filter bed console panel

1 Supply, installation, Testing & commissioning of PLC system with minimum features as follows:

PLC: PLC should have Ethernet TCP/IP port. The PLC can be easiliy extendable with additional IO cards in future. The PLC software should support all 5 languages as per IEC 61131-3, The ambient operating temperature shall be 55 deg C. Minimum no. of IOs should be DI-64 ; DO- 32 ; AI-16 ; AO-4 .Suitable fuse terminal should be used in all DI & DO. Intermediate relay should be considered for all DOs. Power supply to the PLC should be redundant type with suitable diode oring module. The PLC should be neatly wired up inside the operator console. Operator console also should have push button & lamps for manual operation in case of failure of PLC. Front & rear access may also be considered if required.

HMI: 12", TFT Color, Panel mounted, touchscreen type, alarm generation, trend generation, report generation with 30 days data back up facility. HMI should control individual filter bed in auto mode. Individual PLC also should have send data to centralized SCADA system which will be placed inside main control room.

2 Supply ,installation ,Testing & commissioning of differential level transmitter,LOH/ROF indicater with minimum features as follows: differential Level Transmitter:
Measuring Principle : Eletronic
Supply / Communication : 2/4-wire, PROFIBUS PA
Accuracy : +/- 2 mm or +/- 0,2 % of set measuring range
Ambient temperature : -40 °C ... 80 °C
Process temperature : -40 °C ... 80 °C
Main wetted parts : PVDF
Process connection : G / NPT 2"
Blocking distance : 0.35 m (1.15 ft)
Max. measurement distance : 8 m (26 ft)
Communication : 4 ... 20 mA

2 Supply ,installation ,Testing & commissioning of Pressure trans mitter with minimum features as follows:
Pressure Transmitter:
Measuring Principle : Hydrostatic
Characteristic : Digital transmitter with capacitive sensor and ceramic membrane
Supply voltage : 4...20mA
Reference Accuracy : Standard: 0.05%
Platinum: up to 0.025%
Process temperature : -20°C...150°C
Ambient temperature : -40°C...85°C
Measuring cell : 100mbar...40bar or (1.5psi...600psi)

3 Supply ,installation ,Testing & commissioning of ultrasonic level transmitter with minimum features as follows: Ultrasonic Level Transmitter:
Measuring Principle : Ultrasonic
Supply / Communication : 2/4-wire, PROFIBUS PA
Accuracy : +/- 2 mm or +/- 0,2 % of set measuring range
Ambient temperature : -40 °C ... 80 °C
Process temperature : -40 °C ... 80 °C
Main wetted parts : PVDF
Process connection : G / NPT 2"
Blocking distance : 0.35 m (1.15 ft)
Max. measurement distance : 8 m (26 ft)
Communication : 4 ... 20 mA

4 Supply of PLC enclosure of following specification;
Profile : 16 fold in a single steel construction
Painting : triple anti-corresion, nano-ceramic surface treatment with dipcoat priming and textured power coating ral-7035.which help to protect rust &corrosion.Protection : ip 55.
Mounting plate : 3mm zinc plated.Front door : 2mm.Side panel : 1.5mm. Gasket : polyurethene. Door : hinged door
Door designed : 130 degree hinged door. Looking arrangment : comfort handle with security lock

5 Supply ,installation ,Testing & commissioning of Online UPS (minimum 1 KVA with 1 Hour Backup) with following Specifications:
Rack mounted. Hot swapablebattary replacement. Doubble Conversion technology.Battery Type: VRLA (Dry - Maintenance Free).
Monitoring of battery health thru PLC

6 31/2 core aluminium power cable (2.5sqm)

7 Armoured Screened instrumentation cable - 2 Pair

8 Cable Gland

9 GI Coated Cable Tray

10 Chemical Earthing - 3 pit system

C Wash water handling & recirculation system

1 Supply ,installation ,Testing & commissioning of PLC system with minimum features as follows:

PLC: PLC should have Ethernet TCP/IP. The PLC can be easiliy extendable with additional IO cards in future. The PLC software should support all 5 languages as per IEC 61131-3, The ambient operating temperature shall be 55 deg C. Minimum no. of IOs should be DI-64 ; DO- 32 ; AI-16 ; AO-4 .Suitable fuse terminal should be used in all DI & DO. Intermediate relay should be considered for all DOs. Power supply to the PLC should be redundant type with suitable diode oring module. The PLC should be neatly wired up inside the operator console. Operator console also should have push button & lamps for manual operation in case of failure of PLC. Front & rear access may also be considered if required.

HMI: 12", TFT Color, Panel mounted, touchscreen type, alarm generation, trend generation, report generation with 30 days data back up facility. HMI should control individual filter bed in auto mode. Individual PLC also should have send data to centralized SCADA system which will be placed inside main control room.

3 Supply ,installation ,Testing & commissioning of ultrasonic level transmitter with

minimum features as follows:Ultrasonic Level Transmitter:
Measuring Principle : Ultrasonic
Supply / Communication : 2/4-wire, PROFIBUS PA
Accuracy : +/- 2 mm or +/- 0,2 % of set measuring range
Ambient temperature : -40 °C ... 80 °C
Process temperature : -40 °C ... 80 °C
Main wetted parts : PVDF
Process connection : G / NPT 2"
Blocking distance : 0.35 m (1.15 ft)
Max. measurement distance : 8 m (26 ft)
Communication : 4 ... 20 mA

4 Supply of PLC enclosure of following specification;
Profile : 16 fold in a single steel construction
Painting : triple anti-corresion, nano-ceramic surface treatment with dipcoat priming and textured power coating ral-7035.which help to protect rust &corrosion.Protection : ip 55.
Mounting plate : 3mm zinc plated.Front door : 2mm.Side panel : 1.5mm. Gasket : polyurethene. Door : hinged door
Door designed : 130 degree hinged door. Looking arrangment : comfort handle with security lock

5 Supply ,installation ,Testing & commissioning of Online UPS (minimum 1 KVA with 1 Hour Backup) with following Specifications:
Rack mounted. Hot swapablebattary replacement. Doubble Conversion technology.Battery Type: VRLA (Dry - Maintenance Free).
Monitoring of battery health thru PLC

6 31/2 core aluminium power cable (2.5sqm)

7 Armoured Screened instrumentation cable - 2 Pair

8 Cable Gland

9 GI Coated Cable Tray

10 Chemical Earthing - 3 pit system

D Clear water pumping unit

1 Supply ,installation ,Testing & commissioning of PLC system with minimum features as follows:

PLC: PLC should have Ethernet TCP/IP and MODBUS RTU/Profibus port. The PLC can be easiliy extendable with additional IO cards in future. The PLC software should support all 5 languages as per IEC 61131-3, The ambient operating temperature shall be 55 deg C. Minimum no. of IOs should be DI-64 ; DO- 32 ; AI-16 ; AO-8 ;Modbus- 4 channels. Suitable fuse terminal should be used in all DI & DO. Intermediate relay should be considered for all DOs. Power supply to the PLC should be redundant type with suitable diode oring module. The PLC should be neatly wired up inside the operator console. Operator console also should have push button & lamps for manual operation in case of failure of PLC. Front & rear access may also be considered if required.

HMI: 12", TFT Color, Panel mounted, touchscreen type, alarm generation, trend generation, report generation with 30 days data back up facility. HMI should control individual filter bed in auto mode. Clear water pumping PLC should send data to centralized SCADA system which will be placed inside main control room of WTP.

EMS: All energy meter should read Current, Voltage, Power, energy and any other

parameters required for EMS. EMS should calculate pump running hours, total energy consumption etc. Data from EMS shall be displayed on the HMI in the PLC panel

2 Supply ,installation ,Testing & commissioning of Pressure trans mitter with minimum features as follows:
Pressure Transmitter:
Measuring Principle : Hydrostatic
Characteristic : Digital transmitter with capacitive sensor and ceramic membrane
Supply voltage : 4...20mA
Reference Accuracy : Standard: 0.05%
Platinum: up to 0.025%
Process temperature : -20°C...150°C
Ambient temperature : -40°C...85°C
Measuring cell : 100mbar...40bar or (1.5psi...600psi)

3 Supply ,installation ,Testing & commissioning of ultrasonic level transmitter with minimum features as follows:Ultrasonic Level Transmitter:
Measuring Principle : Ultrasonic
Supply / Communication : 2/4-wire, PROFIBUS PA
Accuracy : +/- 2 mm or +/- 0,2 % of set measuring range
Ambient temperature : -40 °C ... 80 °C
Process temperature : -40 °C ... 80 °C
Main wetted parts : PVDF
Process connection : G / NPT 2"
Blocking distance : 0.35 m (1.15 ft)
Max. measurement distance : 8 m (26 ft)
Communication : 4 ... 20 mA

4 Supply of PLC enclosure of following specification;
Profile : 16 fold in a single steel construction
Painting : triple anti-corresion, nano-ceramic surface treatment with dipcoat priming and textured power coating ral-7035.which help to protect rust &corrosion.Protection : ip 55. Mounting plate : 3mm zinc plated.Front door : 2mm.Side panel : 1.5mm. Gasket : polyurethene. Door : hinged door
Door designed : 130 degree hinged door. Looking arrangment : comfort handle with security lock

5 Supply ,installation ,Testing & commissioning of Online UPS (minimum 1 KVA with 1 Hour Backup) with following Specifications:
Rack mounted. Hot swapablebattary replacement. Doubble Conversion technology.Battery Type: VRLA (Dry - Maintenance Free).
Monitoring of battery health thru PLC

6 31/2 core aluminium power cable (2.5sqm)

7 Armoured Screened instrumentation cable - 2 Pair

8 Cable Gland

9 GI Coated Cable Tray

10 Chemical Earthing - 3 pit system

E Central control, operation, data transmission & monetering

1 Supply ,installation ,Testing & commissioning of Networking system with minimum features as follows:

All the PLCs in RAW WATER & CHEMICAL DOSING area, FILTER BED area, WASH WATER HANDLING & RECIRCULATING area and CLEAR WATER PUMPING area should communicate with SCAD system located in the CENTRAL CONTROL ROOM located in WTP. In WTP redundant SCADA system shall be considered for operator with one additional Engineering station.The SCADA system should also read and write all ZONAL PLC and INTAKE PLC.

The SCADA software must support OPC. To establish the entire network between ZONAL PLCs, INTAKE PLC and WTP PLC SYSTEM the designer should consider required HARDWARE FIREWALL to restrict unauthorized entries into the network.

Fiber optic should be single mode type, 6 core, suitable for data transmission minimum upto 80 KM. HDPE conduit also to be considered for FO.

All ETHERNET SWITCH required for the network establishment should be INDUSTRIAL, DIN RAIL MOUNTED, MANAGED type with operating temperature of 65 deg C. All ethernet switches must have spare ports for future use. For converting the optic signal to ethernet signal and vice versa, fiber optic port inbuilt in eternet switch shall be considered. No stand alone type medi converter will be entertained.

One number of ODP server, sutiable to commuicate with 30 ODP clients shall be considered in the centralised SCADA system.

Data transmission from WTP to NIC also shall be considered via VPN technology.
A3 Colour Inkjet Printer
Dot Matrix Printer for A3 paper
Industrial PC with 21", TFT Color moniter for Engineering Work Station
Industrial PC with 21", TFT Color moniter for Opereter Station
Data receiving redandantServer at NIC From Central PLC with all Peripharls
Licencedsoft ware at NIC server with antivirus
Dedicated Static IP Connection NIC,BBSR for data acquision& report Generation (1 year)

4 Supply of enclosure for networking component of following specification;
Profile : 16 fold in a single steel construction
Painting : triple anti-corresion, nano-ceramic surface treatment with dipcoat priming and textured power coating ral-7035.which help to protect rust &corrosion.Protection : ip 55.
Mounting plate : 3mm zinc plated.Front door : 2mm.Side panel : 1.5mm. Gasket : polyurethene. Door : hinged door
Door designed : 130 degree hinged door. Looking arrangment : comfort handle with security lock

5 Supply ,installation ,Testing & commissioning of Online UPS (minimum 3 KVA with 1 Hour Backup) with following Specifications:
Rack mounted. Hot swapablebattary replacement. Doubble Conversion technology.Battery Type: VRLA (Dry - Maintenance Free).
Monitoring of battery health thru PLC

7 Single mode 6 core fiber optic cable suitable for minimum 80 KM data transmission

8 Cable Gland

9 GI Coated Cable Tray

10 HDPE conduit

11 Chemical Earthing - 3 pit system

12 Furniture

Note: 1. *Any item or any provision/requirement if not included in the Scope of work, but is necessary to be provided for the completion of the project and for its functional necessity, the contractor shall provide the same.*

2. [Notwithstanding anything to the contrary contained in Paragraph 1 above, the following Specifications and Standards shall apply to the Water Supply Project, and for purposes of this Agreement, the aforesaid Specifications and Standards shall be deemed to be amended to the extent set forth below:]

[Note 1: Deviations from the aforesaid Specifications and Standards shall be listed out here. Such deviations shall be specified only if they are considered essential in view of project-specific requirements.]

CIVIL SPECIFICATIONS

9.3.1 EARTH WORK SPECIFICATIONS

EARTHWORK IN GRADING, EXCAVATION AND BACK FILLING

9.3.1.1 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.

9.3.1.2 APPLICABLE CODES

The following Indian Standard Codes, unless otherwise specified herein, shall be applicable. In all cases, the latest revision of the codes shall be referred to.

1.0	IS 1200 (Part 1) (Part 27)	Method of measurement of building and civil engineering works Part 1 Earthwork Part 27 Earthwork done by mechanical appliances.
2.0	IS 3764	Excavation work-code of safety.
3.0	IS 2720	Methods of test for soils:
3.1	(Part 1)	Part 1 Preparation of dry soil samples for various tests.
3.2	(Part 2)	Part 2 Determination of water content.
3.3	(Part 4)	Part 4 Grain size analysis.
3.4	(Part 5)	Part 5 Determination of liquid and plastic limit.
3.5	(Part 7)	Part 7 Determination of water content-dry density relation using light compaction.
3.6	Part (9)	Part 9 Determination of dry density - moisture content relation by constant weight of soil method.
3.7	(Part 14)	Part 14 Determination of density index (relative density) of cohesion-less soils.
3.8	(Part 28)	Part 28 Determination of dry density of soils in place, by the sand replacement method.
3.9	(Part 33)	Part 33 Determination of the density in place by the ring and water replacement method.
3.10	(Part 34)	Part 34 Determination of density of soil in place by rubber balloon method.
3.11	(Part 38)	Part 38 Compaction control tests (Hilf Method).

9.3.1.3 DRAWINGS:

The Engineer will furnish drawings wherever, in his opinion, such drawings are required to show areas to be excavated/ filled grade level, sequence of priorities etc. The Contractor shall follow strictly such drawings.

9.3.1.4 GENERAL:

- **Definitions:** The following terms shall have the meanings hereby assigned to them: -

"Topsoil"	Means any surface materials, including turf, suitable for use in soiling areas to be grassed or cultivated.
"Ordinary and Hard Soils"	means all kinds of soils containing kankar, sand, silt, murum and/or shingle, gravel, clay, loam, peat, ash, shale, etc. which can generally be excavated by spades, pick axes and shovels. This shall also include embedded rock boulders not longer than 1 metre in any direction and not more than 200 mm in any one of the other two directions.
"Soft and Decomposed Rock"	means rock, boulders and other materials which in the opinion of the Engineer could normally be removed by picks, hammer, crowbars, wedges and pneumatic breaking equipment. This shall also include rock boulders not longer than 1 metre in any direction and not more than 500 mm in any one of the other two directions. Excavation in macadam & tarred roads and pavements and dismantling masonry shall also be included under this item.
"Hard Rock"	Means rock occurring in large continuous masses which in the opinion of the Engineer could be loosened by blasting or by other rock quarrying methods. Rock boulders in sizes not classified under Ordinary/Hard Soils and Soft & Decomposed Rock shall be considered as hard rock.
"General Excavation"	means excavation in open cut in top soil, ordinary & hard soils or soft & decomposed rock or hard rock (excluding Trench Excavation) down to levels specified on the Drawings or Otherwise as being the general levels after completion of excavation but excluding excess excavation.
"Trench Excavation"	means excavation of trenches in any material into which pipes are to be laid to levels and limits specified on the Drawings or otherwise.
"Excess Excavation"	means excavation outside the limits specified for General or Trench Excavation (see also Cl. 14.1.7) (Excess Excavation will not be paid for).
"Controlled Blasting"	means blasting under express control by designing and limiting the charge of blast to ensure that the peak particle velocity due to blast at the nearest structure as measured by engineering seismograph does not exceed 5mm per second.

- **Levels to be Recorded:** Before the surface of any part of the Site is disturbed or the works thereon are begun, the Contractor shall take and record levels of any such part, in the manner specified or as agreed with the Engineer, in the presence of the Engineer and such levels when agreed with the Engineer shall form the basis for measurement.
- **Explosives and Blasting:** The Engineer shall have the power to regulate, restrict or prohibit blasting if in his opinion it is necessary to do so for the safety of persons or property or to safeguard the Works.

  No blasting shall be carried out in any part of the Works without the permission in writing of the Engineer. Such permission shall not absolve the Contractor from any of his obligations or liabilities under the Contract and he shall take all necessary precautions including the use of blasting nets to avoid damage, loss or injury to persons and to public or private property.

  The Contractor shall keep the Engineer fully informed at all times when blasting is proposed to be carried out and of any details the Engineer may require concerning strength of charges and their positions.

Explosives shall not be used within fifteen metres, or such greater or lesser distances as the Engineer may direct, of concrete placed in the Works, of any existing structure, water main, electric cable, sewer or other services.

The Contractor shall obtain the necessary licences for the storage, transport and handling of explosives and shall provide a store or stores suitable for explosives and shall carry out every aspect of blasting work in full conformity with the regulations of all competent authorities including the police and Inspector of Explosives, Orissa State. Only experienced and competent blasting operatives possessing licences from the Commissioner of Police shall be employed on blasting work.

Audible and visible warning (such as the waving of red danger flags and beating of gongs) shall be given for at least five minutes before blasting is due to begin. The Contractor's foreman or other responsible persons shall inspect the whole of the blasting area during the warning period to ensure that no one remains within or is likely to enter the danger area. All operatives except those responsible for detonating the explosives shall be removed to a safe distance, which in any case shall not be less than two hundred metres. If combustible fuses are used these shall be cut to length before insertion.

Under no circumstance shall the removal of an unexploded charge be attempted. The hole containing the charge shall be marked and filled with water. A second hole shall be drilled some 450 mm away, charged and fired. This procedure shall be repeated until the foreman is satisfied that both charges have exploded. In general the size of explosive charges used shall be the smallest compatible with efficient working so as to minimise the chances of danger to persons and property.

- **Excess Excavation to be made good**: The Contractor, at his own expense, shall, if directed, remove from the Site all materials resulting from Excess Excavation and shall make good the same with such kind of fill material or such class of concrete as may be reasonably required by the Engineer having regard to the circumstances.

9.3.1.5 SITE CLEARANCE

- **General:** All areas of the Site falling within the area marked for site grading and excavation or from which material is to be excavated or upon which filling is to be deposited, as directed by the Engineer shall be cleared by the Contractor to the extent required by the Engineer, of all buildings, walls, gates, fences and other structures and obstructions and of all bushes, hedges, trees and stumps (of girth upto 300mm), roots and other vegetation except for trees marked for preservation and trees with girth greater than 300mm. Material so cleared shall so far as suitable be preserved and stacked for further use but shall otherwise be burnt to ash or disposed off the Site as directed by the Engineer.

- **Trees:** Where directed by the Engineer trees shall be uprooted or cut down as near to ground level as possible. Branches and foliage shall be removed and burnt to ash or disposed off the Site. Useful timber shall remain the property of PHEO and shall be cut into suitable lengths and transported a distance not exceeding 15-25 kilometres to a location designated by the Engineer where it shall be offloaded and stacked.

- **Stumps:** Stumps and roots whether existing or remaining after tree felling shall where directed by the Engineer be grubbed out and disposed off the Site up to 20 km. The resulting hole shall be filled with approved material deposited in 225 mm layers and compacted to the same dry density as the adjoining soil.

- **Forestry Regulations:** The Contractor shall familiarise himself with all local rules and regulations governing land clearance including the special requirements for forestry areas and shall carry out his work in strict compliance with all such requirements.
- **Measurement of Site Clearance:** Items in the Bill of Quantities for Excavations shall include for clearing the Site, including felling of trees and grubbing up of stumps of trees of girth less than or equal to 300 mm. Items for felling trees exceeding 300 mm girth shall include for felling, cutting up, and transporting useful timber to the Municipal stockyard as directed by the Engineer. Trees shall be classified for measurement according to their girth measured at 1.5 metres above mean ground level. Separate measurement will not be made for trees with girth less than 300 mm. Items for felling trees shall also include for grubbing up and disposal off the Site of stumps and roots and for filling up the resulting hole all as directed by the Engineer.

9.3.1.6 GENERAL EXCAVATION

- **General:** General excavation means excavation required for general site grading, structures, road works and borrow areas and shall not include Trench Excavation. General excavation may also include miscellaneous isolated lengths of trenches inside or adjacent to other structures.

  The ground shall be excavated by such methods and to such dimensions and depths as shall allow for the proper construction of the Works and safety of personnel and equipment used on excavation.

  Slopes required for stable formation of sides shall be catered to in the rates quoted for the item.

  Where nominal payment limits of excavation are not shown in the Drawings or otherwise specified, they shall be deemed to be the minimum net limits which would allow the outline of the completed structure to be lowered vertically from ground level into its final position. The Contractor shall make his own allowance for any working space required, and any excavation outside the aforesaid limits which has not been ordered by the Engineer, whether it be excavated to suit the Contractor's method of working or unavoidable over break or due to his carelessness or error, shall be held to be Excess Excavation and shall not be paid.

  Wherever a socket or collar of pipe or fitting/special occurs, a grip is to be cut in the bottom of the trench or concrete bed to a depth of at least 75 mm below the bed of the pipe so that the pipe may have a fair bearing on its shaft and does not rest upon its socket. Such grip shall be of sufficient size in every respect to admit the hand all around the socket in order to make the joint, and the grip shall be maintained clear until the joint has been approved by Owner/Engineer.

  When welding is to be carried out with the pipes and specials in the trench, additional excavation of not more than 60 cm in depth and 90 cm in length shall be made at joints in order to facilitate welding.

- **Stripping Topsoil:** Where ordered by the Engineer, Topsoil shall be stripped to such depths and over such areas as he may direct, as a separate operation prior to any further excavation, which may be required.

- **Soft & Decomposed Rock and Hard Rock in General Excavation:** Any material in General Excavation which the Contractor considers may be classified as Soft &

Decomposed Rock or Hard Rock as defined above shall be notified to the Engineer before excavation of the material is begun. The quantities of this material excavated from within the nominal limits of excavation shall be recorded and the record shall be signed by the Engineer and the Contractor each day or at such shorter intervals as the Engineer may require. Only such proportion of material so notified and recorded as the Engineer classifies as Soft & Decomposed Rock or Hard Rock shall qualify for additional payment under respective items of BOQ. Over break (that is excavation outside the nominal limits of excavation) shall be kept to a minimum and shall be held to be Excess Excavation.

The excavation in earth, murrum, boulders and soft rock shall be carried out to the correct levels required and specified and no tolerance, plus or minus, shall be permitted. However, if any depressions are formed due to removal of boulders, they shall be made good by filling with M20 concrete up to the bottom of the blinding layer below footing/raft. No payment for the excavation below the specified level and for filling such hollows with M20 concrete shall, however, be made. Excavation in hard rock may be done either by blasting or chiselling depending upon the site conditions. When excavation has reached within 300 mm of the prescribed formation level, further excavation shall be carried out carefully either by blasting or chiselling. Where blasting is resorted to, small charges shall be used to minimise occurrence of heavy overcuts. The Contractor shall make every effort to carry out the excavation to the correct formation level as far as practicable. However, undercuts and overcuts upto 200 mm in case of blasting and 80 mm in case of wedging and/or chiselling from the formation level shall only be permitted, whichever method of excavation is adopted. All overcuts below the formation shall be made good by filling in with M15 concrete upto the bottom of the blinding layer below footing/raft. All excavation within the permissible limits of overcuts and filling in with M15 concrete shall be paid for separately. In case of undercuts the payment of excavation shall be restricted to the actual line of excavation done by the Contractor.

- **Supporting Excavations**: The Contractor shall well and effectively support the sides and ends of all excavations to prevent any fall or run from any portion of the ground outside the excavation and to prevent settlement or damage to structures adjacent to the excavation. Any extra excavation necessary to provide space for such support or other working space shall be held to be Excess Excavation. If, for any reason, any portion of the bottoms, sides or ends of any excavations shall give way, the Contractor shall at his own expense take all necessary remedial measures including the excavation and removal of all the ground thereby disturbed both within and outside the nominal limits of excavation and such extra excavations shall be held to be Excess Excavation.

  Where the Contractor elects and is permitted by the Engineer to perform excavations with sloping faces (other than sloping excavations shown on the Drawings or required as permanent features of the Works) and without shoring, the excavated faces shall be to stable slopes and heights and the resulting extra excavation shall be held to be Excess Excavation.

- **Trimming Excavations:** When excavating to specified levels for the foundation of any structure or to specified limits for the face of any structure required to about undisturbed ground, the Contractor shall not excavate the last 150 mm until immediately before commencing the constructional work, except where the Engineer shall permit otherwise. Should the Contractor have excavated to within 150 mm above these specified levels or to within 150 mm of these specified limits before he is ready or able to commence the constructional work he shall, where required by the Engineer, excavate further so as to

remove not less than 150 mm of material immediately before commencing the constructional work and such further excavation shall be held to be Excess Excavation.

Before commencement of any constructional work all shattered and loose material shall be removed from the excavations by hand so as to ensure that the work rests on a solid and perfectly clean foundation or abuts against solid ground.

- **Inspection by the Engineer:** When the specified levels or limits of excavation are reached, the Engineer will inspect the ground exposed and if he considers that any part of the ground is by its nature unsuitable he may direct the Contractor to excavate further. Such further excavation shall be refilled to the specified levels or limits with concrete, selected excavated material or selected imported material as directed by the Engineer, but shall not be held to be Excess Excavation.

  Should the material forming the bottom of any excavation, while acceptable to the Engineer at the time of his inspection, subsequently become unacceptable to him due to exposure to weather conditions or due to flooding or have become puddled, soft or loose during the progress of the Works, the Contractor shall remove such damaged, softened or loosened material and excavate further by hand. Such further excavation shall be held to be Excess Excavation.

9.3.1.7 DEWATERING

All excavations shall be kept free of water. Grading in the vicinity of excavations shall be controlled to prevent tidal and surface water running into excavated areas. Contractor shall remove by pumping or other means any water inclusive of rain water and subsoil water accumulated in excavation and keeps all excavations dewatered until the foundation work is completed and backfilled. Sumps made for dewatering must be kept clear of the excavations/trenches required for further work. Method of pumping shall be acceptable to the Engineer, but in any case, the pumping arrangement shall be such that there shall be no movement of subsoil or blowing in due to differential head of water during pumping. Pumping arrangements shall be adequate to ensure no delays in construction.

When there is a continuous inflow of water and quantum of water to be handled is considered in the opinion of Engineer as large, well point system, single stage or multistage, shall be adopted. The Contractor shall submit to Engineer his scheme of well point system including the stages, the spacing, number and diameter of well points, headers etc., and the number, capacity and location of pumps for approval. Unless separately provided for in the schedule of prices, the cost of dewatering shall be included in the item rate for excavation.

9.3.1.8 TIMBER SHORING

Close timbering shall be done by completely covering the sides of the trenches and pits generally with short, upright members called `polling boards'. The boards shall generally be placed in position vertically side by side without any gap on each side of the excavation and shall be secured by horizontal walling of strong wood at maximum 1.2 metres spacing and suitably strutted. If the soil is very soft and loose, the shoring shall be progressively done as the excavation progress. The boards shall be placed horizontally against each side of the excavation and supported by vertical walling, which in turn shall be suitably strutted. The lowest boards supporting the sides shall be driven into the ground and no portion of the vertical side of the trench or pit shall remain exposed, so as to render the earth liable to slip out.

The shoring material shall not be of sizes less than those specified below unless steel sheet piling

is used or unless otherwise approved by the Engineer in writing:

a) Planks - 5 cm x 25 cm

b) Walling pieces - 10 cm x 20 cm

c) Struts - 15 cm x 20 cm

Timber shoring shall be `close' or `open' type, depending on the nature of soil and the depth of pit or trench. The type of timbering shall be as acceptable to the Engineer. It shall be the responsibility of the Contractor to take all necessary steps to prevent the sides of excavations, trenches, pits, etc., from collapsing.

Timber shoring may be required to keep the sides of excavation vertical to ensure safety of adjoining structures or to limit the slope of excavations, or due to space restrictions or for other reasons. Such shoring shall be carried out, except in an emergency, only under instructions from Engineer.

The withdrawal of the timber shall be done very carefully to prevent the collapse of the pit or trench. It shall be started at one end and proceeded systematically to the other end. Concrete or masonry shall not be damaged during the removal of the timber. No claim shall be entertained for any timber, which cannot be retrieved.

In the case of open timbering, the entire surface of the side of trench or pit is not required to be covered. The vertical boards of minimum 25 cm x 4 cm sections shall be spaced sufficiently apart to leave unsupported strips of maximum 50 cm average width. The detailed arrangement, sizes of the timber and the spacing shall be subject to the approval of Engineer. In all other respects, specification for close timbering shall apply to open timbering.

In case of large pits and open excavations, where shoring is required for securing safety of adjoining structures, the method of shoring shall be submitted to the Engineer for his approved. If, the Engineer directs any timbering to be left-in, Contractor shall be paid for at an agreed rate for such left-in timbering.

Unless separately provided for in the Schedule of Quantities, shoring is deemed to have been included in the unit rates quoted for excavation. If separately provided in the Bill of Quantities the actual effective area of shored faces as approved by Engineer shall be measured in sq.m. All planks, boards, walling, verticals, struts, props and all other materials required for shoring and subsequent safe dismantling and removal shall be deemed to be included in the quoted unit rates.

9.3.1.9 BACKFILLING, GENERAL SITE GRADING & SAND FILLING

Fill Material: All fill material whether such material is brought from outside borrow areas or excavation within the site, will be subject to Engineer's approval. Notwithstanding any approval given to the fill material or borrow areas from which fill material is proposed to be brought, the Engineer reserves the right to reject such material which in his opinion either does not meet the specification requirements or is unsuitable for the purpose for which it is intended.

It shall be Contractor's responsibility to locate suitable borrow areas for required fill material. Such areas will be inspected by Engineer and approved before Contractor makes arrangements to borrow the fill material. The topsoil, which may contain vegetation, rubbish, slush etc., shall not be used. If required by Engineer, Contractor shall arrange to have trial pits of specified dimensions and numbers dug at specified locations, for the Engineer to examine the nature and type of material likely to be obtained from the borrow areas.

Unless separately provided for, all lead, lift and transportation required for bringing in the fill

material from borrow areas or from excavation from within the site shall be included in the Contractor's quoted unit rates.

The borrowed soil shall be generally granular, and non-cohesive. It shall consist of sand, silty sand, murrum, ordinary soil, gravel and shingle. Dredged material, free from clayey deposit, will be accepted. Fill material shall also be free from sulphates, salts, organic, foreign and other harmful or objectionable materials. Any material rejected by the Engineer shall be removed from the site immediately.

Roads, of temporary nature, required to be constructed for access and for movement of men, materials, equipment, transport vehicles, vehicles carrying fill material etc. to or over borrow areas and/or to or over areas on which fill has to be deposited shall be constructed by the Contractor at his own cost. Such costs shall be deemed to have been included in the unit rates quoted by Contractor. Such access roads shall be maintained in good condition during all seasons to ensure completion of the work according to the time schedule.

Backfilling: Excavated material used as backfilling to excavations or completed structures shall be free from rubbish, vegetation, clods and lumps and shall be approved by the Engineer. The approved materials shall be placed in layers, not exceeding 225 mm in depth before compaction and shall be compacted to a dry density not less than 95% of the maximum dry density obtained by the test in Part VII of IS:2720 or to such higher density as is specified hereinafter or shown on the Drawings. During compaction the backfill shall have a uniform moisture content equal to or a little above the optimum moisture content recorded in the IS Compaction Test. Where necessary the Contractor shall adjust the moisture content of the backfill either by drying out or by adding water. After such drying out or adding of water the backfill shall be thoroughly mixed until the moisture content is uniform.

Soft material shall not be used as backfilling around structures in rock. The Contractor shall backfill such excess excavation with concrete, rubble, stone or rockfill as directed by the Engineer. Filling other than concrete shall be placed in layers not exceeding 300 mm in thickness, shall be thoroughly compacted and have adequate fines content to fill the voids.

Should the material being placed as backfilling, while acceptable at the time of selection, become unacceptable to the Engineer due to exposure to weather conditions or due to flooding or have become puddled, soft or segregated during the progress of the Works, the Contractor shall at his own expense remove such damaged, softened or segregated material and replace it with fresh approved material.

The Contractor shall when placing the backfilling make due allowance for any settlement that may occur before the end of the Defects Liability Period. Where necessary, the Contractor shall during the Defects Liability Period and at or before the end of the Defects Liability Period remove any excess material or make up any deficiency or backfilling to the specified levels.

Backfilling as per specification the sides of foundations of columns, footings, structures, walls, tanks, rafts, trenches, etc. with excavated material will be paid for separately. It shall be clearly understood that the rate quoted for excavation shall include conveying of selected stacked material 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 of 300 metres unless otherwise required by the Engineer. If Engineer permits a lead of over 300 metres for such material, the conveyance of the material for the extra distance over the basic lead of 300 metres for backfilling will be paid for.

Payment for fill inside plinth or similar filling with selected excavated material will be made separately. Payment for this work will be made based on measurement of plinth dimensions filled.

The plinth ground levels shall be recorded before hand for this purpose.

Backfilling, plinth filling and site grading with borrowed earth will be paid for at rates quoted. The quoted rate shall include all operations such as lead and transport, fill, compaction, etc. as specified. Actual quantity of consolidated filling or actual quantity or excavation in the borrow pits (less such top soil which has been excavated and not used for filling) whichever is less shall be measured and paid for in cubic metres. The lead, lift etc. shall be as indicated in the schedule of quantities.

Compaction shall be carried out to achieve at least 95% of standard Proctor Dry Density at an optimum moisture content determined in accordance with the relevant IS Specification. It shall be ensured however that the minimum compacted dry density is not less than 1.6 M.T./M^3. As the work progresses field density tests shall be conducted on each layer at the rate of one test for every 1000 square metres to check whether the desired compaction has actually been achieved.

General Site Grading: Site grading shall be carried out as indicated in the drawings and as directed by Engineer.

Excavation shall be carried out as specified. Filling and compaction shall be carried out as specified below.

The approved material shall be placed in layers not exceeding 225 mm in depth before compaction and shall be compacted to a dry density not less than 95 percent of the maximum dry density obtained by the test in Part 7 of IS 2720 or to such a higher density as shown on the drawing.

To ensure that the fill has been compacted as specified, field and laboratory tests shall be carried out by the Contractor at his own cost.

Field compaction test shall be carried out at different stages of filling and also after the fill to the entire height has been completed. This shall hold good for embankments as well.

The Contractor shall protect the earth fill from being 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 own cost.

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

If specifically permitted by Engineer, compaction can be obtained by allowing loaded trucks conveying fill or other material to ply over the fill area. Even if such a method is permitted, it will be for Contractor to demonstrate that the desired / specified compaction has been obtained. In order that the fill may be reasonably uniform throughout the material should be dumped in place in approximately uniform layers. Traffic over the fill shall then be so routed to compact the area uniformly throughout.

If so specified, the rock as obtained from excavation may be used for filling and levelling to indicated grades without further breaking. In such an event, filling shall be done in layers not exceeding 50 cms approximately. After rock filling to the approximate level indicated above has been carried out, the void in the rocks shall be filled with finer materials such as earth, broken stone, etc. and the area flooded so that the finer materials fill up the voids. Care shall be taken to ensure that the finer fill material does not get washed out. Over the layer so filled, a 100 mm thick mixed layer of broken material and earth shall be laid and compaction carried out by a 12 tonne roller. Not less than twelve passes of the roller shall be accepted before subsequent similar operations are taken up.

Sand Filling in Plinth and Other Places: Backfilling shall be carried out with local sand at places as directed by the Engineer. The sand used shall be clean, medium grained and free from imMunduli,Bhubaneswarties. The filled-in-sand shall be kept with water for 24 hours to ensure maximum consolidation. Any temporary work required to contain sand under flooded condition shall be to Contractor's account. The surface of the consolidated sand shall be dressed to required level or slope. Construction of floors or other structures on sand fill shall not be started until Engineer has inspected and accepted the fill.

Measurement: Actual quantity of the consolidated sand filling shall be measured and paid for in cubic metres. Payment for filling upto the proposed finished grade level shall be made under general site grading and filling from proposed finished grade level to proposed plinth level shall be made under plinth filling.

Backfilling will be paid separately after the completion of the work.

9.3.1.10 SPOIL TIPS ON THE SITE

The limits of permanent spoil tips may be required by the Engineer for landscaping purposes. Temporary spoil tips may be used to store excavated material as required and shall be arranged by the Contractor subject to the Engineer's approved having regard to any particular requirements of the Contract.

Only material which is required by the Engineer shall be placed in the various spoil tips, topsoil being placed in separate spoil tips where so ordered. No tree trunks, stumps, roots, branches or rubbish of any kind shall be placed in spoil tips.

The Contractor shall form separate spoil tips of useful materials as follows:-

i) Good quality rubble and hardcore

ii) khandkies and corner stones

iii) Inferior quality rubble

iv) Soft rock, earth and murrum

v) Hard rock

Permanent spoil tips shall be finished to shapes as required by the Engineer. Temporary spoil tips shall be so shaped as to maintain stability and good drainage at all times.

9.3.1.1 DISPOSAL OF EXCAVATED MATERIAL OFF SITE

Excavated material which is not required for or is unsuitable for re-use in the works shall be disposed off as directed to locations designated by the Engineer (Engineer's tip). Such material shall remain the property of the PHEO and shall be transported and deposited at places designated by the Engineer. Material so deposited shall be shaped up or spread and levelled as directed by the Engineer. Any necessary work to provide access to Engineer's tips or other preliminary work in connection therewith shall be carried out by the Contractor in consultation with the Engineer and the expenses thereof shall be included in the rate quoted for the item.

9.3.1.11 FIELD DRAINS IN GENERAL EXCAVATION

Should any existing sub-soil or field drains be uncovered during general excavation, the Contractor shall either carefully replace them when backfilling, or, if this is impracticable shall divert them to new drains or ditches, or otherwise relay them as the Engineer may direct, and all work in this connection shall be ordered by the Engineer as additional work.

9.3.1.12 LOCAL RULES AND REGULATIONS

The Contractor shall familiarise himself with the local rules and regulations governing the excavation, quarrying operations, etc. and the work shall be carried out strictly in accordance with rules and regulations, if any. Whenever a quarry is required to be opened in connection with the execution of work covered under this Contract, the Contractor shall investigate that it shall yield stones and other materials such as sand, murrum, soil etc., of approved quality and shall satisfy himself as to the availability in desired quantity. He shall supply free of cost necessary quantity of sand, stone, metal aggregate, etc. to the Engineer for carrying out tests as required by the Engineer and well in advance of its use so as to get approval to the quality of the material. The cost of opening and operating and transporting the material from the quarry shall be borne entirely by the Contractor.

The Contractor shall obtain all necessary permission from the concerned authorities before opening the quarry. In case of quarries in private lands, it is for the Contractor at his cost to arrange for quarrying of the material on payment of what-ever charges as may be due to the owner.

9.3.1.13 MEASUREMENT OF GENERAL EXCAVATION

Items in the Bill of Quantities for “excavations” except where expressly indicated otherwise shall apply to excavation in any material and shall include not only all works in connection with excavation and backfill but also stacking the excavated material on the Site for being used as backfill or disposing the excavated material to permanent spoil tips or to embankments all as specified.

Items for “Disposal to Engineer’s tip” measured extra over excavation items, shall include for the disposal of excavated material to any tipping location designated by the Engineer, all as specified, at a distance from the place of excavation not exceeding five kilometres. by the most direct practicable route. Material disposed off at an Engineer’s tip at a distance greater than five kilo meters shall qualify for additional payment under a further E.O item for “Haulage” to Engineer’s tip in excess of five kilometres.

Items for “Excavation in Soft & Decomposed Rock or Hard Rock”, measured E.O. other excavation items, shall include for all additional work in connection with excavation in Soft & Decomposed Rock or Hard Rock and also for any allowance the Contractor considers necessary to cover over break and the making good thereof.

All work in connection with excavation and subsequent disposal of excavated material as specified shall be valued by measurement of such items as are set forth in the Bill of Quantities for “Excavation” and where appropriate, items for “Soft & Decomposed Rock or Hard Rock” and for disposal to the Engineer's tips. All such measurement shall be the net volume of the material excavated to the specified levels and limits described herein or shown on the Drawings, no allowance being made for bulking. No separate payment shall be made in respect of Excess Excavation.

9.3.2 CONCRETE & ALLIED WORKS

9.3.2.1 SCOPE

- This Specification covers the general requirements for ready mixed concrete and for concrete using on-site production facilities including requirements in regard to the quality, handling, storage of ingredients, proportioning, batching, mixing, transporting, placing, curing, protecting, repairing, finishing and testing of concrete; formwork; requirements in 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 ENGINEER from time to time. The decision of ENGINEER as regards 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.

9.3.2.2 APPLICABLE CODES AND SPECIFICATIONS

The following specifications, standards and codes, including all official amendments/ revisions and other specifications & 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.

- **Materials**

a)	IS:269	Specification for 33 grade ordinary portland cement.
b)	IS:455	Specification for portland slag cement.
c)	IS:1489	Specification for portland pozzolana cement (Parts 1 & 2).
d)	IS:8112	Specification for 43 grade ordinary portland cement.
e)	IS:12330	Specification for sulphate resisting Portland Cement.
f)	IS:383	Specification for coarse and fine aggregates from natural sources for concrete.
g)	IS:432	Specification for mild steel and medium tensile (Parts steel bars and hard drawn steel wires for 1 & 2) concrete reinforcement.
h)	IS:1786	Specification for high strength deformed steel bars and wires for concrete reinforcement.
i)	IS:1566	Specification for hard drawn steel wire fabric for (Parts II) concrete reinforcement.
j)	IS:9103	Specification for admixtures for concrete.
k)	IS:2645	Specification for integral cement waterproofing compounds.
l)	IS:4900	Specification for plywood for concrete shuttering work.
m)	IS:4926	Ready mixed concrete.
n)	IS:12269	Specification for 53 grade ordinary portland cement.
o)	IS:8041	Specification for rapid hardening cement.
p)	IS:12600	Specification for low heat cement.
q)	IS:6909	Specification for supersulphated cement.
r)	IS:12089	Specification for granulated ground blast furnace slag.
s)	IS:6699	Specification for granulated ground blast furnace slag.
t)	IS:6073	Specifications for precast concrete masonry units (Part 1). Methods for specifying precast concrete masonry (Part 2).

- **Material Testing**

a) IS:4031 Methods of physical tests for hydraulic cement (Parts 1 to 15).
b) IS:4032 Method of chemical analysis of hydraulic cement.
c) IS:650 Specification for standard sand for testing of cement.
d) IS:2430 Methods for sampling of aggregates for concrete.
e) IS:2386 Methods of test for aggregates for concrete (Parts 1 to 8).
f) IS:3025 Methods of sampling and test (physical and chemical) water used in industry (Part 1 to 51).
g) IS:6925 Methods of test for determination of water soluble chlorides in concrete admixtures.

- **Material Storage**

a) IS:4082 Recommendations on stacking and storing of construction materials at site.

- **Concrete Mix Design**

a) IS:10262 Recommended guidelines for Concrete Mix Design.
b) SP:23 Handbook on Concrete Mixes.

- **Concrete Testing**

a) IS:1199 Method of sampling and analysis of concrete.
b) IS:516 Method of test for strength of concrete.
c) IS:9013 Method of making, curing and determining compressive strength of accelerated cured concrete test specimens.
d) IS:81130 Method of test for determining setting time of concrete by penetration resistance.
e) IS:9284 Method of test for abrasion resistance of concrete.
f) IS:2770 Methods of testing bond in reinforced concrete.

- **Equipment**

a) IS:1791 Specification for batch type concrete mixers.
b) IS:2438 Specification for roller pan mixer.
c) IS:4925 Specification for concrete batching and mixing plant.
d) IS:5892 Specification for concrete transit mixer and agitator.
e) IS:72130 Specification for concrete spreaders.
f) IS:2505 General Requirements for concrete vibrators: Immersion type.
g) IS:2506 General Requirements for screed board concrete vibrators.
h) IS:2514 Specification for concrete vibrating tables.
i) IS:3366 Specification for pan vibrators.
j) IS:4656 Specification for form vibrators for concrete.
k) IS:11993 Code of practice for use of screed board concrete vibrators.
l) IS:7251 Specification for concrete finishers.
m) IS:2722 Specification for portable swing weigh batchers for concrete (single and double bucket type).
n) IS:2750 Specifications for steel scaffoldings.

- **Codes Of Practice**

a) IS:456 Code of practice for plain and reinforced concrete.
b) IS:457 Code of practice for general construction of plain and reinforced concrete for dams and other massive structures.

c) IS:3370 Code of practice for concrete structures for storage of liquids (Parts 1 to 4).
d) IS:3935 Code of practice for composite construction.
e) IS:2204 Code of practice for construction of reinforced concrete shell roof.
f) IS:2210 Criteria for the design of reinforced concrete shell structures and folded plates.
g) IS:2502 Code of practice for bending and fixing of bars for concrete reinforcement.
h) IS:5525 Recommendation for detailing of reinforcement in reinforced concrete works.
i) IS:2751 Code of practice for welding of mild steel plain and deformed bars used for reinforced concrete construction.
j) IS:9417 Specification for welding cold worked bars for reinforced concrete construction.
k) IS:3558 Code of practice for use of immersion vibrators for consolidating concrete.
l) IS:3414 Code of practice for design and installation of joints in buildings.
m) IS:4326 Code of practice for earthquake resistant design and construction of buildings.
n) IS:4014 Code of practice for steel tubular scaffolding. (Parts 1 & 2).
o) IS:2571 Code of practice for laying in situ cement concrete flooring.
p) IS:7861 Part1 - Recommended practice for hot weather concreting.
Part2 – Recommended practice for cold weather concreting.
q) IS:3370 Code of practice for concrete structures for the storage of liquid (Part I to IV).

- **Construction Safety**

a) IS:3696 Safety code for scaffolds and ladders (Parts 1 & 2).
b) IS:7969 Safety code for handling and storage of building materials.
c) IS:8989 Safety code for erection of concrete framed structures.

- **Measurement**

a) IS:1200 (Part 1 to 12) Method of measurement of building and engineering works (Parts 2 and 5).

9.3.2.3 GENERAL

- ENGINEER shall have the right at all times 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 ENGINEER'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 ENGINEER and after establishing their performance suitability based on previous data, experience or tests.

9.3.2.4 MATERIALS

(i) ***Cement***

Unless otherwise specified or called for by ENGINEER/OWNER, cement shall be ordinary portland cement conforming to IS: 269, IS: 8112 or IS: 12269.

- The portland pozzolana cement shall conform to IS: 1489 and it shall be used as directed by ENGINEER. Where portland pozzolana or slag cements are used, it shall be ensured that consistency of quality is maintained and there will be no adverse interactions between the materials and the finish specified is not marred.
- Only one type of cement shall be used in any one mix unless specifically approved by ENGINEER. The source of supply, type or brand of cement within the same structure or portion thereof shall not be changed without prior approval from ENGINEER.
- Cement, which is not used within 90 days from its date of manufacture, shall be tested at a laboratory approved by ENGINEER and until the results of such tests are found satisfactory, it shall not be used in any work.

(ii) ***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 in Munduli, Bhubaneswar City/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 ENGINEER.
- Aggregates containing reactive materials shall be used only after tests conclusively prove that there will be no adverse affect 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.
- The maximum size of coarse aggregate shall be as stated on the drawings, but in no case greater than 1/4 of the minimum thickness of the member, provided that the concrete can be placed without difficulty so as to surround all reinforcement thoroughly and fill the corners of the form. For most work 20mm aggregate is suitable. Where there is no restriction to the flow of concrete into sections, 40mm or larger size is permitted.
- In concrete elements with thin sections, closely spaced reinforcements or small cover, consideration should be given to the use of 10mm nominal maximum size.
- 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 ENGINEER.
- 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.
- The proposed admixtures shall comply with requirements of Specification for Admixtures for Concrete.

(iii) ***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 ENGINEER.

(iv) ***Wastage***

- Wastage allowance for cement and steel shall be as specified under Instruction to Bidders.

(v) ***Samples and Tests***

- All materials used for the works shall be tested before use. The frequency of such confirmatory tests shall be decided by ENGINEER.
- Manufacturer's test certificate shall be furnished for each batch of cement/steel and when directed by ENGINEER samples shall also be got tested by the CONTRACTOR in a laboratory approved by ENGINEER at no extra cost to OWNER. However, where material is supplied by OWNER, all testing charges shall be borne by OWNER, 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 ENGINEER. The cost of all tests, sampling, etc. shall be borne by CONTRACTOR. For coarse aggregate crushing value shall be tested.
- 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.

(vi) ***Storing Of Materials***

- All material shall be stored in a manner so as to prevent its deterioration and contamination, which would preclude its use in the works. Requirements of IS: 4082 shall be complied with.
- CONTRACTOR will have to make his own arrangements for the storage of adequate quantity of cement even if cement is supplied by OWNER. 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 OWNER, shall be recovered at issue rate or open market rate which ever 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 ENGINEER. 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 coarse 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.

9.3.2.5 **CONCRETE**

(i) ***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 upto grade M15 shall be NOMINAL MIX CONCRETE whereas all other grades, M20 and above, shall be DESIGN MIX CONCRETE.

(ii) ***Design Mix Concrete***

- Design Mix Concrete are classified in three categories, viz. "Normal Concrete (M)", "Heavy Concrete (H)", "Super Heavy Concrete (SH)". Each class of concrete shall be identified by a prefix and two numbers. Prefix "M" would denote Normal Concrete, prefix "H" would denote heavy concrete and prefix "SH" would denote super heavy concrete. The two numbers e.g. 25 - 40 would denote the crushing strength of cube at 28 days in N/sq.mm and maximum size of the coarse aggregates in millimetres respectively.
- Normal concrete shall have a net dry unit weight of not less than 25 kN/cum, for the finished structure after curing, Heavy concrete shall have a net dry unit weight of not less than 36.30 kN/cum, for the finished structure after curing and special heavy concrete shall have a net dry unit weight of not less than 41 kN/cum for the finished structure after curing.

(iii) ***Mix Design & Testing***

For Design Mix Concrete, the mix shall be designed as per any of four methods given in SP: 23 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 Table 3 of IS: 456.
- The minimum cement content for Design Mix Concrete shall be as per Table 5 of IS: 456 or as given below, whichever is higher.

Grade of Concrete (M)	**Minimum Cement Content in kg/cum. of Concrete**
20	300
25	320
30	360
35	360
40	360
45	400

The minimum cement content stipulated above shall be adopted irrespective of whether the CONTRACTOR achieves the desired strength with less quantity of cement. The CONTRACTOR's quoted rates for concrete shall provide for the above eventuality and nothing extra shall become payable to the CONTRACTOR on this account. Even in the case where the quantity of cement required is higher than that specified above to achieve desired strength based on an approved mix design, nothing extra shall become payable to the CONTRACTOR.

- It shall be CONTRACTOR's sole responsibility to carry out the mix designs at his own cost. He shall furnish to ENGINEER 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 IS: 456.

Grade of Concrete M	**Minimum Compressive Strength N/Sq.mm at 7 days**	**Specified Characteristic compressive strength N/sq.mm at 28 days**
15	10.0	15.0
20	13.5	20.0
25	17.0	25.0
30	20.0	30.0
35	23.5	35.0
40	27.0	40.0
45	30.0	45.0

- A range of slumps recommended for various types of construction, unless otherwise instructed by the ENGINEER, shall be as given below:

Structure/Member	**Slump in millimeters**	
	Maximum	**Minimum**
Reinforced foundation walls and footings	75	25
Plain footings, caissons and substructure walls	75	25
T. G. and massive compressor foundations	50	25
Slabs, Beams and reinforced walls	50	25
Pumps & miscellaneous Equipment Foundations	75	25
Building columns	50	25
Pavements	50	25
Heavy mass construction	50	25
Liquid retaining/ conveying structures	50	25

(NOTE: These values are not meant for pumped concrete placed using slip formed technique.)

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

(iv) Batching & 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 ENGINEER.

- 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. Water- cement ratio specified for use by ENGINEER shall be maintained. 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 ENGINEER. 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 specimen) for testing at 7 days and 14 days.

9.3.2.6 NOMINAL MIX CONCRETE

(i) Mix Design & Testing

Mix Design and preliminary tests are not necessary for Nominal Mix Concrete. However works tests shall be carried out as per IS: 456. Proportions for Nominal Mix Concrete and w/c ratio may be adopted as per Table 9 of IS: 456. However, it will be CONTRACTOR's

sole responsibility to adopt appropriate nominal mix proportions to achieve the specified characteristic strength.

(ii) Batching & Mixing of Concrete

Based on the adopted nominal mixes, aggregates shall be measured by volume. However cement shall be by weight only. Appropriate correction shall be made for bulking of sand after testing.

9.3.2.7 READY MIXED CONCRETE

- All specification as per IS: 4926 – "Specification for ready mixed concrete" shall be used.
- The Contractor shall identify at least two sources of ready mix concrete supplier and get it approved by ENGINEER prior to start of the Works. Any change in the source of the RMC, shall be got approved by the ENGINEER.
- 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.

9.3.2.8 PRECAST CONCRETE

(i) *General*

Precast concrete shall comply with the preceding Sections relating to Concrete as far as they are applicable. Precast concrete blocks shall comply with the requirements and recommendations of BS 6073.

(ii) *Precasting bed*

All precast units shall be cast on, or their shutters supported from a suitably prepared level unyielding paved area.

(iii) Marking

All units shall be suitably marked in a clean and legible manner with a reference number and the date of casting, which information shall be clearly visible when units are stacked. Reinforced precast members shall be clearly marked to indicate the upper face.

(iv) *Formwork*

The formwork shall be either steel or lined with steel, waterproof / laminated board or such other material as directed and approved by the ENGINEER. 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.

(v) *Casting tolerance*

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

(vi) *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 ENGINEER may specify minimum time in which case the CONTRACTOR must comply with the ENGINEER'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 Engineer has specified a minimum striking time or not.

(vii) *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 relevant the 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 ENGINEER 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.

(viii) 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 ENGINEER may direct. It is preferable to have a curing pond for this purpose.

(ix) Precasting records

Complete records shall be maintained of all precast work. Every unit shall have a reference number, date of casting, date of removal from bed and date and position of placing shall be recorded together with corresponding test cube reference number and results.

(x) CONTRACTOR shall submit a method statement to ENGINEER for approval, furnishing details of each stage of operation**.**

9.3.2.9 **FORMWORK**

(i) 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.

(ii) The design and engineering of the formwork as well as its construction shall be the responsibility of CONTRACTOR. However, if so directed by ENGINEER, the drawings and calculations for the design of the formwork shall be submitted to ENGINEER for approval.

(iii) Formwork shall be designed to fulfill 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.

- Capable of withstanding without deflection the worst combination of selfweight, reinforcement and concrete weight, all loads and dynamic effects arising from construction and compacting activities, wind and weather forces.

- Capable of easily striking without shock, disturbance or damage to the concrete.

- Soffit forms capable of imparting a camber if required.

- Soffit forms and supports capable of being left in position if required.

- Capable of being cleaned and/or coated if necessary immediately prior to casting the concrete; design temporary openings where necessary for these purposes and to facilitate the preparation of construction joints.

(iv) 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 ENGINEER. 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.

(v) 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.

(vi) Forms intended for reuse shall be treated with care. Forms that have deteriorated shall not be used. Before reuse, all forms shall be thoroughly scraped, cleaned, nails removed, holes suitably plugged, joints repaired and warped lumber replaced to the satisfaction of ENGINEER. CONTRACTOR shall equip himself with enough quantity of shuttering to allow for wastage so as to complete the job in time.

(vii) 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.

(viii) Wire ties passing through beams, columns and walls shall not be allowed. In their place bolts passing through sleeves may be used. Formwork spacers left in situ shall not impair the desired appearance or durability of the structure by causing spalling, rust staining or allowing the passage of moisture.

(ix) 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.

(x) Where specified or shown on drawings all corners and angles exposed in the finished structure shall have chamfers or fillets of 20 mm x 20 mm size.

(xi) Forms for substructure may be omitted when, in the opinion of ENGINEER, 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 ENGINEER, than that required as per drawing to compensate for irregularities in excavation.

(xii) CONTRACTOR shall provide adequate props of adjustable steel pipes carried down to a

firm bearing without overloading any of the structures.

(xiii) The shuttering for beams and slabs shall be so erected that the side shuttering of beams can be removed without disturbing the bottom shuttering. If the shuttering for a column is erected for the full height of the column, one side shall be built up in sections as placing of concrete proceeds or windows left for placing concrete from the side to limit the drop of concrete to 1.5 m or as directed by ENGINEER. CONTRACTOR shall temporarily and securely fix items to be cast (embedment/inserts) in a manner that will not hinder the striking of forms or permit loss of grout.

(xiv) 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.

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

a) Development of adequate concrete strength;

b) Permissible deflection at time of striking form work;

c) Curing procedure employed - its efficiency and effectiveness;

d) Subsequent surface treatment to be done;

e) Prevention of thermal cracking at re-entrant angles;

f) 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.

(xvi) Under normal circumstances (generally where temperatures are above 20 Deg. C) forms may be struck after expiry of the period given in IS:456 unless directed otherwise by ENGINEER. For Portland Pozzolona/slag cement the stripping time shall be suitably modified as directed by the ENGINEER. 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.

9.3.2.10 REINFORCEMENT FABRICATION AND PLACEMENT

- Reinforcing bars supplied in the form of bent coils shall be straightened cold without damage at no extra cost. No bending shall be done when ambient temperature is below 5 Deg.C. Suitable preheating may be permitted if steel bar bending is to be done at below 0 Deg.C. Bars supplied in bent coils shall be straightened only by machine.

- All bars shall be accurately bent gradually and according to the sizes and shapes shown on the drawings/ schedules or as directed by ENGINEER. Bar bending machines shall be used to achieve desired accuracy.

- Re-bending or straightening incorrectly bent bars shall not be done without approval of ENGINEER.

- Reinforcement shall be accurately fixed and maintained firmly in the correct position by the use of blocks, spacers, chairs, binding wire, etc. to prevent displacement during placing and compaction of concrete. The tied in place reinforcement shall be approved by

ENGINEER prior to concrete placement. Spacers (PVC or Concrete) shall be of such material and design as will be durable, not lead to corrosion of the reinforcement and not cause spalling of the concrete cover.

- Binding wire shall be 16 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 and approved by ENGINEER.
- If permitted by ENGINEER, 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.

9.3.2.11 TOLERANCES

(i) Tolerance for formed and concrete dimensions shall be as per IS: 456 and/ or ACI-117-90, ACI-347 unless specified otherwise.

(ii) Tolerance specified for horizontal or vertical building lines or footings shall not be construed to permit encroachment beyond the legal boundaries.

(iii) Tolerance for top of concrete of equipments and structural steel foundations shall be as under:

a) Where grout thickness is less than or equal to 25mm: +5mm and –10mm.

b) Where grout thickness is more than 25mm: ±15mm.

9.3.2.12 PREPARATION PRIOR TO CONCRETE PLACEMENT

(i) Before concrete is actually placed in position, the inside of the formwork shall be cleaned and mould oil applied, inserts and reinforcement shall be correctly positioned and securely held, necessary openings, pockets, etc. provided.

(ii) All arrangements-formwork, equipment and proposed procedure, shall be approved by ENGINEER. CONTRACTOR shall maintain separate Pour Card for each pour as per the format enclosed.

9.3.2.13 TRANSPORTING, PLACING AND COMPACTING CONCRETE

(i) 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.

(ii) In all cases concrete shall be deposited as nearly as practicable directly in its final position. To avoid segregation, concrete shall not be rehandled or caused to flow. 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 form a height of more than 1.5 m as stipulated in clause 9.13.

(iii) 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.

(iv) While placing concrete the CONTRACTOR shall proceed as specified below and also ensure the following:

a) Continuously between construction joints and predetermined abutments.

b) Without disturbance to forms or reinforcement.

c) Without disturbance to pipes, ducts, fixings and the like to be cast in; ensure that such items are securely fixed. Ensure that concrete cannot enter open ends of pipes and conduits, etc.

d) Without dropping in a manner that could cause segregation or shock.

e) In deep pours only when the concrete and formwork is designed for this purpose and by using suitable chutes or pipes.

f) Do not place if the workability is such that full compaction cannot be achieved.

g) 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.

h) If placed directly onto hardcore or any other porous material, dampen the surface to reduce loss of water from the concrete.

i) Ensure that there is no damage or displacement to sheet membranes.

j) Record the time and location of placing structural concrete.

(v) *Concrete shall normally be compacted in its final position within thirty minutes (Initial setting time) of leaving the mixer. 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. Immersion vibrators shall be inserted vertically at points not more than 450 mm apart and withdrawn slowly till air bubbles cease to come to the surface, leaving no voids. 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.*

(vi) *Concrete may be conveyed and placed by mechanically operated equipment after getting the complete procedure approved by ENGINEER. 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.*

(vii) *CONTRACTOR shall submit a method statement to ENGINEER for approval, furnishing details of pour sequence, thickness of each layer, mixing and conveying equipments proposed etc. preferably with a sketch.*

(viii) *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 ENGINEER. Concrete shall be protected against damage until final acceptance.*

9.3.2.14 PLACING OF CONCRETE BY PUMPING METHODs

(i) *General*

- Placing of concrete by pumping will be as specified or authorised by Engineer 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 Engineer 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. Concrete pumps used shall be able to deliver concrete over a horizontal distance of about 400 m or of about 100 m in a vertical direction, (with intermediate figures for a combination of horizontal and vertical movements). They shall be used for concreting densely reinforced structures, internal structural elements of buildings and for large pours of concrete.
- Placement of normal concrete by pumping will be permitted as specified or authorised by the Engineer. The decision, whether or not to pump any particular mix shall rest entirely with the Engineer and no extra claims for payment on this account will be entertained. The pumping equipment, pipe lines and accessories as well as proportioning of pumpable concrete shall generally confirm to the recommendations of ACI-304.2 (latest revision) – Placing of concrete by pumping method - Proportioning of pumpable mixes gives certain guide lines on concrete mix. However, final selection of mix shall be as instructed by the Engineer.

(ii) *Pumping Equipment*

- Requisite numbers 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 Engineer.
- 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 particular concrete pour, to enable the Engineer to conduct pumpability tests and necessary adjustments for the concrete mix, prior to use of the pumping for placement of concrete.

(iii)*Type Of Pump*

- The selection of the concrete pump shall be done as per the project requirement. The Contractor shall submit the concrete pump data sheets proving the suitability for the given project to ENGINEER for approval.
- The concrete pump shall be selected on its best pumping capacity and the speediness to be achieved in the project. The piston pumps of a net horizontal pumping capacity of 30 m3/hr or 20 m3/hr or 15 m3/hr or 10 m3/hr can be utilised. The combination of various pumps to be used shall be decided by Contractor and shall submit the necessary documents and targeted progress to be achieved in line with the Time Period and Milestones.
- These pumps shall have capacity to pump the concrete upto at a horizontal distance of 400 m and capable of generating a minimum pressure of 80 bar. These parameters shall depend

upon the building sizes, manoeuvrability and other construction features. These pumps shall consist of a receiving hopper with a bolted grill at top of capacity not less than 600 liters. The hoppers shall be provided with hydraulically driven re-mixing blades or other agitating devices to keep the concrete mixed continuously and maintain consistency and uniformity. The pumps shall be provided with two cylinders with max. diameter not less than 150 mm, stroke of about 1200 mm and the number of strokes not exceeding 25 per minute. The outlet valves shall be located on the discharge lines. Type of inlet and outlet valves may vary depending on the manufacturer, but they shall preferably be of sliding-rod-flat-gate type. The piston shall be hydraulically driven. Primary power shall be supplied by gasoline, diesel or electric motor of requisite power rating. Care shall be taken by the Contractor to ensure uninterrupted operation of the pumps during the entire period of concreting by providing adequate standby arrangements. The primary power and pump equipment shall be either truck or trailer mounted, and not skid mounted.

(iv) *Pipelines And Accessories*

- Rigid pipelines

  Concrete transported to the placement area by pumping methods shall be pumped thorough rigid pipes or a combination of rigid and heavy-duty flexible hoses. Rigid pipe shall be made available in minimum 125 mm diameter size. Aluminum alloy lines shall not be used for delivery of concrete. Rigid pipes shall be furnished in such lengths as can be manually handled by a single person.

- Flexible conduit (hose)

  Flexible conduit shall be made of rubber, or spirally wound flexible metal, and plastic flexible conduits generally present greater resistance to movement of concrete and their performance is not the same as that of a rigid pipe and also larger sizes (100 mm to 123 mm) have a tendency to leak. Flexible conduits provided, shall be interchangeable with rigid pipes and their use restricted to curves, difficult placement areas, and as connection to moving cranes or to water borne lines.

- Couplings

  The couplings provided to connect both flexible and rigid pipe sections shall be adequate in strength to withstand handling during erection of the pipe system, misalignments, and poor support along the lines. They should be nominally rated for at least 3.45 Mpa and greater for rising over 30 mtr. The strength and tightness of joints shall be guaranteed. Couplings shall be designed to allow replacement of any pipe section without moving other pipe sections, and shall provide a full internal cross-section with no obstructions or crevices to disrupt the smooth flow of concrete.

- Accessories

  The pump and the distribution system for a particular concreting job shall use the accessories as listed below and they shall be approved by the Engineer.

(a) Rigid and flexible pipes in varying lengths, such as 3, 1.5,0.9,0.6 and 0.3 m lengths.

(b) Curved sections of rigid pipes such as large radius elbows at angles of 90 deg., 45 deg., 22 deg. 30 min. and 11 deg. 15 min.

(c) Swivel joints and rotary distributors.

(d) Pin and gate valves to prevent back-flow in the pipe line.

(e) Switch valve to direct flow into another pipe line.

(f) Connection devices to fill forms the bottom up.

(g) Temporary supports, rollers and other devices for protection of conduit over rock, concrete, reinforcement, steel and forms. Lifting and leashing points.

(h) Extra strong coupling for vertical runs in inaccessible areas.

(i) Transition for connecting different sizes of pipes.

(j) Air vents for downhill pumping

(k) Clean-out equipment

(l) Adequate numbers of separate placement booms of various radius and reach, either stationary steel column mounted or tower crane mast mounted moving on rail tracks, or truck mounted shall be provided by the Contractor to match within concrete placement schedule and pumps. For maximum flexibility of operation the separate placement boom shall be such that they can be easily lifted by the tower cranes provided. Their mounting arrangements shall be quick connecting type and interchangeable between tower crane masts, steel columns and truck mountings etc. The placement booms shall consist of three hinged parts incorporating a concrete pipe line with articulated inserts at boom joints and ending in a flexible hose. The boom shall be remote controlled.

- The pumping plant and the pipe distribution system
- The concrete pumping plant apart from the receiving hopper and the pump shall also be provided with a water pressure valve, connecting pipes with needle valve, cleaning rods, outlets for drainage water and a high pressure pumps for flushing out the concrete in pipe line.
- The shortest way shall be selected in planning the direction of the concrete pipeline, and the number of bends (elbows) shall be as small as possible. Should a change be made of the direction in plan of the pipe lines or a change of their vertical profile, these shall be arranged with easy transitions.
- Before the pipeline is assembled all pipe flanges shall be tested and carefully cleaned, packing rings cleaned or replaced, and the internal surfaces of all pipe section cleaned. Horizontal lengths of concrete pipe lines shall be laid on supports, wooden trestles, scaffolding, staging etc. Vertical and inclined lengths of pipe shall be fastened by clamp irons or stirrups to masts, or to the frame of the structure being erected. It is recommended to replace vertical sections of the pipeline by inclined sections where possible. Sharp turns and bends at an angle of 90 deg. shall be avoided. Pipes shall be supported in such a manner that they do not disturb the forms during concreting.

- A vertical section of the concrete pipeline shall not be arranged closer than 8 to 9 m from the concrete pump. Before a vertical section a valve shall normally be placed, to prevent back flow of the concrete when the pump stops or when the pipe is cleaned or replaced. When pumping vertically through the placer boom, a thrust block shall be provided at the base of the vertical riser to resist the forces in the pipeline due to the pumping of concrete.
- When pumping downwards, 15 m or more, it is desirable to provide an air release valve at the middle of the top bend.

(v) *Line resistance and lubrication*

- When concrete is pumped through a straight section of a pipe or hose, it moves as a

cylinder riding on a thin lubricant film of a grout or mortar. At changes in direction or cross-section some re-mixing occurs. In all cases at the start of pumping operation lubricating mortar is required, and this shall be a properly designed mortar of cement-sand grout (1:1) or a batch of the regular concrete with the coarse aggregate omitted. Except for a small portion of this mortar which may be used for bedding at the construction joint, it shall be wasted and not used in the concrete placement. It can be assumed that about 0.35 cu. m of mortar will lubricate a 125 mm diameter horizontal pipeline of about 300 m length and the lubrication shall be maintained as long as the pumping continues. For vertical or smaller lines less mortar will be required. The mortar shall have the same cement content as that of the concrete. The water cement ratio shall be determined by the placing condition and finally decided by the Engineer. In order to ensure that only minimum quantity of grout mortar is used to lubricate the pipeline, a rubber sponge ball shall be allowed to pass through the pipeline immediately before the first batch of grout mortar is pumped. This rubber ball shall be pushed by the following mortar along the pipeline slowly and allowed to emerge at the open end. The cost of the lubricating mortar to be used, shall be deemed to have been included in the general rate structure for works in the schedule of items and nothing extra shall be payable.

- It shall be taken into account when planning the pipeline that, in straight horizontal and vertical section of pipe and at bends the resistance to the movements of concrete differ. For convenience in calculating the resistance of a concrete pipeline experimental co-efficient of equivalent length shall be used by means of which the equivalent length of a horizontal concrete pipeline is to be obtained. In absence of the pump manufacturer's data, equivalent lengths of concrete pipeline as indicated in Table below may be used.

Table –EQUIVALENT LENGTH OF CONCRETE PIPELINES

Characteristics of a length of concrete pipeline	Equivalent length of horizontal concrete pipeline in meter
Bend in pipeline at an angle of 90 deg.	12
Bend in pipeline at an angle of 45 deg.	7
Bend in pipeline at an angle of 22 deg. 30 min.	4
1 m of vertical concrete pipeline	8

The equivalent length of the concrete pipeline must be less than or equal to the range of feed in horizontal direction as specified by the pump manufacturer for the same rate of pumping. To obtain the least line resistance, the layout of the pipeline system shall contain a minimum number of bends and preferably with no change in pipe size. If two sizes of pipes are required to be used, the smaller diameter shall be used at the pump end and the larger at the discharge end. The contractor shall exercise care in handling of the pipeline, during assembly, cleaning and dismantling so as to lower the line resistance by preventing the formation of rough surfaces, dents in pipe section and crevices in couplings. If any pipe, bend, coupling and other accessories are considered to be defective or damaged by the Engineer, the same shall not be used in the concrete pipeline till such time the defect has been removed and the damage repaired to the entire satisfaction of the Engineer. Qualified chemical admixtures shall be used effectively to get workable concrete.

(vi) Proportioning pumpable concrete

- **Basic Consideration**

a) 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 effected by the equipment and the operator, with the control of all of the ingredients in the mixture, the batching and mixing operations, and the knowledge and experience of all the personnel from beginning to end.

b) Concrete mixes for pumping shall be "plastic" at all times. Stiff mixes shall not be used for pumping as they do not pump well. Particular attention shall be given to the mortar (cement, sand and water) and the amounts and sizes of coarse aggregates.

- **Normal Weight Aggregates**

Coarse normal weight aggregates

The maximum size of angular coarse aggregate shall be limited to one-third of the smallest inside diameter of the hose or pipe based on simple geometry of cubical shape aggregates. For well-rounded aggregates, the maximum size shall be limited to 40% of the pipe or hose diameter. Adequate provisions shall be made to eliminate over size particles in the concrete by screening or by careful selection of aggregate. Gradation of sizes of coarse aggregates shall correspond to Grades A and B of Table below and shall meet IS:2386 requirements. If required certain fractional sizes shall be combined and blended to produce the required gradation. Greater emphasis shall be laid on uniformity of gradation through out the entire job.

The maximum size of the coarse aggregate has a significant effect on the volume or amount of coarse aggregate that may be effectively used in a mix. As will be seen from Table below the quantity of coarse aggregate must be substantially reduced as the maximum size become smaller. Mixes consisting of too large a portion of coarse aggregate with less cement shall be avoided.

Table: Grading Requirement of Coarse Aggregates for Pumped Concrete

Grade - A (Maximum Size 40 mm) Grade –B (Maximum Size 20 mm)

Sieve Size	Percent Passing By weight	Sieve Size	Percent passing by weight
50 mm	100	25 mm	100
40 mm	95 to 100	20 mm	90 to 100
20 mm	35 to 70	12.5 mm	20 to 55
10 mm	10 to 30	10 mm	0 to 15
4.75 mm	0 to 5	4.75 mm	0 to 5

Table: Volume of coarse Aggregate per unit of volume of concrete.

Max. size	Volume of Dry-rodded Coarse Aggregate per Unit volume of aggregates of concrete for different fineness modulli of sand			
	FMS =2.40	FMS =2.60	FMS =2.80	FMS =3.00
10	0.50	0.48	0.46	0.44
12.5	0.59	0.57	0.55	0.53
20	0.66	0.64	0.62	0.60
25	0.71	0.69	0.67	0.65
40	0.76	0.74	0.72	0.70
50	0.78	0.76	0.74	0.72

- Note :
- Volume are based on aggregates in dry-rodded condition.
- These volumes are selected from empirical relationships to produce concrete with a degree of workability suitable for usual reinforced construction. When placement is to by pump, they shall be reduced by about 10 percent.
- FMS = Fineness Modulus of Sand.

Fine normal weight aggregate

Fine aggregate shall consist of natural sand, manufactured sand or a combination thereof and shall be graded within the following limits.

Sieve Size	Percent passing by weight
9.5 mm	100
4.75 mm	95 to 100
2.36 mm	80 to 100
1.18 mm	50 to 85
600 microns	25 to 60
300 microns	10 to 30
150 microns	2 to 10

Fine aggregates shall conform to the requirements of IS:2386. Particular attention shall be given to those passing through finer screen sizes. For small line system (less than 150 mm) 15 to 30 percent shall pass 300 micron sieve and 5 to 10 percent shall pass 150 micron sieve. Sands which are deficient in either of these two sizes shall be blended with selected finer sands or inert material such as quarry dust to produce these desired percentages.

The fineness modulus of sand meeting the above grading limits will fall between 2.13 and 3.37 with the median being 2.75. Pumpability of mixes will generally improve with a decrease in the fineness modulus value or in other words with the use of finer sands. Sands

having a fineness modulus between 2.40 and 3.00 are generally satisfactory provided that the percentages passing 300 micron and 150 micron sieves meet the previously stated requirements. It shall also be emphasized that for uniformity, the fineness modulus of the sand shall not vary more than 0.20 from the average value used in proportioning.

Table is suggested as a guide to determine the amounts of coarse aggregate to be combined with sand of different fineness modulus. The foot note of Table –10 require a reduction in the volume of coarse aggregate by 10 percent for pumping. This margin shall be considered as a safety margin for variations in sand gradation to reduce pumping pressure. Under conditions of good materials control and uncomplicated line systems, this reduction may not be required.

Although in practice it may not be possible to duplicate this recommended sand gradation exactly, sands having a gradation closer to the upper limit (fine sand) are more desirable for pumping than those near the lower limit (coarse sand). The fineness modulus of sand according to the recommended curve is 2.68 and the gradation meets all the requirements stated earlier.

(vii) *Water and Slump*

- Water requirements and slump control for pumpable normal weight concrete are interrelated and extremely important considerations. The mixing water requirements for a particular mix shall be determined by the Engineer and modified to suit the fineness of sands, quality of admixtures, additives, cement replacements or other special materials being used in the concrete.
- The Contractor shall establish the optimum slump jointly with the Engineer for a pumpable mix at the discharge hose end and shall maintain control of that particular slump throughout the course of a job. Excess water shall not be added in the receiving hopper to make the concrete mix pumpable, instead attempt shall be made to obtain 'truly plastic mix' by proper proportioning.
- Slump of concrete may undergo change between initial mixing and final placement. If the slump at the discharge hose end are to be maintained within specified limits, it will be necessary for the concrete to enter the pump at a higher slump to give the required mobility during transport. Slump adjustments by re-proportioning of the constituents as may be required shall be carried out by the Contractor jointly in consultation with the Engineer for every type of mix and for every new placement and set up of pump and pipelines.

(viii) *Cement Content*

- The determination of the cement content for a normal weight pump mix shall follow the same basic principles used for conventionally placed concrete. The water cement ratio shall be established by the Engineer on the basis of exposure conditions, strength requirements or minimum cement consumption, whichever governs. However, because of slightly higher ranges of slump and ratios of fine to coarse aggregates, the pump mix may require an increase in the amount of cement above those pumpable concrete mass. The total quantity of fines passing through the 300 micron sieve including cement, fine sand, stone dust etc. shall be in the range of 380 to 450 kg/cu.m of concrete.
- Cement content in case of M-50 shall be maximum of 1305 kg/m3, and shall be a mix with high range of workability i.e. 175 mm +/- 25 mm. All the contents shall be mixed based on the mix design & trial studies.

- While establishing the cement content for normal weight trial mixes, it will be necessary to take into account the capabilities of the particular pump and its operator for over strength proportioning in the laboratory to provide for field variations.
- In case of pumping difficulties, it is desirable and economical to correct any deficiencies in the aggregates, especially in the sand instead of using extra quantities of sand. With well graded coarse and fine aggregates properly combined, the cement requirement for pumpable mixes shall closely resemble to those used in conventially placed concrete.

(ix)*Admixtures*

The use of poor aggregate grading or aggregate with continuous change in overall grading of the 'combinations' during concreting operation will make special admixtures quite useful in overcoming the main difficulty like blockage in pumping. These admixtures shall be incorporated in pumpable concrete to aim the following.

- Increase in the range of mix designs which may be successfully pumped using water reducing admixtures/Super plasticizers with the approval of the Engineer.
- Reducing the risk of pipeline blockages by preventing segregation of concrete mix.
- To have satisfactory/specified performance both in fresh and hardened state.

Any admixture that increases workability in normal weight concrete may usually improve pumpability. The choice of type of admixture and the advantage gained from its use in concrete to be pumped will depend on the characteristics of the pump mix and will be finally decided by the Engineer in consultation with the admixture manufacturer.

For improvement of pump ability the following admixtures are generally recommended. Such admixtures used shall be conform to ASTM C-494/IS 9103.

a) **Water Reducing Admixtures/Super Plasticizers**

These cause reduction in water requirements at constant slump or an increase in slump at constant water-cement ratio. They can be designed to have no apparent effect on setting time, or alternately to achieve varying degrees of acceleration or retardation in rate of hardening of the mixture. Most water reducing admixtures increase the pumpabillity of the concrete mix through plasticising action.

b) **Air Entraining Admixtures**

Air entrained concrete is considerably plastic and more workable than non air entrained concrete. It can be pumped with less coarse aggregate segregation and has less tendency for concrete to bleed. Start-up after shut down is also generally easier due to reduced bleeding. For pumped concrete these limits shall be obtained at the point of placement in the structure. To compensate for air content loss in the air entrained concrete higher entrainment of air may be required at the batching plant. The required adjustment of admixture dose shall be carried out by the Engineer after carrying out necessary air loss tests. An air content in the range of 3 to 5 % shall be preferred as higher ranges reduces the delivery capacity of pump systems due to increased compressibility of the concrete and also reduces strength of concrete.

If air-entraining plasticizer is used, typically 13 % minimum water reduction is possible. Therefore, strength loss due to air entrainment will be compensated by using such air-entraining plasticizer.

c) **Finely Divided Mineral Admixtures**

Contractor, if specifically approved by the engineer, can use mineral admixture. In concrete mixtures, deficient in fines, the addition of a finely divided inert mineral admixture generally improves workability, pump ability, reduces the amount of bleeding and increases the strength. The effect on strength depends on the type of mineral admixture used, conditions under which the concrete is cured, and the amount of admixture used. Water soluble polymers obtained from cellulose derivations may also be used as an admixture with a small dose of 60 to 150 gms/cu.m. to increase viscosity of the mixing water and reduce the frictional resistance to flow and bleeding in the pipe system.

(x) Trial Mixes

The trial mixes for pumping shall be prepared and tested in the Site laboratory by contractor in accordance with clause (xi) (xi) of this specification. The ingredients, particularly the coarse and fine aggregates shall also be checked for the conformance to the desired properties described, by the contractor. Table may be used to select the volume of coarse aggregate per cu. m. of concrete. In using this table it is recommended that the highest probable fineness modulus of sand be used rather than the average fineness modulus to ensure consistent performance during pumping. For additional plasticity, 10 % reduction in coarse aggregate quantities shall be considered. Experience with the use of local aggregate and their uniformity shall also be considered in the proportioning concepts.

(xi) Mix Design For Pumpable Concrete

Taking the above factors into account, the concrete shall first be designed for normal placement conditions and then modified as necessary to suit pumping. The following procedure shall be adopted:

a) Design the mix for specified characteristic strength and workability.

b) Check and ensure combined grading of aggregates i.e. as uniform grading as possible. This requirement is vital as gaps or partial gaps are the basic reasons for poor water retention property and segregation under pressure.

c) Determine the optimum sand content for the required workability and increase sand content by reducing volume of coarse aggregate per unit volume of concrete by about 10 % as a degree of protection against under sanding due to batch variations.

d) Recheck the minimum cement content for durability.

e) Examine the total fines content i.e. cement and fine aggregates passing through 300 micron sieve and readjust the mix, if necessary. A very rich mix with fine sand will be as problematic as a coarse sand with lean mix.

f) Re-appraise the grading if the particle shape of any particular fraction is such as may cause excessive voids. Re-adjust as required, if necessary examining the void ratio of various combinations, using void meter to achieve minimum voids at the expense of ‘sufficient fines’ content.

g) If dissatisfied with (a) to (f) as above, consider what remedial action may be taken to overcome the troublesome factor. For example, the following two situations may occur :

h) If the sand has more coarser fraction it is worth considering the addition of a proportion of finer sand, or alternately if the sand has more finer fraction, the addition of coarse fraction may be considered. Addition or reduction of cement may help, but the correct solution is to overcome the gap in overall grading as stated above.

i) In a 20 mm aggregate max. size, if there is an excess of 10 to 4.75 mm fraction, and this fraction is flaky with unduly large surface area, either increase the sand content to reduce the possibility of segregation and to reduce the inter-practical stresses, or (better) re-grade using single sized aggregates.

j) At the trial mix stage small variations can be made preferably in the light of the pressures registered and observed performances through the pump. In certain cases admixtures may be economically and beneficially used to improve or eliminate circumstances that cannot readily be overcome by other means.

(xii) 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 Engineer. Concrete used in such tests shall not be used in the actual construction, unless specifically permitted by the Engineer.

Following parameter shall be established by pumpability trials:

a) Insitu compressive & split tensile strength of concrete by

b) Curing the sample at Site by sprinkling water.

c) Curing the sample at Laboratory in curing tanks.

d) Wet sieve analysis of concrete to ensure that proportions of ingredients before and after pumping are same.

(xiii) Field Practices

a) 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 Engineer 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.

b) Direct communications 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.

c) 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.

d) 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 has to be removed.

e) 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.

f) 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.

g) 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 particular size, or excessively wet or dry will be rejected by the pump either by blockage or by hard pumping involving excessive pressures.

h) 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.

i) 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.

(xiv) Quality Control

a) 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.

b) 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 Engineer jointly, as frequently as the Engineer desires to determine, if any change in the slump air content, and other significant mix characteristics occur take necessary corrective actions.

c) 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.

(xv) All the crew engaged in each of the concrete activities shall demonstrate in the presence of the Engineer, their skills and capabilities to produce the final product as specified.

9.3.2.15 MASS CONCRETE WORKS

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

9.3.2.16 LACING TEMPERATURE OF CONCRETE

(i) *Placing temperature of concrete should be maintained as specified in Bill of Quantities or as directed by ENGINEER, to avoid shrinkage cracking*

(ii) *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 ENGINEER. 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 –2oc. 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.*

(iii) *Ice when used as replacement for a portion or all the mixing water shall be produced from water which meets the requirements of clause 14.2.4 (iii). Ice when used shall be in flakes of size 3mm or below or crushed condition and the crushed ice shall be such as to pass completely, 10mm sieve.*

9.3.2.17 CURING

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

a) Premature drying out, particularly by solar radiation and wind;
b) leaching out by rain and flowing water;
c) rapid cooling during the first few days after placing;
d) high internal thermal gradients;
e) low temperature or frost;
f) vibration and impact which may disrupt the concrete and interfere with its bond to the reinforcement.

(ii) *All concrete, unless directed otherwise by ENGINEER, shall be cured by use of continuous sprays or ponded water or continuously saturated coverings of sacking, canvas, hessian or other absorbent material for the period of complete hydration with a minimum of 7 days. The quality of curing water shall be the same as that used for mixing.*

(iii) *Where a curing membrane is directed to be used by the ENGINEER, 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 ENGINEER before use and shall be applied with*

spraying equipment capable of a smooth, even textured coat.

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

(v) *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.*

(vi) *Curing arrangement shall be subjected to ENGINEER's approval.*

9.3.2.18 CONSTRUCTION JOINTS AND KEYS

(i) Construction joints (location and type) shall be as shown on the drawing or as approved by ENGINEER. 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 ENGINEER.

(ii) Dowels for concrete work, not likely to be taken up in the near future, shall be coated with cement slurry and encased in lean concrete as indicated on the drawings or as directed by ENGINEER.

(iii) 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.

(iv) 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.

(v) 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.

9.3.2.19 FOUNDATION BEDDING

(i) 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 ENGINEER. The surfaces of absorptive soils shall be moistened.

(ii) 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.

9.3.2.20 BASE CONCRETE

(i) The thickness and grade of concrete and reinforcement shall be as specified in the item of work.

(ii) Before placing the blinding concrete of 1:4:8 mix, 50/75mm thick as per the item of work, the sub-base of rubble packing shall be properly wetted and rammed. Concrete for the base shall then be deposited between the forms, thoroughly tamped and the surface finished level with the top edges of the forms. Two or three hours after the concrete has been laid in position, the surface shall be roughened using steel wire brush to remove any scum or laitance and swept clean so that the coarse aggregates are exposed. The surface of the base concrete shall be left rough to provide adequate bond for the floor finish to be provided later.

(iii) Measurement

Measurement shall be in sq.m correct to two places of decimal. This work could be either separate or combined along with the floor finish as indicated in the respective items of work.

9.3.2.21 FINISHES

(i) General

The formwork for concrete works shall be such as to give the finish as specified. The CONTRACTOR shall make good as directed any unavoidable defects consistent with the type of concrete and finish specified; defects due to bad workmanship (e.g. damaged or misaligned forms, defective or poorly compacted concrete) will not be accepted. CONTRACTOR shall construct the formwork using the correct materials and to meet the requirements of the design and to produce finished concrete to required dimensions, plumbs, planes and finishes.

(ii) Integral Cement Finish on Concrete Floor

In all cases where integral cement finish on a concrete floor has been specified, the top layer of concrete shall be screeded off to proper level and tamped with tamper having conical projections so that the aggregate shall be forced below the surface. The surface shall be finished with a wooden float and a trowel with pressure. The finish shall be continued till the concrete reaches its initial set. No cement or cement mortar finish shall be provided on the surface. Where specified, a floor hardener of appropriate thickness as approved by the ENGINEER shall be supplied and used as recommended by the manufacturer.

9.3.2.22 REPAIR AND REPLACEMENT OF UNSATISFACTORY CONCRETE

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

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

(iii) Rejected concrete shall be removed and replaced by CONTRACTOR at no additional cost to OWNER.

(iv) For patching of defective areas all loose materials shall be removed and the surface shall be prepared as directed by the ENGINEER.

(v) Bonding between hardened and fresh concrete shall be done either by placing cement mortar or by applying epoxy. The decision of the ENGINEER 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 ENGINEER.

(vi) CONTRACTOR shall submit a method statement for such repairs to ENGINEER for approval.

9.3.2.23 VACUUM DEWATERING OF SLABS

Where specified floor slabs, either on grade or suspended, shall be finished by vacuum dewatering including all operations such as poker vibration, surface vibration, vacuum processing, floating and trowelling as per equipment manufacturer's recommendation. The equipment to be used shall be subject to ENGINEER'S approval.

9.3.2.24 HOT WEATHER REQUIREMENT

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

(ii) Adequate provisions shall be made to lower concrete temperatures which shall not exceed 40 °C at the time of placement of fresh concrete.

(iii) Where directed by ENGINEER, CONTRACTOR shall spray non-wax based curing compound on unformed concrete surface at no extra costs.

9.3.2.25 COLD WEATHER REQUIRMENTS

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

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

(iii) 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.

9.3.2.26 LIQUID RETAINING STRUCTURES

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

(ii) The minimum level of surface finish for liquid retaining structures shall be of smooth type. All such structures shall be hydro-tested.

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

(iv) Any temporary arrangements that may have to be made to ensure stability of the structures shall also be considered to have been taken into account while quoting the rates.

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

9.3.2.27 OPTIONAL TESTS

(i) If ENGINEER 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 ENGINEER, as per relevant IS Codes. OWNER shall pay only for the testing of material supplied by the OWNER, 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 OWNER.

(ii) 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, ENGINEER 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 OWNER. Alternately ENGINEER also reserves the right to ask the CONTRACTOR to dismantle and re-do such unacceptable work at the cost of CONTRACTOR.

(iii) If the structure is certified by ENGINEER as having failed, the cost of the test and subsequent dismantling/reconstruction shall be borne by CONTRACTOR.

(iv) The quoted unit rates/prices of concrete shall deemed to provide for all tests mentioned above.

9.3.2.28 **GROUTING** : Removed Section

9.3.2.29 QUALITY CONTROL

(i) If CONTRACTOR has his own QC formats he may adopt them subjected to such modifications considered necessary by ENGINEER.

(ii) In either case CONTRACTOR shall submit his detailed Quality Assurance Plan along with the bid. This would be reviewed, appropriately modified and approved by ENGINEER after the award of contract.

9.3.2.30 INSPECTION

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

9.3.2.31 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.

9.3.2.32 ACCEPTANCE CRITERIA

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

a) properties of constituent materials;
b) characteristic compressive strength;
c) specified mix proportions;
d) minimum cement content;
e) maximum free-water/cement ratio;
f) workability;
g) temperature of fresh concrete;
h) density of fully compacted concrete;
i) cover to embedded steel;
j) curing;
k) tolerances in dimensions;
l) tolerances in levels;
m) durability;
n) surface finishes;
o) special requirements such as :

- ❖ *water tightness*
- ❖ resistance to aggressive chemicals
- ❖ resistance to freezing and thawing
- ❖ very high strength
- ❖ improved fire resistance
- ❖ wear resistance
- ❖ resistance to early thermal cracking

(ii) ENGINEER's decision as to the acceptability or otherwise of any concrete work shall be final and binding on the CONTRACTOR.

(iii) For work not accepted, ENGINEER may review and decide whether remedial measures

are feasible so as to render the work acceptable. ENGINEER 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 OWNER for executing remedial measures.

9.3.2.33 MODE OF MEASUREMENT AND PAYMENT

(i) The unit rate for concrete work under various categories shall be all inclusive and no claims for extra payment on account 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.

(ii) Payments for concrete will be made on the basis of unit rates quoted for the respective items in the Schedule of Quantities. No deduction in the concrete quantity will be made for reinforcements, inserts etc. and opening less than 0.100 Sq.m, in areas where concrete is measured in sq.m. and 0.010 cum. where concrete is measured in cubic metres. Where no such deduction for concrete is made, payment for shuttering work provided for such holes, pockets, etc. will not be made. Similarly, the unit rates for concrete work shall be inclusive or exclusive of shuttering as provided for in the Schedule of Quantities.

(iii) 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 upto the underside of slabs.

(iv) 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.

(v) Only the actual quantity of steel embedded in concrete including laps as shown on drawings or as approved by ENGINEER 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.

(vi) 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, deshuttering etc. complete. Only the net area of concrete formed (shuttered) shall be measured for payment.

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

CONCRETE POUR CARD

(i) CLIENT: DATE: POUR NO:

(ii) PROJECT: STRUCTURE:

(iii) CONTRACTOR:

(iv) MAX AGGREGATE SIZE: mm SLUMP: mm

(v) DRG. NO:

(vi) START/COMPLETION TIME:

(vii) CONCETE GRADE/QUANTITY: M / M^3 MIXING TIME :

SR.	ITEM		CONTRACTOR 'S REP. SIGNATURE	ENGINEER'S SIGNATURE	REMARKS
1.	BEFORE CONCRETING	CENTERLINES CHECKED			
2.		FORMWORK AND STAGING CHECKED			
3.		REINFORCEMENT CHECKED			
4.		COVER TO REINFORCEMENT CHECKED			
5.		VERFIED TEST CERTIFICATE FOR CEMENT/ STELL	YES/NO	YES/NO	
6.		ADEQUENCY OF MATERIALS/ EQUIPMENT FOR POUR	YES/NO	YES/NO	
7.		EMBEDED PARTS CHECKED (LOCATION & PLUMB) — CIVIL			
		MECHANICAL			
		ELECTRICAL			
	POUR AUTHORISED SITE ENGINEER				
8.	SOFFIT(S) AND POUR TOP (T) LEVELS CHECKED BEFORE (B) AND AFTER (A) FROM REMOVAL (ONLY OF BEAMS OF OVER 10 M SPAN & IMPORTANT STRUCTURES LIKE T.G. ETC.)		S(B) T(B) S(A) T(A)		
9.	CONSTRUCTION JOINT LOCATION & TIME (IF NOT AS PER DRAWING)				
10.	CEMENT CONSUMPTION IN kg.				
11.	NUMBER OF CUBES AND IDENTIFICATION MARK				
12.	TEST CUBE RESULTS (7 DAYS/ 28 DAYS)		/ / /		
13.	CONCRETE CONDITION ON FORM REMOVAL		V.GOOD/ GOOD/ FAIR/ POOR		
	SITE-IN-CHARGE				

NOTES:

(a) EACH ITEM TO BE CHECKED & SIGNED BY THE RESPECTIVE ENGINEERS.

(b) ITEMS 8 TO 13 (BOTH INCLUSIVE) TO BE FILLED BY ONLY ENGINEER.

(c) EACH POUR TO HAVE SEPARATE CARDS, IN TRIPILCATE ONE EACH FOR PHEO, ENGINEER & SITE OFFICE. FORM 279.

(d) UNDER REMARKS INDICATE DEVIATIONS FROM DWGS & SPECIFICATIONS, CONGESTION IN REINFORCEMENT IF ANY, UNUSUAL OCCURENCES, SUCH AS FAILURE OF EQUIPMENT'S, SINKING OF SUPPORTS/PROPS, HEAVY RAINS AFFECTING CONCRETEING, POOR COMPACTION, IMPROPER CURING, OTHER DEFICIENCIES, OBSERVATION ETC.

9.3.3 BUILDING WORKS

9.4.2.1 **SCOPE**

This specification covers the general requirements for building works comprising brick and stone masonry, flooring, doors, windows, ventilators, wood/aluminium work, water- proofing, plastering, painting and such other related works forming a part of this job, which may be required to be carried out though not specifically mentioned above. The works under this specification shall consist of furnishing of all tools, plants, labour, materials, and everything necessary for carrying out the works.

9.4.2.2 **APPLICABLE CODES AND SPECIFICATIONS**

The following codes, standards and specifications are made a part of this specification. All standards, specifications, codes of practice referred to herein shall be the latest version on the date of offer made by the Bidder.

In case of discrepancy between this specification and those referred to herein, this specification shall govern.

IS:110 - ly mixed paint, brushing, grey filler, for enamels for use over primers.

IS:280 - ification for mild steel wire for general engineering purposes.

IS:287 - ommendations for maximum permissible moisture content of timber used for different purposes.

IS:337 - ish, finishing interior.

IS:345 - d filter transparent liquid

IS:348 - ch polish.

IS:383 - ification for coarse and fine aggregates from natural sources for concrete.

IS:412 - nded metal steel sheets for general purposes.

IS:419 - ification for putty for use on window frames.

IS:1306 - e filler for colour coats.

IS:1308 - emper, oil emulsion, colour as required.

IS:702 - ification for industrial bitumen.

IS:710 - ification for marine plywood.

IS:712 - ification for building limes.

IS:733 - ught aluminium and aluminium alloys, bars, rods and sections for general engineering purposes.

IS:1003 - ification for timber panelled and glazed shutters (Part 1)

IS:1003 - - (Part 2)

IS:1038 - ification for steel doors, windows and ventilators.

IS:1077 - ification for common burnt clay building bricks.

IS:1081 - e of practice for fixing and glazing of metal (steel & aluminium) doors, windows and ventilators.

IS:1124 - hod of test for determination of water absorption, apparent specific gravity and porosity of natural building stones.

IS:1200 - hod of measurement of building and civil engineering works.

IS:1203 - rmination of penetration of bitumen.

IS:1237 - ification for cement concrete flooring tiles.

IS:1322 - men felts for water- proofing and damp proofing.

IS:1346 - e of practice for water-proofing of roofs with bitumen felts.

IS:1361 - ification for steel windows for industrial buildings.

IS:1397 - ification for Kraft paper.

IS:1443 - e of practice for laying and finishing of cement concrete flooring tiles.

IS:15130 - ification for sand for plaster.

IS:1580 - ification for bituminous compounds for water-proofing and caulking purposes.

IS:1597 - e of practice for construction of stone masonry : Part 1 Rubble stone masonry.

IS:1658 - ification for fibre hardboards

IS:1659 - ification for block boards.

IS:1661 - e of practice for application of cement and cement-lime plaster finishes.

IS:1834 - ification for hot applied sealing compound for joint in concrete.

IS:1838 - ification for preformed fillers for expansion joint in concrete

pavements and structures (non extruding and resilient type) : Part 1 Bitumen impregnated fibre.

IS:1948 - ification for aluminium doors, windows and ventilators.

IS:1949 - ification for aluminium windows for industrial buildings.

IS:2074 - ly mixed paint, air drying, red oxide-zinc chrome, priming.

IS:2114 - e of practice for laying in-situ terrazzo floor finish.

IS:2116 - ification for sand for masonry mortars.

IS:2185 - ification for concrete masonry units (Parts 1,2 & 3).

IS:2202 - ification for wooden flush door shutters(Solid core type): Part 1.

IS:2202 - - Part 2.

IS:2212 - e of practice for brickwork.

IS:2250 - e of practice for preparation and use of masonry mortars.

IS:2338 - e of practice for finishing of wood and wood based materials (Part 1).

IS:2338 - - (Part 2)

IS:2339 - ninium paint for general purposes, in dual container.

IS:2395 - e of practice for painting Concrete, masonry and plaster surfaces (Part 1).

IS:2395 - - Part 2

IS:2402 - e of practice for external rendered finishes.

IS:2571 - e of practice for laying in-situ cement concrete flooring.

IS:2572 - e of practice for construction of hollow concrete block masonry.

IS:2645 - ification of integral cement water-proofing compounds.

IS:2690 - ification for burnt clay flat terracing tiles : Part 1 Machine made.

IS:2691 - ification for burnt clay facing bricks.

IS:2750 - ification for steel scaffoldings.

IS:2835 - transparent sheet glass.

IS:2932 - ification for enamel, synthetic, exterior type (a) undercoating, (b) finishing.

IS:3036 - e of practice for laying lime concrete for a water-proofed roof finish.

IS:3067 - e of practice of general design details and preparatory work for damp-proofing and water-proofing of buildings.

IS:3068 - ification for broken brick (burnt clay) coarse aggregates for use in lime concrete.

IS:3384 - ification for bitumen primer for use in water-proofing and damp-proofing.

IS:3461 - ification for PVC-asbestos floor tiles.

IS:3462 - ification for un-backed flexible PVC flooring.

IS:3495 - iod of test for burnt clay building bricks : Part 1 to 4.

IS:3536E - ification for ready mixed paint, brushing, wood primer, pink.

IS:3564 - ification for door closers (hydraulically regulated.)

IS:3696 - ty code of scaffolds and ladders (Part 1).

IS:3696 - - (Part 2).

IS:4020 - iods of test for wooden flush door (Part 1 to 16).

IS:4021 - ification for timber door, window and ventilator frames.

IS:4351 - ification for steel door frames

IS:4443 - e of practice for use of resin type chemical resistant mortars.

IS:4457 - ification for ceramic unglazed vitreous acid resisting tile.

IS:4631 - e of practice for laying epoxy resin floor toppings.

IS:4832 - ification for chemical resistant mortars (Part 2).

IS:4860 - ification for acid resistant bricks.

IS:4948 - ification for welded steel wire fabric for general use.

IS:5318 - e of practice for laying of flexible PVC sheet and tile flooring.

IS:5410 - ent paint, colour as required.

IS:5411 - ification for plastic emulsion paint (Part 1).

IS:54112 - - (Part 2)

IS:5437 - d and figured glass.

IS:5491 - e of practice for laying of in-situ granolithic concrete floor topping,

IS:6041 - e of practice for construction of autoclaved cellular concrete block masonry.

IS:60130 - e of practice for construction of light weight concrete block masonry.

IS:6248 - ification for metal rolling shutters and rolling grilles.

IS:7193 - ification for glass fibre base coal tar pitch and bitumen felts.

IS:7452 - ification for hot rolled steel sections for doors, windows and ventilators.

IS:80130 - ification for white portland cement.

IS:8112 - ification for 43 grade ordinary Portland cement.

IS:8543 - ıods of Testing Plastics (Part 4 / Section 1)

IS:9197 - ification for epoxy resin, hardeners and epoxy resin composites for floor topping.

IS:9766 - ible PVC compounds – specification

IS:9862 - ification for ready mixed paint, brushing, bituminous, black, lead-free, acid, alkali, water and chlorine resisting.

IS:12200 - e of practice for provision of water-stops at transverse contraction joints in masonry and concrete dams.

IS:12830 - ber based adhesive for fixing PVC tiles to cement.

IS:13756 - pressed ceramic tiles with low water absorption of E≤3% group B1- specification.

IS:13360 (Part 5-sec-11) - Method of testing plastics Part-5-Mechanical properties. Sec-11- Determination of hardness

IS:15058 - water stops at transverse contraction joints – specification.

9.4.2.3 BRICKWORK

(i) Materials

- Bricks used in the works shall conform to the requirements laid down in IS:1077. The class of the bricks shall be as specifically indicated in the respective items of work.
- Standard modular size of common bricks shall be 190mm x 90mm x 90mm as per IS: 1077. The nominal thickness of one brick and half brick walls using modular bricks shall be considered as 200 mm and 100 mm respectively. In the event of use of non-modular bricks, standard size shall be 230mm x ll0mm x 70mm. The nominal thickness of one brick and half brick walls using non-modular bricks shall be considered as 230 mm and 115 mm respectively. The dimensional tolerances of modular and non-modular sized bricks over the standard sizes shall be as per IS 1077.
- Bricks shall be sound, hard, homogenous in texture, well burnt in kiln without being vitrified, hand/machine moulded, deep red, cherry or copper coloured, of regular shape and size & shall have sharp and square edges with smooth rectangular faces. The bricks shall be free from pores, cracks, flaws and nodules of free lime. Hand moulded bricks shall be moulded with a frog and those made by extrusion process may not be provided with a frog. Bricks shall give a clear ringing sound when struck and shall have a minimum crushing strength of 5N/sq.mm unless otherwise specified in the item.
- The average water absorption shall not be more than 20 percent by weight upto class 12.5 and 15 percent by weight for higher classes. Bricks which do not conform to this requirement shall be rejected. Over or under burnt bricks are not acceptable for use in the works.
- Sample bricks shall be submitted to the ENGINEER for approval and bricks supplied shall conform to approved samples. If demanded by ENGINEER, brick samples shall be got tested as per IS: 3495 by CONTRACTOR at no extra cost to OWNER. Bricks rejected by ENGINEER shall be removed from the site of works within 24 hours.
- Mortar for brick masonry shall consist of cement and sand and shall be prepared as per IS:2250. Mix shall be in the proportion of 1:5 for all brickworks, unless otherwise specified in the respective items of work. Sand for masonry mortar shall conform to IS:2116. The sand shall be free from clay, shale, loam, alkali and organic matter and shall be of sound, hard, clean and durable particles. Sand shall be approved by ENGINEER. If so directed by the ENGINEER, sand shall be screened and washed till it satisfies the limits of deleterious materials.
- For preparing cement mortar, the ingredients shall first be mixed thoroughly in dry condition. Water shall then be added and mixing continued to give a uniform mix of required consistency. Mixing shall be done thoroughly in a mechanical mixer, unless hand mixing is specifically permitted by the ENGINEER. The mortar thus mixed shall be used as soon as possible, preferably within 30 minutes from the time water is added to cement. In case, the mortar has stiffened due to evaporation of water, this may be re-tempered by adding water as required to restore consistency, but this will be permitted only upto 30 minutes from the time of initial mixing of water to cement. Any mortar which is partially set shall be rejected and shall be removed forthwith from the site. Droppings of mortar shall not be re-used under any circumstances.

- The CONTRACTOR shall arrange for test on mortar samples if so directed by the ENGINEER.

(ii) Workmanship

- Workmanship of brick work shall conform to IS: 2212. All bricks shall be thoroughly soaked in clean water for at least one hour immediately before being laid. The cement mortar for brick masonry work shall be as specified in the respective item of work. Brick work 200mm/230mm thick and over shall be laid in English Bond unless otherwise specified. 100mm/115mm thick brickwork shall be laid with stretchers. For laying bricks, a layer of mortar shall be spread over the full width of suitable length of the lower course. Each brick shall be slightly pressed into the mortar and shoved into final position so as to embed the brick fully in mortar. Only full size bricks shall be used for the works and cut bricks utilised only to make up required wall length or for bonding. Bricks shall be laid with frogs uppermost.
- All brickwork shall be plumb, square and true to dimensions shown. Vertical joints in alternate courses shall come directly one over the other and be in line. Horizontal courses shall be levelled. The thickness of brick courses shall be kept uniform. In case of one brick thick or half brick thick wall, atleast one face should be kept smooth and plane, even if the other is slightly rough due to variation in size of bricks. For walls of thickness greater than one brick both faces shall be kept smooth and plane. All interconnected brickwork shall be carried out at nearly one level so that there is uniform distribution of pressure on the supporting structure and no portion of the work shall be left more than one course lower than the adjacent work. Where this is not possible, the work shall be raked back according to bond (and not saw toothed) at an angle not exceeding 450. But in no case the level difference between adjoining walls shall exceed one metre. Brick-work shall not be raised more than one metre per day.
- Bricks shall be so laid that all joints are well filled with mortar. The thickness of joints shall not be less than 6 mm and not more than 10 mm. The face joints shall be raked to a minimum depth of 10mm/15mm by raking tools during the progress of work when the mortar is still green, so as to provide a proper key for the plastering/pointing respectively to be done later. When plastering or pointing is not required to be done, the joints shall be uniform in thickness and be struck flush and finished at the time of laying. The face of brickwork shall be cleaned daily and all mortar droppings removed. The surface of each course shall be thoroughly cleaned of all dirt before another course is laid on top.
- During inclement weather conditions, newly built brick masonry works shall be protected by tarpaulin or other suitable covering to prevent mortar being washed away by rain.
- Brickwork shall be kept constantly moist on all the faces for at least seven days. The arrangement for curing shall be got approved from the ENGINEER.
- Double scaffolding having two sets of vertical supports shall be provided to facilitate execution of the masonry works. The scaffolding shall be designed adequately considering all the dead, live and possible impact loads to ensure safety of the workmen, in accordance with the requirements stipulated in IS:2750 and IS:3696 (Part 1). Scaffolding shall be properly maintained during the entire period of construction. Single scaffolding shall not be used on important works and will be permitted only in certain cases as decided by the ENGINEER. Where single scaffolding is adopted, only minimum number of holes, by omitting a header shall be left in the masonry for supporting horizontal scaffolding poles. All holes in the masonry shall be carefully made good before plastering/painting.
- In the event of usage of traditional bricks of size 230 mmxll5mmx75mm, the courses at the top of the plinth and sills as well as at the top of the wall just below the roof/floor or

slabs and at the top of the parapet shall be laid with bricks on edge.

- All brickwork shall be built tightly against columns, floor slabs or other structural members.
- To overcome the possibility of development of cracks in the brick masonry following measures shall be adopted.
- For resting RCC slabs, the bearing surface of masonry wall shall be finished on top with 12 mm thick cement mortar 1:3 and provided with 2 layers of Kraft paper Grade 1 as per IS:1397 or 2 layers of 50 micron thick polyethylene sheets.
- RCC/steel beams resting on masonry wall shall be provided with plain or reinforced concrete bed blocks of dimensions as indicated in the drawings duly finished on top with 2 layers of Kraft paper Grade 1 as per IS:1397 or 2 layers of 50 micron thick polyethylene sheets.
- Steel wire fabric shall be provided at the junction of brick masonry and concrete as specified elsewhere before taking up plastering work.
- The above items shall be measured and paid for separately under the respective items of work.
- Bricks for partition walls shall be stacked adjacent to the structural member to pre-deflect the structural member before the wall is taken up for execution. Further, the top most course of half or full brick walls abutting against either a de-shuttered slab or beam shall be built only after any proposed masonry wall above the structural member is executed to cater for the deflection of the structural element.
- Reinforced cement concrete transoms and mullions of dimensions as indicated in the construction drawings are generally required to be provided in half brick partition walls. Reinforced concrete for transoms and mullions shall be measured and paid for separately under the respective items of work.
- Where drawings indicate that structural steel sections are to be encased in brickwork, the brick masonry shall be built closely against the steel section, ensuring a minimum of 20mm thick cement-sand 1:4 over all the steel surfaces. Steel sections partly embedded in brickwork shall be provided with bituminous protective coating to the surfaces at the point of entry into the brick masonry.
- CONTRACTOR shall note that the unit rates quoted for the masonry work shall be deemed to include for the installation of miscellaneous inserts such as pipe sleeves, bolts, steel sections with anchors etc. and providing pockets, leaving openings, cutting chases etc. in accordance with the construction drawings. Miscellaneous inserts shall be either supplied FREE by the OWNER or to be furnished by the CONTRACTOR. Any of the miscellaneous inserts which are required to be fabricated and supplied by the CONTRACTOR and cement concrete to be provided in the pockets for the hold fasts of door/window frames etc. shall however, be measured and paid separately under the respective items of work. .
- Facing bricks of the type specified conforming to IS:2691 shall be laid in the positions indicated on the drawings and all facing brickwork shall be well bonded to the backing bricks/RCC surfaces. The level of execution of the facing brickwork shall at any time be lower by at least 600 mm below the level of the backing brickwork.
- Facing bricks shall be laid over 10 mm thick backing of cement mortar. The mortar mix, thickness of joint and the type of painting to be carried out shall be as specified in the item of work. The pattern of laying the bricks shall be as specifically indicated in the drawings.
- For facing brickwork, double scaffolding shall be used.
- Faced works shall be kept clean and free from damage, discoloration etc., at all times.
- Cutting of chases in 230 thick wall and above for routing GI pipes, CI pipes or for any

other services shall preferably be in the vertical direction. Horizontal chases shall be avoided, as far as possible. The depth of vertical chases and horizontal chases, if any, shall not exceed one third and one sixth of the thickness of masonry respectively. Vertical chases shall not be closer than 2m in any stretch. Not more than 2 horizontal chases shall be permitted in a stretch of wall and these should be located in upper or lower one-third of height of wall. No continuous horizontal chase should exceed 1m length. No horizontal chases will be permitted in half brick wall.

- No lintel need be provided for circular openings upto 400mm diameter in 230mm thick wall and above. Similarly, no lintel need be provided for rectangular holes of 300mm wide and below. No openings shall be provided in 115mm thick brick wall.

(iii) Measurement

- Measurement shall be in cu.m correct to two places of decimal for brickwork of thickness one brick i.e. 200mm/230mm and above. Measurement shall be in sq.m correct to two places decimal for facing brickwork and brickwork of thickness half brick i.e. l00mm/115mm and below. Measurement shall be for the quantities as actually executed duly deducting for openings, lintels, transoms/mullions etc. subject to relevant clauses below.
- No deductions shall be made for openings less than 0.1sq.m area or for embedments upto 0.1 sq.m in section.
- Brick works curved in plan to a mean radius upto 6m shall be measured and paid as curved wall as a separate item of works. Brick works curved in plan to a mean radius more than 6m shall be measured and paid like a straight wall.
- All concrete works shall he measured and paid for separately under the respective items of work.

9.4.2.4 UNCOURSED RANDOM RUBBLE MASONRY, IN FOUNDATION. PLINTH AND SUPERSTRUCTURE

(i) Materials

- Stones for the works shall be of the specified variety which are hard, durable, fine grained and uniform in colour (for superstructure work) free from veins, flaws and other defects. Quality and work shall conform to the requirements specified in IS:1597 (Part-1). The percentage of water absorption shall not exceed 0.5 percent as per test conducted in accordance with IS:1124. The CONTRACTOR shall supply sample stones to the ENGINEER for approval. Stones shall he laid with its grains horizontal so that the load transmitted is always perpendicular to the natural bed.
- Cement-sand mortar for stone masonry works shall be in the proportion of 1:6 unless otherwise specified in the respective items of work. Materials and preparation of mortar shall be as specified in relevant clauses.

(ii) Workmanship

- For all works below ground level the masonry shall be random rubble un-coursed with ordinary quarry dressed stones for the hearting and selected quarry dressed stones for the facing.
- For all works above ground level and in superstructure the masonry shall be random rubble un-coursed, well bonded, faced with hammer dressed stones with squared quoins at corners. The bushings on the face shall not be more than 40 mm on an exposed face and on the face to be plastered it shall not project by more than 12 mm nor shall it have depressions more than 10 mm from the average wall surface.
- Face stones shall extend back sufficiently and band well with the masonry. The depth of

stone from the face of the wall inwards shall not be less than the height or breadth at the face. The length of the stone shall not exceed three times the height and the breadth on base shall not be greater than three-fourths the thickness of wall nor less than 150 mm. The height of stone may be upto a maximum of 300 mm. Face stones or hearting stones shall not be less than 150 mm in any direction.

- Chips and spalls shall be used wherever necessary to avoid thick mortar joints and to ensure that no hollow spaces are left in the masonry. The use of chips and spalls in the hearting shall not exceed 20 percent of the quantity of stone masonry. Spalls & chips shall not be used on the face of the wall and below hearting stones to bring them to the level of face stones.
- The maximum thickness of joints shall not exceed 20 mm. All joints shall be completely filled with mortar. When plastering or pointing is not required to be done, the joints shall be struck flush and finished as the work proceeds. Otherwise, the joints shall be raked to a minimum depth of 20 mm by a raking tool during the progress of the work while the mortar is still green.
- Through or bond stones shall be provided in walls up to 600 mm thick and in case of walls above 600 mm thickness, a set of two or more bond stones overlapping each other by at least 150 mm shall be provided in a line from face to back. In case of highly absorbent types of stones (porous lime stone and sand stone, etc.) the bond stone shall extend about two-thirds into the wall and a set of two or more bond stones overlapping each other by at least 150 mm shall he provided. Each bond stone or a set of bond stones shall be provided for every 0.5 sq.m of wall surface.
- All stones shall be sufficiently wetted before laying to prevent absorption of water from the mortar. All connected walls in a structure shall be normally raised uniformly and regularly. However if any part of the masonry is required to be left behind, the wall shall he raked back (and not saw toothed) at an angle not exceeding 450. Masonry work shall not be raised by more than one metre per day.
- Green work shall be protected from rain by suitable covering. Masonry work shall be kept constantly moist on all the faces for a minimum period of seven days for proper curing of the joints.
- Type of scaffolding to be used shall be as specified in relevant clause.
- Installation of miscellaneous inserts in the masonry shall be as specified in relevant clause.

(iii) Measurement

- Measurement shall be in cu.m correct to two places of decimal. The quantities measured and paid for, shall be those as actually executed after making deductions for openings, lintels etc.
- No deductions shall be made for openings less than 0.1sq.m area or for embedments upto 0.1 sq.m in section.
- Brick works curved in plan to a mean radius upto 6m shall be measured and paid as curved wall as a separate item of works. Brick works curved in plan to a mean radius more than 6m shall be measured and paid like a straight wall.

9.4.2.5 COURSED RUBBLE MASONRY (FIRST SORT) FOR SUPERSTRUCTURE

(i) Materials

- The material specification for the work shall be as per relevant clause.

(ii) Workmanship

- All courses shall be laid truly horizontal and shall be of the same height in any course. The height of course shall not be less than 150 mm and not more than 300 mm. The width of stone shall not be less than its height.

- Face stones shall tail into the work for not less than their height and at least 1/3rd the number of stones, shall tail into the work for a length not less than twice their- height but not more than three-fourths the thickness of the wall whichever is smaller. These should be laid as headers and stretchers alternately to break joints by at least 75 mm.
- The face stones shall be squared on all joints and beds; the bed joints being hammer or chisel dressed true and square for at least 80 mm back from the face and the side joints for at least 40 mm. The face of the stone shall be hammer dressed so that the bushing shall not be more than 40 mm on an exposed face and 10 mm on a face to be plastered. No portion of the dressed surface shall show a depth of gap more than 6 mm from a straight edge placed on it. The remaining unexposed portion of the stone shall not project beyond the surface of bed and side joints.
- No spalls or pinnings shall be allowed on the face. All bed joints shall be horizontal and side joints shall be vertical and no joints shall be more than 10 mm in thickness. When plastering or pointing is not required to be done, the joints shall be struck flush and finished as the work proceeds. Otherwise, the joints shall be raked to a minimum depth of 20 mm by a raking tool, during the progress of the work while the mortar is still green.
- Hearting shall consist of flat bedded stones carefully laid an their proper beds and solidly bedded in mortar. The use of chips shall be restricted to the filling of interstices between the adjacent stones, in hearting and these shall not exceed 10 percent of the quantity of the stone masonry. Care shall be taken so that no hollow spaces are left anywhere in the masonry.
- The requirement regarding through or bond stones shall be as specified in clause 4.2.6 with the further stipulation that these shall be provided at 1.5 m to 1.8 m apart clear in every course but staggered at alternate courses.
- The quoins which shall be of the same height as the course in which they occur, shall not he less than 450 mm in any direction. Quoin stones shall be laid as stretchers and headers alternately. They shall be laid square on their beds, which shall he rough chisel dressed to a depth of at least 100 mm from the face. These stones shall have a minimum uniform chisel drafts of 25mm width at four edges, all the edges being in the same plane.
- Type of scaffolding to be used shall be as per relevant clause.
- Requirements of execution of the work and curing shall be as stipulated in relevant clause.
- Installation of miscellaneous inserts in the masonry shall be as specified in relevant clause.

(iii) Measurement

- Measurement shall be in cu.m correct to two places of decimal. The quantities measured and paid for, shall be those as actually executed after making necessary deductions for openings, lintels etc.

9.4.2.6 CONCRETE BLOCK MASONRY

(i) Materials

- Masonry units of hollow and solid concrete blocks shall conform to the requirements of IS : 2185 (Part 1).
- Masonry units of hollow and solid light-weight concrete blocks shall conform to the requirements of IS:2185 (Part 2).
- Masonry units of autoclaved cellular concrete blocks shall conform to the requirements of IS: 2185 (Part 3).
- The height of the concrete masonry units shall not exceed either its length or six times its width.
- The nominal dimensions of concrete block shall be as under.

Length 400,500 or 600 mm.

Height 100 or 200 mm.

Width 100 to 300 mm in 50 mm increments

Half blocks shall be in lengths of 200, 250 or 300 mm to correspond to the full length blocks. Actual dimensions shall be 10 mm short of the nominal dimensions.

- The maximum variation in the length of the units shall not be more than + 5mm and maximum variation in height or width of the units shall not be more than + 3mm.
- Concrete blocks shall be either hollow blocks with open or closed cavities or solid blocks.
- Concrete blocks shall be sound, free of cracks, chipping or other defects which impair the strength or performance of the construction. Surface texture shall be as specified. The faces of the units shall be flat and rectangular, opposite faces shall be parallel and all arises shal1 be square. The bedding surfaces shall be at right angles to the faces of the block.
- The concrete mix for the hollow and solid concrete blocks/light weight concrete blocks shall not be richer than one part of cement to six parts of combined aggregates by volume i.e. (1:6).
- Concrete blocks shall be of approved manufacture, which satisfy the limitations in the values of water absorption, drying shrinkage and moisture movement, as specified for the type of block as per relevant IS code. CONTRACTOR shall furnish the test certificates and also supply the samples, for the approval of ENGINEER.

(ii) Workmanship

- The type of the concrete block, thickness and grade based on the compressive strength for use in load bearing and/or non-load bearing walls shall be as specified in the respective items of work. The minimum nominal thickness of non-load bearing internal walls shall be 100 mm. The minimum nominal thickness of external panel walls in framed construction shall be 200 mm.
- The workmanship, shall generally conform to the requirements of IS: 2572 for concrete block masonry, IS:60130 for light weight concrete block masonry and IS:6041 for autoclaved cellular concrete block masonry works.
- From considerations of durability, generally concrete block masonry shall be used in superstructure works above the damp-proof course level.
- Concrete blocks shall be embedded with a mortar which is relatively weaker than the mix of the blocks in order to avoid the formation of cracks. Cement mortar of proportion 1:6 shall be used for the works unless otherwise specified in the respective items of work. Preparation of mortar shall be as specified.
- The thickness of both horizontal and vertical joints shall be 10 mm. The first course shall he laid with greater care, ensuring that it is properly aligned, levelled and plumb since this will facilitate in laying succeeding courses to obtain a straight and truly vertical wall. For the horizontal (bedding) joint, mortar shall be spread over the entire top surface of the block including front and rear shells as well as the webs to a uniform layer of 10 mm. For vertical joints, the mortar shall be applied on the vertical edges of the front and rear shells of the blocks. The mortar may be applied either to the unit already placed an the wall or an the edges of the succeeding unit when it is standing vertically and then placing it horizontally, well pressed against the previously laid unit to produce a compacted vertical joint. In case of two cell blocks with slight depression on the vertical sides these shall also

be filled up with mortar to secure greater lateral rigidity. To assure satisfactory bond, mortar shall not be spread too far ahead of actual laying of the block as the mortar will stiffen and lose its plasticity. Mortar while hardening shrinks slightly and thus pulls away from the edges of the block. The mortar shall be pressed against the units with a jointing tool after it has stiffened to effect intimate contact between the mortar and the unit to obtain a weather tight joint. The mortar shall be raked to a depth of 10 mm as each course is laid to ensure good bond for the plaster.

- Dimensional stability of hollow concrete blocks greatly affected by variations of moisture content in the units. Only well dried blocks should be used for the construction. Blocks with moisture content more than 25% of maximum water absorption permissible shall not he used. The blocks should not be wetted before or during laying in the walls. Blocks should be laid dry except slightly moistening their surface on which mortar is to be applied to obviate absorption of water from the mortar.
- As per the design requirements and to effectively control cracks in the masonry, RCC bond beam/studs, joint reinforcement shall he provided at locations as per details indicated in the construction drawings. Joint reinforcement shall be fabricated either from mild steel wires conforming to IS:280 or welded wire fabric/high strength deformed bass as per the drawings.
- For jambs of doors, windows and openings, solid concrete blocks shall he provided. If hollow units are used, the hollows shall be filled with concrete of mix 1:3:6. Hold fasts of doors/windows should be arranged so that they occur at block course level.
- At intersection of walls, the courses shall laid up at the same time with a true masonry bond between atleast 50% of the concrete blocks. The sequence for construction of partition walls and treatment at the top of load bearing walls for the RCC slab shall be as detailed under clause 3 for the brick work.
- Curing of the mortar joints shall be carried out for atleast 7 days. The walls should only be lightly moistened and shall not be allowed to become excessively wet.
- Double scaffolding as per relevant clause shall be adopted for execution of block masonry work.
- Cutting of the units shall be restricted to a minimum. All horizontal and vertical dimensions shall be in multiples of half length and full height of units respectively, adapting modular co-ordination for walls, opening locations for doors, windows etc.
- Concrete blocks shall be stored at site suitably to avoid any contact with moisture from the ground and covered to protect against wetting.

(iii) Measurement

- Measurement shall be in cu.m. correct upto two places of decimal for walls of thickness 200 mm and above. Measurement shall be in sq.m correct upto two places of decimal for walls of 100mm/150mm in thickness. Measurement shall be for the quantities as actually executed duly deducting for openings, and concrete works. Concrete and reinforcement will be measured and paid separately. The rate quoted shall be for the type of masonry blocks specified in the respective items of work which shall include for the specific sequential operations as stipulated in the construction drawings.

9.4.2.7 DAMP - PROOF COURSE

(i) Materials and Workmanship

- Where specified, all the walls in a building shall be provided with damp-proof course to prevent water from rising up the wall. The damp-proof course shall run without a break throughout the length of the wall, even under the door or other openings. Damp-proof

course shall consist of 50 mm thick cement concrete of 1:2:4 nominal mix with approved water-proofing compound admixture conforming to IS: 2645 in proportion as directed by the manufacturer. Concrete shall be with 10 mm down graded coarse aggregates.

- The surface of brick/stone masonry work shall be levelled and prepared before laying the cement concrete. Side shuttering shall be properly fixed to ensure that slurry does not leak through and is also not disturbed during compaction. The upper and side surface shall be made rough to afford key to the masonry above and to the plaster.
- Damp-proof course shall be cured properly for atleast seven days after which it shall be allowed to dry for taking up further work.

(ii) Measurement

- Measurement of damp-proof course shall be in Sq.m. correct to two places of decimal as actually executed. No separate payment will be made for formwork.

9.4.2.8 MISCELLANEOUS INSERTS, BOLTS ETC.

(i) 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 ENG INEER without any extra cost to the OWNER.

(ii) Measurement

Miscellaneous inserts, supplied by the CONTRACTOR shall be measured and paid for as per the respective items of work.

9.4.2.9 WOOD WORK IN DOORS, WINDOWS, VENTILATORS & PARTITIONS

(i) Materials

- Timber to be used shall be first class Teak wood as per IS:4021. Timber shall be of the best quality and well seasoned by a suitable process before being planed to the required sizes. The maximum permissible moisture content shall be from 10 to 16 percent for timber 50mm and above in thickness and 9 to 14 percent of timber less than 50mm in thickness for different regions of the country as stipulated In IS:287. Timber shall be close grained, of uniform colour and free from decay, fungal growth, boxed heart, pitch pockets or streaks on the exposed edges, borer holes, splits and cracks.
- Flush door shutters of the solid core type with plywood face panels shall conform to IS:2202 (Part 1) and with particle board/hard board face panels shall conform to IS:2202 (Part 2).
- Transparent sheet glass shall conform to the requirements of IS:2835. Wired and figured glass shall be as per IS:5437.
- Builder's hardware of fittings and fixtures shall be of the best quality from approved manufacturers.

(ii) Workmanship

- The workmanship and finish of wood work in doors, windows, ventilators and partitions shall be of a very high order. CONTRACTOR shall ensure that work is executed in a professional manner by skilled carpenters for good appearance, efficient and smooth operation of the shutters.

- All works shall be executed as per the detailed drawings and/or as directed by the ENGINEER.
- All members of the door, window, and ventilator shall be straight without any warp or bow and shall have smooth well planed faces. The right angle shall be checked from the inside surfaces of the respective members of the frame. Frames shall have mortise and tenon joints which shall be treated with an approved adhesive and provided with metal or wood pins. The vertical members of the door frame shall project 50 mm below the finished floor level. The finished dimension of frames shall be rebated on the solid for keying with the plaster and for receiving the shutters. The depth of rebate for housing the shutter shall be 15 mm. The size of the frames shall be as specified in the respective items of work. The workmanship shall generally conform to the requirements specified in IS:4021.
- The face of the frames abutting the masonry or concrete shall be provided with a coat of coal tar.
- Three hold fasts using 25 mm x 6 mm mild steel flats 225 long with split ends shall be fixed an each side of door and window frames, one at the centre and the other two at 300 mm from the top and bottom of the frame. For window and ventilator frames less than 1 m in height, two hold fasts on each side shall be fixed at quarter points.
- Timber panelled shutters for doors, windows and ventilators shall be constructed in the form of framework of stiles and rails with panel insertion. The panels shall be fixed by either providing grooves in the stiles and rails or by beading. Glazing bars shall be as detailed in the drawings. The stiles and rails shall be joined by mortice and tenon joints at right angles. All members of the shutter shall be straight without any warp or bow and shall have smooth, well planed faces at right angles to each other. The right angle for the shutter shall be checked by measuring the diagonals and the difference shall not be more than + 3 mm. Timber panels made from more than one piece shall be jointed with a continuous tongued and grooved joint, glued together and reinforced with metal dowels. The workmanship shall, generally conform to the requirements specified in IS:1003 (Parts 1 & 2). The thickness of the shutter, width/thickness of the stiles/rails/panel type shall be as indicated in the bid drawings/item of work. Marine plywood panels conforming to IS:710 shall be used for doors where specified.
- Details of the wooden flush door shutters, solid core type with specific requirement of the thickness, core, face panels, viewing glazed panel, venetian louver opening, teak wood lipping etc. shall be as indicated in the respective items of work. Panels of shutter shall be of marine plywood conforming to IS:710, if so specified in the item of work. Flush door shutters shall be from reputed manufacturers and CONTRACTOR shall submit test results as per IS:4020, if so desired by the ENGINEER..
- Glazing of door, window, ventilator and partitions shall be with either flat transparent sheet glass, wired or figured glass. Transparent sheet glass shall be of 'B' quality as per IS:2835. The thickness and type of glazing to be provided shall be as specified in the item of work.
- The material of the fittings and fixtures either of chromium plated steel, cast brass, copper oxidised or anodised aluminium shall be as specified in the item of work. The number, size and type of the fittings and fixtures shall be as indicated in the drawings/item of work.
- Wood work shall not be provided with the finishes of painting, galvanising etc. unless it has been approved by the ENGINEER. The type of finish and the number of coats shall be as stipulated in the respective items of work. Preparation of the wood surface and application of the finishes shall be in accordance with clause 35. Painting and Polishing of wood works.
- Wooden hand railing and architraves shall be of the size and shape with the fixing

arrangement as indicated in the bid drawings/described in the item of work.

- The framework of the partitions with mullions and transoms shall be with the sections of dimensions as per the item at work. Panels of double/single glazing/ plywood shall be fixed as per details indicated in the drawings. Partitions shall be fixed rigidly between the floor and structural columns/beams including provision of necessary shims for wedging etc. Finished work shall be of rigid construction, erected truly plumb to the lines and levels, at locations as per the construction drawings.
- Any carpentry work which show defects due to inadequate seasoning of the timber or bad workmanship shall be removed and replaced by CONTRACTOR with work as per specification requirements, at no extra cost to the OWNER.

(iii) Measurement

- Measurement for doors, windows, ventilators architraves and partitions shall be in sq.m correct to two places of decimal. Hand railing shall be measured in running metres, correct to two places of decimal. Measurement shall be from out to out of the frames. Rate quoted shall be for all the works including glazing, painting, builder's hardware of fittings and fixtures as specifically described in the respective items of work.

9.4.2.10 STEEL DOORS, WINDOWS AND VENTILATORS

(i) Materials

- Hot rolled steel sections for the fabrication of steel doors, windows and ventilators shall conform to IS:7452, which are suitable. for single glazing.
- Pressed steel door frames for steel flush doors shall be out of 1.25 mm thick mild steel sheets of profiles as per IS:4351.
- Transparent sheet glass shall conform to the requirements of IS:2835. Wired and figured glass shall be as per IS:5437.
- Builder's hardware of fittings and fixtures shall be of the best quality from approved manufacturers.

(ii) Workmanship

- All steel doors, windows and ventilator's shall be of the type as specified in the respective items of work and of sizes as indicated in the drawings. Steel doors, windows and ventilators shall conform to the requirements as stipulated in IS:1038. Steel windows shall conform to IS:1361, if so specified.
- Doors, windows and ventilators shall be of an approved manufacture. Fabrication of the units shall be with rolled sections, cut to correct lengths and mitred. Corners shall be welded to form a solid fused welded joint conforming to the requirements of IS:1038. Tolerance in overall dimensions shall be within ± 1.5mm. The frames and shutters shall be free from warp or buckle and shall be square and truly plane. All welds shall be dressed flush on exposed and contact surfaces. Punching of holes, slots and other provisions to install fittings and fixtures later shall be made at the correct locations as per the requirements. Samples of the units shall be got approved by the ENGINEER before further manufacture/purchase by the CONTRACTOR.
- Type and details of shutters, hinges, glazing bar requirement, couplings, locking arrangement, fittings and fixtures shall be as described in the respective items of work and/or as shown in the drawings for single or composite units.
- For windows with fly proof mesh as per the item of work, rotor operator arrangement, for the operation of the glazed shutters from the inside shall be provided.
- Pressed steel doer frames shall be provided with fixing lugs at each jamb, hinges, lock-

strike plate, mortar guards, angle threshold, shock-absorbers of rubber or similar material as per the requirements of IS:4351. Pressed steel door frames shall be fixed as 'built-in', as the masonry work proceeds. After placing it plumb at the specified location, masonry walls shall be built up solid on either side and each course grouted with mortar to ensure solid contact with the door frame, without leaving any voids. Temporary struts across the width shall be fixed, during erection to prevent bow/sag of the frame.

- Door shutters of flush welded construction shall be 45mm thick, fabricated with two outer skins of 1.25mm thick steel sheets, l.00mm thick steel sheet sufferers and steel channels an all four edges. Double shutters shall have meeting stile edge bevelled or rebated. Provision of glazed viewing panel, louvers shall be made as per the item of work and/or drawings. Shutters shall be suitably reinforced for lock and other surface hardware and to prevent sagging/twisting. Single sheet steel door shutters shall be fabricated out of 1.25mm thick steel sheets, mild steel angles and stiffeners as per the drawings.
- Doors, windows and ventilators shall be fixed into the prepared openings. They shall not be 'built-in' as the masonry work proceeds, to avoid distortion and damage of the units. The dimensions of the masonry opening shall have l0mm clearance all-round the overall dimensions of the frame for this purpose. Any support of scaffolding members on the frames/glazing bars is prohibited.
- Glazing of the units shall be either with flat transparent glass or wired/figured glass of the thickness as specified in the item of work. All glass panels shall have properly squared corner and straight edges. Glazing shall be provided on the outside of the frames.
- Fixing of the glazing shall be either with spring glazing clips and putty conforming to IS:419 or with metal beads. Pre-formed PVC or rubber gasket shall be provided for fixing the beads with concealed screws. The type of fixing the glazing shall be as indicated in the item of work and/or in drawings.
- Steel doors, windows and ventilators shall be provided with finish of either painting as specified or shall be hot dip galvanised with thickness of zinc coating as stipulated all as described in the respective items of work.
- The material of the Builders hardware of fittings and fixtures of chromium plated steel, cast brass, brass copper oxidised or anodised aluminium shall be as specified in the item of work. The number, size and type of fittings and fixtures shall be as in the bid drawings/item of work.
- Installation of the units with fixing lugs, screws, mastic caulking compound at the specified locations shall generally conform to the requirements of IS:1081. Necessary holes etc required for fixing shall be made by the CONTRACTOR and made good after installation. Workmanship expected is of a high order for efficient and smooth operation of the units.

(iii) Measurement

- Measurement shall be in sq.m correct to two places of decimal. Measurement shall be from out to out of the frames. Rates quoted shall be for the works including glazing, painting, Builder's hardware of fittings and fixtures as specifically described in the respective items of work.

9.4.2.11 ALUMINIUM DOORS, WINDOWS, VENTILATORS & PARTITIONS

(i) Materials

- Aluminium alloy used in the manufacture of extruded sections for the fabrication of doors, windows, ventilators shall conform to designation 63400 WP of IS:733.
- Transparent sheet glass shall conform to the requirements of IS:2835. Wired and figured glass shall be as per IS:5437.

- Builder's hardware of fittings & fixtures shall be of the best quality from approved manufacturers.

(ii) Workmanship

- All aluminium doors, windows, ventilators and partitions shall be of the type as specified in the respective items of work and of sizes as indicated in the drawings. The doors, windows, ventilators shall conform to the requirements of IS:1948. Aluminium windows, shall conform to IS:1949, if so specified.
- All aluminium units shall be supplied with anodised finish. The minimum anodic film thickness shall be 0.015 mm.
- Doors, windows and ventilators shall be of an approved manufacture. Fabrication of the units shall be with the extruded sections, cut to correct lengths, mitred and welded at the corners to a true right angle conforming to the requirements of IS:1948. Tolerance in overall dimensions shall be within + 1.5mm. The frames and shutters shall be free from warp or buckle and shall be square and truly plane. Punching of holes, slots and other provisions to install fittings or fixtures later shall be made at the correct locations, as per the requirements.
- Aluminium swing type doors, aluminium sliding windows, partitions shall be as described in the item of work and/or bid drawings which indicates generally the arrangement along with the overall size of the various components and weight per running metre of the extruded sections to be adopted.
- IS:1948 and IS:1949 referred to incorporates the sizes, shapes, thicknesses and weight per running metre of extruded sections for the various components of the units. However, new sizes, shapes, thicknesses with modifications to suit snap-fit glazing clips etc. are continuously being added by various leading manufacturers of extruded sections, which are available in the market. As such, the sections of the various components of the unit proposed by the CONTRACTOR, will be reviewed by the ENGINEER and will be accepted only if they are equal to or marginally more than that specified in the codes/ item of works.
- The framework of the partitions with mullions and transomes shall be with anodised aluminium box sections of dimensions as per the item of work. Anodised Aluminium box sections shall be in-filled with timber of class 3 (silver oak or any other equivalent) as per IS:4021. Panels of double/single glazing/plywood shall be fixed as per details indicated in the drawing. Partitions shall be fixed rigidly between the floor and the structural columns/beams including provision of necessary shims for wedging etc. Finished work shall be of rigid construction, erected truly plumb to the lines and levels, at locations as per the construction drawings.
- Specific provisions as stipulated for steel doors, windows, ventilators under clauses 14.3.10.2 (ii to xii) shall also be applicable for this item work. Glazing beads shall be of the snap-fit type suitable for the thickness of glazing proposed as indicated in the item of work. A layer of clear transparent lacquer shall be applied on aluminium sections to protect them from damage during installation. This lacquer coating shall be removed after the installation is completed.

(iii) Measurement

- Measurement shall be in sq.m correct to two places of decimal. Measurement shall be from out to out of the frames. Rate quoted shall be for the works including glazing, Builder's hardware of fittings and fixtures as specifically described in the respective items of work.

9.4.2.12 METAL ROLLING SHUTTERS AND ROLLING GRILLS

(i) Materials and Workmanship

- Metal Rolling shutters and rolling grills shall be of an approved manufacture, conforming to the requirements specified in IS:6248.
- The type viz. self coiling type (manual) for clear areas upto 12 sq.m, gear operated type (mechanical) for clear areas upto 35 sq.m and electrically operated type for areas upto 50 sq.m shall be as specified in the respective items of work. Mechanical type shall be suitable for operation from both inside and outside with the crank handle or chain gear operating mechanism duly considering the size of wall/column. Electrical type shall also be provided with a facility for emergency mechanical operation.
- Rolling shutters / grill shall be supplied duly considering the type, specified clear width/height of the opening and the location of fixing as indicated in the drawings.
- Rolling Shutter curtain shall be built-up of interlocking laths 75mm width between rolling centres formed from cold rolled steel strips. The thickness of the steel strip shall not be less than 0.90 mm for shutters upto 3.50m width and not less than 1.20 mm for shutters above 3.50 m width. Each lath section shall be continuous single piece without any welded joint.
- Fabrication and assembly of rolling grill curtain shall have the type of links and other additional requirements as specified in the item of works.
- The guide channels out of mild steel sheets of thickness not less than 3.15 mm shall be of either rolled, pressed or built up construction. The channel shall be of size as stipulated in IS:6248 for various clear width of the shutters / grill.
- Hood covers shall be of mild steel sheets not less than 0.90mm thick and of approved shape.
- Rolling shutters / grill shall be provided with a central hasp and staple safety device in addition to one pair of lever locks and sliding locks at the ends.
- Where a rolling shutter is combined with rolling grill, height of rolling grill shall be 500mm maximum.
- All steel components (excepting springs and insides of guide channels) shall be provided with one coat of zinc chrome primer conforming to IS:2074 at the shop before supply. These surfaces shall be given an additional coat of primer after erection at the site along with the number of coats and type of finish paint as specified in the respective Items of work. Painting shall be carried out as per clause 36.
- Where galvanising is called for, the curtain sections, guides, lock plate, bracket plates, suspension shaft and the hood cover shall be hot dip galvanised with a zinc coating containing not less than 97.5 percent pure zinc. The weight of the zinc coating per sq.m shall be as specified in the item of work.
- Guide channels shall be installed truly plumb at the specified location. Bracket plate shall be rigidly fixed with necessary bolts and holdfasts. Workmanship of erection shall ensure strength and rigidity of rolling shutter for trouble free and smooth operation.
- Rolling shutter/grills manufactured by reputed manufacturer as part of their standard product can also be used, provided the quality and size of members satisfy the stipulations above.

(ii) Measurement

- Measurement shall be in sq.m correct to two places of decimal of the clear area of the opening. Quoted rate shall be inclusive of painting as specified in the item of work.

9.4.2.13 RUBBLE SUB-BASE

(i) Materials

- Stones used for rubble packing under floors on grade, foundations etc., shall be clean,

hard, durable rock free from veins, flaws, laminations, weathering and other defects. Stones shall generally conform to the requirements stipulated in IS:1597 (Part-I).

- Stones shall be as regular as can be obtained from quarries. Stones shall be of height equal to the thickness of the packing proposed with a tolerance of + 10mm. Stones shall not have a base area less than 250 sq.cm nor more than 500 sq.cm, and the smallest dimension of any stone shall not be less than half the largest dimension. The quality and size of stones shall be subject to the approval of the ENGINEER.

(ii) Workmanship

- Stones shall be hand packed carefully and laid with their largest base downwards resting flat on the prepared sub-grade and with their height equal to the thickness of the packing. Stones shall be laid breaking joints and in close contact with each other-. All interstices between the stones shall be wedged-in by small stones of suitable size, well driven in by crow bars and hammers to ensure tight packing and complete filling-in of the interstices. The wedging shall be tarried out simultaneously with the placing in position of rubble packing and shall not lag behind. After this, any interstices between the smaller wedged stones shall be in-filled with clean hard sand by brooming so as to fill the joints completely.
- The laid rubble packing shall be sprinkled with water and compacted by using suitable rammers.

(iii) Measurement

- Measurement shall be in sq.m correct to two places of decimal for the specified compacted thickness of rubble sub-base.

9.4.2.14 BASE CONCRETE

- The thickness and grade of concrete shall be as specified in the item of work.
- Before placing the blinding concrete, 50/75mm thick as per the item of work, the sub-base of rubble packing shall be properly wetted and rammed. Concrete for the base shall then be deposited between the forms, thoroughly tamped and the surface finished level with the top edges of the forms. Two or three hours after the concrete has been laid in position, the surface shall be roughened using steel wire brush to remove any scum or laitance and swept clean so that the coarse aggregates are exposed. The surface of the base concrete shall be left rough to provide adequate bond for the floor finish to be provided later.

(i) Measurement

- Measurement shall be in sq.m correct to two places of decimal. This work could be either separate or combined along with the floor finish as indicated in the respective items of work.

9.4.2.15 TERRAZZO AND PLAIN CEMENT TILING WORK

(i) Materials

- Terrazzo tiles and cement tiles shall generally conform in all respects to standards stipulated in IS:1237. Tiles shall be of the best quality manufactured adopting hydraulic pressure of not less than 14N/mm2.
- The type, quality, size, thickness colour etc, of the tiles for flooring/dado/ skirting shall be as specified in the respective items of work.
- The aggregates for terrazzo topping shall consist of marble chips which are hard, sound and dense. Cement to be used shall be either ordinary portland cement or white cement with or without colouring pigment. The binder mix shall be with 3 parts of cement to 1 part of marble powder by weight. The proportion of cement shall be inclusive of any pigments. For every one part of cement-marble powder binder mix, the proportion of

aggregates shall be 1.75 parts by volume, if the chips are between l mm to 6mm and 1.50 parts by volume if the chips are between 6mm to 25mm.

- The minimum thickness of wearing layer of terrazzo tiles shall be 5mm for tiles with chips of size varying from 1mm upto 6mm or from 1mm upto 12mm. This shall be 6mm for tiles with chips varying from 1mm upto 25mm. The minimum thickness of wearing layer of cement/coloured cement tiles shall he 5mm. This shall be 6mm for heavy duty tiles. Pigment used in the wearing layer shall not exceed 10 percent of the weight of cement used in the mix.

(ii) Workmanship

- Laying and finishing of tiles shall conform to the requirements of workmanship stipulated in IS: 1443.
- Tiling work shall be commenced only after the door and window frames are fixed and plastering of the walls/ ceiling is completed. Wall plastering shall not be carried out upto about 50mm above the level of proposed skirting/dado.
- The base concrete shall be finished to a reasonably plane surface about 40 to 45mm below the level of finished floor. Before the tiling work is taken up, the base concrete or structural slab shall be cleaned of all loose materials, mortar droppings, dirt, laitance etc. using steel wire brush and well wetted without allowing any water pools on the surface.
- A layer of 25mm average thickness of cement mortar consisting of one part of cement to four parts of sand shall be provided as bedding for the tiles over the base concrete. The thickness of bedding mortar shall not be less than l0mm at any place. The quantity of water to be added for the mortar shall be just adequate to obtain the workability for laying. Sand for the mortar shall conform to IS:2116 and shall have minimum fineness modulus of 1.5. The surface shall be left rough to provide a good bond for the tiles. The bedding shall be allowed to harden for a day before laying of the tiles.
- Neat cement slurry using 4.4 kg of cement per one sq.m of floor area shall be spread over the hardened mortar bedding over such an area at a time as would accommodate about 20 tiles. Tiles shall be fixed in this slurry one after the other, each tile being gently tapped with a wooden mallet till it is properly bedded and in level with the adjoining tiles. The joints shall be in straight lines and shall normally be 1.5mm wide. On completion of laying of the tiles in a room, all the Joints shall be cleaned and washed fairly deep with a stiff broom/wire brush to a minimum depth of 5mm. The day after the tiles have been laid, the joints shall be filled with cement grout of the same shade on the colour of the matrix of the tile. For this purpose white cement or grey cement with or without pigments shall be used. The flooring should be kept moist and left undisturbed for 7 days for the bedding/joints to set properly. Heavy traffic shall not be allowed on the floor for atleast 14 days after fixing of the tiles.
- About a week after laying the tiles, each and every tile shall be lightly tapped with a small wooden mallet to find out if it gives a hollow sound; if it does, such tiles along with any other cracked or broken tiles shall be removed and replaced with new tiles to proper line and level. The same procedure shall be followed again after grinding the tiles and all damaged tiles replaced, properly jointed and finished to match. For the purpose of ensuring that such replaced tiles match with those laid earlier, it is necessary that the CONTRACTOR shall procure sufficient quantity of extra tiles to meet this contingency.
- Wherever a full tile cannot be provided, tiles shall be cut to size and fixed. Floor tiles adjoining the wall shall go about 10mm under the plaster, skirting or dado.
- Tile skirting and dado work shall be executed only after laying tiles on the floor. For dado and skirting work, the vertical wall surface shall be thoroughly cleaned and wetted. Thereafter it shall be evenly and uniformly covered with 12mm thick backing of 1:4

cement sand mortar. For this work the tiles as obtained from the factory shall be of the size required and practically full polished. The back of each tile to be fixed shall be covered with a thin layer of neat cement paste and the tile shall then be gently tapped against the wall with a wooden mallet. Fixing shall be done from the bottom of the wall upwards. The joints shall be in straight lines and shall normally be 1.5mm wide. Any difference in the thickness of the tiles shall be evened out in the backing mortar or cement paste so that the tile faces are in conformity & truly plumb. Tiles for use at the corners shall be suitably cut with bevelled edges to obtain a neat and true joint. After the work has set, hand polishing with carborundum stones shall be done so that the surface matches with the floor finish.

- Wall plastering of the strip left out above the level of skirting/dado shall be taken up after the tiles are fixed.
- CONTRACTOR shall note that the unit rate quoted for skirting shall also include for any chipping of the brick work required to be carried out for this item.
- Chequered terrazzo tiles for flooring and for stair treads shall be delivered to site after the first machine grinding.
- Machine grinding and polishing shall be commenced only after a gap of 14 days of laying. The sequence and three numbers of machine grinding operations, usage of the type of carborundum stones, filling up of pin holes, watering etc. shall be carried out all as specified in IS:1443.
- Tiles shall be laid to the levels specified. To ensure this, finished floor levels should be marked at all door locations and also on the floor at frequent intervals. Where large areas are to be tiled the level of the central portion shall be kept l0mm higher than that at the walls to overcome optical illusion of a depression in the central portion. Localised deviation of ± 3mm in any 3m length is acceptable in a nominally flat floor.
- All corners shall be in perfect right angle matching up with the corners of walls. If due to any misalignment during construction, the corners of wall are not at right angle, adjustment shall be made in the title portion lying below skirting.
- Flooring in toilets, kitchen shall be taken up only after fixing water closet, squatting pans & floor traps.

(iii) Measurement

- Measurement for floor tiling and dado shall be in sq.m correct to two places of decimal. Actual quantity of tiling work as laid shall be measured for payment as per the respective items of work after making deductions for openings etc. No deduction shall be made nor any extra to be paid for openings not exceeding 0.20 sq. m Measurement for skirting be in running metres correct to two places of decimal for the specified height as per the item of work.

9.4.2.16 IN-SITU TERRAZZO WORK

(i) Materials

- The requirements of marble aggregates for terrazzo topping shall be as per clause 14.1.15.1(iii).
- Cement shall first be mixed with the marble powder in dry state. The mix thus obtained shall be mixed with the aggregates in the specified proportions. Care shall be taken not to get the materials into a heap which results in the coarsest chips falling to the edges and cement working to the centre at the bottom. Materials shall be kept, as far as possible, in an even layer during mixing. After the materials have been thoroughly mixed in the dry state, water shall be added, just adequate to obtain plastic consistency for the desired

workability for laying. The mix shall be used in the works within 30 minutes of the addition of water to the cement.

(ii) Workmanship

- The thickness, type, quality, size and colour of chips etc. for the in-situ terrazzo finish for flooring/dado skirting shall be as specified in the respective items of work. Laying and finishing of in-situ work shall conform to the requirements of workmanship stipulated in IS: 2114.
- In-situ terrazzo finish shall be laid over hardened concrete base. The finish layer consists of an under layer and terrazzo topping. The under layer shall be of cement concrete of mix 1:2:4 using l0mm down graded coarse aggregates. The combined thickness of under layer and topping shall not be less than 30 mm for flooring and 20mm for dado/skirting work.
- The minimum thickness of topping shall be 6mm if chips used are between 1mm to 4mm, 9mm if chips are between 4mm to 7mm and 12mm if chips are between 7mm to l0mm. If chips larger than l0mm size are used, the minimum thickness shall be one and one third the maximum size of chips.
- Both the under layer and later the topping shall be divided into panels not exceeding 2 Sq.m. for laying so as to reduce the possibility of development of cracks. The longer dimension of any panel shall not exceed 2m. Dividing strips shall be used to separate the panels. When the dividing strips are not provided, the bays shall be laid alternately, allowing an interval of atleast 24 hours between laying adjacent bays.
- Dividing strips shall be either of aluminium, brass or other material as indicated in the item of work. Aluminium strips should have a protective coating of bitumen. The thickness of the strips shall be not less than 1.5mm and width not less than 25mm for flooring work.
- Concrete base shall be finished to a reasonably plane surface to a level below the finished floor elevation equal to the specified thickness of terrazzo finish. Before spreading the under-layer, the base concrete surface shall be cleaned of all loose materials, mortar droppings, dirt, laitance etc. and well wetted without allowing any water pools on the surface. Dividing strips or screed strips, if dividing strips are not provided, shall be fixed on the base and levelled to the correct height to suit the thickness of the finish. Just before spreading the under-layer the surface shall be smeared with cement slurry at 2.75 Kg/sq.m. Over this slurry, the under-layer shall be spread and levelled with a screed board. The top surface shall be left rough to provide a good bond for the terrazzo topping.
- Terrazzo topping shall be laid while the under-layer is still plastic and normally between 18 to 24 hours after the under-layer is laid. Cement slurry of the same colour as the topping shall be brushed on the surface immediately before laying is commenced. The terrazzo mix shall be laid to a uniform thickness and compacted thoroughly by tamping and with a minimum of trowelling. Straight edge and steel floats shall be used to bring the surface true to the required level in such a manner that the maximum amount of marble chips come up and spread uniformly all over the surface.
- The surface shall be left dry for air-curing for a period of 12 to 18 hours. Thereafter it shall be cured by allowing water to stand in pools for a period of not less than 4 days.
- Machine grinding and polishing shall be commenced only after a gap of 7 days from the time of completion of laying. The sequence and four numbers of machine grinding operations, usage of the type of carborundum stones, filling up of pinholes, wet curing, watering etc shall be carried out all as specified in IS: 2114. Where machine polishing is

not possible, polishing shall be carried out by hand in the same sequence and procedure as for machine polishing.

- Where the dampness from ground may find its way to the top of floor, concrete floor on the ground or basement shall be provided with an effective damp proof course as described in clause 20.2.9 later.
- Flooring in toilet and kitchen shall be taken up after fixing water closet, squatting pans and floor trap.

(iii) Measurement

Measurement shall be as per clause 14.3.15.2(xi).

9.4.2.17 SHAHABAD/TANDUR/KOTA STONE SLAB WORK

(i) Materials

- The slabs shall be of approved selected quality, hard, sound, dense and homogenous in texture, free from cracks, decay, weathering and flaws. The percentage of water absorption shall not exceed 5 percent as per test conducted in accordance with IS:1124.
- The slabs shall be hand or machine cut to the required thickness. Tolerance in thickness for dimensions of tile more than 100 mm shall be ±5mm. This shall be + 2mm on dimensions less than l00mm.
- Slabs shall be supplied to the specified size with machine cut edges or fine chisel dressed to the full depth. All angles and edges of the slabs shall be true and square, free from any chipping giving a plane surface. Slabs shall have the top surface machine polished (first grinding) before being brought to site. The slabs shall be washed clean before laying.

(ii) Workmanship

- The type, size, thickness and colour/shade etc. of the slabs for flooring/dado/ skirting shall be as specified in the respective items of the work.
- Preparation of the concrete base, laying and curing shall be as per clause 14.3.15.2(iii) to (v). Concrete base shall be finished below the finished floor level equal to the thickness of stone slab and cement mortar below.
- Dado/skirting work shall be as per clause. 14.3.15.2(viii). The thickness of the slabs for dado/skirting work shall not be more than 25mm. Slabs shall be so placed that the back surface is at a distance of 12mm.from the wall. If necessary, slabs shall be held in position temporarily by suitable method. After checking for verticality, the gap shall be filled and packed with cement sand mortar of proportion 1:3. After the mortar has acquired sufficient strength, the temporary arrangement holding the slab shall be removed. The recommended mortar mix for joints and beddings for stone blocks shall be two parts of white cement and seven parts of stone dust. The thickness of joints shall be 5 mm. For fixing of stones to the walls, fixing clamps of non-ferrous metal should be used.
- Grinding and polishing shall be as per clause 14.3.15.2(ix) except that first grinding with coarse grade carborundum shall not be done and cement slurry with or without pigment shall not be applied before polishing.
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(iii) MEASUREMENT

Measurement shall be as per clause 14.3.15.2(xi)

9.4.2.18 CARBORUNDUM TILE FINISH

a) **Materials**

- Carborundum tiles shall generally conform in all respects to the standards stipulated in IS:1237 for heavy duty tiles. Tiles shall be of the best quality manufactured adopting hydraulic pressure of not less than 14 N/mm2.
- Each tile shall bear on its back, permanent and legible trade mark of the manufacturer. All angles of the tiles shall be right angle, all edges sharp and true, colour and texture of the wearing face uniform through out. Maximum tolerance/allowance for length and breadth shall be + 1 mm and thickness +3mm along the wearing surface of the tile and the wearing surface shall be planed free from pin-holes and other blemishes.
- The backing shall be composed of 1 part ordinary grey cement, 2 parts sand and 4 parts of stone chips by volume and mixed with water.

- The topping shall be uniform and of thickness not less than 6mm. The quantity of carborundum grit shall be not less than 1.35 kg/sq.m used with cement with or without pigment. The carborundum grit shall pass through 1.18mm mesh and shall be retained on 0.60mm mesh. The total thickness of tiles including the topping shall be not less than 20 mm.
- The tile shall be cured at the shop for atleast 14 days before delivery to site. Tiles shall be packed properly to prevent damage during transit and storage. The tiles must be stored carefully to prevent staining by damp, rust, oil and grease or other chemicals. Tiles made in each batch shall be kept and used separately so that the colour of each area of floor may remain uniform.
- The manufacturer shall supply along with the tiles the grout mix containing cement and pigment in exact proportions as used in topping of tiles. The containers of the grout mix shall be suitably marked to relate it to the particular type and batch of tiles
- The size, thickness, colour and plain or chequered etc. of the tiles for flooring/skirting shall be as specified in the respective items of work. The under bed for floors shall be 1 part cement: 2 parts coarse sand: 4 parts stone aggregate by volume mix with sufficient water to form a stiff workable mass. For skirting and dado, it shall be 1 part cement: 3 parts coarse sand by volume.
- The total average thickness shall be minimum 50 mm for floors and 30 mm for walls.

b) **Workmanship**

Requirements as detailed for terrazzo/cement tile finish under clause 14.3.15.2 shall be applicable for carborundum tile flooring.

c) **Measurement**

Measurement shall be as per clause 14.3.15.2(xi).

9.4.2.19 **GLAZED TILE FINISH**

(i) **Materials**

Glazed earthenware tiles shall conform to the requirements of IS:13756. Tiles shall be of the best quality from an approved manufacturer. The tiles shall be flat, true to shape and free from flaws such as crazing, blisters, pinholes, specks or welts. Edges and underside

of the tiles shall be free from glaze and shall have ribs or indentations for a better anchorage with the bedding mortar. Dimensional tolerances shall be as specified in IS: 13756.

(ii) **Workmanship**

- The size, thickness, colour, with or without designs etc of the tiles for flooring/dado/skirting shall be as specified in the respective items of work.
- The total thickness of glazed tile finish including the bedding mortar shall be maximum 20 mm in flooring/dado/skirting. The minimum thickness of bedding mortar shall be 12mm for flooring and l0mm for dado/skirting work.
- The bedding mortar shall consist of 1 part of cement to 3 parts of sand mixed with just sufficient water to obtain proper consistency for laying. Sand for the mortar shall conform to IS: 2116 and shall have minimum fineness modules of 1.5
- Tiles shall be soaked in water for about 10 minutes just before laying. Where full size tiles cannot be fixed, tiles shall be cut to the required size using special cutting device and the edges rubbed smooth to ensure straight and true joints.
- Coloured tiles with or without designs shall be uniform and shall be preferably procured from the same batch of manufacture to avoid any differences in the shade.
- Tiles for the flooring shall be laid over hardened concrete base. The surface of the concrete base shall be cleaned of all loose materials, mortar droppings etc well wetted without allowing any water pools on the surface. The bedding mortar shall then be laid evenly over the surface, tamped to the desired level and allowed to harden for a day. The top surface shall be left rough to provide a good band for the tiles. For skirting and dado work, the brick walls shall be raked to a depth of 15mm. In case of concrete walls, the surfaces shall be hacked. The raked / hacked masonry surfaces shall be cleared, wet and then the bedding mortar to specified thickness shall be applied. The mortar surfaces shall be roughened using wire brush and allowed to harden.
- Neat cement slurry using 3.3 kg cement per one sq.m of floor area shall be spread over the hardened mortar bed over such an area as would accommodate about 20 tiles. Tiles shall be fixed in this slurry one after the other, each tile being gently tapped with a wooden mallet till it is properly bedded and in level with the adjoining tiles. For skirting and dado work, the back of the tiles shall be smeared with cement slurry for setting on the backing mortar. Fixing of tiles shall be done from the bottom of the wall upwards. The joints shall be in perfect straight lines and as thin as possible but shall not be more than l mm wide. Tiles used for corners shall be suitably bevelled to obtain a true and neat joint. The surface shall be checked frequently to ensure correct level/required slope. Floor tiles near the walls shall enter skirting/dado to a minimum depth of 10mm. Tiles shall not sound hollow when tapped.
- All the joints shall be cleaned of grey cement with wire brush to a depth of atleast 3mm and all dust, loose mortar etc. shall be removed. White cement with or without pigment shall then be used for flush pointing the joints. Curing shall then be carried out for a minimum period of 7 days for the bedding and joints to set properly. The surface shall then be cleaned using a suitable detergent, fully washed and wiped dry.
- Specials consisting of caves, internal and external angles, cornices, beads and their corner pieces shall be of thickness not less than the tiles with which they are used.
-

(iii) **Measurement**

Measurement shall be as per Clause 14.3.15.2(xi).

9.4.2.20 IN-SITU CEMENT CONCRETE FLOOR TOPPING

(i) Materials

- The mix proportion for the in-situ concrete floor topping shall be 1:2½ :3½ (one part cement : two and half parts sand : three and half parts coarse aggregates) by volume unless otherwise specified in the item of work.
- The aggregates shall conform for the requirements of IS:383.
- Coarse aggregates shall have high hardness surface texture and shall consist of crushed rock of granite, basalt, trap or quartzite. The aggregate crushing value shall not exceed 30 percent. The grading of the coarse aggregates shall be of size 12.5mm and below and shall be as per IS:2571.
- Grading of the sand shall be within the limits indicated in IS:2571.

(ii) Workmanship

- The thickness of the floor topping shall be as specified in the item of work. The minimum thickness of the floor topping shall be 25mm, if it is laid separately. 15mm thick wearing course of cement concrete 1:2 (1 cement:2 stone) aggregate of size 4.75 & below) by volume shall be applied monolithically over floor topping, if called for in the schedule of item. Wearing course shall be 20mm thick, if it is cast monolithically over ground floor slab. Laying and finishing of in-situ topping shall conform to the requirements of IS 2571.
- Preparation of base concrete/structural slab before laying the topping shall be as per clause 15.2.3. The surface shall be rough to provide adequate bond for the topping. It shall be finished to a level below the finished floor equal to the thickness of topping and / or wearing courses, if specified.
- Mixing of concrete shall be done thoroughly in a mechanical mixer unless hand mixing is specifically permitted by the ENGINEER. The concrete shall be as stiff as possible and the amount of water added shall be the minimum necessary to give just sufficient plasticity for laying and compacting. The mix shall be used in the work within 30 minutes of the addition of water for its preparation.
- Floor finish shall be laid in suitable panels to reduce the risk of cracking. No dimension of a panel shall exceed 2 meters and the length of a panel shall not exceed one and a half times its breadth. Topping shall be laid in alternate panels, the intermediate panels being cast after a gap of atleast one day. Construction joints shall be plain vertical butt joints.
- Screed strips shall be fixed dividing the area into suitable panels. Immediately before depositing the concrete topping, neat cement slurry at 2.75 kg/sq.m of area shall be thoroughly brushed into the prepared surface. Topping shall then be laid, very thoroughly tamped, struck off level and floated with wooden float. The surface shall then be tested with a straight edge and mason's spirit level to detect any inequalities from that specified in the drawings and these shall be made good immediately.
- Finishing of the surface by trowelling shall be spread over a period of one to six hours depending upon the temperature and atmospheric conditions. The surface shall be trowelled 3 times at intervals so as to produce a smooth uniform and hard surface. Immediately after laying, the first trowelling just sufficient to give a level surface shall be carried out avoiding excessive trowelling at this stage. The surface shall be re-trowelled after sometime to close any pores and to scrap off excess water or laitance, which shall not be trowelled back into the topping. Final trowelling shall be done well before the concrete has become too hard but at a time when considerable pressure is required to make any impression on the surface. Sprinkling of dry cement or cement-sand mixture for absorbing moisture shall not be permitted.

- Immediately after the surface is finished, it shall be protected suitably from rapid drying due to wind/ sunlight. After the surface has hardened sufficiently to prevent any damage to it, the topping shall be kept continuously moist for a minimum period of 10 days.
- It is preferable to lay the topping on hardened base concrete, as against being laid monolithically with a lesser thickness, since proper levels and slopes with close surface tolerance, is achievable in practice, owing to its greater thickness. Further, as this would be laid after all other building operations are over, there will be no risk of any damages or discoloration to the floor finish which are difficult to repair satisfactorily.
- In severe condition, where dampness from ground may find its way on the top of the floor, the floor slab shall be cast in two equal halves. The top surface of bottom half shall be made plane and smooth after it is cast. A coat of bitumen primer conforming to IS 3384 shall be applied on the hard surface over which two coats of bitumen conforming to IS 1580 shall be applied @ 1.5 kg/m2 for each layer. After the bitumen surface is dry, the top half of floor slab shall be cast.

(iii) **Measurement**

Measurement shall be in sq.m correct upto two places of decimal.

9.4.2.21 **IN-SITU GRANOLITHIC CONCRETE FLOOR TOPPING**

(i) **Materials and Workmanship**

The requirements of materials and workmanship shall be all as per clause 20 for in-situ cement concrete floor topping except that the mix proportion of the concrete shall be 1:1:2 (cement:sand:coarse- aggregates) by volume.

The thickness of the floor topping shall be as specified in the item of work. The minimum thickness of granolithic floor topping on hardened concrete base shall be 40mm, if laid separately. It shall be 20mm, if the topping is laid monolithically over the floor concrete.

(ii) **Measurement**

Measurement shall be in sq.m correct upto two places of decimal.

9.4.2.22 **FLOOR HARDENER TOPPING**

(i) **Materials & Workmanship**

- Floor hardener topping shall be provided either as integrally finished over the structural slab/grade slab or laid monolithically with the concrete/granolithic floor finish on top of hardened concrete base.
- Floor hardener of the metallic or non-metallic type suitable for the performance of normal/medium/heavy duty function of the floor, the quantum of ingredients and the thickness of topping shall be as specified in the respective items of work.
- For monolithic application with the floor finish/slab, the thickness of the layer shall be 15mm. It shall be 20mm if it is laid separately over floor slab. The topping shall be laid within 2 to 3 hours after concrete is laid and it is still plastic but stiffened enough for the workmen to tread over it by placing planks. The surface of the concrete layer shall be kept rough for providing adequate band for the topping. Laitance shall be removed before placing the topping. The topping shall be screeded and thoroughly compacted to the finished level. Trowelling to a smooth finish shall be carried out as per clause 20.2.6. After the surface has hardened sufficiently, it shall be kept continuously moist for atleast 10 days.

- The procedure for mixing the floor hardener topping shall be as per manufacturer's instructions.
- Floor hardener topping shall be prevented from any damages due to subsequent building operations by covering with 75 mm thick layer of sand, if it is laid monolithically with the slab.

(ii) **Measurement**

Measurement shall be in sq.m correct to two places of decimal. This work could be either separate or combined along with the floor finish as indicated in the respective items of work.

9.4.2.23 **PVC SHEET/TILE FLOORING**

(i) **Materials**

- PVC floor covering shall be of either unbacked homogeneous flexible type in the form of sheets/tiles conforming to IS:3462 or homogeneous PVC asbestos tiles conforming to IS:3461.
- The surface of the sheets/tiles shall be free from any physical defects such as pores, blisters, cracks etc. which affects the appearance and serviceability. Tiles/ sheets shall meet with the tolerance limits in dimensions specified in the IS codes. CONTRACTOR shall submit the test certificates, if so desired by the ENGINEER.
- Each tile/sheet shall be legibly and indelibly marked with the name of the manufacturer or his trade mark, IS certificate mark and batch number.
- The adhesive to be used for laying the PVC flooring shall be rubber based conforming to IS 12830 and of the make as recommended and approved by the manufacturer of PVC sheets/tiles.
- The type, size, thickness, colour, plain or mottled and the pattern shall be as specified in the respective items of work.

(ii) **Workmanship**

- Laying of PVC sheets / tiles shall conform IS 5318. PVC floor covering shall be provided over an underbed of cement concrete floor finish over the base concrete or structural slab. It is essential that the sub-floor and the underbed are perfectly dry before laying the PVC flooring. This shall be ensured by methods of testing as stipulated in Appendix-A of IS:5318. Concrete floor on the ground / basement shall be treated with an effective damp proof course as described in clause 20.2.9.
- The surface of the underbed shall have trowelled finish without any irregularities which creates poor adhesion. Surface shall be free of oil or grease and thoroughly cleaned of all dust, dirt and wiped with a dry cloth.
- PVC sheets/tiles shall be brought to the temperature of the area in which they are to be laid by stacking in a suitable manner within or near the laying area for a period of about 24 hours. Where air-conditioning is installed, the flooring shall not be laid on the underbed until the A/C units have been in operation for atleast 7 days. During this period, the temperature range shall be between 20^0C and 30^0C and this shall be maintained during the laying operations and also for 48 hours thereafter.
- Layout of the PVC flooring shall be marked with guidelines on the underbed and PVC tiles/sheets shall be first laid for trial, without using the adhesive, according to the layout.
- The adhesive shall be applied by using a notched trowel to the surface of the underbed and to the backside of PVC sheets/tiles. When the adhesive has set sufficiently for laying, it will be tacky to the touch, which generally takes about 30 minutes. The time period need

be carefully monitored since a longer interval will affect the adhesive properties. Adhesive shall be uniformly spread over only as much surface area at one time which can be covered with PVC flooring within the stipulated time.

- PVC sheet shall be carefully taken and placed in position from one end onwards slowly so that the air will be completely squeezed out between the sheet and the background surface and no air pockets are formed. It shall then be pressed with a suitable roller to develop proper contact. The next sheet shall be laid edge to edge with the sheet already laid, so that there is minimum gap between joints. The alignment shall be checked after each row of sheet is completed and trimmed if considered necessary.
- Tiles shall be laid in the same manner as sheets and preferably, commencing from the centre of the area. Tiles should be lowered in position and pressed firmly on to the adhesive with minimum gap between the joints. Tiles shall not be slided on the surface. Tiles shall be rolled with a light wooden roller of about 5kg to ensure full contact with the underlay. Work should be constantly checked to ensure that all four edges of adjacent tiles meet accurately.
- Any excess adhesive which may squeeze up between sheets/tiles shall be wiped off immediately with a wet cloth. Suitable solvents shall be used to remove hardened adhesive.
- A minimum period of 24 hours shall be given after laying for the development of proper bond of the adhesive. When the flooring in thus completed, it shall be cleaned with a wet cloth soaked in warm soap solution.
- Metallic edge strips shall be used to protect the edges of PVC sheets/tiles which are exposed as in doorways/ stair treads.
- Hot sealing of joints between adjacent PVC sheet flooring to prevent creeping of water through the Joints shall be carried out, if specified in the item of work, using special equipment as per manufacturer's instructions.
- It is desirable that the PVC flooring are taken up after completing all other works in the area so as to avoid any accidental damage to the flooring.

(i) **Measurement**

Measurement shall be in sq.m correct to two places of decimal. The item could be either separate or as a combined item with the floor finish as specified in the respective items of work.

9.4.2.24 ACID RESISTING BRICK/TILING WORK

(i) **Materials**

- The ceramic unglazed vitreous acid resisting tiles shall conform to the requirements of IS:4457. Acid resistant bricks shall be of class I and shall conform to the requirements of IS:4860.
- The finished tile/brick when fractured shall appear fine grained in texture, dense and homogeneous. Tile/brick shall be sound, true to shape, flat, free from flaws and any manufacturing defects affecting their utility. Tolerance in the dimensions shall be within the limits specified in the respective IS.
- The tiles/bricks shall be bedded and jointed using chemical resistant mortar prepared from resin type conforming to IS:4832 (Part II) filter, accelerator and catalyst mixed in proportion as recommended by manufacturers. Method of usage shall generally be as per the requirements of IS:4443.

(ii) **Workmanship**

- The size and thickness of tiles/size and class of bricks for use in the flooring/skirting/dado shall be as specified in the respective items of work.
- The resin shall have viscosity for readily mixing with the filler by manual methods. The filler shall have graded particles which permit minimum joint thickness of 1.5 mm.
- The base concrete surface shall be free from dirt and thoroughly dried. The surface shall be applied with a coat of bitumen primer conforming to IS:3384. The primed surface shall then be applied with a uniform coat of bitumen conforming to IS:1580. Tiles or bricks shall be laid directly without the application of bitumen, if epoxy or polyester resin is used for the mortar.
- Just adequate quantity of mortar which can be applied within the pot life as specified by the manufacturer shall be prepared at one time for bedding and jointing. Rigid PVC/Stainless steel/chromium plated tools shall be used for mixing and laying.
- For laying the floor 6 to 8 mm thick mortar shall be spread on the back of the tile/brick. Two adjacent sides of the tile/brick shall be smeared with 4 to 6 mm thick mortar. Tile/brick shall be pressed into the bed and pushed against the floor and with the adjacent tile/ brick, until the joint in each case is 2 to 3 mm thick. Excess mortar shall then be trimmed off and allowed to harden fully. Similar procedure shall be adopted for the work on walls by pressing the tile/brick against the prepared wall surfaces and only one course shall be laid at a time until the initial setting period.
- The mortar joints shall be cured for a minimum period of 72 hours with 20 to 25% hydrochloric acid or 30 to 40% sulphuric acid. After acid curing, the joints shall be washed with water and allowed to thoroughly dry. The joints shall then be filled with mortar to make them smooth and plane. Acid curing is not required to be carried out if epoxy or polyester resin is used for the mortar.
- Resin mortars are normally self curing. The area tiled shall not be put to use before 48 hours in case epoxy, polyester and furane type of resin is used for the mortar. If phenolic or cashewnut shell liquid resin is used for the mortar, the area tiled shall not be put to use for 7 to 28 days respectively, without heat treatment. This period shall be 2 to 6 days respectively if heat treatment is given with infrared lamp.
- Temperature during preparation of mortar, its application, curing etc. shall be controlled and maintained as recommended by manufacturer.
- It is necessary that the concrete slab / wall shall be made leak proof against water, if necessary by pressure grouting etc. before taking up any titling works. Cost of such works shall be deemed to have included in the cost of tiling works, whether same is specifically mentioned or not.

(iii) **Measurement**

Measurement shall be in sq.m correct to two places of decimal for flooring/dado. Measurement shall be in running metres correct to two places of decimal for skirting of height as specified in the item of work.

9.4.2.25 EPOXY LINING WORK

(i) **Materials**

- The epoxy resin and hardener formulation for laying of Pointless lining work in floors and walls of concrete tanks/trenches, floor toppings etc shall be as per the requirements of IS:9197. Method of laying shall be as per the requirements of IS 4631.
- The epoxy composition shall have the chemical resistance to withstand the following conditions of exposure:
  a) Hydrochloric acid upto 30% concentration

b) Sodium hydroxide upto 50% concentration
c) Liquid temperature upto 60"C
d) Ultraviolet radiation
e) Alternate wetting and drying

- 25.1.3 Epoxy resin shall be of liquid type of suitable grade and class as recommended by the manufacturer.
- The hardener shall be of the liquid type such as Aliphatic Amine or an Aliphatic/Aromatic Amine Adduct or a polyamide or amido polyamine of suitable characteristics. The hardener shall react with epoxy resin at normal ambient temperature above 5^{o}C.
- Sand shall conform to grading zone III or IV of IS 383.
- Accelerator, plasticizer and coaltar may be added for the preparation of epoxy composition, to the proportion as recommended in IS 9197.
- CONTRACTOR shall furnish test certificates for satisfying the requirements of the epoxy formulation if so directed by the ENGINEER.

(ii) **Workmanship**

- The minimum thickness of epoxy lining shall be as recommended in IS 4631 based on type of application & usage. The thickness and areas of application shall be as specified in the respective items of work. It is essential that the base concrete is properly cured, dried and made rough at the time of application.

- The epoxy lining shall be of the trowel type to facilitate execution of the required thickness for satisfactory performance.
- The concrete surfaces over which epoxy lining is to be provided shall be thoroughly cleaned of oil or grease by suitable solvents, wire brushed to remove any dirt/dust and laitance. The surfaces shall then be washed with dilute hydrochloric acid (10% to 15%) and rinsed thoroughly with plenty of water or dilute ammonia solution. The surfaces shall then be allowed to dry. It is essential to ensure that the surfaces are perfectly dry and even, before the commencement of epoxy application.
- Just adequate quantity of epoxy resin which can be applied within the pot life as specified by the manufacturer shall be prepared at one time for laying and jointing.
- Rigid PVC/stainless steel/chromium plated tools shall be used for laying. Trowelling shall be carried out to obtain uniformly the specified thickness of lining.
- Lining shall be allowed to set without disturbance for a minimum period of 24 hours. The facility shall be put to use only after a minimum period of 7 days of laying of the lining.
- For epoxy lining over the inside concrete surfaces of underground tank or trenches, it should be ensured that they are leak proof against water by conducting leakage test as described in clause 24.2.9.

(iii) **Measurement**

Measurement shall be in sq.m correct to two places of decimal.

9.4.2.26 **WATERSTOPS**

(i) **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 (Part 4/sec1), IS 13360 (Part 5/sec11) 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	:	-25^{o}C minimum
f)	Accelerated extraction		
i)	Tensile strength	:	10.3 MPa minimum
i)	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.

(ii) **Workmanship**

- Water stops shall be laid as per IS 12,200. It should be cleaned before placing them in position. Oil or grease shall be removed thoroughly using water and suitable detergents.
- 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 waterstops shall not be permitted. All jointing shall be of fusion-welded type as per manufacturer's instructions.
- Waterstops 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 honey-combing occurs because of the serrations/end grips, by placing concrete with smaller size aggregates in this region. Projecting portions of the waterstops embedded in concrete shall be thoroughly cleaned of all mortar/ concrete coating before resuming further concreting operations. The projecting waterstop 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.

(iii) Measurement

Measurement shall be in running metres correct to two places of decimal. No separate payment shall be made for joints or intersection pieces.

9.4.2.27 PREFORMED FILLERS AND JOINT SEALING COMPOUND

(i) **Materials**

- Preformed filler for expansion/isolation joints shall be non-extruding and resilient type of bitumen impregnated fibres conforming to IS:1838 (Part I).
- 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.
- Sealing compound for filling the joints above the preformed bitumen filler shall conform to Grade 'B' as per IS:1834.

(ii) **Workmanship**

- 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.
- 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.
- 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.
- 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.

(iii) **Measurement**

Measurement for the preformed joint filler shal1 be in sq.m correct to two places of decimal for the specified thickness as per the items of work. Measurement for applying the bitumen coat to concrete/masonry surfaces shall be in sq.m correct to two places of decimal. Measurement for the joint sealing compound shall be in running metres correct to two places of decimal for the specified width and thickness as per the items of work. Measurement for the mild steel corner angle and plate shall be by weight as per the item of work.

9.4.2.28 WATER-PROOFING OF ROOFS WITH BITUMEN FELTS

(i) **Materials**

- Bitumen felt shall be either Hessian-base self-finished felt Type 3 Grade I conforming to IS: 1322 OR glass fibre base self-finished felt Type 2 Grade-1 conforming to IS:7193.
- Bitumen primer shall conform to IS:3384.
- Bitumen used as bonding material shall be Industrial blown type bitumen of Grade 85/25 conforming to IS:702.
- Pea sized gravel shall be hard, round, of size 6mm and down, free from fine sand, dust etc.

(ii) **Workmanship**

- Water-proofing treatment to roofs shall be either normal, heavy or extra heavy depending upon the requirements. The type of treatment and the type of bitumen felt to be used shall be as specified in the item of work and conforming to IS 1346.

- Normal treatment which provides for one layer of felt shall comprise of five courses as under.

a) Bitumen primer at the rate of 0.27 litre/sq.m (min)

b) Bitumen bonding material hot applied at the rate of 1.20 kg/sq.m (min).

c) One layer of bitumen felt.

d) Bitumen bonding material hot applied at the rate of 1.20 kg/sq.m (min).

e) Pea sized gravel at the rate of 0.006 cu.m/sq.m.

- Heavy treatment which provides for two layers of felt shall comprise of seven courses as under.

a) Bitumen primer at the rate of 0.27 litre/sq.m (min)

b) Bitumen bonding material hot applied at the rate of 1.20 kg/sq.m (min)

c) One layer of bitumen felt.

d) Bitumen bonding material hot applied at the rate of 1.20 kg/sq.m (min)

e) Second layer of bitumen felt.

f) Bitumen bonding material hot applied at the rate of 1.20 kg/sq.m (min)

g) Pea sized gravel at the rate of 0.006 cum/sq.m.

- Extra heavy treatment provides for three layers of felt and comprises of nine courses laid in the same procedure as above.

- The roof slope shall be at least 1 in 100. Concrete or mortar screed to achieve the specified slope as per drawings shall be executed and properly cured before taking up water-proofing treatment.

- The surfaces over which water-proofing treatment is to be carried out, shall be cleaned of all foreign matter by wire brushing, dusting and made thoroughly dry. Preparation of surfaces shall be as stipulated In IS:3067. Bitumen primer shall then be applied uniformly.

- Each length of felt shall be prepared by brushing them clean and laid out flat on the roof for softening to eliminate curls. Bitumen bonding material shall be heated to the correct working temperature for pouring across the full width of the rolled felt and the felt steadily rolled out and pressed down. Excess bonding material squeezed out at the ends shall be removed as the laying proceeds.

- Felts shall be laid in lengths at right angles to the direction of the run-off gradient, commencing at the lowest level and working upto the crest. Minimum overlaps of l00mm at the ends and 75mm at the sides of the felt strip shall be provided. All overlaps shall be firmly bonded with hot bitumen. Laying of the second layer of felt shall be so arranged that the joints are staggered with those of the layer beneath it.

- It shall be ensured that a concave fillet 75mm in radius is provided in cement mortar 1:4 at the junction of the roof and vertical face of masonry or RCC parapet wall or column projections.

- Water-proofing treatment shall be taken up on the brick masonry wall/parapet/column projection by a minimum of 150 mm. Felts shall be laid as flashing with minimum overlap of 100mm. The lower edge of the flashing shall overlap the felt laid on the flat portion of the roof and the upper edge shall be tucked into the groove. Each layer shall be arranged so that the joints are staggered with those of the layer beneath it. For the vertical portion of the felt, two coats of bituminous paint at the minimum rate of 0.10 litres/sq.m shall be provided in lieu of pea size gravel finish. Groove 75mm wide and 65mm deep shall be left for tucking in the waterproofing treatment and the groove filled with cement mortar 1:4 for securing it satisfactorily. Curing of the mortar shall be carried out properly for atleast 4 days to avoid shrinkage cracks.

- Water-proofing treatment for gutters shall normally contain 2 layers of felt corresponding to heavy treatment. The sixth course of hot bitumen shall however be at the rate of 1.50 kg/sq.m (minimum). Pea sized gravel finish shall however be replaced by 2 coats of bituminous paint at the minimum rate of 0.1 litre/sq.m. The felt layers shall be carried down the outlet pipes for a minimum depth of l00mm.

- Expansion joints shall be treated with water-proofing treatment in a manner as illustrated in IS:1346 in accordance with the type and details specified in the construction drawings.

- In order to avoid damage to water-proofing treatment where it is subjected to traffic, additional surface treatment by provision of cement concrete flooring tiles conforming to IS:1237 or machine made burnt clay flat terracing tiles conforming to IS:2690 (Part 1)

shall be made if so specified in the item of work. Execution of these works shall be as specified in clauses 29.2.11 or 29.2.12.

- Testing against an leakage or soaking of water below the roof shall be carried out as specified in clause 29.2.13.
- The contractor shall give guarantee for all of his works as specified in clause 14.3.29.0(xiv).

(iii) **Measurement**

- Measurement shall be in sq.m correct to two places of decimal. Measurement shall be for the plan area where the treatment is executed. No separate payment will be made for the overlapping of the felts, fillets and work as specified on vertical faces. Screed an top of roof, cement concrete tiling work or machine pressed clay tile work shall be paid for separately unless they are specifically included in the item of work.

9.4.2.29 WATER-PROOFING OF ROOFS WITH LIME CONCRETE

(i) **Materials**

- Broken brick coarse aggregates prepared from well/over burnt bricks shall be well graded having a maximum size of 25mm and shall generally conform to IS:3068.

- Lime shall be class "C lime (fat lime)" or factory made hydrated lime conforming to IS:712.

(ii) **Workmanship**

- Unless noted otherwise, lime concrete shall be laid as per IS 3036. Lime concrete shall be prepared by thoroughly mixing the brick aggregates inclusive of brick dust obtained during breaking with the slaked lime in the proportions of 2 ½ (two and a half) parts of brick aggregates to 1 part of slaked lime by volume. Water shall be added just adequate to obtain the desired workability for laying.

  a. Washing soap and alum shall be dissolved in the water to be used. The quantity of these materials required per cum of lime concrete shall be 12kg of washing soap and 4kg of alum. Brick aggregates shall be soaked thoroughly in water for a period of not less than six hours before use in the concrete mix. Lime concrete shall be used in the works within 24 hours after mixing.

- The roof surface over which the water-proof treatment is to be carried out shall be cleaned of all foreign matter by wire brushing, dusting and made thoroughly dry. Preparation of surfaces shall be as stipulated in IS:3067.

- The slope of the finished waterproofing treatment shall be not less than 1 in 60 for efficient drainage. This shall be achieved either wholly in the lime concrete layer or otherwise as indicated in the drawings.

- The average thickness of lime concrete, slope and the finish on top of machine made burnt clay flat terracing tiles conforming to IS:2690 (part 1) shall be as specified in the item of

work. Cement concrete flooring tiles in lieu of clay terracing tiles shall be provided if so specified in the item of work, duly considering the traffic the terrace will be subjected to.

- The minimum compacted thickness of lime concrete layer shall be 75mm and average thickness shall not he less than l00mm. In case, the thickness is more than l00mm, it shall be laid in layers not exceeding 100mm to 125mm.

- Laying of lime concrete shall be commenced from a corner of the roof and proceeded diagonally towards centre and other sides duly considering the slopes specified for effectively draining the rain-water towards the down take points.

- Lime concrete fillet for a minimum height of 150mm shall be provided all along the junction of the roof surface with the brick masonry wall/parapet/column projections. These shall then be finished an top with provision of clay terracing tiles/cement concrete tiles.

- After the lime concrete is laid it shall be initially rammed with a rammer weighing not more than 2 Kg and the finish brought to the required evenness and slope. Alternatively, bamboo strips may be used for the initial ramming. Further consolidation shall be done using wooden THAPIES with rounded edges. The beating will normally have to be carried an for atleast seven days until the THAPI makes no impression on the surface and rebounds readily from it when struck. Special care shall be taken to properly compact the lime concrete at its junction with parapet walls or column projections.

- During compaction by hand-beating, the surface shall be sprinkled liberally with lime water (1 part of lime putty and 3 to 4 parts of water) and a small proportion of sugar solution for obtaining improved water-proofing quality of the lime concrete. On completion of beating, the mortar that comes on the top shall be smoothened with a trowel or float, if necessary, with the addition of sugar solution and lime putty. The sugar solution may be prepared in any one of the following ways as directed by the ENGINEER

a) By mixing about 3 Kg of Jaggery and 1.5 Kg of BAEL fruit to 100 litres of water by boiling.

b) By mixing about 600 gm of KADUKAI (the dry nuts shall be broken to small pieces and allowed to soak in water), 200 gm of jaggery and 40 litres of water for 10 sq.m of work. This solution shall be brewed for about 12 to 24 hours and the resulting liquor decanted and used for the work.

- The lime concrete after compaction shall be cured for a minimum period of ten days or until it hardens by covering with a thin layer of straw or hessian which shall be kept wet continuously.

- For finishing on top, machine made burnt clay flat terracing tiles conforming to IS 2690 (Part-1) or cement concrete flooring tiles conforming to IS 1237 shall be used and shall be of the size and thickness as specified in the item of work. Tiles shall be soaked in water for at least one hour before laying. Bedding for the tiles shall be 12mm thick in cement mortar 1:3. Tiles shall be laid, open jointed with 4 to 6 mm wide joints, flat on the mortar and lightly pressed and set to plane surface true to slope, using a trowel and wooden

straight edge. They shall be laid with their longitudinal lines of joints truly parallel and generally at right angles to the direction of run-off gradient. Transverse joints in alternate rows shall come directly in line with each other. Transverse joints in adjacent courses shall break joints by atleast 50 mm. The joints shall be completely filled and flush pointed with cement mortar l:2 mixed with water proofing compound as per manufacturer's instructions. Curing shall be carried out for a minimum period of seven days.

- Cement concrete tiles if used shall be supplied after the first machine grinding of the surface.

- After completing all the water proofing works over the roof surface and curing, the works shall be tested against any leakage / soaking of water below the roof. For this, arrangement shall be made by Contractor to store minimum 50mm height of water over the roof surface and shall be maintained for a period of 7 days. If any wet patch is observed on the ceiling, rectification of water proofing works should be attended immediately by the contractor. The test should be repeated till the leakage / soaking through the ceiling completely stops.

- The contractor shall give guarantee for a minimum period of 10 years against any leakage / soaking through the ceiling, for the quality of materials supplied and for the good workmanship carried out. The guarantee should be in writing on a format prepared by owner. In case of any defect found in the above during guarantee period, it should be attended to and rectified immediately by the contractor at his own cost

(iii) **Measurement**

Measurement shall be in sq.m correct to two places of decimal. Measurement shall be for the plan area between the inside of plastered walls where the treatment is executed. No separate payment shall be made for the fillets.

9.4.2.30 **CEMENT PLASTERING WORK**

(i) **Materials**

- The proportions of the cement mortar for plastering shall be 1:4 (one part of cement to four parts of sand) unless otherwise specified under the respective item of work. Cement and sand shall be mixed thoroughly in dry condition and then water added to obtain a workable consistency. The quality of water and cement shall be as per relevant IS. The quality and grading of sand for plastering shall conform to IS:15130. The mixing shall be done thoroughly in a mechanical mixer unless hand mixing is specifically permitted by the ENGINEER. If so desired by the ENGINEER sand shall be screened and washed to meet the specification requirements. The mortar thus mixed shall be used as soon as possible preferably within 30 minutes from the time water is added to cement. In case the mortar has stiffened due to evaporation of water this may be re-tempered by adding water as required to restore consistency but this will be permitted only upto 30 minutes from the time of initial mixing of water to cement. Any mortar which is partially set shall be rejected and removed forthwith from the site. Droppings of plaster shall not be re-used under any circumstances.

(ii) **Workmanship**

- Preparation of surfaces and application of plaster finishes shall generally confirm to the requirements specified in IS:1661 and IS:2402.

- Plastering operations shall not be commenced until installation of all fittings and fixtures such as door/window panels, pipes, conduits etc. are completed.

- All joints in masonry shall be raked as the work proceeds to a depth of l0mm/20mm for brick/stone masonry respectively with a tool made for the purpose when the mortar is still green. The masonry surface to be rendered shall be washed with clean-water to remove all dirt, loose materials, etc., Concrete surfaces to be rendered shall be roughened suitably by hacking or bush hammering for proper adhesion of plaster and the surface shall be evenly wetted to provide the correct suction. The masonry surfaces should not be too wet but only damp at the time of plastering. The dampness shall be uniform to get uniform bond between the plaster and the masonry surface.

- **Interior plain faced plaster** - This plaster shall be laid in a single coat of 13mm thickness. The mortar shall be dashed against the prepared surface with a trowel. The dashing of the coat shall be done using a strong whipping motion at right angles to the face of the wall or it may be applied with a plaster machine. The coat shall be trowelled hard and tight forcing it to surface depressions to obtain a permanent bond and finished to smooth surface. Interior plaster shall be carried out on jambs, lintel and sill faces, etc. as shown in the drawing and as directed by the ENGINEER. Rate quoted for plaster work shall be deemed to include for plastering of all these surfaces.

- **Plain Faced Ceiling plaster** - This plaster shall be applied in a single coat of 6mm thickness. Application of mortar shall be as stipulated in clause 14.3.30.2(iv)

- **Exterior plain faced plaster** - This plaster shall be applied in 2 coats. The first coat or the rendering coat shall be approximately 14mm thick. The rendering coat shall be applied as stipulated in clause 30.2.4 except finishing it to a true and even surface and then lightly roughened by cross scratch lines to provide bond for the finishing coat. The rendering coat shall be cured for atleast two days and then allowed to dry. The second coat or finishing coat shall be 6 mm thick. Before application of the second coat, the rendering coat shall be evenly damped. The second coat shall be applied from top to bottom in one operation without joints and shall be finished leaving an even and uniform surface. The mortar proportions for the coats shall be as specified in the respective item of work. The finished plastering work shall be cured for atleast 7 days.

- Interior plain faced plaster 20mm thick if specified for uneven faces of brick walls or for random/coursed rubble masonry walls shall be executed in 2 coats similar to the procedure stipulated in clause14.3.30.2(vii)

- **Exterior Sand Faced Plaster** - This plaster shall be applied in 2 coats. The first coat shall be 14mm thick and the second coat shall be 6mm thick. These coats shall be applied as stipulated in clause 30.2.6. However, only approved quality white sand shall be used for the second coat and for the finishing work. Sand for the finishing work shall be coarse and of even size and shall be dashed against the surface and sponged. The mortar

proportions for the first and second coats shall be as specified in the respective items of work.

- Wherever more than 20mm thick plaster has been specified, which is intended for purposes of providing beading, bands, etc. this work shall be carried out in two or three coats as directed by the ENGINEER duly satisfying the requirements of curing each coat (rendering/floating) for a minimum period of 2 days and curing the finished work for atleast 7 days.

- In the case of pebble faced finish plaster, pebbles of approved size and quality shall be dashed against the final coat while it is still green to obtain as far as possible a uniform pattern all as directed by the ENGINEER.

- Where specified in the drawings, rectangular grooves of the dimensions indicated shall be provided in external plaster by means of timber battens when the plaster is still in green condition. Battens shall be carefully removed after the initial set of plaster and the broken edges and corners made good. All grooves shall be uniform in width and depth and shall be true to the lines and levels as per the drawings.

- Curing of plaster shall be started as soon as the applied plaster has hardened sufficiently so as not to be damaged when watered. Curing shall be done by continuously applying water in a fine spray and shall be carried out for atleast 7 days.

- When the specification items of work calls for waterproofing plaster the CONTRACTOR shall provide the waterproofing compound as specified while preparing the cement mortar. Payment for water-proofing compound will be made separately if it is not included as a combined item of work.

- Where lath plastering is specified, it shall be paid for at the same rate as for plaster work except that separate payment for metal lath will be made.

- For external plaster, the plastering operations shall be commenced from the top floor and carried downwards. For internal plaster, the plastering operations for the walls shall commence at the top and carried downwards. Plastering shall be carried out to the full length of the wall or to natural breaking points like doors/windows etc. Ceiling plaster shall be completed first before commencing wall plastering.

- Double scaffolding to be used shall be as specified in clause 14.3.4.2(vi)

- The finished plaster surface shall not show any deviation more than 4mm when checked with a straight edge of 2m length placed against the surface.

- To overcome the possibility of development of cracks in the plastering work following measures shall be adapted.

- Plastering work shall be deferred as much as possible so that fairly complete drying shrinkage in concrete and masonry works takes place.

- Steel wire fabric shall be provided at the junction of brick masonry and concrete to overcome reasonably the differential drying shrinkage/thermal movement. This steel item shall be measured and paid for separately.

- Ceiling plaster shall be done, with a trowel cut at its junction with wall plaster. Similarly trowel cut shall be adopted between adjacent surfaces where discontinuity of the background exists.

(iii) **Measurement**

- Measurement for plastering work shall be in sq.m correct to two places of decimal. Unless a separate item is provided for grooves, mouldings, etc., these works are deemed to be included in the unit rates quoted for plastering work. The quantity of work to be paid for under these items shall be calculated by taking the projected surface of the areas plastered after making necessary deductions for openings for doors, windows, fan openings etc. The actual plaster work carried out on jambs/sills of windows, openings, etc. shall be measured for payment.

9.4.2.31 **CEMENT POINTING**

(i) **Materials**

- The cement mortar for pointing shall be in the proportion of 1:3 (one part of cement to three parts of fine sand) unless otherwise specified in the respective items of work. Sand shall conform to IS:15130 and shall be free from clay, shale, loam, alkali and organic matter and shall be of sound, hard, clean and durable particles. Sand shall be approved by ENGINEER and if so directed it shall be washed/screened to meet specification requirements.

(ii) **Workmanship**

- Where pointing of joints in masonry work is specified on drawings/respective items of work, the joints shall be raked at least 15mm/20mm deep in brick/stone masonry respectively as the work proceeds when the mortar is still green.
- Any dust/dirt in the raked joints shall be brushed out clean and the joints shall be washed with water. The joints shall be damp at the time of pointing. Mortar shall be filled into joints and well pressed with special steel trowels. The joints shall not be disturbed after it has once begun to set. The joints of the pointed work shall be neat. The lines shall be regular and uniform in breadth and the joints shall be raised, flat, sunk or 'V' as may be specified in the respective items of work. No false joints shall be allowed.

- The work shall be kept moist for atleast 7 days after the pointing is completed. Whenever coloured pointing is to be done, the colouring pigment of the colour required shall be added to cement in such proportions as recommended by the manufacturer and as approved by the ENGINEER.

(iii)**Measurement**

The quantity of work to be paid for under this Item shall be measured in sq.m correct to

two places of decimal by taking the projected surface of the area pointed after making necessary deductions for openings, etc.

9.4.2.32 METAL LATH & WIRE FABRIC

(i) **Materials**

- Welded steel wire fabric shall conform to IS:4948
- Expanded metal shall conform to IS:412
- Galvanised wire mesh shall be of approved quality.

(ii) **Workmanship**

- The type and details of the steel material to be used for metal lath plastering work and at the junctions of brick masonry/concrete before wall plastering shall be as specified in the respective items of work.
- For metal lath plastering work, the weight of steel material shall be not less than 1.6 kg/sq m.
- Steel material for use at the Junction of brick masonry/ concrete shall have the mesh dimensions not greater than 50 mm.
- Steel material shall be obtained in maximum lengths as manufactured to restrict joints to the minimum. Overlap at the joints shall be minimum 25 mm which shall be securely tied with wires of diameter not less than 1.25 mm at spacing not more than 100 mm for lath plastering work. Nailing to wall shall be at spacing not exceeding 200 mm. The material shall be straightened, cut and bent to shape if required for fixing as per the details indicated in the drawings.

(iii) **Measurement**

Measurement shall be in sq.m correct to two places of decimal for the type as specified in the respective items of work.

9.4.2.33 WATER-PROOFING ADMIXTURE

Water-proofing admixture shall conform to the requirements of IS:2645 and shall be of approved manufacture. The admixture shall not contain calcium chloride. The quantity of the admixture to be used for the works and method of mixing etc. shall be as per manufacturer's instructions and as directed by the Engineer. Payment shall be made for the actual quantity of such admixture used unless it is already covered in the rate for the relevant item of work.

9.4.2.34 PAINTING OF CONCRETE MASONRY & PLASTERED SURFACES

(i) **Materials**

- Oil bound distemper shall conform to IS:1308. The primer shall be alkali resistant primer of the same manufacture as that of the distemper.

- Cement paint shall conform to IS:5410. The primer shall be a thinned coat of cement paint.
- Acrylic emulsion paint shall be of an approved manufacture.
- Plastic emulsion paint shall conform to IS:5411.
- Lead free acid, alkali and chlorine resisting paint shall conform to IS:9862.

- White wash shall be made from good quality fat lime conforming to IS:712. It shall be slaked at site and mixed with water in the proportion of 5 litres of water to 1 kg of un-slaked lime stirred well to make a thin cream. This shall be allowed to stand for a minimum period of one day and strained through a clean coarse cloth. Four kg of gum dissolved in hot water shall be added to each cu.m of cream. 1.30 kg of sodium chloride dissolved in hot water shall then be added per 10 kg of lime used for the white wash to be ready for application.
- Colour wash shall be made by addition of a suitable quantity of mineral pigment, not affected by lime, to the prepared white wash to obtain the shade/tint as approved by the ENGINEER.

- All the materials shall be of the best quality from an approved manufacturer. CONTRACTOR shall obtain prior approval of the ENGINEER for the brand of manufacture and the colour/shade. All materials shall be brought to the site of works in sealed containers.

(ii) **Workmanship**

- CONTRACTOR shall obtain the approval of the ENGINEER regarding the readiness of the surfaces to receive the specified finish, before commencing the work on painting.

- Painting of new surfaces shall be deferred as much as possible to allow for thorough drying of the sub-strata.

- The surfaces to be treated shall be prepared by thoroughly brushing them free from dirt, mortar droppings and any loose foreign materials. Surfaces shall be free from oil, grease and efflorescence. Efflorescence shall be removed only by dry brushing of the growth. Cracks shall be filled with Gypsum. Workmanship of painting shall generally conform to IS:2395.

- Surfaces of doors, windows etc. shall be protected suitably to prevent paint finishes from splashing on them.

<u>WHITE WASH</u>

The prepared surfaces shall be wetted and the finish applied by brushing. The operation for each coat shall consist of a stroke of the brush first given horizontally from the right and the other from the left and similarly, the subsequent stroke from bottom upwards and the other from top downwards, before the first coat dries. Each coat shall be allowed to dry before the next coat is applied. Minimum of 2 coats shall be applied unless otherwise specified in the item of work. The dry surface shall present a uniform finish without any

brush marks.

COLOUR WASH

Colour wash shall be applied in the same way as for white wash. A minimum of 2 coats shall be applied unless otherwise specified in the item of work. The surface shall present a smooth and uniform finish without any streaks. The finished dry surface shall not show any signs of peeling/powdery and come off readily on the hand when rubbed.

CEMENT PAINT

The prepared surfaces shall be wetted to control surface suction and to provide moisture to aid in proper curing of the paint. Cement paint shall be applied with a brush with stiff bristles. The primer coat shall be a thinned coat of cement paint. The quantity of thinner shall be as per manufacturer's instructions. The coats shall be vigorously scrubbed to work the paint into any voids for providing a continuous paint film free from pinholes for effective water- proofing in addition to decoration. Cement paint shall be brushed in uniform thickness and the covering capacity for two coats on plastered surfaces shall be 3 to 4 kg/sq.m. A minimum of 2 coats of the same colour shall be applied unless otherwise specified in the item of work. Atleast 24 hours shall be left after the first coat to become sufficiently hard before the second coat is applied. The painted surfaces shall be thoroughly cured by sprinkling with water using a fog spray at least 2 to 3 times a day. Curing shall commence after about 12 hours when the paint hardens. Curing shall be continued for atleast 2 days after the application of final coat. The operations for brushing each coat shall be as detailed in 34.2.5.

OIL BOUND DISTEMPER

The prepared surfaces shall be dry and provided with one coat of alkali resistant primer by brushing. The surface shall be finished uniformly without leaving any brush marks and allowed to dry for atleast 48 hours. A minimum of two coats of oil bound distemper shall be applied unless otherwise specified in the item of work. The first coat shall be of a lighter tint. Atleast 24 hours shall be left after the first coat to become completely dry before the application of the second coat. Broad, stiff, double bristled distemper brushes shall be used for the work. The operations for brushing each coat shall be as detailed in 34.2.5.

PLASTIC EMULSION PAINT

The prepared surface shall be dry and provided with one coat of primer which shall be a thinned coat of emulsion paint. The quantity of thinner shall be as per manufacturer's instructions. The paint shall be laid an evenly and smoothly by means of crossing and laying off. The crossing and laying off consists of covering the area with paint, brushing the surface hard for the first time over and then brushing alternately in opposite directions two or three times and then finally brushing lightly in a direction at right angles. In this process, no brush marks shall be left after the laying off is finished. The full process of crossing and laying off constitutes one coat. The next coat shall be applied only after the first coat has dried and sufficiently become hard which normally takes about 2 to 3 hours. A minimum of 2 finishing coats of the same colour shall be applied unless otherwise specified in the item of work. Paint may also be applied using rollers. The surface on

finishing shall present a flat velvety smooth finish and uniform in shade without any patches.

ACRYLIC EMULSION PAINT

Acrylic emulsion paint shall be applied in the same way as for plastic emulsion paint. A minimum of 2 finishing coats over one coat of primer shall be provided unless otherwise specified in the item of work.

ACID, AIKALI RESISTING PAINT

A minimum of 2 coats of acid/alkali resisting paint shall be applied over the prepared dry surfaces by brushing. Primer coat shall be as per manufacturer's instructions.

(iii) **Measurement**

Measurement shall be in sq.m correct to two places of decimal. Measurement shall be for the areas as executed duly deducting for any openings etc. Rate quoted shall take into account the provision of necessary enabling works such as scaffolding, painter's cradle etc.

9.4.2.35 PAINTING & POLISHING OF WOOD WORK

(i) **Materials**

- Wood primer shall conform to IS:3536E.
- Filler shall conform to IS:110 or IS 345.
- Varnish shall conform to IS:337.
- French polish shall conform to IS:348.
- Synthetic enamel paint shall conform to IS:2932.
- All the materials shall be of the best quality from an approved manufacturer. CONTRACTCOR shall obtain prior approval of the ENGINEER for the brand of manufacture and the colour/shade. All materials shall be brought to the site of works in sealed containers.

(ii) **Workmanship**

- The type of finish to be provided for woodwork of either painting or polishing, the number of coats, etc. shall be as specified in the respective items of work.
- Primer and finish paint shall be compatible with each other to avoid, cracking and wrinkling. Primer and finish paint shall be from the same manufacturer.

- Painting shall be either by brushing or spraying. CONTRACTOR shall procure the appropriate quality of paint for this purpose as recommended by the manufacturer. The workmanship shall generally conform to the requirements of IS:2338 (Part I).
- All the wood surfaces to be painted shall be thoroughly dry and free from any foreign matter. Surfaces shall be smoothened with abrasive paper using it across the grains and dusted off. Wood primer coat shall then be applied uniformly by brushing. The number of primer coats shall be as specified in the item of work. Stopping as per IS 1306 shall be used to fill up large holes & cracks on the surface. For small holes or minor cracks, fillers as per IS 110 should be used. Any slight irregularities of the surface shall then be made up by applying an optimum coat of filler conforming to IS:110 and rubbed down with an abrasive paper for obtaining a smooth surface for the undercoat of synthetic enamel paint conforming to IS:2932. Paint shall be applied by brushing evenly and smoothly by means of crossing and laying off in the direction of the grain of wood. After drying, the coat shall be carefully rubbed down using very fine grade of sand paper and wiped clean before the next coat of finishing is applied. Atleast 24 hours shall elapse between the application of successive coats. Each coat shall vary slightly in shade and this shall be got approved by the ENGINEER. The number of coats of paint to be applied shall be as specified in the item of work.
- All the wood surfaces to be provided with clear finishes shall be thoroughly dry and free from any foreign matter. Surfaces shall be smoothened with abrasive paper using it in the direction of the grains and dusted off.
- Any slight irregularities of the surface shall be made up by applying an optimum coat of transparent liquid filler conforming to IS 345. The Surface when hard shall be rubbed down with fine abrasive paper. All dust and dirt shall be cleaned and on this surface water or spirit stains shall be applied to enhance the natural grain or figuring effect of wood. After the surface is dry, a suitable seater shall be applied to prevent bleeding of stain and filler into the finish coat. The surface shall be rubbed down lightly, wiped off and allowed to dry. Over this prepared surface, varnish conforming to IS: 337 shall be applied by brushing. Varnish should not be retouched once it has begun to set. Staining if required shall be provided as directed by the ENGINEER. When two coats of varnish is specified, the first coat should be a hard-drying undercoat or flatting varnish which shall be allowed to dry hard before applying the finishing coat. The number of coats to be applied shall be as per the item of work. For works where clear finish of French polish is specified the prepared surfaces of wood shall be applied with the polish using a pad of woollen cloth covered by a fine cloth. The pad shall be moistened with polish and rubbed hard an the surface in a series of overlapping circles to give an even finish over the entire area. The surface shall be allowed to dry before applying the next coat. Finishing shall be carried out using a fresh clean cloth over the pad, slight dampening with methylated spirit and rubbing lightly and quickly in circular motions. The finished surface shall have a uniform texture and high gloss. The number of coats to be applied shall be as per the item of work.

(iii) **Measurement**

Measurement shall be in sq.m correct to two place of decimal. Measurement shall be for the projected area between out to out of frames and no multiplying factor is allowed on any account. Rate shall be inclusive of enabling works such as scaffolding, etc. Measurement and payment is applicable only if a separate item is specified and not if it is already made as part of a combined item.

9.4.2.36 **PAINTING OF STEEL WORK**

For painting of structural steel refer separate section.

9.4.2.37 **FLASHING**

(i) **Materials**

- Anodised aluminium sheets shall be 1.00mm thick with anodic film thickness of 0.025 mm.
- Galvanised mild steel sheets shall be 1.00mm thick with zinc coating of 800 gms/sq.m.
- Bitumen felt shall be either Hessian base self finished bitumen felt Type-3 Grade I conforming to IS:1322 or glass fibre base self finished felt Type-2 Grade I conforming to IS:.7193.

(ii) **Workmanship**

- The type of the flashing and method of fixing shall be as specified in the respective items of work.
- Flashing shall be of the correct shape and size as indicated in the construction drawings and they shall be properly fixed to ensure their effectiveness.
- Flashing shall be of long lengths so as to provide minimum number of joints. The minimum overlap at joints shall be l00mm.
- Fixing of the flashing shall be either by bolting with bitumen washers or by tucking into the groove 75 mm wide X 65 mm deep in masonry/concrete along with cement mortar 1:4 filleting as indicated in the drawings. Curing of the mortar shall be carried out for a minimum period of 4 days.
- Bitumen or glass fibre felt flashing of the type as specified shall be provided with 1 coat of bitumen primer as per IS 3384 and 2 coats of bituminous bonding material, hot applied, of grade 85/25 conforming to IS 702 at the rate of 1.2 kg/sq.m, after the installation.

(iii) **Measurement**

Measurement shall be in sq.m correct to two places of decimal. Measurement shall be for the actual area of the flashing material provided and the rate shall include for all the incidental works of bending to shape and fixing details as per the construction drawings.

9.4.2.38 **INSERTS AND CUTOUTS IN CONCRETE WORK**

- Numerous inserts are required to be fixed/embedded in concrete as indicated in construction drawings/as directed by the Engineer. 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.
- The rate quoted by the Bidder for concrete works shall hold good for accurately fixing the inserts at the correct levels/alignment and shall include the cost of any temporary supports/anchors such as bars including cutting, bending, welding, etc. as required.
- 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.

- 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.
- 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.

(i) **Measurement**

Inserts which are fabricated by contractor at his workshop will be weighed and paid as per the items of work.

9.4.2.39 **FALSE CEILING**

(i) **Fibre Board False Ceiling**

FIBRE BOARD

- The hard fibre board to be used in false ceiling shall be of an approved manufacture as per IS:1658 or as approved by the Owner.

- The fibre boards shall be made from substances compound of vegetable fibres such as wood pulp, wood chips or shavings bonded by a synthetic resin. Veneered particle boards shall have a core of particle board sandwiched or glued in between two or more veneers on outer surfaces.

- The fibre boards shall be fire resistant, termite and insect resistant, weather resistant, acoustically satisfactory, dimensionally stable, warp-free, easily workable, treated with anti-fungus chemicals, heat insulated and of adequate structural strength and should have good surface finish as approved by the Owner.

- The size of fibre board ceiling tile shall generally be 600 x 600 x 12 mm thick. All types of boards and ceiling tiles shall be stored flat under cover at a clean dry place on firm ground. The Contractor should ensure that boards are not stacked on termite infected, wet or loose ground. The boards should be always carried on edges.

(ii) **Metal Frame Work**

- The metal frame work shall be interlocking type and made of sections of light metal, such as extruded anodised aluminium. The shape and cross section shall be such as to

facilitate proper suspension and proper fixing of the ceiling boards covering them and shall be structurally sound and rigid.

(iii) **Construction**

- The Contractor shall ensure that the frame to support the ceiling is designed for its structural strength to withstand the weight of ceiling boards to be fixed, live load of 75 kg/m^2, and other loads such as that of air- conditioning ducts, grills, electrical wiring and lighting fixtures, thermal insulation, etc. as shown on the drawings. The Contractor shall also submit a detailed drawing to show the grid work, sizes of grid members, method of suspension, position of openings for air-conditioning and lighting, access doors, etc.

- The metal frame work of extruded anodised aluminium false ceiling grid system shall consist of aluminium main members of special T-profile of 32 mm x 32 mm interlocking with each other and run both ways at 600 mm centre to centre. The aluminium false work shall be suspended from the roof structures by means of aluminium painted steel hangers at suitable intervals and supported at the walls by means of extruded aluminium wall angles.

- In the case of aluminium grid system, boards are just placed into the frames formed by the main `T' members and the cross members fitted with the clips for locking the boards. Contractor should take utmost care so as not to force the boards in position, and a very little gap is preferable to a tight joint. Fixing fibre boards by adhesives shall not be permitted unless approved by the Owner. The fibre boards should be cut with a fine toothed saw, if required.

- The hard boards shall be conditioned by wetting the screen surface with clean water by a sponge or brush. The damp boards should be stacked back to back on flat surface at site for 48 hours and then fixed immediately. Conditioning if required shall be done as per the manufacturer's specifications.

- As the work of false ceiling may be interconnected with the work of air-conditioning ducts and lighting, the Contractor shall fully cooperate with other agencies entrusted with the above works and who may be working simultaneously. The Contractor shall provide necessary openings, in the false ceiling work for air- conditioning, lighting and other fixtures. Additional framing, if required, for the above openings shall also be provided at no extra cost to the Owner. Removable or hinged type inspection or access trap doors shall be provided at locations specified by the Owner.

9.4.2.40 GYPSUM PLASTER BOARD FALSE CEILING

(i) **Gypsum Plaster Board**

- Gypsum Plaster Board to be used in false ceiling shall be of an approved manufacturer and approved by OWNER/ENGINEER.

- The boards shall be of maximum size 1220mm x 1800mm and 12.5 mm thick with tapered edges. They should be dimensionally stable, warp free, easily workable and should have a good surface finish.

- The boards should be carried and stacked as per manufacturer's recommendations.

(ii) **Metal Frame Work Construction**

- The metal framework shall consist of a GI perimeter channel fixed along the perimeter of the ceiling having a size of 27mm x 0.5mm thick with one flange of 20mm and the other flange of 30mm. Channels are to be held in position by means of screw driven rawl plugs at 600mm centers. GI intermediate channels of size 45mm x 15mm (flange) x 0.9mm thick shall be suspended from the soffit at a maximum spacing of 1220mm by means of MS flats 25mm x 3mm fixed to the soffit at 1220mm centres by means of a GI cleat and expansion fasteners. GI Ceiling sections of 0.5mm thickness having knurled wedge 51.5mm and two flanges of 26mm each with lips of 10.5mm are then fixed to the intermediate channel by means of connecting clips perpendicular to the direction of the intermediate channel at 450mm centres.

  a. Gypsum plaster boards of 12.5mm thick shall then be fixed to the ceiling sections by means of drywall screws at 230mm centres. The joints between boards shall be staggered.

- The tapered edges shall be jointed in the following manner:

  a. A band of jointing compound is applied to the taper in the board joints. Required length of paper tape is pressed in to the band of jointing compound by means of a taping knife. After the joints have dried, a thin layer of jointing compound is applied as a first coat of finish, followed by the same treatment as a second coat of finish. Finally two coats of top coat are applied on the entire surface to get an even form surface. All nail and screw heads should be filled flush with the board surface.

- The Contractor shall ensure that the frame to support the ceiling is designed for its structural strength to with-stand the weight of ceiling boards to be fixed, live load of 75 kg/m^2, and other loads such as that of air-conditioning ducts, grills, electrical wiring and lighting fixtures, thermal insulation, etc. as show on the drawings. The Contractor shall also submit a detailed drawing to show the grid work, sizes of grid members, method of suspension, position of openings for air-conditioning and lighting, access doors, etc.

- As the work of false ceiling may be interconnected with the work of air-conditioning ducts and lighting, the Contractor shall fully cooperate with other agencies entrusted with the above works and who may be working simultaneously. The Contractor shall provide necessary openings, in the false ceiling work for air- conditioning, lighting and other fixtures. Additional framing, if required, for the above openings shall also be provided at no extra cost to the Owner. Removable or hinged type inspection or access trap doors shall be provided at locations specified by the Owner.

(iii)**Luxalon Ceiling**

- The false ceiling frame work shall be designed to withstand the self weight, and weight of AC grills, lighting fixture etc.

- Based on the outline duly furnished by Owner locating AC grills, lighting fixtures etc., the Contractor shall prepare detailed working drawings including framing around openings access doors etc. Only on obtaining approval on the drawings shall the fabrication commence.

(iv)**Measurement**

Measurement for payment shall be superficial area of the false ceiling less openings if any. Openings in false ceilings less than 0.2 sq.m in area shall not be deducted for the purpose of payment.

9.4.2.41 THERMAL INSULATION FOR CEILING

(i) **Material**

- Thermal Insulation material consisting of boards, slabs and rolls of approved manufacture, shall be of approved thermal conductivity for creating the required design conditions and shall be provided as indicated in item of works and as shown in the drawings. The insulation shall be provided after the sample is approved by the Owner.

- The quoted rate shall include supply, delivery, cutting and fixing of all materials for covering the roof with thermal insulation material, including wood pegs, slotted angle, G.I rawl plugs, wood/coach screws, lacing wire, G.I washers, wire mesh, any covering as stipulated in schedule of prices and quantities, finishing at all levels and elevation etc., complete.

(ii) **Measurement**

Measurement for payment shall be same as given in clause 14.3.41.

9.4.2.42 WATER-PROOFING WITH ELASTOMERIC MEMBRANE (ISOTHANE EMA)

(i) **Materials**

- It is a liquid which is Urethane Pre-polymer based that can be applied with a brush on concrete surfaces to form a permanent, flexible, seamless membrane coating after it is cured.

- The salient features of Isothane EMA are as given below:

Application temp limit	0 to 70 degree centigrade
Elongation percent	500

Approx. drying time	a) 12 to 20 hours for touch dry b) 7 days for full cure
Accelerated weathering	No appreciable depreciation after 1200 hrs
Resistant to Ultraviolet rays, hydrolysis and Industrial environment	Excellent
Resistant to Mechanical Damage	Good
Shelf life	9 months

- Once the can containing the liquid is opened, it starts to cure and form a scum on the top. It should be removed to use the material below.

(ii) **Workmanship**

- The roof shall be sloped with concrete or mortar screed to achieve the specified slope as per drawing and shall be properly cured before taking up water-proofing treatment.

- The surface shall be cleaned of all foreign matters by wire brushing, dusting etc. and shall be made thoroughly dry. All cracks and voids on the surface shall be filled with mastic sealant, if required..

- Over the cleaned surface, a suitable coat of polyurethane primer @ 5 – 6 sq.m/ litre shall be applied.

- First coat of Isothane EMA elastomeric membrane shall be applied on the primed surface @ 0.50 kg/sq.m with a minimum average thickness of 0.50 mm.

- After the first coat is touched dry, second coat of Isothane EMA @ 0.50 kg/sq.mm and minimum average thickness of 0.50mm shall be applied.

- Due to unavoidable circumstances, if application of second coat is delayed, special primer shall be applied over the entire surface of first coat and is allowed to dry for 4 to 8 hours before second coat is applied.

- It shall be ensured that a concave fillet 75mm in radius is provided in cement mortar 1:4 at the junction of roof and vertical faces of masonry or RCC parapet wall or column projections.

- Water proofing treatment shall be taken on the brick masonry wall / parapet / column projection by a minimum of 150 mm along its height. Groove 75mm wide and 65mm deep in masonry shall be left for tucking the water proofing treatment. The groove shall be filled with 1:4 cement mortar for securing the water proofing treatment firmly.

- All completed works shall be cleaned to remove any spillage from chemicals.

- Finishing on top with cement concrete floor tiles or machine made burnt clay flat terracing tiles shall be carried out, if specified, as described in clause 14.3.29.0.

- Testing against any leakage or soaking of water through the roof shall be carried out as specified in clause 14.3.29.0

- The contractor shall give guarantee for all of his works as specified in clause 14.3.29.0

(iii) **Measurement**

Measurement shall be for the plan area of treatment and for the finished work. No separate payment shall be made for the fillets and work as specified on the vertical faces. Cement concrete tiling works or machine pressed clay tile works shall be paid separately, unless they are specifically included in the item of works.

9.4.2.43 AUTOMATIC SLIDING DOOR

(i) **Materials and Workmanship**

- These doors shall be from reputed approved manufacturers specialised in this area of works. However, it shall have following minimum features.

- Size of module shall be 6000 mm wide and 2400 mm height. Clear door opening shall be 2000 mm wide and 2400 mm height. It shall have 2000 mm wide fixed panels on either side.

- It should consist of microprocessor control unit, monitoring device for opening and closing, automatic reverse system on contact with obstruction. In general, it should be operable without the use of any additional instrumentation or gadgets by the user.

- The module should be provided with short circuit proof power supply unit for power rating of 220/240 V, 50/60 Hz. A power point will be made available at a suitable location by electrical contractor.

- The door shall have facilities for activation by infrared movement detector on both sides.

- The door shall have adjustable shutter speed as follows:

- Opening and closing speed – 10 to 60 cm/sec/leaf.

- Creep speed – 3 to 9 cm/sec/leaf

- Opening time – 0 to 180 sec.

- Both the fixed and sliding panels shall be made of 12 mm thick toughened glass with or without etching. It should be provided with all required fittings and fixtures, digital entry – exit function on the top and electro- mechanical locking system.

(ii) **Payment**

The rate shall be on lump- sum basis and shall include the cost of all materials, labour, transport, handling, loading and unloading, installation, power requirement, testing, commissioning all necessary hardware, structural supports required for erection, protecting the module and glass till handing over and all other features as per manufacturer's specification.

9.4.2.44 **PLUMBING**

(i) **Scope**

- This specification covers the general requirements of providing and laying water mains and water supply piping, providing and fixing sanitary fixtures and piping and providing and laying drainage lines.

- The said work shall be carried out and completed under this contract in every respect in conformity with the rules and regulations of the local authority.
- The Contractor shall supply all labour, material, appliances, tools and equipment necessary for the work for plumbing services installation including testing, commissioning and maintenance as specified herein, and as per the relevant Bureau of Indian Standards (BIS), British Standards codes, and local legalities. This also includes any material, appliances and equipment not specifically mentioned herein or noted on the drawings as being supplied or installed which are necessary and customary to make a complete installation properly connected and in working order.

- For specifications, mode of measurements and scope of work covered under the respective items for the work included under this contract, following documents shall be referred to in the order of precedence as given below:

a) Description of the items and notes if any given in the Schedule of Quantities.
b) Specifications.
c) Additional Conditions of Contract.
d) General Conditions of Contract.
e) Applicable Codes and Standards as specified herein with amendments/ revisions issued till date.

- In the event of any discrepancy among the documents referred above, the document in the higher order of precedence shall prevail.
- In the event of any element of specification not being available in any of the documents mentioned above, the instructions of the Engineer-in-Charge in writing shall be followed by the Contractor.
- The Work shall be carried out in accordance with the drawings and designs as would be issued to the Contractor by the Engineer-in-Charge duly signed and stamped by him. The Contractor shall not take cognisance of any drawings, designs, specifications, etc. not bearing Engineer-in-Charge's signature and stamp. Similarly the Contractor shall not take

cognisance of instructions given by any other Authority except the instructions given by the Engineer-in-Charge in writing.

- The Work shall be executed and measured as per metric dimensions given in the Schedule of Quantities, drawings etc.
- The Contractor shall acquaint himself fully with the partial provisions for supports that may be available in the structure and utilise them to the extent possible. In any case the Contractor shall provide all the supports regardless of provisions that have been already made. Nothing extra shall be payable for situations where bed plates (for supports) are not available or are not useful.
- The Contractor shall incorporate seismic considerations of anchoring and isolation in the design of the systems as called for the different equipment.
- The contractor shall carryout all incidental works connected with plumbing services installation such as excavation of trenches and back filling, cutting and chasing in concrete and brick and making good, cutting/drilling holes through walls, floors, slabs, beams and grouting for fixing of fixtures / equipment and so forth.

- The contractor shall furnish and install complete workable plumbing services installation as shown on the drawings and described in this specification and as per the latest Bureau of Indian Standards (BIS), British Standards (BS) specifications including all that which is necessary to all the buildings, internally and externally including MS angle Iron brackets, high quality pipe supports required for pipe fixing on walls and ceiling.
- The contractor shall furnish, receive, store and install the sanitary wares, accessories, sewerage pipes and sewerage appurtenances (a complete and workable sewerage system) internally as well as around the building and up to the sewage treatment plant as indicated in the drawing.
- The contractor has to co-operate, co-ordinate and achieve interfacing with other trade contractors in putting the installation in place. Any work done without regard or consultation with other trade contractors, shall be removed by the contractor without additional cost, to permit proper installation of all other work, as desired by the client / consultants.
- The contractor has to repair all damage done to the premises as a result of this installation and remove all debris left by those engaged for this installation to the satisfaction of client / consultants. All the pipes, concealed as well as exposed shall be painted as specified. Shop coats of paint that may be damaged during shipment or erection shall be cleaned off with mineral spirits, wire brushed and spot primed over the affected areas, then coated with paint to match the finish over the adjoining shop painted surface.
- The contractor has to clean and test all plumbing and sanitary fixtures. In addition to the sectional testing carried out during the construction, the Contractor shall test the entire installation after connections to the overhead tanks or pumping system or mains. He shall rectify all leakage and shall replace all defective materials in the system. Any consequential damage done, on account of Contractors carelessness, open or burst pipes or failure of fittings, during testing and commissioning to the building, furniture and fixtures shall be made good by the Contractor.
- It is the responsibility of the contractor to take care of all fittings and fixtures fitted until the time of final handing over to the clients.
- The contractor shall complete the plumbing work of wing-A in 30 days wing-B in another 30 days from start date of execution.

(ii) General Provisions

- Specifications and drawings

The specifications and drawings shall be considered as part of this contract and any work or materials shown on the drawings and not called for in the specifications or vice versa shall be executed as if specifically called for in both.

- The tender drawings indicate:

a) The extent and general arrangement of the sanitary fixtures, drainage system, etc.
b) The points of supply and network layout. However, any changes found essential to co-ordinate this work with other trades shall be made without any additional cost. The drawings and specifications are meant for the assistance and guidance of the contractor, and exact location, distance and levels will be governed by the individual building and site conditions. Therefore, approval of the clients / consultants shall be obtained before commencement of work.
c) Exact run and sizes of all pipes on all floors and vertical stacks
d) Ground and invert levels of all drainage pipes together with location of all gully traps, inspection chambers, manholes and connections up to outfall.
e) Run of all water supply lines with diameters, location of control valves, access panels etc.
f) Location of all mechanical equipment with layout and piping connections.

- Shop drawings & as built drawings:

  Contractor shall prepare Shop drawings indicating the layout, Specifications of pipes fittings, levels, and all other information required for execution of work. The Shop drawings shall be got approved before carrying out any section of work. The Shop drawings shall be submitted 7 days in advance for approval from the Clients.

  On completion of work, Contractor shall submit 5 copies of drawings and one CD of the same Drawings, indicating all works with size, level, and other information duly certified by the Architects to the Clients.

  Contractor shall also submit all operations and maintenance manual along with list of spare parts to the Client.

a) Contractor will have to attend weekly site meetings as per the directions and Architects/Owners.

b) Chasing of walls for concealing of Plumbing pipes shall be done by cutter only.

c) All debris emanating out of the Plumbing work shall be removed and dumped at a designated dumping place within the building premises.

d) Scaffolding if required for Plumbing work shall be provided by contractor at no extra cost.

e) Contractor has to submit his activity schedule in accordance with the civil activity bar chart (especially water proofing, tiling etc.) and ensure proper coordination with the civil agency.

f) All temporary water lines required for the civil activity shall be done by contractor at no extra labour cost.

g) Contractor shall depute sufficient Nos. of competent Engineers for supervision of works from his end and ensure that the quality of work is carried out as per the specifications and quality standards specified in the tender.

h) Contractor shall insert all the necessary sleeves as indicated in the drawings fabricated out of PVC material for Over Head Tanks which shall be provided by the Contractor at no extra cost.

All "Warranty Cards" given by the manufacturers shall be handed over to the client / consultants.

- Manufacturer's Instructions

Where manufacturers have furnished specific instructions relating to the materials used in this job and methods of construction that are not specifically mentioned in these documents, such instructions shall be followed in all cases. The contractor shall also furnish six sets of the detailed instruction, operating and maintenance manuals including detailed completion drawings on a bound copy to approved scale. Further it is the responsibility of the contractor to train the Employer's Authorized Representatives' personnel in the operation and maintenance of the system.

- Equipments, materials and workmanship

Determine that each piece of equipment meets the detailed requirements of the contract documents and that it is suitable for the installation shown. Notify the Architect of any shortcomings found during the tendering period. Each piece of equipment not meeting all requirements will not be acceptable, even though specified by name along with other manufacturers.

Where two or more units of the same class of equipment are furnished, use product of the same manufacture component parts of entire system need not be product of the same manufacture. Furnish all material and equipment, new and free from defects and of size, make, type and quality herein specified or approved by the Architect or consultant. All shall be installed in a near and workmanlike manner.

Materials shall be of approved make and quality specified, however the final choice shall always remain with the client / consultants. They shall conform to the respective Bureau of Indian Standards, British Standards Specifications and supported by Manufacturing Certificate / test certificate.

In any case of non-availability of materials in metric sizes, the nearest size of FPS units shall be provided with prior approval of the client / consultants at no extra cost.

- Protection against damage

All pipe and conduit openings shall be closed by means of plugs or caps to prevent the entrance of foreign matter. All piping, conduit, fixtures, equipment or apparatus shall be protected. Any such items damaged prior to final completion of work shall be restored to its original conditions or replaced at no expense to the Owner.

a) Care shall be taken to avoid damage from any cause at all stages. Packing pieces used for protection shall not disfigure or otherwise permanently mark the Works.
b) Surface protection shall be afforded by careful handling and the avoidance of the use of hooks, crowbars, or other implements that are likely to damage the works.
c) Protection during construction: Decorative surfaces shall be carefully protected during construction by a temporary cover.
d) Protection of finished work: At all stages of the Contract it is essential that all works are properly protected.
e) Suitable packing shall be used to ensure that scaffolding does not damage erected stone, marble, granite or other finished works.
f) Any disfigurement, discolouration or imperfection whatsoever due to any reason shall not be accepted and the Contractor shall either remedy the same or redo the work at no extra cost. The decision of the Engineer-in-Charge, as to whether any work either in whole or in part, is acceptable or not shall be final and binding on the Contractor.

- Licensed Plumber

All work performed by the contractor shall be through licensed plumbing supervisor possessing a valid plumbing contractors license employing engineers, technicians, foremen, plumbers, masons, helpers, etc., as required.

- Fees, permits and notices

Contractor shall comply with all bye-laws and regulations of local and other statutory authorities having jurisdiction over the works and shall be responsible for the payment of all fees and other charges and giving and receiving of all necessary notices. Contractor shall keep the clients / consultants timely informed about regulations and requirements of statutory authorities and shall obtain the final certificates of inspection and approval from the authorities.

- Guarantee

The contractor shall guarantee both the material and workmanship of first class quality corresponding to standard engineering practice for a period of 12 months from the date of issue of completion. The Contractor shall indemnify the Engineer-in-Charge for a similar period against any damage to property and injury to persons on account of any defective work or maintenance carried out by the Contractor. The format and text of the Guarantee and the Indemnity Bond shall be given by the Engineer-in-Charge.

- Quality assurance and quality control

a) *At the site level the Contractor shall arrange the materials stacking/ storage in appropriate manner to ensure their quality. Contractor shall provide equipment and manpower to test continuously the quality of materials, assemblies etc. as directed by the Engineer-in-Charge. The test shall be conducted continuously and the result of tests maintained. In addition the Contractor shall keep appropriate tools and equipment for checking alignments, levels, slopes and evenness of surface.*

b) *The Engineer-in-Charge shall be free to carry out tests as may be considered necessary 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.*

c) *The test shall be conducted at the site laboratory that may be established by Engineer-in-Charge or at any other Standard Laboratory selected by Engineer-in-Charge.*

d) *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-in-Charge shall have them transported and recover two times the actual cost from the Contractor's bills.*

e) *Testing charges shall be borne by the Engineer-in-Charge.*

f) *Testing may be witnessed by the Contractor or his authorised representative. Whether witnessed by the Contractor or not, the test results shall be binding on the Contractor.*

(iii) Sanitary and other fixtures

- *Scope of Work*

a) Without restricting to the generality of the foregoing, sanitary and other appliances shall inter-alia include the following:

✓ Sanitary appliances and fixtures for toilets like WC pan, wash basins, urinals, bidets, slop sinks etc

✓ Chromium plated brass fittings like water supply faucets, bib taps, stop cocks, showers, mixers etc

✓ Accessories e.g. seats for WC, traps, fixing brackets, waste couplings, flexible PVC or CP brass connector pipes, towel rods, toilet paper holders, soap dish, liquid soap dispensers, towel rails, coat hooks etc.

b) Whether specifically mentioned or not the Contractor shall provide for all appliances and fixtures all fixing devices, nuts, bolts, screws, hangers as required.

c) All exposed pipes within toilets and near appliances/ fixtures shall be of chromium plated brass or copper unless otherwise specified.

d) General requirements

✓ All materials shall be new and of quality conforming to specifications and subject to the approval of the Engineer-in-Charge. Wherever particular makes are mentioned, the choice of selection shall remain with the Engineer-in-Charge.

✓ All appliances, fixtures and fittings shall be provided with all such accessories as are required to complete the item in working condition whether specifically mentioned or not

in the Schedule of Quantities, specifications or drawings. Accessories shall include proper fixing arrangement, brackets, nuts, bolts, washers, screws and required connection pieces.

- ✓ Fixing screws shall be half round head chromium plated (CP) brass screws, with CP brass washers unless otherwise specified
- ✓ Porcelain sanitary ware shall be glazed vitreous china of first quality free from warps, cracks and glazing defects conforming to IS: 2556. The choice of the color of the Sanitary ware shall be that of the Engineer-in-Charge and nothing extra shall be payable to the Contractor for fixing of Sanitary ware of any color.
- ✓ Sinks for kitchen shall be of stainless steel or as specified in the Schedule of Quantities.
- ✓ Chromium plated fittings shall be cast brass chromium plated of the best quality approved by the Engineer-in-Charge.
- ✓ All appliances, fittings and fixtures shall be fixed in a neat workmanlike manner true to level and to heights shown on the drawings and in accordance with the manufacturer's recommendations. Care shall be taken to fix all inlet and outlet pipes at correct positions. Faulty locations shall be made good and any damage to the finished floor, tiling, plaster, paint, insulation or terrace shall be made good by the Contractor at his own cost.
- ✓ All materials shall be rust proofed; materials in direct or indirect contact shall be compatible to prevent electrolytic or chemical (bimetallic) corrosion.
- ✓ Sanitary appliances, subject to the type of appliance and specific requirements, shall be fixed in accordance with the relevant standards and the following:

  Contractor shall, during the entire period of installation and afterwards protect the appliances by providing suitable cover or any other protection in order to absolutely prevent any damage to the appliances until handing over. (The original protective wrapping shall be left in position for as long as possible).

  The appliance shall be placed in correct position or marked out in order that pipe work can be fixed or partially fixed first.

  The appliance shall be fixed in a manner such that it will facilitate subsequent removal if necessary.

  All appliances shall be securely fixed. Manufacturers' brackets and fixing methods shall be used wherever possible. Compatible rust proofed fixings shall be used. Fixing shall be done in a manner that minimises noise transmission.

  Appliances shall not be bedded (e.g. WC pans, pedestal units) in thick strong mortar that could crack the unit (e.g. a ceramic unit).

  Pipe connections shall be made with de-mountable unions. Pipe work shall not be fixed in a manner that it supports or partially supports an appliance.

  Appliances shall be fixed so that water falls to the outlet (e.g. baths).

  Appliances shall be fixed true to level firmly fixed to anchor or supports provided by the manufacturer and additional anchors or supports where necessary.

  Sizes of Sanitary fixtures given in the Specifications or in the Schedule of Quantities are for identification with reference to the catalogues of makes considered. Dimensions of similar models of other makes may vary within +10% and the same shall be provided and no claim for extra payment shall be entertained nor shall any payment be deducted on this account.

e) Squatting type Water Closet - Orissa pattern

Squatting type water closet (WC) pan shall be of Orissa pattern of size as specified in Schedule of Quantities. Each WC pan shall be provided with a 100 mm dia PVC P or S trap with or without vent horn as directed by the Engineer-in-Charge.

WC shall be flushed by means of concealed type or exposed type (as detailed in the

drawings or as directed by the Engineer-in-Charge) 32mm size CP brass flush valve with regulator valve.

f) Wash Down Water Closet

WC shall be wash down or siphonic wash down type wall mounted set, as shown in the drawings, designed for low volume flushing from 3-9litres of water, flushed by means of an exposed or concealed type (as detailed in the drawings or as directed by the Engineer-in-Charge) 32mm size CP brass flush valve with regulator valve. Flush pipe/ bend shall be connected to the WC by means of a suitable rubber adaptor. Wall hung WC shall be supported by CI floor mounted chair which shall be fixed in a manner as approved by the Engineer-in-Charge.

Each WC set shall be provided with a solid plastic seat, rubber buffers and chromium plated hinges. Plastic seat shall be so fixed that it remains absolutely stationary in vertical position without falling down on the WC.

Each WC set shall be provided with a fixed type CP brass ablution jet, if called for in schedule of quantities, complete with CP/ plastic piping, concealed type CP brass angle cock etc. all of approved make and brand. The nozzle of the ablution jet and its holding down plate shall have smooth and rounded edges and shall not be capable of causing any injury to a user or cleaner.

g) Urinals

Urinals shall be lipped type half stall white glazed vitreous china of size as called for in the Schedule of Quantities and shall include the following.

Half stall urinals shall be provided with 15 mm dia CP spreader, 32 mm dia CP domical waste and CP cast brass bottle trap with pipe and wall flange and shall be fixed to wall by CI brackets, CI wall clips and CP brass screws as recommended by manufacturer complete as directed by the Engineer-in-Charge.

Flushing for urinals shall be by means of no hand operation, with electrically operated automatic sensor system (built in sensor with common electrical supply system).

Flush pipes shall be PVC pipes concealed in wall chase but with chromium plated bends at inlet and outlet or as given in Schedule of Quantities. These shall be measured and paid for separately.

PVC waste pipes shall be provided for urinals. Waste pipes may be exposed on wall or concealed in chase as directed by the Engineer-in-Charge. These shall be measured and paid for separately.

h) Urinal partitions

Urinal partitions shall be white glazed vitreous china or granite stone of size specified in the Schedule of Quantities.

Porcelain partitions shall be fixed at proper heights with CP brass bolts, anchor fasteners and MS clips as recommended by the manufacturer and directed by the Engineer-in-Charge.

i) Wash basin

Wash basins shall be white/ pastel colored glazed vitreous china of size, shape and type specified in the Schedule of Quantities.

Each basin shall be provided with painted MS angle or C.I. brackets and clips and the basin securely fixed to wall. Placing of basins over the brackets without secure fixing shall not be accepted. The MS angle shall be provided with two coats of red oxide primer and two coats of synthetic enamel paint of make, brand and color as approved by the Engineer-in-Charge.

Each basin shall be provided with 32mm dia CP waste with overflow, pop-up waste or rubber plug and CP brass chain as specified in the Schedule of Quantities, 32mm dia CP brass bottle trap with CP pipe to wall flange.

Wash basin shall be provided with hot and cold water mixing fitting or as specified in the Schedule of Quantities.

Basins shall be fixed at proper heights as shown on drawings. If height is not specified, the rim level shall be 790mm from finished floor level or as directed by the Engineer-in-Charge.

j) Toilet Paper Holder

Toilet paper holder shall be white glazed vitreous china of size, shape and type specified in the Schedule of Quantities or of stainless steel/powder coated brass.

Porcelain toilet paper holder shall be fixed in walls and set in cement mortar 1:2 (1 cement: 2coarse sand) and fixed in relation to the tiling work.

The latter shall be fixed by means of crews/capping having finish similar to the toilet paper holder in wall/ timber partitions with rawl plugs or nylon sleeves. When fixed on timber partition, it shall be fixed on a solid wooden base ember provided by the Engineer-in-Charge through another agency.

k) Measurement and rates

Sanitary fixtures (Porcelain ware and CP fittings) shall be measured by numbers.

Rate for providing and fixing of sanitary fixtures, accessories, shall include all items, and operations stated in the respective specifications and Schedule of Quantities and nothing extra is payable.

Rates for all items under specification Clauses above shall be inclusive of cutting holes and chases and making good the same, CP brass screws, nuts, bolts and any other fixing arrangements required and recommended by manufacturers, testing and commissioning etc. complete.

(iv) Soil, waste, vents and rain water pipes

- Scope of work

Work under this section consists of supplying all labour, materials, equipment and appliances necessary and required to completely install soil, waste, vent pipes as indicated on the drawings and specification. Without restricting to the generality of the foregoing, the soil, waste, vent and rain water pipes system shall inter-alia include the following:

a) Vertical and horizontal soil, waste, vent and rainwater pipes and fittings, joints, clamps and connections to fixtures.
b) Connection of all pipes to sewer lines as shown on the drawings at ground level.
c) Floor and urinal traps, clean out plugs, inlet fittings and rainwater (roof) outlets.
d) Testing of all pipes and fittings in the workshop.
e) Testing of all pipes lines after installation.

- General requirements

a) Materials shall be of the approved make and quality specified. They shall conform to the respective Bureau of Indian Standards, British Standards Specifications, supported by Manufacturing Certificate and any other specification referred to herein.
b) Pipes and fittings shall be fixed truly vertical, horizontal or in slopes as required in a neat workmanlike manner.
c) Pipes shall be fixed in a manner so as to provide easy accessibility for repair and maintenance and shall not cause obstruction in shafts, passages etc.
d) Pipes shall be securely fixed to walls, and ceilings by suitable clamps at intervals specified. Only approved type of anchor fasteners shall be used for fixing pipes on RCC ceilings and RCC/ masonry walls.
e) Access doors for fittings and clean outs shall be so located that they are easily accessible for repair and maintenance.
f) Short or long bends shall be used on all main pipelines as far as possible. Use of elbows shall be restricted for short connections.
g) Wherever piping is going across the separation / expansion joints of buildings, piping shall be provided with flexible connectors on both sides of such joints or on single side depending on whether any wall is to be crossed or not.

(v) **Internal & External Drainage (Upvc Pipes)**

a) Unplasticised PVC. pipes:

U.P.V.C. Pipes for Rain Water, Planter and AC drains shall conform to I.S.13592-1992 (type - B, SWR quality) for concealed pipe within the toilet sunk portion. The jointing of the pipes shall be in solvent cement joints. All the shaft piping shall conform to I.S.13592- 1992 (type - B, SWR quality). Vent Piping shall conform to I.S.13592- 1992 (type - A, SWR quality). All jointing in the shaft shall be by rubber ring joints. Rubber rings shall conform to IS 5382 and fittings to BS 4515 DIN 19531 & 19534. All the fittings like tees, bends, couplers cross etc. shall conform to IS 7834-1975. The joints of U.P.V.C. Pipes recommended shall be solvent cement, flanged, or threaded, joints. Pipes and fittings shall be free of any defects like cracks, etc.

b) Storage and handling:

U.P.V.C. Pipes: The pipes should be given adequate support at all times. Pipes should be

stored in a reasonably flat surface free from stones and sharp projection so that the pipe is supported throughout its length. In storage, pipes racks should provide continuous support and sharp corners of Metal Racks should be avoided. Socket and spigot pipes should be stacked in layers with sockets placed at alternate ends of the stacks to avoid top sided stacks. It is recommended not to store pipe inside another pipe.

On no account pipes shall be stored in a stressed or bent condition or near the source of heat.

Pipes should not be stacked more than 1.5M high and pipes of different sizes and classes should be stacked separately.

The ends of pipes should be protected from abrasion particularly those specially prepared for jointing either by spigot or socket solvent welded joints or soldered for use with couplings.

If due to unsatisfactory storage or handling a pipe becomes kinked' the damaged portion should be cut out completely.

Kinking' is likely to occur in very thin walled pipes.

c) Jointing of unplasticised p.v.c. Pipes:

Methods of Jointing:

a) Solvent Welded Joints
b) White cement & linseed oil mixture (Connection of U.P.V.C. to Cast Iron)
c) Screwed or threaded Joints
d) Rubber ring joints

d) Solvent Welded Joints:

This technique is used with spigot and socket type joints, in which the socket is made specially to form a close fit on the pipe end and with injection moulded/fabricated fittings.

Solvent Cement of Supreme Industries Ltd. Or equivalent make shall be used as per the recommendations of the manufacturers. The dust, oil, water grease etc. should be wiped out with dry cloth from the surface to be coated with solvent cement. The coating of solvent cement shall be applied evenly on the inside of the fittings for full length of insertion and then on the outside of the pipe end up to the marked line and the pipe twisted to a quarter of a turn to spread the cement evenly at the same time ensuring the pipe, pushed home fully into the socket. The pipe should be pushed into the fitting socket and held for one to two minutes as otherwise the pipes comes out of the fitting due to slippery quality of cement and the tapering inside bore of the fitting.

The surplus cement on the pipe surfaces shall be wiped out. In most of the cases the pipe inserted should be up to the marked line and in no case shall be less than 2/5 of the diameter of the pipe and up to marked line.

When the joint is made, the remaining cement on the pipe surfaces shall be wiped off immediately without fail as the continued action of solvent cement will weaken the wall on the pipe and cause failure under pressure.

Since solvent cements are inflammable they should not be used near the naked flames. In certain cases fumes given off from cement may be a source of danger if not carried in a well ventilated area.

When not in use containers of cement should be kept closed tightly to avoid loss of solvent or entry of dirt. Cement which has gelled or hardened should be discarded and removed from the site.

e) Rubber ring joints or 'o' ring shrink joints (shaft piping):

Unplasticized P.V.C. Pipe may be joined by employing approved rubber ring to provide the water tight seal. The ring may be housed in groove formed in a plastic or metallic housing. The rubber is compressed and makes a seal between the pipe and the housing.
U.P.V.C.Pipes to be connected to cast iron pipes shall be joined by using putty (mixture of white cement and linseed oil) as directed by Engineer-in-charge and as shown in the Drawing.

f) Traps:

General: Provide traps on all fixtures connected to the waste system, except for fixtures having integral traps. All traps, Suspended `P' Traps Inside Building: Provide heavy C.I. sealed gully traps, with single or double inlet as shown. Provide cast iron sealed cover for each trap secured with threaded gun metal bolts and felt gaskets of size 150mm square.

g) Fixing to supports:

The pipes and specials or fittings before being laid or fixed shall be examined to see that there are no cracks or defects. The pipes and fittings shall be thoroughly cleaned of all dust and dirt. After laying or fixing the pipes in position they shall be arranged in such a way that centre line of pipes coincide with the centre line of the alignment. Fittings, cleanout and floor drains shall also be laid in their position as stated above. U.P.V.C. Pipes shall be fixed vertically in shaft by means of U.P.V.C. clips anchored to walls using P.V.C. washers, G.I. Screws and Fibre Glass Plugs. In case of pipes laid horizontally, pipes shall be supported on G.I. Brackets/Hangers of approved design.
All pipes laid shall have its open ends securely closed with wooden plugs during progress of work.
Pipes and fittings shall be fixed by using proper approved holder bat clamps and special hangers. The pipes shall be fixed perfectly vertical or in a line as directed or as shown in the drawings. The Vertical Pipes shall have supporting CLAMPS at 1.5 Meter C/C and pipes laid horizontally, at every 1- 2 Meter C/C as shown in the Drawing or as directed. Vertical spacers shall be fixed after the first coat of plaster.

h) Testing:

All U.P.V.C. Soil, Waste, Vent, Antisyphonage and Fittings shall be tested by smoke test and left in working order after completion. The smoke test shall be carried out as stated below: Smoke shall be pumped into the Drain pipes at the lowest level from a smoke machine which consists of a bellow and a burner.
The materials usually burnt are greasy cotton waste which form clear pungent smoke which is easily detectable by sight as well as by smell if leaking at any point of the drain. During testing if any joint is found leaking the same shall be rectified by the Contractor at no extra cost & to the satisfaction of the Engineer-in-charge.

i) Cutting and making good holes / chases

Pipes shall be fixed and tested as the building work proceeds. Contractor shall provide all necessary holes, cut outs and chases in structural members as the building work proceeds. Wherever holes are cut or left originally, they shall be made good with cement concrete 1:1:2 (1 cement: 1coarse sand :2 stone aggregate 20mm nominal size) or cement mortar 1:2 (1 cement :2 coarse sand) as directed by the Engineer-in-Charge and the surface restored as in original condition to the entire satisfaction of the Engineer-in-Charge at no extra cost.

j) Inserts & Sleeves:

Network layout work done in advance of placing concrete slabs or construction of walls, will furnish and set inserts and sleeves necessary to complete the work. Cost of cutting or patching work necessary as a result of this operation shall be at no expense to the Owner. Openings shall be as per structural consultant's approval.

k) Clean out Plugs

Floor clean out plugs shall be provided on head of each long drain / header at location indicated on plans or as directed by the Engineer-in Charge. Clean out plugs shall be of size matching the full bore of the pipe leading to it which shall be 110 mm dia unless stated other wise. The clean out plugs shall be threaded and provided with keyholes for opening. Top of this cover shall be 15 mm above the top of slab. A removable flooring / tile will rest on this on a bed of rubber sheet as shown in drawing.

l) Clamps

a) Holder bat clamps shall be of standard design fabricated from MS flats 40x3mm thick and 12mm dia MS rod and 6mm nuts and bolts; painted with two coats of black bitumen paint before fixing. The clamps shall be fixed in cement concrete 1:2:4 mix (1 cement:2 sand:4 stone aggregate 20mm nominal size) blocks 100x100x100mm deep.

b) Where holder bat clamps are to be fixed in RCC column or slotted angles, walls or beam they shall be fixed with 40x3mm flat iron "U" type clamps with anchor fasteners of approved design.

c) Structural clamps shall be fabricated from MS structural members e.g. rods, angles, channels, flats as per detailed drawing or as directed. Contractor shall provide all nuts, bolts, welding material and paint the clamps with one coat of red oxide and two or more coats of black enamel paint to give an even shade.

m) Angles / channels

Slotted angle/ channel supports on walls shall be provided wherever shown on drawings. Angles/channels/ bolts shall be of sizes shown on drawings or specified in Schedule of Quantities. Angles / channels shall be fixed to brick walls with bolts embedded in cement concrete blocks of 1:2:4 mix (1cement: 2sand: 4 stone aggregate 20mm nominal size) and to RCC walls with suitable anchor fasteners as directed by the Engineer-in-Charge. The spacing of support bolts horizontally shall not exceed 1m.

n) Hangers and Supports

Hangers are provided to support water supply or drainage pipes when they run parallel to the ceiling in space.

General

Proper solid angle iron / channel section, supports shall be provided for all pipes complete with clamps. Wherever insulations come, wooden guide to support pipe on the angle iron

hangers / supports, shall be provided. For attachment on concrete, “Dash” fasteners or Anchor plug tube inserts or equivalent shall be used. Hangers shall be provided within 90 mm of all changes in direction of main and minimum of three hangers per expansion band wherever shown in drawing. Any additional structural steel angles, channels or other members not specifically shown but are required for proper support, shall be provided.

Where necessary, additional hangers to be provided to arrest water hammer or hydraulic resonance with proper rubber padding.

Hanger Spacing

Hangers shall be spaced as noted below, except on all soil pipe which shall have a hanger of multiple fittings, sufficient no. of hangers shall be provided to maintain proper slope without sagging.

Pipe size in mm	Hanger Rod Dia
20 through 50	10 mm
65 through 125	12 mm
150 and above	15 mm
Pipe sizes	Spacing of supports
12 to 20 mm	1.5 m apart
25 to 40 mm	2 m apart
50 above	2 m apart

Hanger Supports

Provide floor stands, wall brackets or masonry piers etc. for all lines running near the floor or near walls. Pipes may be hung also by hangers carried from wall brackets at a higher level than pipes. Hanging of any pipe from another is prohibited.

For pipes running in shafts, they should be fixed away from the wall by supporting on an angle projecting from the wall and the pipe fixed to the angle by ‘U’ bolt and nut.

o) Traps

Floor Traps

a) The PVC floor trap shall be of multi-inlet and one single outlet type. The floor trap shall be deep seal type with an effective seal of minimum 75mm. The waste from sanitary fixtures shall be directly discharged to the floor trap. Jointing of the waste pipe to the floor trap shall be done as per manufacturer's instructions. The height riser fitting shall be made use of, wherever the floor drain is located in deep-sunk floors or is suspended from the ceiling. The floor trap shall be of reputed make and preferably of the same make as of the pipes used.

b) The floor trap shall be provided with 150 x 150mm square or circular cast bronze CP or stainless steel frame and grating of approved design. Frame and grating shall be of a make and model approved by the client / consultants.

Urinal Traps

a) The urinal trap shall be double outlet type. The traps shall be deep seal type with an effective seal of minimum 75mm. The outlet from urinals after the trap shall be directly discharged to the floor trap. The floor trap shall be provided with 150 x 150mm SS or cost bronze chrome plated frame with screw type cover for airtight fitting. Frame and cover shall be of a make and model approved by the client / consultants.

Cockroach Traps

a) Floor/ urinal traps shall be provided with 100-150mm square or round stainless steel cockroach trap assembly complete with ring, outer cup, inner cup, jali etc. of an approved make.

p) Wire Balloons / gratings for rain water pipes

a) The wire balloons and the domical gratings shall conform to IS: 1729. The wire balloons shall be of galvanised steel. The CI domical gratings for the roof outlet shall be minimum 13mm thick.
b) Leaf and Gravel grates along with a perforated ring shall be made out of M.S. flat/bars of a design and dimension as shown in the drawing or as directed by the Engineer-in-Charge. These shall be painted with epoxy paint with a DFT of 200 microns.
c) Wire balloons/gratings for rainwater pipes shall be measured by numbers for different sizes. Leaf and gravel grates along with the perforated ring shall be measured in kgs.

q) Measurements and Rates

General

a) Rates for all items shall be inclusive of all work and items called for in the specifications given above and the Schedule of Quantities as applicable for the work under floors, in shafts or at ceiling level at all heights and depths.
b) All rates are inclusive of cutting holes and chasing in RCC and masonry work and making good the same.
c) All rates are inclusive of supply of material and labour for installation and shop testing, pre-testing at site and final testing of the installations, materials and commissioning.

Pipes

a) The unit of measurement shall be linear metre to the nearest centimetre.
b) All PVC soil, waste, vents, anti-siphonage and rain water pipes shall be measured net, correct to a centimetre, including all fittings along their length after fixing. The length shall be taken along centre line of the pipes and fittings. No allowance shall be made for the portions of pipe lengths entering the sockets of the adjacent pipes or fittings. The above shall apply to all cases i.e. whether pipes are fixed on wall face or pillars or embedded in masonry or pipes running at ceiling level.

Pipe Encasing/ supports

Cement concrete around pipes shall be measured along the centre of the pipe line measured per linear metre and include any masonry supports, shuttering and centring, curing, cutting etc. complete as described in the relevant specifications.

Clamps

Wherever MS clamps are required to be anchored directly to brick walls, concrete slabs, beams or columns, nothing extra shall be payable for clamping arrangement, RCC block and making good with cement concrete 1:2:4 mix (1 cement:2 sand:4stone aggregate 20mm nominal size) as directed by the Engineer-in-Charge.

Angles/ channels

Slotted angles/ channels shall be measured per linear metre of finished length and shall include support bolts and nuts, length embedded in the cement concrete blocks of 1:2:4 (1cement: 2 coarse sand: 4 stone aggregate 20mm nominal size) formed in the masonry walls; nothing extra shall be paid for the cement concrete block and making good the masonry wall, anchor fasteners etc. complete.

Traps

Unit of measurement shall be the number of pieces. All urinal traps, trap gratings, hoppers, clean out plugs shall be measured by number and shall include all items described in the relevant specifications and Schedule of Quantities. Cockroach traps shall not be measured separately and are deemed to be included in the rate for Traps.

Painting

Painting of pipes shall be measured per running metre for each diameter of pipe and shall be inclusive of all fittings and clamps. No deduction shall be made for fittings.

Excavation for soil pipes

No extra payment shall be admissible for excavation, dewatering, back filling, consolidation and disposal of surplus earth for soil and waste pipes.

(vi) **External & Internal Water Supply**

- ***Scope of Work***

The water supply system shall inter-alia include the following:

a) Distribution system from main supply or overhead tank to all fixtures and appliances for cold and hot water.
b) Insulation for hot water pipes
c) Pipe protection and painting.
d) Control valves, masonry chambers and other appurtenances.
e) Connections to all plumbing fixtures, tanks, appliances and municipal mains
f) Inserts, nozzles for R.C.C. tanks

The term water supply is used as indicative of all water supply work required and necessary for the building including such external work as may be necessary to make the system functional.

- **General Requirements**

If necessary and if approved by the Engineer-in-Charge, where unavoidable, bends may be formed by means of a hydraulic pipe bending machine for pipes upto 20mm dia. No bending shall be done for pipes of 25mm dia and above. After bending zinc rich paint shall be applied wherever the zinc coating is damaged.

Valves and other appurtenances shall be so located as to provide easy accessibility for operations, maintenance and repairs. Valves shall be located at a height not exceeding 1.6m above their operating floor/ platform level. Where such a provision is not possible and the valve is to be frequently operated a MS chain shall be provided for its operation.

- ***CPVC High Pressure Pipes For Cold & Hot Water Supply***

Chlorinated polyvinyl chloride (CPVC) pipes conforming to IS: 15778- 2007 are used for hot & cold water supply in toilets concealed, ducts, underground and suspended below floor.

Coefficient of thermal expansion- ASTM D - 696-6.3x10^{-5} m/m^{0}K

Thermal conductivity – ASTM C 177 – 0.14 Wm/^{0}K/m^{2}

(FOR PIPE DIAMETER UPTO 50MM SDR 11)

Nominal Pipe Size	Outer Dia.	Inner Dia.	Wall Thickness

(Inch)	(mm)	(mm)	(mm)	(mm)
½”	15	15.90	12.44	1.73
¾”	20	22.20	18.14	2.03
1”	25	28.60	23.130	2.59
1 ¼”	32	34.90	28.54	3.18
1 ½”	40	41.30	33.78	3.76
2”	50	54.00	44.20	4.90

Pressure rating @23^0C – 27.6 Kg/cm^2
Pressure rating @82^0C – 7.03 Kg/cm^2

(FOR PIPE DIAMETER ABOVE 50MM Sch.40)

Nominal Pipe Size		Outer Dia.	Inner Dia.	Wall Thickness	Pressure rating
(Inch)	(mm)	(mm)	(mm)	(mm)	(Kg/cm^2)
2½”	65	73.30	62.10	5.16	21.10
3”	80	88.90	77.27	5.49	18.28
4”	100	114.30	101.50	6.02	15.47
6”	150	168.28	153.19	7.11	12.66

- ***Jointing tubing and fittings:***

a. CUTTING:

Tubing should be cut with a wheel type plastic tuning cutter, a hack saw or other fine toothed hand or power saws. Use of ratchet cutters is permitted provided blades are sharpened regularly. A miter box should be used to ensure a square cut when using a saw. Cutting as squarely as possible provides optimal bonding area within the joint. If any indication of damage or cracking is evident at the tubing end, cut off at least 2 inches (5cm) beyond any visible crack.

b. DEBURRING/BEVELING

Burrs and filings can prevent proper contact between tube and fitting during assembly, and should be removed from the outside and inside of the tubing. A chamfering tool is preferred but a pocketknife or files are suitable for this purpose. A slight bevel on the end of the tubing will ease entry of the tubing into the fitting socket and minimize the chances of pushing solvent cement to the bottom of the joint.

c. FITTING PREPARATION

Wipe any dirt or moisture from the fitting sockets and tubing end. Check the dry fit of the tubing ad fitting. The tubing should make contact with the socket wall 1/3 to 2/3 of the way into the fitting socket. At this stage, tubing should not bottom out in the socket.

d. PRIMER / CLEANER APPLICATION

Primer or cleaner prepares the bonding area for the addition of cement and subsequent assembly. It is important to use a proper applicator. A dauber or natural bristle paint brush approximately 1/2 the size of the tubing diameter is appropriate. Apply primer to both the outside of the tubing end and in the fitting socket. Do not allow primer to

puddle in the fitting.

e. SOLVENT CEMENT APPLICATION

USE ONLY CPVC CEMENT CONFORMING TO ASTM - F-493 - OR JOINT FAILURE MAY RESULT. When the primed pipe and fitting surfaces are dry, apply a heavy, even coat of cement on the tubing end. Apply a thin coat inside the fitting socket.

f. ASSEMBLY

Immediately insert the tubing into the fitting socket, rotating the tube 1/4 to 1/2 turn while inserting. This motion ensures an even distribution of cement within the joint. Properly align the fitting. Hold the assembly for approximately 10 seconds, allowing the joint to set up. An even bead of cement should be evident around the joint. If this bead is not continuous around the socket edge, it may indicate that insufficient cement was applied. In this case, remake the joint to avoid potential leaks. Wipe excess cement from the tubing and fittings surfaces for an attractive, professional appearance.

g. SET AND CURE TIMES

Curing time is shorter for drier environments, smaller sizes, and higher temperatures. Refer to the following table for minimum cure times after the last joint has been made up before pressure testing can begin.

MUM CURE TIME PRIOR TO PRESSURE TESTING AT 150 PSI (10 BAR)		
Ambient Temperature during Cure Period	Pipe Sizes	
	1/2" – 1"	11/4"- 2"
Above 150^0C	1 Hour	2 Hours
4-150^0C	2 Hours	4 Hours
Below 40^0C	4 Hours	8 Hours

In extremely hot temperatures, make sure both surfaces to be joined are still wet with cement when putting them together.

h. TESTING

Once an installation is completed and cured the system should be hydrostically pressure tested-10 bar for one hour at least. When pressure testing the system should be filled with water and all air bled from the highest and farthest points in the run. If a leak is found the joint must be cut out discarded. A new section can be installed using couplings. Air testing is not recommended.

i. HANDLING AND STORAGE

Reasonable care should be exercised in handling tubing and fittings. They should not be dropped, stepped on, or have objects thrown on them. If improper handling or heavy impact results in cracking, splits or gouges, the damaged section should be discarded. Tubing should be covered with non-transparent material when stored outdoors for long periods of time. When installing pipe and fitting in an area that is exposed to direct sunlight for an extended period of time, protect the pipe with insulation or water based latex paint.

j. HANGERS AND SUPPORTS

For vertical runs, provide a support at each floor level, plus a mid-story guide. For horizontal runs, support at 3 foot (90cm) intervals for larger sizes. Piping should not be anchored tightly to support, but rather secured with smooth straps or hangers that allow for movement caused by expansion and contraction. The hangers should not have rough or sharp edges which come in contact with the tubing.

- ***Testing***

All pipes, fittings and valves shall be tested in accordance with IS: 2065 except as may be modified herein under. All pipes, fittings and valves, after fixing at site, shall be tested to a hydrostatic pressure of 5kg/sqcm or 1.5 times the shut off head of the pump whichever is greater.

The test pressure shall be maintained for a period of at least thirty minutes without any drop in pressure.

A test register shall be maintained and all entries shall be signed and dated by Contractor(s) and the Engineer-in-Charge.

After commissioning of the water supply system, the Contractor shall test each valve by closing and opening it a number of times to observe if it is working efficiently and effectively. Valves which do not operate efficiently and effectively shall be replaced by new ones at no extra cost and the same shall be tested as above.All pipes in wall chase or meant to be encased or buried shall be hydro tested before the chase is plastered or the pipe encased or buried.

- ***Measurement and rates***

CPVC pipes

a) CPVC pipes above ground shall be measured per linear meter (to the nearest cm) along the centre line of the pipe and shall be inclusive of all fittings e.g. couplings, tees, bends, elbows, unions, flanges, etc. Deduction for valves shall be made. Rates quoted shall be inclusive of all fittings, clamps, cutting holes chases and making good the same and all other items mentioned in the specifications and Schedule of Quantities.

b) CPVC pipes below ground shall be measured per linear meter (to the nearest cm) along the centre line of the pipe and shall be inclusive of all fittings e.g. couplings, tees, bends elbows, unions and flanges, etc. Deduction for valves shall be made. Rates quoted shall be inclusive of all fittings, cutting holes and chases and making good the same and all other items mentioned in the specifications and Schedule of Quantities. Excavation, filling, back filling with selected excavated earth, compaction and disposal of surplus earth, fine sand filling around CPVC pipes, in external work shall be measured separately, as per respective items.

- ***Valves, Bib cocks and stop cocks***

Gunmetal and cast iron valves, Bib cocks and stop cocks shall be measured by numbers.

- ***Flanges for Nozzles***

a) Flanges for nozzles shall be measured by numbers and the quoted rate shall include welding of the flanges to the pipe nozzles.

b) Painting/ pipe protection/ insulation

Unless otherwise specified painting/ pipe protection/ insulation for pipes shall be measured and paid for separately. These shall be measured per linear meter along the centre line of the pipe, over the finished surface and shall include all valves and fittings for which no deduction shall be made.

(vii) Make Of Equipment And Approved Manufacturers Or Approved Equivalent

1.	R.C.C. Pipe	a. Pranali Industries Bombay or Equivalent b. Prathibha Industries
2.	ASTM UPVC Pipes & Fittings	a. Astral Aquarius
3.	CPVC Pipes & Fittings	a. Flowguard-Astral b. Flowguard-Ashirvad.
4.	Copper Pipes	a. IBP b. Max Flow c. VS Metal
5.	Copper Fittings	a. IBP b. Max Flow
6.	Water Meters	a. Capstan Make or Equivalent
7.	Ball Valves	a. Zoloto
8.	Paint	a. Asian Paints b. Shalimar c. Equivalent
9.	S.W. Pipes	a. Sonya b. Rajura
10.	G. M. Non Return Valve	a. Zoloto b. Equivalent
11.	Cast Iron Pipe	a. Neco
12.	Cast Iron Gratings	a. Neco
13.	GRP Tank Covers	a. Thermodrain
14.	Automatic Air Release Valve	a. Honeywell b. Equivalent
15.	Hot Water Insulation	a. Videoflex
16.	Cast iron Patel pattern chambers	a. Bombay iron works b. Equivalent
17.	C.P Fittings	a. Jaguar b. Grohe
18.	Sanitary Fixtures	a. Hindware

b. Parryware
c. Equivalent

9.4 Mechanical Specifications for WTP & CWPS

9.4.1 General

9.4.1.1 Introduction

This part of the Specification sets out the general standards of materials to be supplied by the Contractor and mention of any specific material or plant does not necessarily imply that such is included in the works.

All component parts of the works shall, unless otherwise specified, comply with the provisions of this part or be subject to the approval of the Engineer.

The names of the manufacturers of materials and equipment proposed for incorporation in the Works together with performance, capacities, certified test reports and other significant information pertaining to the same, shall be furnished when requested for consideration by the Engineer, who shall have power to reject any parts which in his opinion are unsatisfactory or not in compliance with the Specifications and such parts shall be replaced by the Contractor at no extra cost to the Employer.

9.4.1.2 Compliance with Standards

Except where otherwise specified plant, materials and workmanship shall comply with the requirements of the relevant, the British Standard specifications shall refer to the latest issue or revision of those standards as issued by the British Standards Institution of 2 Park Street, London W1 and the Indian Standard Specifications as issued by the Bureau of Indian Standards. Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110 001 and ASTM standards as issued by the American Society for Testing and Materials, 1916, Race Street, Philadelphia, PA, 19103, U.S.A. and ANSI standards as issued by the American National Institute, 1430, Broadway, New York, NY 10018, U.S.A. Equipment conforming to other national or international standards shall be at least equivalent to those specified and shall be subject to approval by the Engineer's Representative. Full details of the difference shall be supplied by the Contractor.

Where the design or choice of materials of plants is affected by the Factory Acts, then the materials and plant supplied shall comply with all relevant sections of those Acts even though no particular reference may be made in this Specification.

9.4.1.3 Materials General

All materials incorporated in the Works and plant shall be the most suitable for the duty concerned and shall be new and of first class commercial quality, free from imperfections and selected for long life and minimum maintenance.

All submerged moving parts of the Plant, or the pins and spindles, etc., of the submerged moving parts or the faces etc. in contact with them shall be of corrosion resistant metals. All parts in direct contact with various chemicals, shall be completely resistant to corrosion, or abrasion by these chemicals, and shall also maintain their properties without aging due to the passage of time, exposure to light or any other cause.

Where "stainless steel" is specified or used it shall have resistance to atmospheric corrosion not less than that provided by B.S.970, Grade 410 S21 for forgings and B.S. 3100, Grade 410-C-21 -for castings. Particular attention shall be paid to the prevention of seizure by fretting where two corrosion resistant metals are in contact, by the selection of materials of suitable relative hardness and surface finish and the application of lubricants.

Where bronze is specified or used it shall be zinc free, to B.S. 1400, Group B- PB1.

Particular attention shall be paid to the prevention of corrosion due to the close proximity of dissimilar metals. Where it is necessary to use dissimilar metals in contact, these shall be selected so that the bimetallic corrosion is as low as possible.

9.4.1.4 Workmanship General

Workmanship and general finish shall be of first class commercial quality and in accordance with best workshop practice and shall provide what is generally recognized as waterworks finish as defined elsewhere, All similar items of plant and their component parts shall be completely interchangeable. Spare parts shall be manufactured from the same materials as the originals and shall fit all similar items of plant; Machining fits on renewable parts shall be accurate and to specified tolerances so that replacements made to manufacturer's drawings may be readily installed.

All equipment shall operate without excessive vibration and with minimum of noise. All revolving parts shall be dynamically balanced so that when running at all operating speeds and any load up to the maximum there shall be no vibration due to lack of balance.

All parts which can be worn or damaged by dust shall be totally enclosed in dust proof housings.

Dynamic balancing of rotary components shall be to the relevant standards. All bearings shall have L-10 rating life of minimum 16,000 hours.

All instruments used for the works whether for permanent installation or for checks/inspection at the Manufacturer's works or for checks/inspection at site shall be calibrated using standard reference instruments from institutions recognised by the Government such as "Institute for Design of Electrical Measuring Instruments (IDEMI), Mumbai."

All outdoor instruments shall be provided with locked, galvanised metallic enclosures of 2 mm thickness, suitably painted."

9.4.1.5 Design Life

All materials and equipment shall be designed for long life and shall be suitable for continuous 24 hour per days operation for prolonged periods with a minimum of maintenance and the Contractor may be called upon to demonstrate this for any component either by the service record of similar equipment elsewhere or by records of extensive type tests. Routine maintenance and repair shall as far as possible, not require the services of highly skilled personnel Except for consumable items such as rubber bushings, gland packings, carbon brushes etc. which normally require replacement more frequently, no part subject to wear shall have a life from new to replacement or repair of less than three years of continuous normal operation and where major dismantling is required to replace a part, such life shall be not less than ten years.

9.4.1.6 Welding

In all cases where welds are liable to be highly stressed the Contractor shall supply to the Engineer before fabrication commences detailed drawings of all welds and weld preparations proposed. No such welding shall be carried out before the Engineer has

signified his approval of the details proposed. No alteration shall be made to any previously approved detail of weld preparation without prior approval of the Engineer.

Welding shall comply with B.S 5135.

Approval of welding procedures shall be as per B.S. EN 288-3:1992. Welders shall be qualified to B.S. EN 287-1:1992. All aspects of fabrication and examination procedures including pre/post heating treatment, electrodes, non-destructive Tests (NDTs) shall be subject to approval of the engineer.

Following codes shall apply for the NDTs :

B.S. 2600 : Radiography
B.S. 3923 : Ultrasonic Test
B.S. 6072 : Magnetic Particle Test
B.S. 6443 : Penetrant Test.

9.4.1.7 Casting

All cast iron shall be of standard grey close-grained quality to B.S.1452: 1977 Grade 220 or better. The structure of the castings shall be homogeneous and free from non-metallic inclusions and other injurious defects. All surfaces of castings which are not machined shall be smooth and shall be carefully fettled to remove all foundry irregularities.

Minor defects not exceeding 12.5 per cent of total metal thickness and which will not ultimately affect the strength and serviceability of the casting may be repaired by approved welding techniques. The Engineer shall be notified of larger defects and no repair welding of such defects shall be carried out without prior approval. If the removal of metal for repair should reduce the stress resisting cross-section of the casting by more than 25 per cent, or to such an extent that the computed stress in the remaining metal exceeds the allowable stress by more than 25 per cent, then that casting may be rejected.

Castings repaired by welding for major defects shall be stress relieved after such welding.

Non-destructive tests will be required for any casting containing defects whose extent cannot otherwise be judged, or to determine that repair welds have been properly made.

9.4.1.8 Nut, Bolt, Studs & Washers

Nuts, bolts, studs and washers for incorporation in the Plant shall conform to the requirements of IS: 1367. Nuts and bolts for pressure parts shall be of the best quality bright steel machined on the shank and under the head and nut. Bolts shall be of sufficient length that one thread shall show through the nut when in the fully tightened condition.

Fitted bolts shall be a light driving fit in the reamed holes they occupy, shall have the screwed portion of a diameter such that it will not be damaged in driving and shall be marked in a conspicuous position to ensure correct assembly at site.

Washers, locking devices and anti-vibration arrangements shall be provided where necessary and shall be subject to the approval of the Engineer.

Where bolts pass through structural members, taper washers shall be fitted where necessary to ensure that no bending stress in caused in the bolt.

Where there is a risk of corrosion, bolts and nuts shall be designed so that the maximum stress in the bolt and nuts does not exceed half the yield stress of the material under all condition.

All bolts, nuts and screws which are submerged in water shall be made of stainless steel SS 316 grade as per specification given below:

Bolts and screws: ASTM A193 B8M
Nuts : ASTM A194 8M

9.4.1.9 Instrument Components

Iron and steel parts shall in general be painted or galvanised as appropriate in accordance with the Specification. Indoor parts may alternatively have chromium or copper-nickel plating or other approved protective finish.

Small iron and steel parts (other than stainless steel) of all instruments and electrical equipment, the poles of electro-magnets and the metal parts of relays and mechanisms shall be chromium or copper-nickel plated or have some other approved finish to prevent rust Cores, etc., which are built up of laminations or cannot for any other reason be antirust treated, shall have all exposed parts thoroughly cleaned and heavily enameled, lacquered or compounded.

9.4.1.10 FABRICS AND WOOD

Fabrics, cork, paper and similar materials which are not subsequently to be protected by impregnation, shall be treated with an approved fungicide. Sleeving and fabrics treated with linseed oil varnish shall not be used. The use of organic materials shall be avoided as far as possible but where these have to be used they shall be treated to make them fire resistant and non-flame propagating. The use of wood shall be avoided as far as possible. If used, woodwork shall be thoroughly seasoned teak or other approved hardwood which is resistant to fungal decay and free from shakes and warp, sap and. wane, knots, faults and other blemishes. All woodwork shall be treated to protect it against damage by fire, moisture, fungus, bacteria or chemical attack, unless it is naturally resistant to those causes of deterioration. All joints in woodwork shall be dove- tailed or tongued and pinned. Metal fittings shall be of non-ferrous material. Adhesives shall be specially selected to ensure the use of types which are impervious to moisture. Synthetic resin cement only shall be used for joining wood. Casein cement shall not be used.

9.4.1.11 ALLOWANCE FOR WASTAGE

The Contractor shall supply as specified and to the satisfaction of the Engineer reasonable excess quantities to cover wastage of those materials which will be normally subject to waste during erection, commissioning and setting to work. After commissioning of the plant the surplus material shall be removed from the site.

9.4.1.12 INSTRUMENTS, GAUGES AND METERS

All instruments, gauges and meters shall be approved by the Engineer and those which perform similar duties shall be of uniform type and manufacture. They shall be flush pattern, dust and moisture proof suitable for the environment in which they are installed. Where hinged covers are necessary they shall be provided with locks. Indicating instruments shall be of the dial type fitted with zero adjuster externally accessible from the front, have no parallax error, and normal maximum reading at approximately 60% full scale.

Dials shall be white with black scales and lettering not subject to fading. Calibration units shall be as specified in Specification Part 6. Scales shall be of such material that no peeling or discoloration will take place with age under humid conditions.

Motor ammeters shall be capable of withstanding the starting current and shall have a compressed overload scale.

9.4.1.13 LUBRICATION

A complete schedule of recommended oils and other lubricants shall be furnished by the contractor. The number of different types of lubricants shall be kept to a minimum. The schedule and the name of the supplier of the lubricants shall be submitted to the Engineer for approval before incorporation in the instruction manuals. In the case of grease lubricated roller type bearing for electric motors lithium base grease is preferred.

Where lubrication is effected by means of grease, preference shall be given to a pressure system which does not require frequent adjustment of recharging. Frequent, for this purpose means more than once a week and grease systems having shorter periods between greasing should be avoided. Where necessary for accessibility grease nipples shall be placed at the end of the extension piping, and, when a number of such points can be grouped conveniently, the nipples shall be brought to a common place mounted in a convenient position. Button head type nipples shall be used for normal grease and all grease nipples shall be of the same size and type for every part of the Plant. Arrangements shall be provided to prevent bearings being overfilled with either grease or oil.

Where more than one special grease is required a grease gun for each special type shall be supplied and permanently labeled.

Oil lubricated bearings shall be provided with an oil reservoir capable of automatically maintaining the correct oil level within the bearings. It must not be necessary to shut down the pump in order to see the oil level or to add oil to the bearings.

Oil sumps shall be fitted with oil level indicators of the sight glass type, or where this is not practicable, with dipsticks. The indicators shall show the level at all temperatures likely to be experienced in service. The normal, maximum and minimum levels at 20°C shall be clearly visible in the sight glass type from the normal access floor to the particular item of plant, and they shall be easily dismantled for cleaning.

All sight glasses shall be firmly held and enclosed in metal protection in such manner that they cannot be accidentally dislodged.

All lubrication systems shall be designed so as not to present a fire hazard and particular care shall be taken to prevent leakage of lubricants and to avoid leaking lubricants coming into contact with any electrical equipment, heated surfaces or another potential source of fire.

The Contractor shall supply flushing oil for each lubrication system when an item of plant is ready for preliminary running and a sufficient quantity of the approved lubricants for setting to work and for the commercial operation of the Plant for two years after the Taking over Certificate has been issued.

9.4.1.14 CLEANING AND PREPARING AT PLACE OF MANUFACTURE

The Contractor shall be responsible for the cleaning and preparation for paintings priming or otherwise protecting as specified of all parts of the Plant at the place of manufacture prior to packing.

(a) Cleaning

Parts shall be cleaned prior to testing at the manufacturer's works. Parts subject to hydraulic test shall be tested before any surface treatment. After test all surfaces shall be thoroughly cleaned and dried out if necessary by washing with an approved dewatering fluid prior to surface treatment.

(b) Preparation

Bright parts: Bright parts and bearing surfaces shall be thoroughly polished and protected

from corrosion by the application of rust preventive lacquer or high melting-point grease, as approved by the Engineer, before the parts are packed. A sufficient quantity of the correct solvent for removal of the protective compounds shall be supplied and packed with each particular part.

Embedded parts: Embedded parts or those parts of an assembly which will be embedded in concrete shall be thoroughly descaled and cleaned to the satisfaction of the Engineer and before being packed shall be protected by a cement wash or other approved method. No cast iron or steel work shall be bitumen or tar coated where it is to be cast into the concrete and provision shall be made for cleaning off any portions so coated.

Grit or shot blasted parts: Grit or shot blasting shall be carried out in accordance with B,S, 7079 to a standard between 'First Quality' and 'Second Quality given in Table 1 after which the maximum amplitude of the surface shall not exceed 0.1 mm.

Cast Iron and Steel pipe work: All ungalvanised steel pipe work including pump suspension mains, bearing spiders and tunnel tubes shall be prepared internally and externally by grit or shot blasting as specified above and the surfaces primed as specified within four hours of blasting.

9.4.1.15 PAINTING AND FINISHING AT PLACE OF MANUFACTURE

This Clause governs the methods for the protective coatings to be applied to structural steel, metalwork and ironwork as corrosion protection systems. The systems designed as specified here shall be applied as specified under Protective Coatings. Protective coating specified elsewhere for particular works such as pipes and cladding shall -firstly be designed in accordance with particular requirements specified elsewhere and secondly in accordance with any requirements herein which are not overridden elsewhere. This specification makes reference to the following standard:

B.S.5493 "code of practice for the protective coating of iron and steel against corrosion"

The Contractor shall design each protective coating system and shall submit details of each system to the Engineer for approval. Submissions shall where possible be in the format of which examples are given at the end of this section with such additional information and samples as the Contractor may provide or the Engineer may require to enable the system to be assessed.

Protective coating shall be designed in accordance with B.S. 5493 to have a long life, generally of at least 10 years to first maintenance. Protection systems shall be chosen to be easily maintained in the future and to allow non-specialist on-site re-coating where necessary using single part paints.

For the purposes of system design the general environment shall be as specified in B.S. 5493 Table 3 Part 2 'Exterior exposed polluted inland' Bulkhead gates and stoplogs shall be assumed to be exposed to a Table 3 Part 8 Non-saline water environment unless otherwise approved by the Engineer.

Interior spaces shall be considered to be dry in administration areas open to continuous access and damp or immersed in other spaces. The protective coating of components or structures which are continuously or infrequently immersed shall be designed for the more onerous of these two conditions relevant to the protection system used.

All exterior exposed items to be coated shall have a final coat of good appearance of a colour and type as approved by the Engineer.

Protective coating systems shall generally fall into one of the following basic systems:

Galvanising;
Galvanising plus painting;
Multi-coat painting;
Bitumen enamel;

Others as proposed by the Contractor and approved by the Engineer.

The Contractor shall submit to the engineer details of his proposals for the corrosion protection of each of the items requiring such protection, which will generally fall into the above categories as follows:
Trash screens, flooring, ladders, access covers and frames, step irons and other components which are inaccessible but subject to abrasion/damage;
Structural steelwork (including crane beams, monorails, crane structures and chassis), bulkhead gates, stoplogs, grappling beams, steel tanks and other large items readily accessible for maintenance.
Valves and other corrosion-susceptible items which may be buried and are not covered by the provisions of other specifications:
Other components not covered by the above for which the contractor may propose a system which he considers to be more suitable for the duty.
All painting material shall be applied in strict accordance with the paint manufacturer's instructions.

(a) **Plant supplied to site with final coating applied:**

Cubicles, cabinets etc.
Before any steel work is painted the steel must be thoroughly cleaned and an approved anti-rusting priming coat applied so that the possibility of rusting or corrosion taking place is negligible. All surfaces should have not less than two stoved undercoats and two top coats or air drying paint. The undercoats shall be easily distinguishable in shade or colour form the priming and finishing coats. The two final coats shall be in a colour and finish to be advised by the Engineer. The inside surfaces of any cubicles, cabinets etc. where condensation is liable to occur, shall be coated with an approved anti-condensation composition. The Contractor shall ensure that all component sections of a switch board wherever manufactured shall have a finish of uniform texture and an exact colour match.
Chromium plated parts: Where chromium plating is specified or offered by the manufacturer it shall comply with the requirements of B.S. 1224 including the following provisions. No blistering of any surfaces will be tolerated. The finished appearance shall be brought. Where the base metal is steel, plating shall be applied in accordance with Table 2. Other base metals shall be plated in accordance with Tables 3, 4, 5 as appropriate. For all base metals the service condition number 2 shall be used.
Small bore pipes, valves and fittings etc., which are sited in architecturally finished areas of the station and selected by the Engineer shall be chromium plated. Damage to chromium plating shall be made good before Taking Over.
Galvanised parts: All materials to be galvanised shall be of the full dimensions shown on the approved drawings or specified and all punching, cutting, drilling, screw tapping and the removal of burrs shall be completed before the galvanising process begins. Parts to be galvanised shall be shot blasted as specified above. Such parts shall be galvanised not more than four hours after commencement of shot blasting.
All galvanising shall be done by the hot dip-process. No alternative process may be used without the approval of the engineer. No components shall be galvanised which are likely to come into subsequent contact with oil.
The zinc coating shall be uniform, clean smooth and as free from spangle as possible. In the case of component parts the zinc coating shall weigh not less that 610 g/sq.m of area covered and shall not be less than 0.090 mm in thickness.
Bolts and nuts shall be sherardised. The Engineer may select for test as many components to be weighed after pickling, and before and after galvanizing as he may think fit.

All galvanised parts shall be protected from injury to the zinc coating due to differential seration and abrasion during the periods of transit, storage and erection. Damaged areas of the coating shall be touched up with an approved zinc-dust paint or other approved flake metallic compound.

Cast iron and steel pipework: (Internal surfaces)

The internal surfaces shall have an approved coating.

Where a bitumen based coating is used, it shall be in accordance with Type 2 of B.S. 4147.

Prior to lining, the ripe shall be grit blasted and primed with an approved primer. The lining shall be in accordance with B.S. 534. After installation, the internal lining shall made good and satisfactorily tested with a Holiday detector to 8 kV.

The coating shall be suitable for use in contact with drinking water. The type of coating shall be entered in Schedule L provided and the Engineer reserves the right to call for test plates of the paint. The manufacturer shall at the time of ordering carry out the ‘Taste and smell test (Appendix E of B.S.4147) and 'Effects on water test (Appendix C of B.S. 3416) and forward 3 copies of the test results to the engineer for approval.

Where pipe are to be welded after the protective coatings have been applied the pipe surfaces shall be primed and all other coating stopped 250 mm short of the weld preparation. Collars and fillings shall be primed but no other coating applied.

The manufacturer shall supply a sufficient quantity of suitable materials to repair damage occurring during delivery to site and to provided a flush finished internal lining at welded joints. He shall supply sufficient coating to fill in the recesses at internal welds over the previously primed areas. The costs of these materials shall be included in the unit rates for the supply of the pipes and specials.

The coating shall be applied in accordance with the manufacturer's instructions and with Appendices J and K of B.S. 3416.

Machinery- (Internal surfaces) e.g. pumps, valves, strainers, rising and suspension mains of wet well pumps:

As for cast iron and steel pipework (Internal surfaces).

Cast iron and steel parts (External surfaces) immersed in Water:

All ungalvanised metal parts which will be immersed in water shall be cleaned by grit blasting and within four hours of blasting given a coating similar to that specified for internal surfaces.

Cast iron and steel (External surfaces) in manholes and areas of high humidity

Ungalvanised metal parts exposed in manholes or areas of high humidity shall be cleaned by grit blasting and given two coats of a black bituminous solution.

(b) Plant forwarded to-site for final finishing, Cast iron and steel parts (External surfaces) outside buildings.

All ungalvanised metal parts which will be exposed to the outside atmosphere shall be cleaned by grit blasting and provided with two coats of an approved primer.

Cast iron and steel parts inside buildings

All exposed metal surfaces which will not be immersed in water nor exposed in areas described above shall be rubbed down, cleaned by grit blasting and within four hours of blasting given one coat of an approved primer before packing.

9.4.1.16 WATERWORKS FINISH

A high standard of finish, defined as "Waterworks finish" is required for all Plant as detailed below.

Welding and flame cutting

A smooth neat finish, by careful grinding if necessary is required on all exterior welding and flame cutting all, plates and bars used in fabrication shall have smooth surfaces with no pitting or deep slag inclusions

Castings

Casting surfaces shall be smooth and free from surface blowholes. Stock castings shall be specially selected with this in mind.

All castings shall be shot blasted before machining.

Covers

All covers shall be firmly fixed. Weldmesh shall sit square in its frame. Where panels are placed next to each other the patterns shall line up.

Flanges and beadings

All bolt holes shall be spot faced parallel with the mating face for good seating of nuts and bolt heads. Surplus jointing shall be removed from mating faces and peripheries.

Items to be chromium plated

Name plates, instruction plates, rotation arrows, indicators and pointers, small bore pipework, tundish oil level gauges and fittings, small valves (including air valves), plugs and grease nipples, which are sited in architecturally finished areas of the station and as selected by the Engineer, shall be chromium plated. Damage to chromium plating shall be made good.

All pipes and fittings etc., shall be fitted in a straight, neat symmetrical manner so as to present a pleasing appearance.

External screws, bolt heads, nuts and washers

These shall be chromium plated, or made in stainless steel.

Gauges

All indicating gauges fitted to any machine assembly shall be of similar appearance and grouped together to present a pleasing aspect.

They shall all have chromium plated cases, bezels, cocks and fittings.

9.4.1.17 SPARE PARTS

The Contractor shall supply the details of spare parts and quantity required for the continuous operation of the Works for the minimum period of 5 years shall describe such spare parts in the Schedule. The cost of spare parts shall not be taken for evaluation. It shall not be binding on the Corporation to buy any/part of the spare parts recommended by the Contractor. The spare parts required shall be decided prior to Award of Contract or during the execution of the Contract, which shall be binding on the Contractor.

All spare parts shall be new, unused and strictly interchangeable with the parts for which they are intended to be replacements and shall be treated and packed for long storage under the climatic conditions prevailing at the site. Each spare part shall be clearly marked or labelled on the outside of its packing with its description and purpose, and when more than one spare is packed in a single case or other container, a general description of its contents shall be shown on the outside of such case or container and a detailed list enclosed. All cases, containers and other packages shall be marked and numbered in an approved manner for purposes of identification.

All cases, containers or other packages are liable to be opened for such examination as the Engineer may require and packings shall be designed to facilitate opening and thereafter repacking.

"Spares, accompanied by technical details/leaflets etc. shall be delivered to site before the

start of commissioning tests. Spare parts shall be indicated in the assembly drawings of respective plant items with clear details of part numbers. Contractor shall also furnish the manufacturers recommendations on spares for respective plant items."

9.4.1.18 TOOLS AND TEST EOUIPMENT

A complete set of necessary special tools and test equipment shall be supplied by the Contractor to enable any erection, dismantling or testing to be carried out on any part of the Plant, whether of an electrical, mechanical or any other nature during the life of the Plant, Accessories and Tools. The cost of Tools and Test equipment shall not be taken for evaluation. It shall not be binding on the Corporation to buy any/part of the tools and test equipment recommended by the Contractor. The spare parts required shall be decided prior to award of contract or during the execution of the Contract, which shall be binding on the Contractor.

The tools and test equipment shall not be used for the erection of the Plant and except that the Engineer may call upon the Contractor to demonstrate their use or effectiveness, they must be handed over to the Purchaser/Employer in a completely new and unused condition. Should the Contractor require any. Such tools and test equipment at the site during erection, he shall provide his own.

The tools for each different type of equipment shall be contained in a suitable box clearly marked or labelled with its description. Each tool shall be identified and a list of tools shall be affixed to the inside of the box lid. Each set of tools shall be supplied with the equipment with which it is associated.

The test equipment shall include only special purpose items essential to the testing or recalibration of related items of Plant.

The tools provided shall include clamps, wrenches, lifting lugs, grease guns; gauges test rigs, jigs or extractors which may be required for the life of Plant. All tools and test equipment shall be clearly detailed with size/capacity etc.

9.4.1.19 PROTECTION AND PACKING FOR TRANSPORTATION

Before any Plant is dispatched from a manufacturer's works it shall be properly prepared and packed.

Prior to dispatch all Plant shall be adequately protected by painting or by other approved means for the whole period of, transit storages and erection, against corrosion and incidental damage, including the effects of vermin, sunlight, rain, high temperatures and humid atmospheres. The Contractor shall be held responsible for the Plant being so packed and/or protected as to ensure that it reaches the site intact and undamaged. The Plant shall be packed to withstand rough handling in transit and all packages shall be suitable for storage including possible delays in transit.

The Contractor shall be deemed to have included in the Schedule of Prices for all materials and packing cases necessary for the safe package, conveyance and delivery of the Plant.

The flanges of pipes, valves and fittings shall be protected by wooden discs attached by means of service bolts (which shall not be used at Site) or by other approved means. The sleeves and flanges of flexible couplings shall be bundled by wire. Cases containing rubber rings, bolts and other small items shall not normally weigh more that 500 kg. gross.

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

All items of Plant shall be clearly marked for identification against the packing list.

Every crate or package shall contain a packing list in a water proof envelope. A duplicate

copy of the packing list shall be sent by post to the Engineer's Representative at Site.
All crates, packages, etc., shall be clearly marked with a waterproof material to show the weight, and where the slings should be attached, and shall also have an indelible identification mark relating them to the packing lists.

9.4.2 MECHANICAL PART

9.4.2.1 GENERAL

The noise level produced by any equipment shall not exceed 85 dBA measured at a distance of 1.86 m from the outer surface of the equipment. At the time of operation, the mechanical vibration shall not exceed the limits given below, at recommended points of measurement as per ISO 2372-1974 with Amendment 1-1983.

Equipment	Velocity of Vibration mm/sec
All rotating equipment not having reciprocating parts with motor kW less than or equal to 15 kW	1.12
All rotating equipment not having reciprocating parts with motor KW more than 15 kW and less than or equal to 75 kW	1.8
All rotating equipment not having reciprocating parts with motor kW greater than 75 kW	2.8

9.4.2.2 REDUCTION GEAR UNITS

Reduction gear units, wherever provided shall be double reduction units without V-belt and pulley. Gears shall be cut from solid cast or forged steel blanks or shall be of 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 conform to B.S. 436 and B.S. 721. Split gears shall not be used. Gears and pinions shall be pressed on and keyed to shafts. All pinions and gears are to be of the totally enclosed type up to the last stage of reduction in all motions and shall be carried in fabricated steel gear cases which must be dust-proof and firmly sealed to prevent oil leakages and shall be oil bath lubricated. The gear boxes shall have covers split horizontally and arranged so that top half can be removed for inspection. They shall be fitted with bolted type machined inspection covers, and with cast steel cartridge housings for carrying roller bearings. Dip sticks or indicator shall be provided for indicating the oil level. Guards shall be strong enough to retain the whole gear or any part that might otherwise fall. No overhanging gears shall be used. Drain plugs shall be provided on all gear cases. Lifting lugs shall be provided for handling purposes.

9.4.2.3 AGITATOR

The agitator equipment shall be provided along with independent supports. The drive motor shall not exceed rpm of 1,500 and directly coupled with the gearbox. It shall be wired for 415 volts, 50 cycles, and three-phase service and shall be totally enclosed, fan cooled, rated for severe chemical duty with a minimum service factor of 1: 1.5.

The rotary speed of the impeller shall not exceed 100 rpm.
The drive motor output shaft and the impeller rotary shaft shall be connected by a direct coupling using such couplings as “Lovejoy” type to avoid cumbersome erections and de-erections. The drive assembly for each agitator shall consist of a suitab le drive motor, directly coupled to a helical gearbox. The Gear reducer shall be of heavy duty, high efficiency type with a rugged housing. It shall have a minimum service factor of 2.0 and suitable for 24 hours continuous service. The gear reducer shall h ave oil bath lubrication and dry well construction on the vertical output shaft to prevent leakage of the lubricant. The casing of the gear reducer shall be of CI. The gears shall be hardened and ground for precision.
The impellers of the each agitator will consist of a single, axial flow design. The inclined SS304 blades shall be bolted to the centre hub. The impeller assembly will be securely keyed to the shaft. Each impeller shaft shall be solid SS304 shaft of suitable diameter designed to resist the applied radial and axial thrust loads. Reinforced flanges at both ends will be used to attach the impeller at the bottom and to the rigid drive coupling at the top. All fasteners used in the assembly will be of SS304. The rotating shaft is best designed as a tubular structure for better torque resistance.

All fasteners and anchor bolts shall be of such metallurgy that they are compatible with the stipulated duty conditions shall be used.

9.4.2.4 PUMPS

(a) Vertical Turbine Pumps

The pump shall be capable of developing the required bowl head at rated capacity for continuous operation. Pump shall be suitable for withstanding reverse rotation due to back-flow of water without mechanical damage to any component of the pump. Pumps of a particular category shall be identical and shall be suitable for parallel operation. Components of the identical pumps shall be interchangeable.

Unfiltered vibration of the pump at the thrust pass bearing shall be limited to 3.2 mm/sec RMS and at discharge elbow shall be limited to 4.5 mm/sec RMS throughout the operating range. The noise level shall not exceed 85 dBA measured at 1.86 m from the outline of pump set.

The total head capacity curve shall be continuously rising towards shut-off, with the highest at shut off. The critical speed of the pumps shall not be less than 130% of the normal operating speed of the pump. The impeller adjustment shall be such that the impellers run free in any installed condition despite extension of line shaft (caused by hydraulic down-thrust) the weight of shafting and weight of impellers.

i) The rating of the pump motors or the prime mover (including service factor) shall be not less than the larger of the following:

ii) Sufficient to drive the pump with the impeller furnished through the entire range of run-off flow to shut-off conditions considering the variation in frequency.

The percentage of pump design point kW tabulated below:

Range of Motor Rating kW	Percentage of power at design point

Less than 20 kW	125%
20 kW to 50 kW	120%
Over 50 kW	116%

The column assembly shall consist of the column pipe to convey the liquid handled from bowl assembly to head assembly, shaft enclosing tube, if required, and shaft assemblies. If shaft-enclosing tube is used for the line shaft, bearing shall be supported from shaft enclosing tube. If shaft-enclosing tube is not used, the line shaft bearings shall be supported from the column pipes.

Head assembly shall consist of the base from which the column shaft assembly is suspended.

The bowls shall be cast, free from blowholes, sand holes and other detrimental defects. The bowls shall be equipped with replaceable wearing rings on suction side of enclosed impellers. Liquid passage shall be smooth finished and enamelled. The bowls shall contain bushes to serve as bearings for the impeller shaft. In case of oil lubricated units, the discharge casing shall be provided with means to prevent the leakage of liquid into the shaft enclosing tube. Suction bell shall be designed for smooth inflow of water with minimum losses.

The shaft shall be straight within 0.125 mm for 3 metres length total dial indicator reading. The maximum permissible error in the axial alignment of the thread axis with the axis of the shaft shall be 0.05 mm in 150 mm.

The shaft shall be furnished with interchangeable sections. The butting faces of shaft shall be machined square to the shaft axis and the shaft ends shall be chamfered on the edges.

Couplings shall be designed with a safety factor of 1.5 times the shaft safety factor and shall have threads to tighten during pump operation.

Line shaft bearings shall be external water or oil lubricated or self-lubricated type.
For self-water lubricated type a pre-lubrication connection with all accessories shall be provided to wet the bearings. The selection of material for such bearings shall suit the quality of water to be pumped and suspension length.

If shaft-enclosing tube is not specified, the shaft bearings shall be lubricated by the liquid being pumped.

The discharge head shall have an arrow indicating the direction of rotation of shaft.
For oil lubricated type, an automatic lubricator shall be installed for electric motor driven pumps and manual or other types of lubricator for engine driven pumps.
A tube tension plate shall be installed on the discharge to tighten up the shaft tubes for the purpose of aligning the shafts. A gland shall be provided at the tube tension plate to seal off any leakage from the discharge head. For water lubricated pumps, the discharge head shall have a stuffing box with a renewable bushing. The discharge elbow shall be designed to directly connect to the discharge pipe without reducer / expander. Pump shall be complete with base plate and foundation bolts.

(b) Centrifugal Pumps

Pumps of a particular category shall be identical and shall be suitable for parallel operation with equal load division. Components of identical pumps shall be inter-changeable. Pump shall be suitable for withstanding reverse rotation due to back-flow of water without mechanical damage to any component of the pump.

Pumps of a particular category shall be identical and shall be suitable for parallel operation. Components of the identical pumps shall be interchangeable. The critical speed of the pumps shall not be less than 130% of the normal operating speed of the pump.

Flow rate versus head curve shall have a stable and continuously rising characteristic towards the shut-off head. In case of unstable (drooping) characteristics the duty point shall be well away from the unstable region. Besides the actual flow rate versus head curve, curves for minimum and maximum impeller diameters shall also be shown.

The shut-off head shall be at least 110% of the differential head. The required NPSH at duty point shall be at least one (1) meter less than the available NPSH.

The rating of the pump driver shall be the larger of the following :

i) The maximum power required by the pump from zero discharge to run-out discharge at site climatic conditions.

ii) 110% of the power required at the duty point at site climatic conditions.

The corrosion allowance for pressure parts shall be 3 mm.

Pumps shall run smooth without undue noise and vibration. Noise level produced individually or collectively shall not exceed 85 dB(A) measured at a distance of 1.86 meters from the source in any direction. The overall vibration level shall be as per zones A and B of ISO 10816-1. Unfiltered vibration of the pump at the thrust pass bearing shall be limited to 3.2 mm/sec RMS and at discharge elbow shall be limited to 4.5 mm/sec RMS throughout the operating range.
Pump shall be provided with renewable type casing ring. Pump having capacity 1,000 M3/Hr and above shall be provided with impeller ring in addition to casing ring. The hardness of impeller ring shall be 50 BHN higher than that of casing ring.

Pump casing shall be provided with drain and vent connection with plugged or valve connection.

Bearing shall be oil-lubricated or grease-lubricated and shall have a life of 40,000 hours of working. In case of oil-lubricated bearing, constant oil leveller with magnetic drain plug shall be provided.

Mechanical seals shall be provided if called for in design parameter. If required, a flushing line shall be furnished, complete with strainer and orifice, from the pump discharge to the sealing face. When pumping liquid is not suitable for this purpose, a flushing connection shall be provided so that it can be connected to an external source

All incidental piping and valves required for sealing, lubrication and cooling for stuffing box packing and/or bearing of pump shall be furnished by the VENDOR. Leakage from the pump shall be led to the nearest surface drain by OTHERS. Pump VENDOR shall provide necessary arrangement like drip tray, base plate drain connection etc.

Stuffing boxes shall be designed for easy adjustment and replacement of the packing material. Alternatively split mechanical seals may be provided. Suitable means shall be provided for the collection of gland leakage and piping to drains.

The design of the pumps shall be such that no thrust is transferred to the driving motor, and where necessary a thrust bearing of the Michell type shall be provided. The combined thrust and journal bearing shall be capable of carrying at least 10% more than the maximum calculated design load and shall be capable of reversed rotation as 130% of full speed. All Michell bearings shall be fitted with an oil level gauge and a dial type thermometer complete with adjustable alarm and cut-out contacts.

Cooling and lubrication water pipework shall be fitted with flow indicators where specified.

On horizontal pumpsets fitted with hydraulic balance devices the couplings shall permit free axial movements of pump shaft under load.

On vertical pumpsets where the shaft couplings are of the screwed type, the couplings shall be positively locked.

Flanges shall be as detailed in the specification.

Pumps shall be provided complete with all fixing bolts, nuts and washers. Non-return valves of the non-slam, quick-closing type and isolating valves shall be fitted to the pump delivery branches and an isolating valve to the suction branch if this is connected by pipework. Automatic float type air valves with cocks in the highest part of the casing or head bend to assist priming shall be fitted. Automatic air valves shall be fitted with pipes to convey leakage back to drains.

The system shall be designed to provide for positive suction for the pumps. Each pump shall be provided with suction and delivery pressure gauges.

(c) <u>Chemical transfer Pumps</u>

Pumps shall be selected taking into account the chemical being pumped, form of chemical, wear leakage and resistance to corrosion.

Each pump shall be provided with inlet and outlet isolating valves and where necessary, with pressure relief and non-return valves.

A relief valve shall be incorporated in the delivery lines under conditions where the pump discharge pipe can be shut off or where pressure may rise to an excessive point. The relief valve shall be sized to handle the system pressure and to discharge maximum pump output freely, and shall be located in the discharge line between the pump and the first downstream isolating valve. Relief valves when used on pumps handling non-hazardous

chemicals shall discharge the vented liquid to waste. When used on hazardous chemicals the valve outlet shall be piped back to the suction supply tank or bunded-area. The open end of the return pipe shall be located where it is visible, so that any relief valve leakage/operation can be detected.
Pump transferring 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.

(d) Sump drainage pumps

Sump drainage pumps shall be of the open impeller centrifugal type vertically mounted close coupled to their fully submersible electric drive motors.

Sump pumps of 1.5 kW and under shall incorporate an integral level detector, control and motor starter and shall be powered only with a suitably fused three phase or single phase low voltage supply and with supply isolation at the building distribution board.
Sump pumps over 1.5 kW shall be controlled and started from the building distribution board and be fed with a 3 phase supply. Control shall be via adjustable float level switches mounted adjacent to the pump.

The pumps shall be supplied with all necessary discharge pipework, including non-return and isolating valves and suitable lifting gear for lowering and removing the pump from the sump. Pumps weighing 40 kg and more shall be lowered in the sump via guide rails and be located to their respective discharge pipework with an angle flange connection and self-locating clamps.

The pump impeller shall be designed to pass solids of sizes which pass through the inlet ports of the pump and shall be capable of pumping solids of up to 20 mm diameter.

(e) Submersible pumps

Submersible pumps shall be of the totally submersible centrifugal or mixed flow type capable of operating below a 15 m head of water. The pumping unit shall be suitable for continuous operation, designed to meet the desired performance and capable of handling the pumped medium without undue wear and tear.

A built-in cooling system must allow the motor to operate continuously at its rated output regardless of whether the electric motor is submerged or not.

The motor shall be direct coupled to its pump and rated for continuous full load operation above or under water.

The insulation rating of the motor shall be Class F. The motor shall have degree of protection IP 68.

The cable termination shall be watertight and provided with a cable sleeve and strain relief.

The motor shall have ball type bearings permanently greased and maintenance free.

The pump and motor shall be separated by two mechanical face seals. The lower seal shall rotate in the water medium and the upper seal shall rotate in an oil bath medium.

The pump shall have a non-overloading performance characteristic and its efficiency shall be high at the duty point and remain at a reasonably high level over the duty range of the pumping system.

Rotating assemblies of pumps shall be statically and dynamically balanced and shall be designed so that the first critical speed of the pump and its drive is at least 50% greater than the maximum operating speed.

The pump wear rings shall be easily replaceable.

(f) Chemical Dosing Pumps

Chemical dosing pumps shall be piston, piston diaphragm or mechanical diaphragm type as specified. Pumps may be simplex or duplex arrangements to suit the capacity or process requirements. The pump design shall incorporate positive stroke return. The maximum stroking speed shall not exceed 100 strokes per minute (spm). Pump, motor and driving arrangement shall be mounted on a robust combined baseplate.

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.

The normal operating range of dosing pump shall be not less than 6:1.

Mechanical Diaphragm Single suction Pumps	Diaphragm rigidly coupled to the drive train. and discharge valves. Glandless. Accuracy: ± 3% of stoke.
Piston Pumps	Cylinder and piston with packed gland. Double suction and discharge valves can be fitted for greater accuracy at high pressure. Accuracy: ± 1% of stroke.
Piston Diaphragm Pumps	Diaphragm hydraulically operated by liquid displaced by a plunger and protected from excess pressure via a relief valve.

Accuracy: ± 2% of stroke.

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 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.

A relief valve shall be incorporated in the delivery lines under conditions where the pump discharge pipe can be shut off or where pressure may rise to an excessive point. The relief valve shall be sized to handle the system pressure and to discharge maximum pump output freely, and shall be located in the discharge line between the pump and the first downstream isolating valve or in the case of dosing pumps the back pressure loading valve. Relief valves when used on pumps handling non-hazardous chemicals shall discharge the vented liquid to waste. When used on hazardous chemicals the valve outlet shall be piped back to the suction supply tank or bunded area. The open end of the return pipe shall be located where it is visible, so that any relief valve leakage/operation can be detected.

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.
Unless otherwise specified 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.

(g) Chemical gravity dosers

Gravity dosers shall have material of construction corrosion resistant to the chemical being dosed. The doser shall have a repeatable accuracy with ±3% of the set rate within the full operating range.

For the purpose of this specification the following definitions of parameters shall apply:

(i) Static Head: The difference between the free water surface level on the suction side of the pump and the delivery level.

(ii) External Friction Head: The head required to overcome friction external to the Works and velocity head at the outlet of the pumping main.

(iii) External Plant Losses: The friction losses in all pipework and valves included in the works.

(iv) Internal Plant Losses: The friction losses in the pump suspension main and head bend up to the delivery flange of vertical wet well pumps.

(v) Total Head: The sum of (i), (ii), (iii) and (iv).

(vi) Net Effective Lift: The sum of (i) and (ii).

9.4.2.5 ELECTRIC MOTORS

INDUCTION MOTOR

Design Requirements

The motors shall be energy efficient conforming to the latest edition of IS: 325 and IS: 12615 or equivalent international standards and shall be of TEFC enclosure. Additionally the specific requirements mentioned in the following clauses shall also be met.

Performance and Characteristics

(a) Motors shall be capable of giving rated output without reduction in the expected life span when operated continuously under the following supply conditions:

i.	Variation in supply voltage	+/- 10%
ii	Variation in supply frequency	+/- 5%

(b) Motors shall be suitable for DOL / Star-Delta / Soft starter starting depending on kW rating of motors as specified elsewhere.

(c) The starting current of motor shall not exceed 200% of rated full load current for star/delta starting and 600% of rated full load current for DOL starting, under any circumstances.

(d) Motors shall be capable of starting and accelerating the load with the applicable method of starting, without exceeding acceptable winding temperatures, when the supply voltage is in the range 85% of the rated motor voltage.

(e) Motors shall be designed to withstand 120% of rated speed for two minutes without any mechanical damage, in either direction of rotation.

Insulation

(a) Any joints in the motor insulation such as at coil connections or between slot and winding sections, shall have strength equivalent to that of slot sections of the coil. The insulation shall be given tropical and fungicidal treatment for successful operation of the motor in hot, humid and tropical climate. The motors shall be provided with class F insulation with temperature rise limited to that of class B insulation.

(b) After the winding coils are placed in slots and all connections have been made, the entire motor assembly shall be impregnated by completely submerging in suitable insulating compound or varnish followed by proper baking. At least three such submersions and baking shall be applied to the assembly.

Constructional Features

(c) The motor construction shall be suitable for easy disassembly and reassemble. The enclosure shall be sturdy and shall permit easy removal of any part of the motor for inspection and repair.

(d) Motors weighing more than 25 kg shall be provided with eyebolts, lugs or other means to facilitate safe lifting.

(e) The rotor bars shall not be insulated in the slot portion between the iron core laminations for squirrel cage motors.

Terminal Box

(f) Terminal boxes shall be of weather proof construction in case of outdoor service. To eliminate entry to dust and water, gaskets of neoprene or approved equivalent shall be provided at cover joints and between box and motor frame. It shall be suitable for bottom entry of cables. It shall be capable of being turned through 360 degrees in steps of 90 degrees.

(g) The terminals shall be of the stud type with necessary plain washers, spring washers and check-nuts. They shall be designed for the current carrying capacity and shall ensure ample phase to phase and phase to ground clearances. Suitable cable glands and cable lugs shall be supplied to match specified cables.

(h) Stator leads shall be brought to the terminal box as insulated cable through a suitable barrier and terminated in clamp type terminals.

Accessories

(i) Two independent earthing points shall be provided on opposite sides of the motor, for bolted connections. These earthing points shall be in addition to earthing stud provided in the terminal box.

(j) Motors shall be suitable of starting and accelerating the load with the applicable method of starting, without exceeding acceptable winding temperatures, when the supply voltage is 85 % of the rated voltage.

(k) The locked rotor current of the motor shall not exceed 600 % of full load current (subject to tolerance as per the applicable standard).

(l) Motors shall have drain plugs so located that they will drain water, resulting from condensation or other cases from all pockets in the motor casing.

Motors shall be designed to withstand 120 % of rated speed for two minutes without any mechanical damage, in either direction of rotation.

Routine Tests

(m) All routine tests shall be carried out as per the latest edition of IS 325 and IS 12615.

Acceptance Tests

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

9.4.2.6 VALVES, GATES AND SCREENS

(a) VALVES

All valve bodies shall give the following information

Manufacturer's name

Hydraulic test pressure

Size of valve

Direction of flow 'Arrow'

The operating gear of all valves shall be such that one man can open and close the valve

against an unbalanced head 15% in excess of the maximum encountered in service.

Where specified, valves 300 mm nominal bore and over shall be fitted with bypasses with isolating valves.

Sluice valves shall be double flanged generally conforming to B.S. 5163. The seats and faces shall be of zinc free bronze as per IS:318 LTB 3 or CI, IS 210 Gr. FG 260 and rings shall be force fitted. Valves of nominal diameter 300 mm and above shall be provided with 'shoe' and 'channel' arrangement so that the gate is guided throughout its travel. Sluice valves shall generally conform to IS 14846. Body of the valve shall be designed for 1.5 times the rating of the valve. Valves shall be free from sharp projections, which are likely to catch and hold stringy materials. The pressure drop across valve shall be limited to 0.05 mwc. Valve flange faces shall be parallel to each other and flange face should be at right angle to the valve centerline. Back side of valve flanges shall be machined or spot faced for proper seating of bolt head and nut. Valves 450 mm and above shall be provided with lifting lugs. Valves 450 mm and above shall be furnished with a bushing arrangement for replacement of packing without leakage. Valves 700 mm and above shall be with renewable channel and shoe linings.

Bypass Valves shall have non-rising spindle. Bypass Valves shall have a back seating arrangement for replacement of packing without leakage. The bypass valve shall incorporate an intermediate valve gear box connecting valve spindle to the actuator. Flanges shall be drilled as per BS 4504 (16 bar rating). Bypass Valves shall be provided with shoe and channel arrangement. The gap between shoe and channel shall not exceed 1.5 mm. bypass Valves shall be with gear arrangement so that force required on hand wheel shall be limited to 7 kg. Direction of closing the bypass valve shall be clockwise. A bypass gate valve on the delivery header, with bypass leading back to the river, will be provided to facilitate draining of the intake well upto minimum water level for cleaning.

Butterfly valves shall be double flanged generally conforming to B.S. 5155. The body seat and retaining rings shall be of stainless steel as per ASTM A351 Gr. CF8M and the disc seal shall be of EPDM rubber. The body and the disc shall be of cast iron as per IS:210 Gr. FG 220. Butterfly Valve of diameter 600 mm and above shall be provided with enclosed gear arrangement for ease of operation. The operation gear shall be such that they can be opened and closed by one man against an unbalanced head of 1.15 times the 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. The time from fully open to fully closed position and vice versa shall be limited to about 2½ minutes. The butterfly valve shall be suitable for controlling flows by throttling. The disc shall be designed to withstand the maximum pressure differential across the valve in either direction of flow. Rubber sealing ring shall preferably attached to disc edge by means of sectional retaining ring.

Non-return valves on the main pump delivery branches shall possess high speed closing characteristics with minimum shock on closing. Non-return valve shall be as per IS 5312.The valves shall be suitable for mounting on horizontal pipeline. Non-return Valves shall be quick closing type with non-slam characteristics. Hydraulic passage and doors shall be designed to avoid cavitations. The pressure drop in the non-return valve at design flow shall be limited to 0.3 mwc.

Non-return Valves shall be of swing check type. Non-return 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 damping arrangement, or counter weights.

Flow direction shall be clearly embossed on the valve body. Non-return Valve flange faces shall be parallel to each other and shall be right angle to valve centerline. Flange back shall be machined or spot faced for proper seating of bolt head and nut.

Non-return Valves 450 mm and above shall be provided with supporting foot. The internal parts shall be easily accessible for inspection through inspection hole. Non-return Valve body shall be designed for 1.5 times the rated pressure. The pressure rating of Non-return valve shall be minimum PN 1.6

Packed glands shall be arranged for easy replacement of the packing, which shall be accessible without removal of the valve from the pipe. Precautions shall be taken to prevent corrosion of the valve spindles in contact with the gland packing.

All the globe valves, gate valves and check valves of size up to 50 mm shall be of forged steel to ASTM-A- 105 with SS-410 type trims. Ball valves shall be of SS-316, with cast steel body to SS ASTM A743 CF8M and Teflon seats.

Each valve or its operating equipment, shall bear an approved nameplate stating its function.

All valves, cocks and operating spindles which are to be suitable for submerged operation, shall be independent of external lubrication and shall be designed for submergence at 9 mwc.

Flanges shall be as per BS 4504 (16 bar rating).

(b) <u>DISMANTLING JOINTS</u>

Dismantling joint shall be designed such that adequate space can be created by collapsing the dismantling joint, for removal and for reinstallation of adjacent valves. All parts of dismantling joints shall be amply proportioned to take care of all stresses that may occur during installation and in operation. Dismantling joints shall have end, thrust and follower flanges and rubber sealing ring. Tie rods shall be provided for rigid fixing after installation to enable transmission of thrust. Tie rods shall be provided for minimum 30% of the holes.

With the use of dismantling joints it shall be possible to have an approximate clearance of 25 mm with the adjoining fittings. All dismantling joints shall be designed for a pressure of 16 bar.

Outside of inner sleeve and inside of outer sleeve shall be machined to close tolerances. Inner sleeve end shall be chamfered for easy introduction of rubber ring. Sleeves shall be of uniform bore and straight in axis. The flanges shall be square to the axis of sleeve. The faces of flanges shall be parallel. The bolt holes circle and outside periphery shall be concentric with the bore and bolt holes equally spaced. Bolt holes in one flange shall be

located in line with those in other. Bolt holes on flanges shall be drilled with the help of drilling jig.

Flanges shall be machined flat faced and shall be full or spot faced on the back side. Flange thickness shall be uniform throughout. Flange periphery also shall be finished smooth. Flanges shall be as per relevant applicable standard corresponding to design pressure. The flanges of dismantling joints mating with valves shall have drilling stranded matching with that of the valve.

(c) BAR SCREENS

Bar Screen are to be installed for arresting floating or stringent materials from raw water as per TCE drawing no. TCE.5925-610-GA-1000
The trash screen shall be rectangular in shape. The screens shall have a perforated tray made out of mild steel (IS:2062) plate, fixed at the bottom on the upstream side of the screen.
The rectangular bar screen shall comprise M.S flats, 10 mm thick and 30 mm wide in section.

Requirement of Bar Screen

Sl. No.	Parameter	Particulars
(a)	Quantity of bar screen	4 nos.
(b)	Size of opening (width x depth)	1500 mm x 750 mm
(c)	Clear space between bars (mm)	50
(d)	Plate Dimension	20 mm wide and 5 mm thick
(e)	Angle of bar screen in screen channel	90^0
(f)	Bar cross section (front/back/depth) (mm)	As per manufacture

(d) PENSTOCKS

Penstocks or sluice gates shall conform generally to IS 30130 or AWWA-C-501 or other applicable standards. Spindle shall be of the non-rising type. The frame and door shall be of cast steel to SS ASTM A743 CF8M. Spindles shall be of stainless steel as per SS ASTM A276, S43100. Nuts and bolts shall be as per ASTM A193 B8M and ASTM A194 8M respectively. For face and seat rings, trim and spindle nuts, stainless steel to ASTM A743 CF8M shall be used.

Frames shall be of unit construction and shall have a robust spigot of an appropriate length, cast integral at the back for case of support in the waterway and to provide an effective seal. A stainless steel side guide strip having a machined taper face on the underside shall be fixed to the frame on each side by studs and extending over the height of the waterway to provide effective guide through the travel of the door. A stopper shall be cast integral immediately below the waterway and central with it to limit the travel of the door.

The floor shall have reinforcement ribs cast integral at the back for strength. On each side

there shall be tapered stainless steel taper strips not less than three, machined to match similar taper faced side guide strips on the frame. Two integrally cast lugs drilled to take a bearing pin shall be provided on doors for use with rising spindles. Integrally cast pocket suitably reinforced to accommodate a nut shall be provided on doors with non-rising spindles. A stopper to match that on the frame shall be cast integrally at the bottom.

Facing shall be so secured by rivet pins in the machined grooves of the frame and door and machined and hand-finished, that with the door fully shut a satisfactory water-tight seal is formed on the waterway. The contact between the facings shall be sufficiently close at every point in their perimeter so as to produce a uniform bearing all round. The attachment of the facing to the frame and door shall be so carried out that when finished they shall remain in place free from distortion or loosening during effective life.

Guide shall be adequately secured to the main frame by stud bolts and provision shall be made for appropriate longitudinal movement to adjust degree of wedging consistent with sealing properly. There shall be little lateral movement and tongues, keys, shoulders or lugs may be provided for the purpose.

(e)**MANUAL OPERATION OF VALVES AND GATES**

Sluice valves, butterfly valves and gates shall be provided with equipment for manual operation by means of a handwheel or other suitable device, which shall be fixed to the valve, but not by means of a tee key and bar unless otherwise specified.

The handwheel for the valves of sizes 80 mm and above shall be turned in a clockwise direction to open the valve and shall be clearly marked with the words 'OPEN' and 'CLOSE' with arrows in the appropriate directions. The rims of handwheels shall be machined to a smooth finish and chromium plated or shall be smooth plastic coated unless otherwise specified.

Hand wheels shall be fitted with an integral locking device to prevent operation by unauthorized persons. A padlock and chain will not be acceptable.

Headstocks and valves of 50 mm nominal bore and over shall be fitted with mechanical position indicators to show the amount which the valve is open or closed in relation to its full travel.

Each valve or gate headstock shall be fitted with damp proof limit switches at extremes of travel to provide remote 'OPEN' and 'CLOSED' indication. Number, type and rating of contacts shall be adequate to comply with the requirements of indication/interlocks etc., where specified.

(f) POWER OPERATION OF VALVES AND GATES

Electrically operated actuators for valves shall be sized to guarantee valve closure at the maximum possible differential pressure across the valve. The safety margin of motor power available for unseating the valve shall be at least 50% in excess of maximum closing torque at the nominal supply voltage. The operating speed shall be such as to give valve closing and opening at approximately 200-300 mm per minute unless otherwise specified.

i) **Motor**

The electric motors shall conform to Clause 4.37 with a time rating of 15 minutes or twice the valve stroking time, whichever is the longer.

ii) **Motor Protection**

Motor burn-out protection shall be provided by direct sensing of motor temperature by a thermostat embedded in the motor winding. The trip shall be self resetting and shall include a changeover volt-free contact for remote indication of motor tripped.

iii) **Gearing**

The actuator gear box shall be of the totally enclosed oil bath lubricated type, suitable for operation at any angle and provided with the appropriate filling and drain plugs: The output shaft shall be hollow to accept a rising stem. Thrust bearings or the ball or roller type shall be provided in such a way that the gear case can be opened for inspection or disassembled without releasing the stem thrust or taking the valve out of service.

iv) **Hand Operation**

A handwheel shall be provided for emergency operation, engaged when the motor is declutched by a lever or similar means, the drive being restored to power automatically by starting the motor. The handwheel drive shall be mechanically independent of the motor drive, and any gearing shall be such as to permit emergency manual operation in a reasonable time.

v) Drive Bushing

The valve actuator shall be furnished with a drive bushing easily detachable for machining to suit the valve stem or gear box input shaft. The drive bushing shall preferably be positioned to enable standard length valve stems to be used.

vi) Torque and Position Limit Switches

Electric actuators shall be provided with open and close torque and position limit switches with changeover volt-free contacts at each end of travel for remote indication and interlocking. Means shall be provided to prevent the open torque switch tripping while the initial high unseating torque requirement occurs.

Provision shall be made in the design for two extra sets for limit switches to be available to order, comprising at least three switches per set, each set independently adjustable to any valve position. Provision or adequate number, -type and rating of contacts to suit the specified requirements shall be the responsibility of the Contractor.

vii) Position Indication

A mechanical dial indicator shall be provided to indicate whether the valve is fully open, fully closed or in an intermediate position.

Provision shall be made in the design for the addition of a sealed potentiometer of at least

three –watts rating, 5k ohm resistance for continuous remote position transmission where required by the specification. When so fitted, the mechanical dial indicator shall also show continuous valve movement.

viii) Motor Controls

The reversing contactor starter and local controls shall be integral with the valve actuator. The starter shall comprise mechanically and electrically interlocked reversing contactors of appropriate rating to the motor size, fed from a 450V/ll0 volt control transformer. The common connection of the contactor coils at the transformer shall be earthed so that the contactors drop out in the event of leakage to earth. The primary winding shall have taps for single and three phase supplies and shall be separated from the secondary by an earthed screen. Two primary and one secondary fuses shall be provided, of an easily replaceable cartridge type.

Local controls shall comprise pushbuttons for open, close and stop, and a Local/Remote selector switch padlockable in any of the four positions :

- Local Control only
- Local and Remote control
- Remote control plus Local stop only
- Stop Locked off -no electrical operation.

ix) Wiring and Terminals

Internal wiring shall be with at least 650V grade PVC insulated, stranded tinned copper, 1.5 sq.mm conductors for control circuits. Each wire shall be clearly numbered identified at each end. The terminals shall be of the stud type, and the 3-phase power terminals compartment shall be designed so that the integral controls are not adversely affected by heavy rainfall while the terminal cover is off for wiring on exposed job sites. Cable entries shall be suitable for armoured power and control cables. A separate terminal box shall be provided for the heater.

x) Enclosure

The actuator enclosure shall be at least fully weatherproof and hose-proof to NEMA 3 and 4 and shall be fitted with an anti-condensation heater.

xi) Documentation

Each actuator shall be supplied complete with installation instruction and wiring diagram and sufficient spare cover screws and seals to make good site losses. A detailed write-up on the operation scheme of actuators shall also be submitted.

9.4.2.7 CAST IRON PIPE WORK

Cast iron and spun iron pipework shall be manufactured and tested to either B.S. 46-22 (Grey) or B.S. 4772 (Ductile) as applicable unless specified otherwise.

Flanges shall be as per B.S. 4504 and shall be machined over the whole face and edge.

After machining, flanges shall be flat and normal to bore of the pipe to within 0.125 mm over the flange diameter.

9.4.2.8 STEEL PIPE WORK

(i) Pipe/fitting material and dimensional standard shall conform to following :
Design Pressure-6 bars, Temperature -ambient, Corrosion Allowance-2 mm

	Size (mm) (NB)	**Material Specification. (Steel)**	**Dimensional Standard**
Pipes	Upto 150 mm 200 to 2400	IS 1239 PT, ERW, Black IS 2062	IS 1239 PT-1 CI..HVY ERW IS 3589- ERW IS 3589 for dimensions and minimum thickness. Pipe thickness shall be as per IS :2825
Elbows	Upto 25 40 to 150 200 & above (metres)	ASTM-A 105 ASTM-A 234 GR WPB IS 2062	ANSI B 16.11 3000 # S.W. ANS1 B 16.9 LR. BE. Sch 40 ANS1 B 31.1
Coupling	Upto 25	ASTM-A 105	ANSI B 16.11 3000 # S.W.
Tees	40 to 200 Above 200	ASTM-A 234 GR WPB IS 2062	ANSI B 16.9 BE, Sch 40 IS 2825 (min. pipe thickness)
Reducers	Upto 25 40 to 200 Above 200	ASTM-A 105 ASTM-A 234 GR WPB IS 2062	ANSI B 16.11 3000 S.W. ANSI B 16.9 BE, Sch 40 IS 2825 (min thickness for larger pipes).
Flanges & Blank flanges	Sizes upto 2000 flanges above this size shall be designed to IS 2825	IS 2062	BS 4504 – 6 Bar
Bolts & nuts	All	IS 1367 Cl 4.6/4.0 (except under-water service which will be SS 316)	IS 1364
Gaskets	ALL	Neoprene rubber As per relevant IS	3 mm thickness

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

(iii) Buried pipes shall in addition be designed to withstand external loading exerted by soil, water and live loads as relevant. The external ground water shall be taken at ground level for design purposes.

(iv) Saddle type/bracket type support wherever required shall be designed and supplied for the above ground pipe lines.

(v) All pipe joints shall be of the butt welded type. End preparations and fabrication requirements shall generally conform to I.S. 2825. Flanges, if fabricated in segments, shall be fully radiographed and stress relieved.

(vi) Laying of welded steel pipes shall meet the requirements of I.S. 5822.
(vii) Protection for pipes laid underground shall be as indicated in sub-clause (d) hereinafter.

(viii) The following stagewise inspection shall be required :

a) Material identification
b) Welder qualification
c) Edge preparation
d) Mechanical tests
e) Hydrostatic test
f) 10% of all welds shall be radiographed.

Hydraulic Losses

The frictional losses due to waterflow in pipework shall be computed, based on the following:

a) Straight Pipes : **Willam-Hazen formula using C = 110**

Head loss in mwc/m run of pipe

$$= 6.815 \times \frac{V}{C}^{\text{exp } 1.852} \times \frac{1}{D}^{\text{exp } 1.167}$$

Where V = flow velocity in m/s

D = pipe internal diameter in m

b) Valves

The losses in mwc shall be calculated as

$$k \times \frac{V^{2,}}{2g}$$ where v = flow velocity through the nominal diameter in m/s

g = 9.81 m/sec^2

k = Coefficient as noted below;

k -	for sluice valves	=	0.2
	for butterfly valves	=	0.3
	for non-return valves =		1.5
	for penstocks	=	as furnished by the manufacturer with documentary evidence.

c) Fittings, specials

For specials like reducers, bell-mouths, tees, elbows, etc., the 'k' values shall be as recommended by the British Hydromechanics Research Association (BHRA), Volume 5, in the BHRA fluid Engineering Series.

d) Pipework Protection:

All underground piping shall have their external surfaces protected by application of one coal tar enamel coat, wrapping of fibreglass, one more coat of enamel and a final wrap of enamel impregnated fibreglass. Pipe surface shall be thoroughly cleaned by shot or sand blasting. Primer paint recommended by the enamel manufacturer for the grade of enamel used shall be applied over this cleaned surface within four hours of cleaning. The primer paint shall be thoroughly mixed and applied as recommended by the manufacturer and the coating shall be free of bubbles, globules, drips and runs. The primer shall be thoroughly dry before enamel is applied and the latter shall not be applied later than 3 days after application of primer. First flood coat of enamel shall be overlaid by a single spiral wrap of fibreglass overlapping at least 20 mm on pipe upto 250 mm diameter and 25 mm on larger diameter pipes. Enamel shall be heated slowly in clean kettles, equipped with indicating or recording thermometers (100°C to 350°C range), to the recommended temperature. The enamel shall be stirred continuously. It shall be seen that fibreglass impregnates in the flood coat. Second coat of enamel and second wrap of bitumen impregnated fibreglass shall be applied in the same way. The total thickness of the coating shall not be less than 2.5 mm. Each end of the pipe left bare for a distance of 150 mm for welding shall be hand coated and wrapped after field welding is completed and hydro tested. Testing of pipe protection shall be done as directed by Engineer using elcometers, coating thickness gauges, bond test and holiday detectors.

External protection

All underground pipework having a cover less than 1.5 m and more than 45 m shall be encased with M 15 concrete of minimum 200 mm thick all around.

All underground pipelines having a cover more than 1.5 m shall be externally protected by guiniting of minimum 40 mm thick as per specification.

All above ground and pipes in galleries shall be externally painted with two coats of epoxy with minimum thickness of 180 microns

Internal protection

All pipes of internal dia 1800 mm and above shall be provided with mortar lining of

minimum 12 mm thick.

All pipes less than 1800 mm dia upto 600 mm dia shall be internally painted with two coats of epoxy paint having dry film thickness of minimum 225 microns.

Pipes below 600 mm dia cannot be painted internally therefore a corrosion allowance of 1 mm is to be added to the design thickness of pipe.

All PVC pipes and specials shall be provided with fibre glass wrapping of minimum 3 mm thickness.

No internal and external painting to be given to SS pipes.

9.4.2.9 FLEXIBILITY IN PIPE WORK

The Contractor shall provide flexibility in the pipework at joints in the main structures and shall submit proposals for the approval of the Engineer. Flexible joints or collars and cut pipes shall be allowed on all pipework where necessary to allow for some margin of error in the building work. Wherever possible flexible joints shall be provided with tie bolts or other means to transfer longitudinal thrusts as a whole so that external anchorages may be kept to a minimum. Flexible joints shall also be provided for case of erection and future dismantling. Particular care shall be taken to ensure that pipework thrusts are not transmitted to machinery or associated apparatus. The Contractor shall indicate on his detailed drawings what thrust blocks are required to anchor pipework supplied by him.

9.4.2.10 PUDDLE FLANGES & PIPES

Puddle flanges shall be fitted to pipes where the structure through which they pass is required to take thrust resulting form the pipe. Puddle flanges shall also be fitted where a water barrier is required. All puddle flanges shall be clearly shown on the drawing and the resultant thrust clearly indicated. Puddle flanges shall only be fitted with the Engineer's prior approval. Puddle flanges shall be as per IS:2062 construction and epoxy painted.

9.4.2.11 SMALL BORE PIPES AND HOSES

Small bore pipes and hoses shall be of non-flame propagating materials. They shall be arranged for easy dismantling for cleaning where appropriate, and if screwed joint or joints formed by solvent welding are proposed for any chemical line, a sufficient number of flanged or flexible joints shall be provided to enable the pipework to be removed in sections without working from one end to the other of a particular run. Tees and cocks shall also be provided at convenient points for the connection of a pressure water supply to flush pipework through as required.

All pipes and hoses shall be labelled to enable individual lines to be identified throughout their run. Wherever possible racks or trays shall be fixed to the duct walls or walls of tanks and buildings and the chemical pipes shall be fixed to these racks or trays with clips which can easily be removed without dismantling adjacent pipes. The Contract includes for the supply and fixing of all such racks or trays. Full details of the type of hoses, pipes and racks of trays proposed, shall be supplied at the time of tendering.

9.4.2.12 SUPPORT OF PIPE WORK AND ACCESSORIES

All necessary supports, saddles, slings, fixing bolts and foundation bolts shall be supplied to support the pipework and its associated equipment in an approved manner. Valve, meters, strainers, and other devices mounted in the pipework shall be supported independently of the pipes to which they connect.

All brackets or other forms of supports, which can conveniently be so designed, shall be rigidly built up of steel by riveting or welding in preference to the use of castings.

No point of passage of pipes through floors or walls shall be used as a point of support.

After the collars and boxes or other fitting have been fixed in position, the floors, walls and roof structure will be made good by the Contractor.

9.4.2.13 AIR BLOWERS AND COMPRESSORS

Compressor blowers shall be of the Roots type, each provided with inlet filter and silencer, and accoustic 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 blowers shall be housed in a separate sound proof room to reduce the noise level.

Blowers shall be driven by squirrel cage motors through a matched eve-belt drive. Motors shall be mounted on slide rails mounted on a common bed plate, to facilitate the tensioning of the belts. Blowers shall not run above 1000 rpm.

Inlet to blowers shall be at the top and discharges at the bottom, the axes of both being vertical. Connecting pipework shall be designed for a maximum velocity of 20 m/s.

Each delivery branch shall include a drain at the lowest part and a reflux valve. Individual stop valves and safety valves shall be provided for each unit.

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.

Electrically driven air compressor sets shall operate up to 10 bar working pressure.

Duplicate compressor sets shall be provided complete with the following:

(a) Pressure relief safety valve
(b) Isolating valve
(c) Air filter and silencer
(d) Common bed plate for compressor and motor
(e) Single stage air-cooled unit
(f) vee-belt and guard
(g) Off loading piston

Compressors shall be arranged for automatic changeover on failure of the duty unit. Failure of the duty unit shall initiate an alarm. Control equipment shall include automatic unloading valves, pressure switches for duty standby and alarm, and lockable changeover switches.

Duplicate after coolers shall be provided. Water- cooled or air blast types will be considered.

Air receivers shall be designed and fabricated in accordance with relevant approved standards. They shall be mounted vertically on steel feet so that sufficient space is allowed for each access to the whole outside surface. Receivers shall be provided with drain cocks piped to drain pressure gauges and relief and check valves.

Supply of all necessary electrical components, devices, equipment, control panels, etc. together with cabling, earthing provisions, etc. shall be the responsibility of the Contractor.

Interconnecting pipework shall be arranged to avoid low points which may trap water. Unavoidable low points shall be provided with drain cocks piped to waste.

9.4.2.14 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. All gears, pinions, shall be cut from cast or forged steel or heat treated alloy steel. 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.

9.4.2.15 EOT CRANES

The crane shall be electrically operated, bridge type complete with all accessories including down shop conductor, crane rails and fixtures, and shall conform to IS 3177. Class M6.

The crane shall consist of bridge girders on which a wheeled trolley is to run. The bridge trucks and trolley frames shall be fabricated from structural steel. Access walkway with safe hand railing as is required along the full span length of the bridge girder. Steel shall be tested quality conforming to ASTM A36 except that, plates more than 20 mm thick shall

conform to BS: 4360 The bridge shall be designed to carry safely the loads specified in IS 807 & IS 800. All anti-friction bearings for bridge and trolley track wheels, gear boxes and bottom sheaves on hook shall be lubricated manually by hand operated grease pump through respective grease nipples.

Wheel and structural frame of the wheel mounting of the end carriages shall be designed so as to ensure that the crane remains square and prevent skewness. Bridge and trolley track wheels shall be of forged steel and shall be double flanged type. The wheel diameter and rail sizes shall be suitable for the wheel loads. The crane rails shall be manufactured from wear resistant austenitic manganese steel. Mountings of the wheels shall be designed to facilitate easy removal for maintenance. Walkways shall be at least 500 mm clear inside width with a 6mm thick non-skid steel plate surface. Steel rail stops to prevent rails from creeping and trolley from running off the bridge shall be abutted against ends of rails and welded to the girders. Bridge and trolley stops to match the wheel radius shall be provided before the buffer stops.

All exposed couplings, shafts, gear, wheels, pinions and chain drives etc. shall be safely encased and guarded completely to prevent any hazard to persons working around. All bearings and gears shall have a design life of 10,000 hours. Electro-magnetic and hydraulic thruster brake shall be provided for the main hoist. One electro-magnetic brake shall be provided for each of the cross travel and long travel motions.

Hook shall be solid forged, heat treated alloy or carbon steel suitable for the duty service. They shall have swivels and operate on ball thrust bearings with hardened races. The lifting hooks shall comply with the requirements of BS: 2903 / BS: 3017 and shall have a safety latch to prevent rope coming off the hook.

Hoist rope shall be extra flexible, improved plough galvanised steel rope with well lubricated hemp core and having six strands of 37 wires per stand with minimum ultimate tensile strength of 1.6 X 106 kN/m2 of Right Hand Ordinary (RHO) lay construction. The ropes shall have a 6:1 safety factor on the specified safe working load. Rope drums shall be grooved and shall be either cast iron or cast steel of or welded steel conforming to IS 3177.

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 conform to IS 807 and IS 800.

A capacity plate showing year of manufacture and rated capacity of hoist in figures not less than 150 mm height shall be placed on each side of the crane girder.

The maximum deflection under full load shall not exceed 1/900 of the span.

All accessory and auxiliary electrical equipment including drive motors, electrically operated brakes, controllers, resistors, conductors, insulators, current collectors, pendant push button station, protective devices, operating devices, cables, conduits, etc. necessary for the safe and satisfactory operation of the crane shall be provided. Switch gear & controller and motors shall conform to respectively IS 13037 and IS 325.

Motor shall be of Variable Frequency Drive (VFD).

Power to the crane shall be provided by down shop conductors manufactured from high conductivity hard drawn copper. Conductors shall be completely shrouded such that they have no exposed current carrying surfaces. Pendant type push button station shall be sheet steel enclosed and shall comprise the following push buttons and indicating lamps:
`Start' and `Stop'.
Long travel - `Right' and `Left'.
Cross travel - `To' and `Fro'.
Hook - `Hoist' and `Lower'.
Red indicating lamp for supply `ON' indication.

Pendant type push button shall be supported independently of the electrical cable and shall be earthed separately, independent of the suspension. Automatic reset type of limit switches shall be provided to prevent over travel for each of the following:
For `UP' and `Down' motions of the hook.

Long travel motion
Cross travel motion
Crane structures, motor frames and metal cases of all electrical equipment including metal conduit and cable guards shall be earthed. All motors, brakes, limit switches, panels, drum controllers, resistor unit sets shall be provided with two studs for earthing.

9.4.2.16 EXHAUST FANS

Fan should comply with IS 2312.

Fan blades shall be of mild steel / cast aluminium of an airfoil design mounted on stream lined hub. It shall be properly balanced so as to avoid noise and vibration. The blade and blade carriers shall be securely fixed so that they do not loosen in operation. Mild steel casing shall be of heavy gauge construction properly reinforced for rigidity. The means provided for securing the fan mounting or fan casing to the wall, partition such as to provide a secure fixing without damage to the fan or wall.

The fan shall have protective insulation or be capable of being earthed. A fan with protective insulation may be of all insulated construction or have either double insulation or reinforced insulation. The fan should be driven by single phase motor. Each fan should be provided with a wall cowl and bird screen. Bird screen shall be of 10mm square mesh and wall cowl shall be 18 G.

Fans shall be with ISI marking.

Bidder to note that above quantities does not include small exhaust fans required in toilet. The costs of such fans are deemed to be included in civil cost.

9.4.2.17 PORTABLE EXTINGUISHERS

Portable extinguishers shall be of Carbon Dioxide type of 5 kg capacity. The extinguishers shall confirm to requirements of NFPA 12 and shall be UL/FM approved.

9.4.3 CLARIFIER MACHINERY

9.4.3.1 GENERAL

Scrapers supplied by the Contractor shall generally be manufactured in protected mild steel, in accordance with the requirements of the Specification Part-5.

Alternative material such as stainless steel may be offered for specific items as sludge scraper blades. Where mild steel is proposed, the protection system shall give a typical life to first maintenance of at least 15 years. All protective coating shall be suitable for submergence/contact with chlorinated potable water.

9.4.3.2 DRIVE UNIT

The drive unit shall have a two speed facility, preferably by changing the no. of poles of motor. The entire drive unit including motor, gear box and rope drum shall be located at platform level above water level. The unit shall be housed in a weather proof enclosure. The motor controls and electrical panels shall be located inside the weather proof enclosures or mounted separately on the outer side walls in a weather proof housing provided with a protective canopy to protect against rain.

9.4.3.3 BOGIE

The Bogie shall be provided with adequate number of wheels from the structural stability point of view. The Bogie shall be provided with leaf springs and wheels to have contact with the side walls. The Bogie wheels shall be directly in contact with the concrete surface. No separate rails shall be provided on the floor.

9.4.3.4 TRANSMISSION SYSTEM

Two rope transmission system shall be adopted i.e. the winding and unwinding rope shall be separately fixed to the rope drum. This is to prevent differential movement of the scraper across its width. The rope system shall be guided/supported at suitable locations above/below water level. It shall be possible to reduce/increase the tension in ropes.

9.4.3.5 SCRAPER ARMS / SCRAPER / CAMS

The scraper arm shall be pivoted on the Bogie. Damping shall be provided to prevent disturbing the sludge blanket when the arm moves from lower position to elevated position and vice versa. Cams shall be provided at each end of the travel to lower the scraper arm in the forward motion and raise the ram in reverse direction.

Scraper system material of constructions:

Rope	:	SS 316
Wheels	:	Polyurethane
Leaf springs	:	Spring steel
Pulleys	:	Nelotron
Bearings.	:	Nylon or similar

Cams	:	MS galvanised
Scraper blade	:	Neoprene rubber
Under water Hardware	:	SS 316

9.4.3.6 BLADES AND FIXINGS

Scrapers shall be arranged to give a continuous scraping of the entire floor of the tank and successive blades shall overlap. The configuration of blades shall be designed to convey sludge and deposited suspended solids form the periphery of the tank and deposit it efficiently in the withdrawal hopper, or the sludge draw-off pockets.

The number and length of individual blades shall be at the discretion of the Contractor, but the depth shall be not less than 300 mm and the thickness not less than 5 mm

The top portion of the blades shall be folded forward in the direction of forward movement and the overall proportions shall be such that individual blades shall maintain rigidity at all times.

Renewable fabric reinforced rubber wearing strips, of cross section not less than 12 mm by 100 mm shall be fitted to each blade to provide continuous contact adjustable for wear. The material chosen shall have a shore hardness not greater than 40 and be manufactured from a well proven compound, details of which shall be submitted with the tender.

Backing strips shall be fitted to give support to the fixing of the rubber wearing strips and the assembly shall be secured by means of stainless steel bolts Grade 316 S16, of not less than 10 mm diameter.

Polytetrafluoroethylene washers shall be fitted beneath bolt head and nuts.

The backing strips shall not project beyond the tip of the scraper blade and the rubber wearing strips shall not project by more than three times their thickness.

Drilling of scraper blades and backing strips shall be uniform about the centre, to facilitate end-to-end and complete reversal of rubbers to compensate for wear.

The uppermost edge of the blades (if mounted on depending arms in such a way that they will, at all times, include varying degrees of wear), shall be inclined slightly forward in the direction of rotation.

The top connection shall permit the blades to follow slight dulations in the tank floor, in the plane of movement. The bottom connection shall allow the blade to maintain contact with the floor throughout it's length, while accommodating slight variations in the plane of the tank floor.

Two complete sets of replacement rubber strips shall be provided with the scrapers.

9.4.3.7 MOTORS

Scraper motors shall be provided in accordance with "14.5 F-Electrical Plant". They shall be of the squirrel-cage type, protected to IP55 and shall be rated 25% in excess of maximum design requirement.

9.4.3.8 STARTERS

Unless otherwise specified, the starter shall be located on a fixed part of the clarifier structure and accommodated within an IP55 protected kiosk and comply with the requirements of "14.5 F-Electrical Plant ".

9.4.4 FILTER MEDIA

9.4.4.1 GENERAL

Tenderers shall describe the methods of selection of correctly graded material, and of the transport, storage on site and placing in filters. Following acceptance of his Tender the Contractor shall supply a 10 kgs. sample of each medium to the engineer's Representative for testing and approval. Only when the Engineer's Representative has approved the samples shall orders be placed.

Test certificates shall be produced from the origin of supply to the approval of the Engineer's Representative and in no case shall delivery be affected to site when the quality or grading material departs from that of the approved sample. If the source quality changes during processing then the contractor shall supply further 10 kg. samples of the media to the Engineer's Representative for testing and approval.

(i) Tests at source shall meet the following minimum requirements:

(a) Check quality of screened media daily.

(b) Produce test certificates for each $50m^3$ of media. Certificates shall include sieve analyses and grading curves, and state media 'effective size' and' uniformity coefficient'.

(c) In addition to (b) above, certificates for each $100m^3$ shall include tests to determine 'loss on acid washing' and 'specific gravity'.

(d) In addition to (a) and (b) above, certificates for each $500m^3$ shall include a 'friability' analysis.

(ii) On delivery to site a kg. of media shall be taken from each bag until 10 or 12 kgs. is obtained. The samples should then be mixed and quartered before testing as follows:

(a) Pebble layers - a sample shall be taken from each delivery and graded. Samples shall be examined to ensure they are similar to the initial 10 kg sample.

(b) Sand media -samples shall be taken from each delivery to Site. Tests shall include a sieve analysis, preparation of grading curves and shall give media 'effective size', 'uniformity coefficient' and 'specific gravity'. A visual inspection shall also be carried out to ensure it is similar to the initial 10 kg. sample. In addition to the above tests, certificates for each $100m^3$ shall incorporate tests to determine 'loss on acid washing'.

The form of packing and storage for shipment and transportation and the manner of placing shall be such as to eliminate obvious causes of degradation of media.

9.4.4.2 FILTER GRAVEL

Filter pebbles or gravel shall be rounded or water worn stones, which when placed in layers in a filter above or around the underdrains effectively distribute washwater. The proposed depths and gradings of each layer of gravel shall be stated in the Schedule of Particulars.

9.4.4.3 FILTER SAND

Filter sand is hard grained quartz or silica sand having no constituent in any way friable or liable to mechanical breakdown when subject to pressure. The sand shall contain no carbonaceous matter, clay or silt and the loss on acid washing and ignition shall in each case be less than 2% by weight. The specific gravity shall be not less than 2.40.

The sand shall be supplied substantially free of fines and coarse material and at least 95% by weight shall be between the grading limits specified by the Contractor.

The effective size is defined as the size of the aperture through which 10% of the sand (by weight) passes.

The uniformity coefficient is defined as the ratio of the size of aperture through which 60% of the sand passes to the effective size.

Fines are defined as the particles which pass through a size of aperture 0.9 times the effective size, and not more than l% shall pass through the nearest sieve size.

All sand shall be obtained from an approved source and supplier and shall be washed, heat dried, graded and packed in plastic or polyethylene bags as approved by the Engineer's Representative for delivery to or storage at site. Hessian bags, and bags made of similar materials which may deteriorate during transit or in open storage will not be accepted. The bags shall be stacked at site in not more than six layers. It shall be the full responsibility of the Contractor to protect the filter media at site up to the Taking Over of the Plant.

9.4.5 CHLORINE PLANT

9.4.5.1 DRUM CONNECTOR TUBES

The tubes of copper with plastic sheaths connecting the chlorine drums and the chlorine header system shall be equipped with adaptors with SS clamps to accept different types of

drums supplied by the Corporation.

9.4.5.2 CHLORINE PRESSURE GAUGES

Pressure gauges for use with chlorine shall be of the Bourdon tube type with a special diaphragm isolating the tube from the gaseous chlorine. Pressure gauges shall have dials not less than 150 mm diameter except where they form an integral part of equipment, such as a chlorinator. No aluminium shall be used in the construction of the gauges; the dials and bezels shall be of bronze and internal components shall be of stainless steel.

All pressure gauge piping shall include isolating valves at each point of connection to the main piping.

Where necessary, pressure gauges shall be fitted with adjustable electrical contacts for initiation of alarm conditions with either rising or failing pressure, to suit the system design.

9.4.5.3 CHLORINE GAS PIPEWORK

Pipework conveying chlorine gas shall be solid draw steel tube conforming to B.S.1387 with BSP taper threads to B.S. 21. All fittings shall be of malleable iron. Chlorine gas pipework shall be adequately supported. Threaded joints shall be sealed using jointing compound compatible with chlorine. Poly tetrafluoroethylene tapes shall not be acceptable.

Where installation involves injectors to be located near the dosing points or remote injectors, the vacuum chlorine gas delivery lines downstream of chlorinators shall be of UPVC or approved equivalent and rated for 10 bar pressure.

9.4.5.4 CHLORINE GAS VALVES

Valves for gaseous chlorine duty shall be specifically designed for chlorine with forged steel bodies, Monel valve packing or special diaphragm in chlorine resistance materials.

9.4.5.5 CHLORINE GAS PRV CUM SHUT-OFF VALVES

Chlorine Gas Pressure Reducing and shut-off valve shall be a spring loaded, diaphragm operated valve with super-imposed electric actuator designed to reduce varying gas pressure upstream to a desired regulated pressure downstream and maintain this pressure within close limits.

The diaphragm shall be made of polytetrafluorethylene (PTFE).

The electric actuator shall ensure quick shut-off of the gas flow in the event of an evaporator breakdown or low pressure or low temperature development and similar events.

The valve shall have capacity equal to or greater than the maximum capacity of the downstream chlorinator units.

9.4.5.6 CHLORINATOR REMOTE VACUUM REGULATOR

Chlorinator remote vacuum regulator shall be provided immediately downstream of gas

PRV cum shut off valve to avoid pressurised chlorine upto chlorinators.

9.4.5.7 CHLORINATORS

The chlorinators shall be vacuum operated aqueous solution feed type units working in conjunction with wall mounted injectors.

The units shall be discrete floor standing cabinets of plastic/composite construction. Where specified, it shall be possible for the chlorinators to be arranged in a single console built-up from discrete modules. The chlorinators shall be suitable for manual feed rate control and incorporate a flow metering device for precise regulating of chlorine gas over a 20:1 flow range, with a metering accuracy of plus or minus 4% of the indicated gas flow rate.

Each chlorinator shall be fitted with the following principal components:

- gas inlet pressure regulating valve (with strainer)
- pressure/vacuum relief valve with safety vent
- vacuum regulating valve
- gas feed rate regulator preferably of the 'V' notch cylindrical plug and variable area orifice type
- variable area type flowmeter with linear feed rate indicator calibrated in kg/h
- thermostatically controlled gas inlet heater
- wall mounted injector, preferably of adjustable throat type
- rigid UPVC pipework to wall mounted remote injectors.

Chlorinators shall be provided with panel mounted indicators for the chlorine gas inlet pressure, injector vacuum, motive water pressure, chlorine solution pressure immediately downstream of injector and a feed rate adjustment knob.

Chlorine gas feed piping shall be provided with valves to allow isolation of each chlorinator without disturbing the operation of the other chlorinators.

Rigid UPVC chlorine vent piping shall also be provided and arranged to discharge at a high level outside the room, housing the chlorinators to ensure safe atmospheric dilution.

The chlorine supply to the injector shall shut down automatically if:

- the water supply to the injectors shall fail

- the injector vacuum line should break

- The chlorine solution line should be accidentally shut down by the closing of a chlorine solution dosing valve.

A carefully selected check valve shall be provided between chlorinator and injector to prevent accidental backflow of water into the chlorinator. This shall be consistent with the injector design with respect to gas flow and water pressure. While effectively preventing backflow, this valve shall allow requisite gas flow.

Additional safety devices shall be incorporated in the equipment to prevent hazards to the operators or damage to the components under normal operating and shut-down conditions.

All electrical services and control signal lines (where applicable) shall be wired to a single termination board within the chlorinator cabinet. The termination board shall preferably be totally enclosed in a gas- tight junction box with glanded cable entries and fitted with a clearly labelled warning sign stating the supply voltage. Electrical supply isolating switches interlocked with the panel doors shall also be provided in each chlorinator cabinet.

9.4.5.8 CHLORINE SOLUTION DISTRIBUTORS AND INJECTION FITTINGS

Where chlorine solution is to be dosed into flow in an open channel, chamber or downstream of a hydraulic jump it shall be applied using a chlorine solution distributor.

The distributor shall be either tube drilled UPVC tubular diffuser, designed to ensure uniform distribution of the specified flow rate of chlorine solution at the point of application.

The materials of construction of the distribution and sealing shall be compatible with 3500 mg/l chlorine solution at operational fluid temperature up to 30°C. UPVC tube used shall conform to BS:3505 Class 'E'.

The distributor shall be adequately supported and designed to withstand the stream velocity at the point of application and any flow or turbulence induced vibrations.

Where chlorine solution is to be dosed into flow in pipe lines it shall be applied using an injection fitting/device designed for specified duty flow rate.

The injection tube shall extend across the pipe bore and be supported with ends located in diametrically opposite flanged branches.

The injection tube shall be drilled at pre-determined centres to ensure uniform distribution across the flow profile.

The injection fitting shall be installed in diametrically opposite flanged branches with their axis making an angle of 45° with the horizontal in a plane normal to the direction of flow within the pipe line.

The injection fittings shall be adequately supported and designed to withstand the flow or turbulence induced vibrations. Provisions shall include necessary support brackets also.

Chlorine solution distributors or injection fittings shall be supplied complete with necessary non-return and isolation valves.

9.4.5.9 CHLORINE RESIDUAL MONITORING EOUIPMENT

Chlorine Residual monitoring equipment where specified shall comprise measuring cells, transmitters and indicator units. These shall be arranged for continuous monitoring of chlorine residual levels from samples delivered to measuring cells from locations stated in

the specification.

The chlorine residual measuring cells shall be either located in floor standing plastic/composite cabinets of modular construction or in wall mounted cabinets arranged to receive samples on a continuous basis from the sample pump. Each measuring unit shall include a BI-metallic cell generating a micro-ampere signal proportional to the residual chlorine level in the sample passed through the cell. Each unit shall incorporate the facility for addition by siphonic means of a buffer solution to minimise the effect of pH variations on cell output. The sample flow rate through the cell shall be adjustable by means of a spring and diaphragm regulator or similar device. The materials of construction and sealing shall be compatible with the specified sample fluid. Cells shall incorporate means of maintaining the electrodes free from fouling; this may take the form of grit recirculation system.

Each cell shall be capable of measuring free available chlorine.

The chlorine residual indicator/recorder/controllers where specified shall be housed in floor mounted plastic/composite cabinets of modular construction capable of being arranged to form part of a console and shall be operated by the signals generated by the residual chlorine measuring cell units.

The chlorine residual recorder units where specified shall preferably be circular chart type, with scale calibrations arranged to have zero at the chart periphery.

The chlorine residual controllers where specified shall be arranged to control the residual chlorine level in the specified range within plus or minus 1.5 per cent of full scale deflection. The controller unit shall incorporate panel mounted indictor lamps indicating increasing residual, decreasing residual, feed alarm, mains on, high alarm and low alarm. The units shall be capable of automatic stop/start control. Set point and alarm levels shall be adjustable from the front of the panel.

In addition to local indication and control where specified, the units shall also be capable of providing DC output signals for remote- indication/recording of residual chlorine levels and shall have volt-free contacts for remote annunciation of high and low residual alarms.

9.4.5.10 CHLORINE LEAK DETECTOR

Chlorine leak detector shall be of the bi-metallic cell amperometric type. The leak detector shall have an alarm level of 5 ml/cubic meter of chlorine gas in the atmosphere to detect any significant leakage from the chlorine plant equipment.

The unit detecting the presence of chlorine gas shall be compact wall-mounted device located at low level remote from the instrument.

The unit shall be sufficiently sensitive to detect increases in the concentration of 0.1 ml/cubic metre at a concentration level in the range of upto 4.0 or 5.0 ml/cubic metre.

The detector shall incorporate relays providing volt- free contacts to initiate alarms on the local control panel, outside the building and for re-transmission to remote panels. Detector shall be arranged to automatically shut down the ventilation fans preventing unregulated

discharge of chlorine fumes into the atmosphere.

The unit shall incorporate test buttons on the front panel, facilitating quick checks of satisfactory operation of the electronic circuits. These circuits shall include input mains filters and high noise rejection components to afford protection from transients and to make the unit suitable for industrial environments.

9.4.5.11 SELF CONTAINED EMERGENCY AIR BREATHING APPARATUS

Self contained emergency air breathing apparatus shall provide complete respiratory protection independent of the surrounding toxic or oxygen deficient atmosphere for about 35 minutes depending upon the degrees of exertion. The unit shall combine total reliability with a high degree of mobility to facilitate unhindered emergency rescue or maintenance work.

9.4.5.12 EMERGENCY SAFETY SHOWER AND EYE BATH

The safety shower and the bath shall incorporate nozzles specially designed to cater an intense deluge of water for rapid decontamination and an additional horizontal spray at approximately waist height level to direct water onto the lower body and legs.

The eye bath unit shall be fitted with fine mesh filters with built-in pressure regulating device to ensure a safe rate of flow to prevent foreign matter being further embedded into the eye and instead flush away contaminations.

9.4.6 INDUCTION MOTOR

Design Requirements

The motors shall be energy efficient conforming to the latest edition of IS: 325 and IS: 12615 or equivalent international standards and shall be of TEFC enclosure. Additionally the specific requirements mentioned in the following clauses shall also be met.

Performance and Characteristics

(f) Motors shall be capable of giving rated output without reduction in the expected life span when operated continuously under the following supply conditions:
   i. Variation in supply voltage +/- 10%
   ii. Variation in supply frequency +/- 5%

(g) Induction Motor Characteristics

- **Main Pump**

1. For Munduli, Bhubaneswar City water supply pumps.

Description	Unit	Particulars
Type		Squirrel cage Induction motor
Rating	kW	250
Rated voltage	kV	0.415
Synchronous speed	Rpm	1500
Quantity	Nos.	2

Description	Unit	Particulars
Type of mounting		Horizontal
Duty type		Continuous (S1)
Method of starting		Star Delta starter
Type of system earthing		Effectively Earthed.
Class of insulation		F
Design ambient temperature	^{0}C	50
Location		Indoor
Degree of Protection		IP54
Cooling designation		IC411
Terminal box		LHS – looking from NDE end
External cable details		1.1 kV, 2 Runs 3C x 240 sq. mm. Aluminium, XLPE, armoured
Space heater for motor		Required if motor rating is 30kW and above

2. For For Munduli, Bhubaneswar City water supply pumps

Description	Unit	Particulars
Type		Squirrel cage Induction motor
Rating	kW	110
Rated voltage	kV	0.415
Synchronous speed	Rpm	1500
Quantity	Nos.	2
Type of mounting		Horizontal
Duty type		Continuous (S1)
Method of starting		Star Delta starter
Type of system earthing		Effectively Earthed.
Class of insulation		F
Design ambient temperature	□C	50
Location		Indoor
Degree of Protection		IP54

Description	Unit	Particulars
Cooling designation		IC411
Terminal box		LHS – looking from NDE end
External cable details		1.1 kV, 2 Runs 3C x 95 sq. mm. Aluminium, XLPE, armoured
Space heater for motor		Required if motor rating is 30kW and above

- **Back wash water Pumps**

Description	Unit	Particulars
Type		Squirrel cage Induction motor
Rating	kW	200
Rated voltage	kV	0.415
Synchronous speed	Rpm	1500
Quantity	Nos.	2
Type of mounting		Horizontal
Duty type		Continuous (S1)
Method of starting		Star Delta starter
Type of system earthing		Effectively Earthed.
Class of insulation		F
Design ambient temperature	^{0}C	50
Location		Indoor
Degree of Protection		IP54
Cooling designation		IC411
Terminal box		LHS – looking from NDE end
External cable details		1.1 kV, 2 Runs 3C x 150 sq. mm. Aluminium, XLPE, armoured
Space heater for motor		Required if motor rating is 30kW and above

- **Air Blower**

Description	Unit	Particulars
Type		Squirrel cage Induction motor
Rating	kW	55

Description	Unit	Particulars
Rated voltage	kV	0.415
Synchronous speed	Rpm	1500
Quantity	Nos.	2
Type of mounting		Horizontal
Duty type		Continuous (S1)
Method of starting		Star Delta starter
Type of system earthing		Effectively Earthed.
Class of insulation		F
Design ambient temperature	□C	50
Location		Indoor
Degree of Protection		IP54
Cooling designation		IC411
Terminal box		LHS – looking from NDE end
External cable details		1.1 kV, 2 Runs 3C x 70 sq. mm. Aluminium, XLPE, armoured
Space heater for motor		Required if motor rating is 30kW and above

- **Dossing, Agitator, Pre Chlorine booster pumps and Flash Mixture**

Description	Unit	Particulars
Type		Squirrel cage Induction motor
Rating	kW	1.5
Rated voltage	kV	0.415
Synchronous speed	Rpm	3000
Quantity	Nos.	20
Type of mounting		Horizontal
Duty type		Continuous (S1)
Method of starting		DOL starter
Type of system earthing		Effectively Earthed.
Class of insulation		F
Design ambient temperature	^{0}C	50

Description	Unit	Particulars
Location		Dossing, Agitator – Indoor Flash Mixture - Outdoor
Degree of Protection		Dossing, Agitator – IP54 Flash Mixture – IP55
Cooling designation		IC411
Terminal box		LHS – looking from NDE end
External cable details		1.1 kV, 3C x 4 sq. mm. Cu, XLPE, armoured
Space heater for motor		Required if motor rating is 30kW and above

- **Clariflocculator**

Description	Unit	Particulars
Type		Squirrel cage Induction motor
Rating	kW	7.5
Rated voltage	kV	0.415
Synchronous speed	Rpm	3000
Quantity	Nos.	2
Type of mounting		Horizontal
Duty type		Continuous (S1)
Method of starting		Star Delta starter
Type of system earthing		Effectively Earthed.
Class of insulation		F
Design ambient temperature	□C	50
Location		Outdoor
Degree of Protection		IP55
Cooling designation		IC411
Terminal box		LHS – looking from NDE end
External cable details		1.1 kV, 2 Runs 3C x 6 sq. mm. Cu, XLPE, armoured
Space heater for motor		Required if motor rating is 30kW and above

- **Service water pump**

Description	Unit	Particulars
Type		Squirrel cage Induction motor
Rating	kW	5.5
Rated voltage	kV	0.415
Synchronous speed	Rpm	3000
Quantity	Nos.	2
Type of mounting		Horizontal
Duty type		Continuous (S1)
Method of starting		Star Delta starter
Type of system earthing		Effectively Earthed.
Class of insulation		F
Design ambient temperature	□C	50
Location		Indoor
Degree of Protection		IP54
Cooling designation		IC411
Terminal box		LHS – looking from NDE end
External cable details		1.1 kV, 3C x 6 sq. mm. Cu, XLPE, armoured
Space heater for motor		Required if motor rating is 30kW and above

- **Post Chlorine booster pump**

Description	Unit	Particulars
Type		Squirrel cage Induction motor
Rating	kW	2.2
Rated voltage	kV	0.415
Synchronous speed	Rpm	3000
Quantity	Nos.	3
Type of mounting		Horizontal
Duty type		Continuous (S1)
Method of starting		DOL starter
Type of system earthing		Effectively Earthed.

Description	Unit	Particulars
Class of insulation		F
Design ambient temperature	□C	50
Location		Indoor
Degree of Protection		IP54
Cooling designation		IC411
Terminal box		LHS – looking from NDE end
External cable details		1.1 kV, 3C x 4 sq. mm. Cu, XLPE, armoured
Space heater for motor		Required if motor rating is 30kW and above

- **Valves and exhaust fan**

Description	Unit	Particulars
Type		Squirrel cage Induction motor
Rating	kW	0.55
Rated voltage	kV	0.415
Synchronous speed	Rpm	1500
Quantity	Nos.	28
Type of mounting		Horizontal
Duty type		Continuous (S1)
Method of starting		DOL starter
Type of system earthing		Effectively Earthed.
Class of insulation		F
Design ambient temperature	□C	50
Location		Exhaust Fan-Indoor Valve - Outdoor
Degree of Protection		Exhaust Fan -IP54 Valve – IP55
Cooling designation		IC411
Terminal box		LHS – looking from NDE end
External cable details		1.1 kV, 3C x 2.5 sq. mm. Cu, XLPE, armoured

Description	Unit	Particulars
Space heater for motor		Required if motor rating is 30kW and above

(h) Motors shall be suitable for DOL / Star-Delta / Soft starter starting depending on kW rating of motors as specified elsewhere.

(i) The starting current of motor shall not exceed 200% of rated full load current for star/delta starting and 600% of rated full load current for DOL starting, under any circumstances.

(j) Motors shall be capable of starting and accelerating the load with the applicable method of starting, without exceeding acceptable winding temperatures, when the supply voltage is in the range 85% of the rated motor voltage.

(k) Motors shall be designed to withstand 120% of rated speed for two minutes without any mechanical damage, in either direction of rotation.

Insulation

(o) Any joints in the motor insulation such as at coil connections or between slot and winding sections, shall have strength equivalent to that of slot sections of the coil. The insulation shall be given tropical and fungicidal treatment for successful operation of the motor in hot, humid and tropical climate. The motors shall be provided with class F insulation with temperature rise limited to that of class B insulation.

(p) After the winding coils are placed in slots and all connections have been made, the entire motor assembly shall be impregnated by completely submerging in suitable insulating compound or varnish followed by proper baking. At least three such submersions and baking shall be applied to the assembly.

Constructional Features

(q) The motor construction shall be suitable for easy disassembly and reassemble. The enclosure shall be sturdy and shall permit easy removal of any part of the motor for inspection and repair.

(r) Motors weighing more than 25 kg shall be provided with eyebolts, lugs or other means to facilitate safe lifting.

(s) The rotor bars shall not be insulated in the slot portion between the iron core laminations for squirrel cage motors.

Terminal Box

(t) Terminal boxes shall be of weather proof construction in case of outdoor service. To eliminate entry to dust and water, gaskets of neoprene or approved equivalent shall be provided at cover joints and between box and motor frame. It shall be suitable for bottom entry of cables. It shall be capable of being turned through 360 degrees in steps of 90 degrees.

(u) The terminals shall be of the stud type with necessary plain washers, spring washers and check-nuts. They shall be designed for the current carrying capacity and shall ensure ample phase to phase and phase to ground clearances. Suitable cable glands and cable lugs shall be supplied to match specified cables.

(v) Stator leads shall be brought to the terminal box as insulated cable through a suitable barrier and terminated in clamp type terminals.

Accessories

(w) Two independent earthing points shall be provided on opposite sides of the motor, for bolted connections. These earthing points shall be in addition to earthing stud provided in the terminal box.

(x) Motors shall be suitable of starting and accelerating the load with the applicable method of starting, without exceeding acceptable winding temperatures, when the supply voltage is 85 % of the rated voltage.

(y) The locked rotor current of the motor shall not exceed 600 % of full load current (subject to tolerance as per the applicable standard).

(z) Motors shall have drain plugs so located that they will drain water, resulting from condensation or other cases from all pockets in the motor casing.
Motors shall be designed to withstand 120 % of rated speed for two minutes without any mechanical damage, in either direction of rotation.

Routine Tests

(aa) All routine tests shall be carried out as per the latest edition of IS 325 and IS 12615.

Acceptance Tests

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

9.4.7 LIST OF APPROVED MAKES

1. Horizontal Split Casing Centrifugal Pump.
   - Kirloskar Brothers
   - Joyti Limited
   - KSB Pumps Ltd, India
   - Mather +Platt

2. Dosing pump
   - Asia LMI
   - Milton Roy India
   - Positive metering India Pvt. Ltd

3. Sluice Valves / Non return Valve/ Butterfly valve/ Diaphragm valve
   - Kirloskar Brothers Ltd.
   - Indian Valve Company (IVC)
   - Upadhyaya Valves
   - Crawley & Ray
   - Avishkar Engineers

4. Pipes
   - Indian Tube Co.Ltd.
   - Jindal Pipe Ltd.
   - Ajantha Tubes Pvt.Ltd.
   - Bharat Steel Tubes Ltd.
   - Maharashtra Seamless

5. Fittings
   - Eby Industries
   - Shivananda Pipe Fittings Ltd.
   - Triveni Engineers
   - Teekay Tubes (P) Ltd.

6. Crane / Chain pulley block
   - Electromech
   - Eddycranes
   - Tractel
   - Demag Cranes

7. Full bore Electromagnetic Flow Meter
   - ABB,
   - SIEMENS,
   - FISHER-Rosemount (EMERSON PROCESS MANAGEMENT),
   - ENDRESS-HAUSER

8. Pressure Transmitter
   - ABB
   - Emerson Process Management
   - Siemens
   - Endress - Hauser

9. Digital Pressure Indicator & Digital Flow Indicator & Integrator
   - ABB
   - Eurotherm DEL
   - Masibus
   - Radix Electrosystems
   - Yokogawa

10. Control & Instrumentation Cables
   - Asian Cable Corporation
   - Delton Cables
   - LAPP
   - Finolex
   - Thermopads
   - Udey Pyro Cables
   - TCL cables,
   - Elkay telelinks,

11. **Prefabricated cabinets FOR Control Panel**
   - Rittal,
   - Enclotek

12. Flow indicator Cum Integrator & Digital Panel Meters
   - Yokogawa,
   - ABB,
   - Masibus,
   - Lectrotek

13. Lightning Protection Unit
   - MTL,
   - Pepperl & Fuchs,
   - Phoenix Contacts

14. Pressure Gauges
    - Manometer India,
    - H.Guru Instruments,
    - General Instruments,
    - Wika,
    - Waaree Instruments

15. Conductivity Type Level Switch
    - S.B.Electromech,
    - pune-techtrol,
    - lectroteck

16. Pressure switches
    - Indfoss,
    - Waaree Instruments,
    - Switzer Instruments

9.5 INSTRUMENTATION AND CONTROL SPECIFICATIONS FOR WTP & CWPS

9.5.1 Level Instruments

9.5.1.1 Ultrasonic Level Meter

Level measurement system shall be provided for sumps/reservoirs for Inatke sumps and clear water reservoir. It shall consist of level transducer & transmitter which will be mounted on the sump/reservoir and panel mounted digital level indicator and connecting cable.

To reduce the effect of water turbulence in the sump/reservoir, averaging facility shall be provided in the transmitter unit for providing steady readings.

The design and application of the level measuring system shall take into account the sump/reservoir construction, the material, size, shape, environment, process fluid or material, the presence of foam, granules, size etc.

The installation shall avoid any degradation of instrument performance due to sMunduli,Bhubaneswarous reflections, absorption, sound velocity variations, sensor detection area, temperature fluctuations, specific gravity changes and condensation. Facilities shall be provided for rejection of sMunduli,Bhubaneswarous reflections.

Technical Particulars of Ultrasonic Type Level Meter:

A)	General		
i)	Service	:	• Intake sump • Clear water reservior
ii)	Overall accuracy of measurement loop	:	± 0.5% of full scale
iii)	Range	:	0 to 15 meters
iv)	Quantity	:	4 Nos.
B)	Level sensor		
i)	Type	:	Ultrasonic
ii)	Weather protection class	:	IP 67
iii)	Process Connection	:	Flanged
iv)	Temperature compensation	:	Required
v)	Beam Angle	:	Narrow Angle (5 Degrees or less).
C)	Level transmitter		
i)	Type	:	Microprocessor based
ii)	Local display		Indicating type with LCD display
iii)	Programming facility	:	Required
iv)	Power Supply	:	24 V DC
v)	Output	:	• 4-20 mA DC, Isolated • High and low level alarm • Loss of echo alarm
vi)	Diagnostic facility	:	Required
vii)	Facility to suppress the echo from interfering structures		Required
viii)	Facility for averaging / dampening the readings due to water turbulence	:	Required
ix)	Weather protection class	:	IP 65
C)	Digital Level Indicator		

i)	Type	:	Microprocessor based
ii)	Mounting	:	Panel
iii)	Display	:	Digital LED display
iv)	Digit Height	:	14 mm or higher
v)	No. of Digits	:	3 ½
vi)	Input	:	4-20 mA DC
vii)	Zero & Span Adjustment	:	Required
viii)	Engineering Units for display	:	Meters
ix)	Accuracy	:	±0.1 % of span
x)	Enclosure Material	:	Non corrosive
xi)	Retransmission output	:	Isolated 4-20 mA DC
xii)	Power supply to Transmitter	:	24 V DC
xiii)	Alarm outputs	:	1NO+1NC for high, low and Low-Low alarms (adjustable)

9.5.1.2 Level Switch

Conductivity type level switch shall be provided on the as indicated in scope above and P&ID for generating control outputs and alarms.

The conductivity type level switch shall consist of level probes mounted on the reservoir, connected by suitable cable to the conductivity controller unit for generating control actions and high / low level alarms.

The controller output shall be connected to the instrument control panel for generating an alarm when the water level becomes Low or High and tripping signal when the level becomes very low.

The conductivity type level switch shall work on the principle of detecting presence or absence of liquid between two electrodes based on conductivity. The voltage at electrodes shall be A.C. The controller unit shall be electronic using ICs or microprocessors. Both the electrode assembly and the controller unit shall be suitable for field installation.

Provide extra lengths of electrodes and adjust the length by cutting the excess lengths at site, as necessary.

The level probes shall be installed on a flanged connection on the reservoir. The Contractor shall provide the required nozzle and the matching flanges.

Stilling pipe shall be provided for level electrodes in order to obviate the effect of water turbulence in the reservoir.

The conductivity type level switch shall function for normal conductivity of water.

Technical Particulars of Level switch:

A.	<u>General</u>		
i)	Service	:	Water as indicated in scope and P&ID
B.	<u>Level probe</u>		
i)	Type	:	Rod / Rope type
ii)	Weather protection class	:	IP 67
iii)	Probe material	:	SS 316
iv)	Probe head material	:	Non corrosive
v)	Insulation on the probe	:	Teflon
vi)	Counter weight for rope type probe to keep it straight		Required
vii)	Spacers between the probes to avoid entangling with each other	:	Required

viii)	No. of electrodes	:	4 nos. (high, Low, Very low and reference)
ix)	Length of the electrodes	:	Suitable for reservoir dimensions
x)	Stilling pipe	:	Perforated HDPE pipe Internal diameter to suit the level probe assembly
	Controller Unit		
i)	Mounting	:	Inside local cabinet fabricated from sheet metal.
ii)	Weather protection class	:	IP 65
iii)	Alarm contacts	:	For high, Low and Lo-Lo.
iv)	Contact rating	:	24 VDC 2 A / 230VAC 1 A.
v)	Power supply	:	230 VAC
vi)	Material of enclosure	:	Non corrosive
vii)	Sensitivity adjustment for conductivity	:	Required

9.5.1.3 Float and Board Type Local Level Meter

Float and Board type Local level indicator shall be provided for the sump/reservoirs as indicated in scope and P&ID.

It shall consist of S.S.316 float, S.S.316 wire rope, pulleys with nylon bushings and aluminium scale board. Entire set shall be made from corrosion resistant material. The pulleys shall be protected from dust and moisture accumulation by providing enclosure. Anchoring shall be provided to make the structure rugged.

The scale board shall be painted in white and the numerals shall be in black. The digit size and scale marking shall be visible from a long distance.

The range of the level indicator shall be 0 to 15 meters.

9.5.2 Flowmeters

9.5.2.1 Full bore type Electromagnetic flow meter

Full bore type Electromagnetic flow meter shall be provided lines as indicated in scope and P&ID.

The flow meter shall consist of flow sensor (i.e. flow tube), flow transmitter/ flow computing unit and remote flow indicator cum integrator. The electromagnetic flowmeter shall be manufactured as per BS EN ISO 6817 standard (Measurement of conductive liquid flow in closed conduits, method using electromagnetic flow meters).

The flow tube flanges and transmitter housing shall be properly earthed.

Flow tube shall have waterproof construction and shall be suitable for installation on underground pipe lines buried directly in the soil and also suitable for above ground pipelines.

The transmitter of the flowmeter shall be microprocessor based using digital technology having facilities for configuration of engineering units, flow range and features of memory and self diagnosis. The transmitter shall be mounted separate from the flow tube, connected by a cable. The flow transmitter and flow computation/ evaluation unit shall be mounted in a field mounted metallic field enclosure / cabinet.

The electromagnetic flow meter shall have bi-directional measurement feature and with accuracy better or equal to $\pm$ 0.5% of measured value inclusive of linearity, repeatability, pressure effect etc.

Flow transmitter/ flow computing unit should be microprocessor based having digital display with flow-rate indications and integrated flow values with the configuration facility from the front facia.

Material of construction of the wetted parts of flow meters shall be suitable for functioning on treated / raw and chlorinated water applications. Flow tube shall be rugged in construction and shall be suitable for continuous operation. Flowmeters shall be suitable for the water turbidity at site during various seasons

The flow meter shall be installed in such a way that it always remains filled with water. To avoid the effects of disturbances in the velocity profile, a straight and uninterrupted run, upstream as well as downstream from the location of the flow meter shall be provided, as required by the flowmeter manufacturer. The flowtube shall be installed at a location free from flow turbulence. In order to achieve the same, the flow tubes shall be installed in the pipe section such that straight lengths of pipe without bends or tee connection shall be minimum 5 diameters on upstream and 2 diameters on downstream side. The Contractor shall finalize the exact location of flow transducers in consultation with Employer.

The flowmeter output signals shall contain the data for flow-rate and integrated flow readings. The output signal of the flowmeter will be connected to panel mounted Flow Indicator & integrator.

Technical Particulars of Electromagnetic Flowmeter:

A) <u>General</u>

i)	Service	:	a) Intake pumps discharge header b) Service water to filters c) CWPS pumps discharge header to Samukha beach d) CWPS pumps discharge header to Munduli,Bhubaneswar town.
ii)	Overall accuracy of measurement loop	:	±0.5 % of reading
iii)	Quantity	:	4 nos.
iv)	Internal diameter of pipe	:	a) 1000 NB b) 80 NB c) 500 NB d) 900 NB respectively
v)	Suitable concrete chamber for enclosing flowmeter.	:	Required

B) <u>Flowtube</u>

i)	Type	:	In line full bore electromagnetic
ii)	Size of flowtube	:	Same as pipe size
iii)	Weather Protection Class	:	IP 68
iv)	Range	:	a) 0 to 5000 m^3/hr b) 0 to 50 m^3/hr c) 0 to 1600 m^3/hr d) 0 to 3000 m^3/hr respectively

v)	Surge protection devices (SPD) between flowtube and flow transmitter	:	Required for protection from lightning surges
vi)	Electrode material	:	Hastelloy C
vii)	Flowtube Lining	:	Polyuethane / Neoprene / Hard Rubber
C)	Flow Transmitter Unit		
i)	Type	:	Microprocessor based with facility to configure the ranges.
ii)	Type of display	:	4 digit, LCD for flow rate in m^3/hr. 8 digit LCD for totalised flow in ML
iii)	Input	:	From flowtube
iv)	Output	:	4-20 mA DC (isolated) proportional to flow rate
v)	Power Supply	:	24 V DC
vi)	Zero and Span Adjustment	:	Required
vii)	Weather Protection Class	:	IP 65
viii)	Battery backup for totalised flow	:	Required
ix)	Facility for on line diagnosis	:	Required
D)	Flow Indicator and Integrator		
i)	Type	:	Electronic, Microprocessor based, single unit for flow indicator and integrator.
ii)	Display	:	Digital, LED display
iii)	Digit Height	:	14 mm or Higher
iv)	No. of Digits		
	- Flow indicator	:	4 Digits
	- Flow integrator	:	6 Digits
v)	Input	:	4-20 mA DC (Isolated) from flow transmitter for flow rate
vi)	Zero and span adjustment	:	Required
vii)	Manual Reset Facility for flow integrator	:	Required (shall be protected)
viii)	Engineering Units for		
	- Flow rate indicator	:	CUM / Hr
	- Flow integrator	:	ML
ix)	Battery backup for flow integrator	:	Required
x)	Retransmitted output	:	Required

9.5.2.2 Open Channel flow meter

Open channel flow measuring system shall be provided on the channel connecting the aerator to the flash mixer and clarifier. It will comprise of ultrasonic type level transducer, flow transmitter cum computing unit, flow indicator cum integrator and any other item required for completing the flow measuring system. The channel shall contain parshall

flume designed for the flow conditions.

The level transducer shall be suitable for bracket mounting as required and shall be environmentally protected to IP-65. It shall have ambient temperature compensation and adjustable datum setting facilities.

The flow transmitter cum computing unit shall have an LCD display and also have facility to feed data like the type of channel, channel dimensions, engineering unit, dead band etc.

Prefabricated cable shall be provided between the transducer probe and the flow transmitter cum computing unit. The same shall be armoured.

The design and application of ultrasonic level transducer shall take into account the channel construction, the material of channel construction, size, shape, environment, process fluid / material, the presence of foam, granules, size etc.

The installation shall avoid any degradation of performance from sMunduli,Bhubaneswarous reflections, absorption, sound velocity variations, sensor detection area, temperature fluctuations, specific gravity changes and condensation. For application where sMunduli,Bhubaneswarous reflections are unavoidable the flow transmitter cum computing unit shall be provided with facilities for sMunduli,Bhubaneswarous reflection rejection.
The structure required for supporting the level sensor, platform, railings etc. shall be in the Contractor's scope.

Technical Particulars of Open channel flow meter

A)	General		
i.	Service	:	Open channel flow measurement.
ii.	Type of channel	:	Parshall flume
iii.	Overall accuracy of measurement loop	:	±0.5 % of reading
iv.	Power supply	:	230 VAC
v.	Quantity	:	1 no.
B)	Level Measuring Unit	:	
i.	Type	:	Ultrasonic
ii.	Mounting	:	On flow channel
iii.	Enclosure material	:	Die cast aluminium
iv.	Enclosure protection	:	IP 67
v.	Integral cable with sensor	:	Required
C)	Flow Transmitter Unit		
i.	Type	:	Microprocessor based with facility to configure the ranges.
ii.	Type of display	:	4 digit, LCD for flow rate in m^3/hr. 8 digit LCD for totalised flow in ML
iii.	Input	:	From flowtube

iv.	Output	:	4-20 mA DC (isolated) proportional to flow rate
v.	Power Supply	:	24 V DC
vi.	Zero and Span Adjustment	:	Required
vii.	Weather Protection Class	:	IP 65
viii.	Battery backup for totalised flow	:	Required
ix.	Facility for on line diagnosis	:	Required
D)	Flow Indicator and Integrator		
i.	Type	:	Electronic, Microprocessor based, single unit for flow indicator and integrator.
ii.	Display	:	Digital, LED display
iii.	Digit Height	:	14 mm or Higher
iv.	No. of Digits		
	- Flow indicator	:	4 Digits
	- Flow integrator	:	6 Digits
v.	Input	:	4-20 mA DC (Isolated) from flow transmitter for flow rate
vi.	Zero and span adjustment	:	Required
vii.	Manual Reset Facility for flow integrator	:	Required (shall be protected)
viii.	Engineering Units for		
	- Flow rate indicator	:	CUM / Hr
	- Flow integrator	:	ML
ix.	Battery backup for flow integrator	:	Required
x.	Retransmitted output	:	Required

9.5.3 Pressure Instruments

9.5.3.1 Pressure measuring System

Pressure measurement system shall be provided for common discharge header of the pumps as indicated in scope and P&ID.

It shall consist of a pressure transmitter mounted adjacent to the discharge header and connected to it by an impulse pipe. The output of the pressure transmitter shall be connected to the display instrument on the control panel.

The pressure measurement system shall be designed for continuous operation and capable of operating in the range of pumping station discharge pressure. The pressure transmitter shall be of the diaphragm type. It shall be provided complete with SS 316 impulse tube, two valve manifold, drain cock and snubber. The manifold shall be provided with a test port so that in-situ calibration can be carried out.
They shall be capable of withstanding surge pressures likely to occur in the system.
Pressure transmitters shall be with adjustable range as per requirement at site.

Technical Particulars of Pressure measuring instrument.

A) General

(i) Service : Pressure measurement on

			a) discharge header of intake pumping station b) discharge header of CWPS to Samukha beach c) discharge header of CWPS to Munduli,Bhubaneswar town
(ii)	Operating Pressure	:	a) 15 MWC b) 36 MWC c) 130 MWC respectively
(iii)	Accuracy of measuring loop	:	± 0.5% of reading or better

B) Pressure Transmitter

(i)	Sensor	:	Diaphragm Sensor
(ii)	Material of sensing diaphragm and other wetted parts	:	SS 316
(iii)	Range	:	a) 0 to 30 MWC b) 0 to 70 MWC c) 0 to 100 MWC respectively. Adjustable
(iv)	Zero and span adjustment	:	Required
(v)	Output	:	4-20mA DC, 2 wire system
(vi)	Enclosure Protection	:	IP 67
(vii)	Accessories	:	Isolation valves, Impulse tubing and all installation hardware
(viii)	Over range protection	:	130 % of full range

C) Digital Pressure Indicator

(i)	Type	:	Microprocessor based
(ii)	Display	:	Digital LED display
(iii)	Digit Height	:	14 mm or higher
(iv)	No. of Digits	:	3 ½
(v)	Input	:	4-20 mA DC
(iv)	Zero & Span Adjustment	:	Required
(iiv)	Engineering Units for display	:	MWC
(iiiv)	Accuracy	:	±0.1 % of span
(ix)	Enclosure Material	:	Non corrosive
(xi)	Retransmission output	:	Isolated 4-20 mA DC
(xii)	Power supply to Transmitter	:	24 V DC
(xii)	Alarm outputs	:	1NO+1NC for high and low pressure alarms (set point adjustable)

9.5.3.2 Pressure Switches

Technical Particulars of Pressure switch.

(i)	Service	:	• Discharge of each pump for detecting high pressure and tripping the pump • On discharge header of set of pumps to detect high and low pressure and generate alarm

			indicated in scope and P&ID)
(ii)	Accuracy	:	+ 1% of full scale
(iii)	Range	:	As per pump design
(iv)	Overrange Protection	:	125% of range
(v)	Body Material of casing	:	Die Cast Aluminium / non-corrosive
(vi)	Material of sensor and other wetted parts	:	SS 316
(vii)	Accessories	:	2 valve manifold with drain cock, impulse tubing, fittings, Snubber and all other installation hardware

Pressure Gauge

Pressure gauges shall be mounted on suction and discharge of each pump/blowers, and on the discharge header of the pumping station/blowers.

Casing for pressure gauges shall be black finished aluminium alloy with retaining ring, and shall be weatherproof and dust proof suitable for outdoor service. It shall have nominal dial size of 150mm. A synthetic rubber blow-out disc shall be provided on the casing. The pressure gauges shall have bottom connection with 1/2 inch male pipe thread. Threads shall be American Standard Taper Pipe. The stainless steel socket with welded stress relieved joints shall be provided.

Movement shall be the rotary geared type. All parts except the hair spring shall be stainless steel.

Measuring assembly for pressure gauges shall be constructed as a unit independent of the case. Pointer shall be micro meter type. Dial shall be of the laminated phenolic material with black figures on white background.

Pressure gauges shall be mounted on a board suitably supported near the pipelines. Pressure gauges shall be connected to the water pipelines pressure using S.S. impulse tubings.

Range of the pressure gauges shall be as per pump/blower design.

Technical Particulars of Pressure gauge.

i.	Service	:	• On suction of each pump • On discharge header for each set of pumps/blowers • On discharge of each pump/blower indicated in scope & P&ID
ii.	Accuracy	:	+ 1% of full scale
iii.	Dial size	:	150 mm
iv.	Glass	:	Shatterproof
v.	Range	:	As per pump design
vi.	Over range Protection	:	150% of maximum pressure
vii.	Blow out disc	:	Required
viii.	Process connection	:	As per process requirement ½" NPT (M)
ix.	Material of dial	:	Aluminum with white back
x.	Material of sensor and other wetted parts	:	SS 316
xi.	Accessories	:	2 valve manifold with drain cock, Impulse tubing, fittings, Snubber and all other installation hardware

li)

Cabinets for Field Instruments shall be fabricated from cold rolled steel with powder coating sheet of minimum 2 mm thick and shall be suitable for wall mounting or pedestal mounting as required.

ii) The cabinet shall be properly painted from inside by white paint and from outside by paint shade RAL 7032.

iii) The cabinet shall conform to IP-65 protection and shall have built in locking facility. The cabinet shall be earthed properly. A steel plate shall be provided in the cabinet for mounting the instrument and accessories.

9.5.4 Instrument Control Panel for Intake pumping station.

The Instrument Panel shall be provided for monitoring of pumping station.
The Instrument Panel shall be pre-fabricated and floor mounted.
The instrument panel shall consist of minimum following devices:

- Microprocessor based Alarm annunciator.
- Power supply modules.
- Surge protection units.
- Indicators for Level, pressure and flow.
- Selector switches.
- Push buttons.
- MCBs.
- Any other item required for functioning of the system.

9.5.4.1 Enclosure Fabrication

The exterior corners and edges shall be rounded to give a smooth overall appearance with projections kept to a minimum. Lifting lugs shall be provided for installation purposes and shall be replaced with corrosion resistant bolts after installation.

Control Panel shall be completely metal enclosed and shall be dust, moisture and vermin proof. Control Panels and instrument enclosures shall give a degree of protection of IP 52.

Metal sills in the form of metal channels properly drilled shall be supplied along with anchor bolts and necessary hardware for mounting the control panels.

9.5.4.2 Mounting

All equipment on front of panel shall be mounted flush. Equipment shall be mounted such that removal and replacement can be accomplished individually without interruption of service to adjacent equipment. Equipment mounted inside the panel shall be so located that terminals and adjacent devices are readily accessible. Terminal markings shall be clearly visible.

Cut-outs and wiring shall be according to equipment manufacturer's drawing. Cut-outs, if any, provided for future mounting of equipment shall be properly blanked-off. Wherever required, panels shall be matched with other panels in the control room in respect of dimensions, colour, appearance and arrangement of equipment on the front.

9.5.4.3 Earthing for Instruments

The panel shall be equipped with an instruments earth bus securely fixed along the inside base of panel. All metallic cases of relays, instruments and other panel mounted equipment and cable shields, shall be connected to the instrument earth bus. Looping of earth connections

which would result in loss of earth connection to other devices when the loop is broken shall not be permitted. However, looping of earth connections between equipment to create alternative paths to earth bus shall be provided. Earth pit for instruments shall be separate from electrical station earth.

9.5.4.4 Frame Earthing

All metal parts other than those forming part of an electrical circuit shall be connected to a copper earth bar run along the inside bottom of the panel. The minimum section of the earth bar shall be 25 mm x 3 mm. Connection of the earth bar to the station earth shall be carried out by Contractor.

9.5.4.5 Space Heater

Strip type space heaters of adequate capacity shall be provided inside control panels to prevent moisture condensation on the wiring and panel mounted equipment when the panel is not in operation. The heaters shall operate on 230 AC. Heaters inside the panels shall not be mounted close to the wiring or any panel mounted equipment. The operation of heaters shall be controlled by thermostats.

9.5.4.6 Interior Lighting and Receptacles

Each panel shall be provided with fluorescent fixture rated for 230V, 1 phase, 50 Hz supply for the interior illumination of the panel during maintenance. The illumination lamp shall be operated by door switch as well as manual switch. Each panel shall be provided with 230V, 1 phase, 50 Hz, combined 5 amps and 15 amps, 3 pin receptacle with a switch and neon indicating. The receptacle with switch shall be mounted inside the panel at a convenient location.

9.5.4.7 Voltage Level and Power Supply Units

An incoming feeder of 230 VAC shall be used of for working of control panel and connected field instruments. The Contractor shall use 230 VAC as the operating voltage or if the same is not suitable, he shall provide the necessary DC-DC covertors, power supply units, inverters etc. which are required for operation of instruments. e.g. if the instruments require power supply of 24 VDC, the Contractor shall provide 230 VAC to 24 VDC convertors.

230 VAC power supply will be used for ICP illumination and for anti-condensation heaters.

9.5.4.8 Labels

All the equipment mounted on the front facia of control panel as well as equipment mounted inside the panels shall be provided with individual labels with equipment designation engraved. The labels shall be mounted directly below the respective equipment. Also the panel shall be provided at the top with a label engraved with panel designation.

9.5.4.9 Switches and Miniature Circuit Breakers (MCBs)

ICP shall be provided with necessary arrangement for distribution of power supply to instruments on the panel and field instruments as applicable. The incoming and sub-circuits shall be separately provided with Miniature Circuit Breakers (MCBs).

For ease of maintenance and safety, power supply to each instrument loop shall be protected with an individual fuse (terminal type).

9.5.4.10 Panel Internal Wiring

Connections within a panel, between panel mounted devices and terminal blocks or between two panel mounted devices will be made by 660 volt grade, stranded copper conductor insulated with PVC and designed for a minimum conductor temperature of 90 degrees centigrade. The wires shall be shielded for all analogue signals. Panels shall be supplied completely wired internally to equipment and terminal blocks and ready for external cable connections at the terminal blocks. The colour coding scheme shall be decided mutually between the Purchaser and the Contractor.

Wires within the panel shall be continuous i.e. without splicing and shall comprise copper conductors. Wire termination shall be made with solderless crimping type of tinned copper lugs which firmly grip the conductor and insulation. Insulated sleeves shall be provided at all the wire terminations. Engraved core identification plastic ferrules, marked to correspond with panel wiring diagram shall be fitted at both ends of each wire. Ferrules shall fit tightly on the wires and shall not fall off when the wire is disconnected from terminal blocks. All wires directly connected to trip circuit of breaker or device, shall be distinguished by the addition of a red coloured unlettered ferrule.

9.5.4.11 Terminal Blocks

Terminal blocks shall be 660V grade, 20 amps rated, one-piece moulded, complete with stud type terminals, washers, nuts and lock nuts and identification markings. Terminal block design shall include a white fiber marking strip with clear plastic, hinged terminal covers. Markings on the terminal strips shall correspond to wire numbers on the wiring diagrams. All spare contacts and terminals of the panel mounted equipment and devices shall be wired to terminal blocks. There shall be a minimum clearance of 250 mm between the row of terminal blocks and the associated cable gland plate. Also the clearance between two rows of terminal blocks shall be a minimum 250 mm. Panel internal wiring shall not be looped directly from instrument to instrument. The same shall be looped through the panel terminal block only. If accidental short circuiting of certain wires is likely to result in malfunction of equipment, such as closing or tripping of a breaker or positive and negative wires, these wires shall not be terminated on adjacent terminal blocks.

9.5.4.12 Cable Supports

All external cables shall present a neat appearance and shall be suitably braced, placed in troughing clipped or laced to prevent effects of vibration.

9.5.4.13 Terminal Identification

Every terminal and test plug shall be uniquely identified within the terminal cabinet by means of a terminal number. Appropriate labels shall be used to permit quick and unambiguous identification of each terminal and test plug.

9.5.4.14 Painting / Coating of Instrument Panel

The Instrument Panel shall be made from pre-fabricated modular cubicles which will be made out of sheet steel work duly phosphated, rust and scales removed by dilute dichromate solution and oil, grease, dirt removed by emulsion cleaning. The control panel shall be powder coated with thickness of coating of minimum 60 microns.

9.5.4.15 Technical Features

Service	:	For monitoring of inatek pumping station
Type	:	Free standing
Construction	:	Prefabricated and modular construction

Weather Protection Class	:	IP 52
Sheet Material	:	Cold rolled sheet steel
Sheet thickness	:	2 mm for all the sides, 3 mm for gland and mounting plate
Internal Lighting	:	Required
Cable Entry	:	Bottom
Access	:	Front
External Colour of the panel	:	As approved by Purchaser / RAL 7032
Internal colour of the panel	:	Glossy white / RAL 7032

9.5.4.16 Alarm Annunciation -

The alarm annunciator shall be provided to generate audio-visual alarms in the pumping station and reserviors in case of abnormal situation.

The alarm annunciator shall be microprocessor based.

The number of channels shall be adequate to monitor the abnormalities of the entire pumping station.

The alarm annunciator sequence shall be configurable.

25% Spare windows shall be provided on the alarm annunciator.

The following minimum alarms shall be annunciated on the alarm annunciator. The alarm list is indicative. The Contractor shall provide annunciation of all alarms necessary in order to achieve control and monitoring requirements.

- Pump tripped on overload (for each pump)
- Discharge header pressure high
- Discharge header pressure low
- Intake sump level low
- Intake sump level high
- Pumping station tripped on very low level

9.5.4.17 Plant Shutdown

- A pressure switch shall be provided on discharge header of the pumping station to detect loss of pressure which may occur in case of pipeline burst. This shall generate an alarm if the pressure in the line falls below the set static pressure and will prompt the operator to switch off the pumps.
- All the pumps shall stop automatically if the water level in the intake sump is very low as detected by the level switch on the intake sump.

9.5.5 Instrument Control Panel with Alarm annunciator, PLC and PC based SCADA system for WTP and CW pumping station.

The Instrument Panel shall be provided for control and monitoring of Water treatment plant and clear water pumping station.

The Instrument Panel shall be pre-fabricated and floor mounted.

The Panel shall consist of minimum following devices in addition to clause 14.6.5:

- Microprocessor based Alarm annunciator.
- PLC with all required hardware and software
- PC based SCADA system with all required hardware, software and peripheries.
- Power supply modules.
- Surge protection units.

- Indicators for Level, pressure and flow.
- Selector switches.
- Push buttons.
- MCBs.
- Any other item required for functioning of the system.

9.5.5.1 Programmable Logic Controller (PLC)

Codes and Standards

PLC shall comply with the following codes and standards :

- National Electricity Manufacturers Association (NEMA)
- International Electro-technical Committee (IEC)
- American National Standards Institute (ANSI)
- Instrument Society of America (ISA)
- The Institution of Electrical and Electronic Engineers (IEEE)
- Deutche Industries Norman (DIN)
- Verein Deutscher Eisecnhuttenleute (VDE)

Design and Construction Requirements

PLC shall be provided as a stand alone controller to perform combinational and sequential logic functions, status monitoring and reporting functions with counter and timer facilities.

PLC shall comprise of necessary processors, input/output (I/O) modules, communication interface modules.

PLC shall have the following attributes as a stand alone controller:

- It shall carry out sequential start/stop logic implementation for operation of the pumps and motorised valves.
- It shall accept downloaded program from a programmer.
- It shall have different functional modules to perform the desired functions
- It shall scan the inputs in time cycles and update the status of inputs/outputs
- It shall have relays, counter/timer functions, internal registers/ flags, watch dog timer, set/reset facilities, up-down counter etc.
- It shall have a provision for spare input and output modules

  The PLC system shall be expandable and shall be modular in construction so as to carry out the future expansion

  PLC shall be microprocessor based with state of the art technology. System components shall be carefully chosen so that the reliability of the PLC shall be high. PLC shall use standard bus protocols and structures for communication within and outside the system.

  In case of system failure or power supply failure all the outputs shall attain pre-

determined fail safe condition. SMunduli,Bhubaneswarous signals shall not cause equipment operation.

Central Processing Units

The Central Processing Unit (CPU) shall be high performance processors with modular configuration suitable for real time process application. High inherent reliability, self checking, error-recovery and trouble-shooting features shall be source of the features of CPU.

Automatic restart of the system on resumption of power shall be provided.

Memory Unit

Memory unit shall comprise of highly reliable memory chips which are industry standard, proven design with fast random access and suitable for operation in process environments. Main memory shall be modular and facility shall be provided for up-gradation and expansion of memory to meet future demands.

Sufficient program memory and data memory space shall be provided. System initialization and application software shall be stored in EEPROM with necessary hardware. Running data shall be stored in a RAM with internal battery back-up. The battery back-up provided shall last for at least one month with life of battery a minimum of 3 years. Appropriate programs for application software modification shall be provided.

At least 20% extra memory space shall be provided over the actual requirements.

Input/Output Modules

Standard rack mounted I/O modules with plug-in cards shall be provided. Field wiring shall be terminated in screwed terminal and interconnected to the processor I/O system with pre-fabricated cables with plug-in type connectors.

20% extra points of installed capacity for each type of input shall be provided as spares and shall be wired to the terminal block of the control panel. Provision shall be made for future expansion of extra I/O modules.

Some of the common features of the I/O modules shall be as follows :

- All inputs shall be terminated with input protective network and necessary isolating barriers.
- Filters for noise rejection.
- Provision for isolation of faulty channels.
- Test points and fault indication LEDs shall be provided to carry out module testing.
- Surge withstand facility as per IEEE standards.
- All the modules shall be of addressable type.

- Protection for continuous overload upto 200% of all input ranges.
- Fuse protection and fuse failure detection.
- Internal battery back up.

Software

The online real time operating system supplied shall be proven for similar application and shall be able to support all the equipment/peripherals.

PLC Programming

The PLC programming software shall be Windows based user friendly package. The software shall be supplied alongwith its documentation (hard copy as well as soft copy).. The software shall have facilities for:

- carrying out program revision and management of these revisions
- insertion of comprehensive program subroutine and rung comments
- search and find and search and replace ‘contacts’ and ‘coils’
- simulation functions and testing of the program by changing the status of contacts and monitoring the outputs
- preparation of coil and contact list and their locations and memory maps
- make system backup copies while the system is online
- upload and down load programs to the PLC online
- carry out line maintenance and fault finding on the PLC

The PLC programming shall be prepared using the PLC manufacturer’s programming software package only. The PLC code shall be structured in the manner of the best industry standard and have comprehensive subroutine and rung annotation.

The PLC shall be commissioned using RAM memory storage modules which shall be replaced with an EEPROM when testing is complete.

Technical Particulars

a)	Mounting	:	Inside the Control Panel
b)	Weather protection class	:	IP 52
c)	Expandability	:	100% of installed capacity
d)	System loading	:	Maximum 60%
e)	Inputs and outputs	:	Refer PLC I/O list below
f)	Software	:	Programming and application software required

Typical PLC I/O List

Signal description	Type of I/O			
	DI	DO	AI	
a. Main Pumpset				
• Running status feedback (for all main pumpsets)	✓			
• Stopped status feedback all main pumpsets)	✓			
• Tripped status feedback all main pumpsets)	✓			
• Motor current (for main pumpsets)			✓	
ves (Refer notes)				
• Open status feedback (for all main valves)	✓			
• Close status feedback (for all main valves)	✓			
• Motorised valve drive fault	✓			
rs				
• Reservoir level low low (for each level switch)	✓			
• Reservoir level high high (for each level switch)	✓			
• Mains power supply failed	✓			
• UPS problem	✓			
• Surge vessel system problem	✓			
• Discharge header pressure			✓	
• Discharge header flow			✓	
• Reservoir level (for each continuous level instrument)			✓	

Notes:

1. The I/Os listed above are indicative and shall be finalised during detailed engineering. The Contractor shall provide all additional I/Os (if required) without any cost implication.
2. For manual valves, limit switches with 2NO+2NC contacts shall be provided for monitoring the open and close position of the valve.

9.5.5.2 PC based SCADA and peripherals :

The specific parameters of the PC based local SCADA system shall be as given below. However the specifications of the system shall be latest and shall be discussed and finalised in consultation with the Engineer's Representative prior to supply without any additional cost to the Corporation.

Technical Particulars

a.	U	:	Intel centrino or latest at the time of supply
b.	U speed		1.8 GHz or better
c.	in memory		512MB DDR2 upgradable to 2048 MB
d.	che memory		2 MB or better
e.	d disk		60 GB or better with shock absorber and data back-up utility
f.	D RW drive		Required 8X or better
g.	B Ports		Required
h.	U		17 inch colour, TFT display
i.	grated		• Graphics controller with 128MB shared memory • Sound card with speaker • Ethernet LAN interface card • Wireless networking • Internal modem
j.	mmunication ports		• One parallel • One serial • Two USB ports
k.	yboard		Integrated keyboard with touchpad
l.	use		External USB optical mouse with scroll
m.	ier I/O connections		IrDA receiver port, Port replicator connector, Audio and Mike jacks
n.	wer supply		Universal AC adapter: 100 to 240 VAC (50 to 60Hz) input; rechargeable Lithium-Ion 1 hour total run time with primary and secondary batteries.
o.	Minimum accessories to be provided		
	i. Battery adapter		Required
	ii. Power chord		Required
	iii. LAN cable		Required
	iv. USB pen drive (4 GB or better at the time of supply)		Required
p.	ed software (latest version) with copy on CDs		system shall be preloaded with the following softwares • Operating system (Microsoft Windows XP) • MS Office

- Anti-Virus
- Adobe Acrobat Reader
- PLC Programming Software

q. : Laser jet printer of HP make subject to purchaser approval.

r. ure For PC and printer as required.

9.5.5.3 <u>UPS</u>

A UPS with 30 minutes backup time shall be provided for the power supply instrumentation, printers and Instrumentation & Control system. The UPS shall have sealed maintenance free batteries and AC distribution board.

The batteries shall be sized such that the maximum recharge time does not exceed 8 hours. Contractor shall furnish UPS sizing calculations for review and approval.

9.5.5.4 <u>Surge Protection Devices</u>

Surge Protection Devices (SPDs) shall be provided for each signal and power loop for field instruments located outdoor. One SPD shall be provided in the field near transmitter and the other SPD of the loop shall be mounted in the control panel. SPDs shall be suitable for withstanding the surge arising out of high energy static discharge / lightning discharges and protect the instrument to which it is connected against damage. SPDs shall provide protection through the use of quick acting semiconductors like Tranzorb, zener diodes, varistors and an automatic disconnect and reset circuit. SPDs shall be passive and shall require negligible power for operation. During the occurrence of a surge it shall clamp on the allowable voltage and pass the excess voltage to the ground. The SPDs shall be self resetting to minimise the down time of the measurement loop. SPDs shall have minimum surge rating of 10 KA.

SPDs shall have a weather proof casing and shall be suitable for field / back of panel mounting as applicable. There should be total isolation between input, output and ground terminals.

Surge protection devices (SPDs) shall be provided at the control panel end of all instrumentation cables for the instruments located outside the building, in addition to the SPD at the instrument end. The SPD s shall be grouped in a specific area within instrument panel.

9.5.5.5 <u>Control system</u>

<u>General</u>

The control systems shall be designed for fully automatic operation of the WTP and CW pumping station. However, in the event of failure of the automatic controls or by operator choice it shall be possible to revert to manual operation of each item of plant independently of the PLC function.

PLC control shall be executed on a command and feedback basis. For example, if a valve does not open within a pre-set time, it shall be deemed to have failed and an alarm shall be raised. If a pump is commanded to start and start feedback is not received by PLC within a pre-set time, a standby unit shall be started (if available) and an alarm shall be raised.

Safety procedures shall be incorporated in the design of software and watchdog operation such that under any fault condition, an alarm shall be given and the most appropriate safe action is employed as follows:

- Continue with "held" values (e.g. when analogue instruments fail)
- Shutdown the plant
- Revert to back-up hardwired control system

Ultrasonic level monitor failure shall be generated when the 4-20mA signal is out of range or the loss of echo signal is present.

All instruments shall be monitored for failure.

All indications, alarms, trips, feedbacks, controls, sequences shall be reflected on PC screen.

Sequencing operation of filters shall be carried out as per design requirements.

Hardwired Interlocks

Interlocks for emergency stops, low low level in sump, overload etc. shall be hardwired in to the appropriate starter circuit to protect personnel and equipment. They shall operate in all modes of control. They shall latch and require to be manually reset at the starter panel, unless stated otherwise in the control philosophy. All other control and monitoring shall generally be implemented through the PLC.

The signals to be hardwired shall be finalised during detailed engineering.

Manual Operation

Control shall be by means of operation of pushbuttons located at the Control Panel / MCC. Selection of manual control shall be by means of 'Auto / Off / Manual' selector switch. Hardware interlocks only shall be active.

Manual control shall be arranged for three functions:

- Operation of critical equipment in the event of PLC failure
- Maintenance functions carried out on the equipment
- Equipment identified as requiring manual control only

9.5.6 Filter Console

The filter consoles shall be provided near each rapid sand filter for local operation of the filters.

The following instruments shall be provided on each filter control console:

a) Digital indicators for the following:
   - Differential head across the filter bed with alarm for low/high D.P.
   - Backwash water flow
b) Open & close pushbuttons for motorized valves across filter beds.
c) Start & Stop pushbuttons for blowers.
d) Indicating lamps for open & close status of motorized valves and for start & stop status of blower.
e) Any other item required for the operation of the filters.
f) Connectivity to central WTP PLC system.

9.5.7 Laboratory equipment

Detailed specifications for some of the laboratory equipment are given below:

One set of the following instruments shall be provided in the laboratory. They shall operate on 230 VAC, 50 Hz power supply. The display shall be backlit LCD.

A <u>pH Meter</u>

The pH meter shall consist of combination pH electrode (combination of reference and measuring electrodes), temperature compensation probe and pH meter electronic instrument with digital indicator.

i. Accuracy : ± 0.1% of reading
ii. Accessories : Standard pH solutions for calibration (pH 4, 7 and 10)

B <u>Turbidity Meter</u>

Turbidity meter shall consist of turbidity cell and turbidity measuring electronic instrument with digital indicator

i. Accuracy : ± 2 % of reading
ii. Accessories : Required standard formazine solution

C <u>Jar Testing Equipment</u>

ix-paddle lab stirrer featuring digital readout. Stainless steel paddles, regulated variable paddle speed of 1-300 rpm, built in illuminator, anti-glare curtain and with dust cover

D <u>Residual Chlorine Meter</u>

Accessories : Reagent required for minimum one-year continuous operation

E <u>Colorimeter</u>

i. Range : 0 to 1.99 Abs.
ii. Stability : ±0.01 Abs in 8 h
iii. Repeatability : ± 0.01 Abs

iv. Light source : Tungsten lamp
v. Detector : Photodiode
vi. Readout : 2 ½ digit 7 segment LED display

9.5.8 Vibration Meters

Vibration monitors shall be provided for measurement of vibrations of pump-motors in the pumping station. The vibration meter shall be portable and shall be used for taking in-situ vibration readings by fixing the accelerometer probe.

Technical Particulars

(a)	Type	:	Portable
(b)	Range	:	Selectable for 0-1mm/sec, 0-10 mm/sec and 0-100 mm/sec,
(c)	Frequency range	:	10Hz to 10 KHz
(d)	Display	:	Backlit LCD type displaying instantaneous, true peak level with m/s and mm/s^2 scales
(e)	Accelerometer Sensor	:	Piezoelectric type
(f)	Accessories	:	Mounting Magnet, Self adhesive tape Shoulder bag, Protective cover, batteries, battery charger
(g)	Power supply	:	battery operated (Rechargeable)
(h)	Memory for measurement data storage and processing	:	The instrument shall be capable of storing records of measurement results

9.5.9 Sound Level Meter

Portable sound level meters shall be provided for measuring the sound level in the pumping station. The sound level meter shall be used to take instantaneous readings. The sound level meter shall comply with BS5969, BS6998, ANSI S 1.4 and S1.43 (Type 2)

Technical Particulars

(a)	Type	:	Portable
(b)	Range	:	0-150 dB
(c)	Display	:	Back lit LCD to Display • Signal level with a quasi analog bar • Menus for displaying and editing settings • Stored measurement results • Selected parameters with levels
(d)	Microphone	:	Prepolorized, free field ½" microphone
(e)	Power supply	:	Battery operated (Rechargeable)
(f)	Internal Real time clock	:	Required
(g)	Data storage	:	The instrument shall be capable of storing records of measurement results
(h)	Accessories	:	Microphone, Shoulder bag, Protective cover, batteries, battery charger

9.5.10 Instrumentation Cables

i) Cables for 24 V DC signals, 4-20 mA DC signals

660 V/1100 V annealed, tinned, high conductivity 1.0 sq.mm stranded copper conductor, extruded PVC insulated two cores twisted into pair, laid up collectively, individual pair shielded and overall shielded with aluminium mylar tape, ATC drain wire run continuously in contact with aluminium side of the tape, inner sheathed with extruded PVC, armoured with galvanised steel wire, overall sheathed with extruded FRLS PVC

conforming to IS 1554, BS:5308 & IEC:189 Part II.

ii) Cables for 230 V AC power supply
660V/1100 V grade multicore cables, multistranded high conductivity annealed 1.5 sq.mm. tinned copper conductor, extruded PVC insulated, inner sheathed with extruded PVC, armoured with galvanised steel wire, overall sheathed with extruded FRLS PVC conforming to IS 1554.

9.6 ELECTRICAL SPECIFICATION FOR WTP & CWPS

9.6.1 Bidder shall supply the equipment in accordance with the specification, data sheets and the enclosed single line diagrams / lighting distribution / general arrangement layout diagrams. This specification covers design, material, manufacture, testing at manufacturers' work, and delivery to site, erection and commissioning of electrical system/equipment for Raw & Clear water Pumping station along with WTP and 33kV substation at Munduli, Bhubaneswar.

9.6.2 GENERAL DESIGN CRITERIA

All electrical equipment will be rated for 45°C designed ambient temperatures. The installation will generally conform to Indian Standards / IEC.

(a) Protections

The following protections are proposed for switchboard, motors and other plant feeders.

- 33kV Switchboard

Main Transformer Feeders

i) IDMT overcurrent, Instantaneous overcurrent and Instantaneous earth fault protection
ii) Transformer differential Protection only for ratings above 5 MVA.
iii) Restricted Earth Fault Protection with inter trip
iv) Transformer auxiliary protection (e.g. WTI, OTI, Bucholz, etc.)

Incomer and Outgoing Feeders

i) IDMT overcurrent, Instantaneous overcurrent and Instantaneous earth fault protection

- LV switchboard
  i) The ACB feeders shall be provided with electronic releases for IDMT Short circuit, over current and earth fault.
  ii) The ACB bus coupler feeders shall be provided with electronic releases for IDMT short circuit and over current.
  iii) The MCCB feeders shall be provided with Thermo magnetic releases for IDMT Short circuit, over current and earth fault.
- LV Motors
  i) For motor ratings less than or equal to 132kW shall be provided with overload protection by thermal (bimetal) relays in all the three phases to trip with single phase preventer (SPP)
  ii) For motor ratings above 132kW shall be provided electronic comprehensive motor protection relay consisting of following protection thermal overload, locked rotor, short circuit, negative sequence and earth fault.

(b) Metering

The following metering shall be provided.

- LV Incomer
  i) Ammeters with ammeter selector switch

ii) Voltmeter with voltmeter selector switch
iii) kW meter
iv) Power factor meter
v) Kilowatthour meter
vi) Frequency meter

- LV Outgoing Feeders

i) Ammeter with ammeter selector switch

(c) Indication:

- LV Incomer

i) Mains ON (red, yellow & blue)
ii) LV Motor Feeders
iii) Motor ON, OFF & Trip indication (Red, green & Amber)

(d) General

The capacity of the transformers shall be decided based on 100 % standby (redundancy) i.e. in the event of outage of any one of the transformer, other transformer can supply the complete load.

L.T motor up to and equal 5.5kW shall be provided with DOL starters, motor ratings above 5.5kW up to or equal to 250kW shall be provided with Star delta starters and all motor above 250kW shall be provided with soft starters.

If a motor rating goes beyond 250kW then H.T motors shall be used with voltage supply 3.3kV. The method of starting shall be either DOL or H.T soft starter such that voltage dips during shall be within 15%.

The main LV switchboard is proposed with 'Form-4' enclosure as per the Indian Standards. All indoor boards/panels and motors are proposed with a degree of protection of IP 54, while all outdoor equipment will be with a degree of protection of IP55. Necessary metering, protections and indications will be provided on the LV switchboard.

All power cables shall be sized based on continuous current capacity, permissible voltage drop and short circuit current rating. The voltage drop will be limited to 2.5 % at rated equipment current rating. The other rating factors for variation in ground temperature, variation in ambient air temperature, grouping of cables, depth of laying, etc. shall also be considered for cable sizing.

All LV power cables up to 6 sq mm shall have stranded copper conductors and above that, it shall be stranded aluminum conductor. Power cables shall be XLPE / PVC insulated, extruded inner and outer sheaths and galvanized flat/wire armoring.

The main L.V cable from transformer secondary to the incomer of main L.V switchboard which is laid directly in ground shall be XLPE insulated.

Control cables will be with stranded copper conductor, PVC insulation, extruded inner and outer sheaths and galvanized flat/wire armoring

The earthing shall be carried out as per IS: 3043. The material of earthing conductor will be GI. The values of fault level for designing the electrical system shall be based on transformer capacity, its impedance and system fault level. Fault clearing time for sizing of earth conductor will be taken as one second.

While sizing the buried earth conductor, a corrosion allowance of at least 20 % shall be taken. Plant earthing system shall be designed such that the overall earthing grid resistance is maximum one ohm.

Main earthing conductors outside and inside the building shall be planned in such a manner that various equipment are connected to earthing system by two connections in a reliable manner.

RCCBs shall be provided at the incomer of lighting panels.

(e) Compliance to Standards:

The electrical safety and clearances will be maintained as per Indian Electricity Rules and CBIP guidelines. The equipment selection and electrical installation will generally conform to the latest edition of Indian Standards (IS) and the International Electro-technical Commission (IEC).

9.6.3 TRANSFORMERS

The transformer tank shall be made from high-grade sheet steel, suitably reinforced by stiffeners made of structural steel sections. All seams, flanges, lifting lugs, braces, and other parts attached to the tank shall be welded. The interior of the tank shall be cleaned by shot blasting and painted with two coats of heat resistant, oil insoluble paint. Adequately sized manholes shall be provided for ease of inspection and maintenance. Steel bolts and nuts exposed to atmosphere, shall be galvanized. The tank cover shall be removable and shall be suitably sloped so that it does not retain rainwater.

Lifting lugs and eyebolts shall be so located that a safe clearance is obtained without the use of a spreader, between the sling and transformer bushings.

Transformers shall be provided with fixed type radiators. Fins of the radiators shall not have sharp edges and shall be rounded in shape.

The transformer core shall be constructed from high grade, non-ageing, cold-rolled, grain oriented, silicon steel laminations. The steel laminations shall be of "core" type. Each lamination shall be coated with insulation which is unaffected by the temperature attained by the transformer during service. Core laminations shall be annealed and burrs removed after cutting. Cut edges shall be insulated. The framework and clamping arrangements of core and coil shall be securely earthed inside the tank by a copper strap connection to the tank.

Windings shall be of insulated copper wire or copper strip. Windings and insulation shall be so arranged that free circulation of oil is possible between coils, between windings, and between winding and core. The windings shall be fully shrunk under vacuum before assembly. High voltage end-windings shall be suitably braced to withstand short circuit stresses and stresses caused up by surges.

The sequence and orientation of HV/LV side phase and neutral bushings shall be as specified in the latest edition of relevant IS.

Transformer shall operate without injurious heating at the rated KVA and at any voltage up to + 10 % of the rated voltage of any tap. Transformer shall be designed for 110 % continuous over-fluxing withstand capability.

Noise level of the transformer shall be less than 80 dB.

(a) Bushing

Solid porcelain bushings with brown glaze shall be used up to 36 kV class. Solid bushings shall have the characteristics specified in the latest edition of IS 2099. Bushings rated 400 A and above shall have non- ferrous flanges and hardware.

(b) Cable Terminations

LV side cable boxes shall have sufficient space for segregating the cable cores and for adequate clearance in air between bare conductors at the terminals. Cable boxes shall be complete with necessary glands, lugs and armor grips.

All auxiliary wiring from current transformers, Bucholz relay, oil/winding temperature indicators, etc. shall be marshalled to a separate weatherproof and vermin proof marshalling box with an independent access cover. The degree of protection of the enclosure of the marshalling box shall be IP 55.

The marshalling box shall be complete with necessary cable glands and cable lugs. The marshalling box and components shall comply with the requirements specified for control

cabinets elsewhere in this specification.

(c) Applicable Standards

The transformer and its accessories shall conform to the latest editions, including all amendments and revisions, of the following standards:

i) Power transformer: IS 2026/IEC 60076
ii) Fittings & Accessories: IS 3639
iii) Transformer oil: IS 335/IEC 60296
iv) Bushing > 1000 V AC: IS 2099/IEC 60137

(d) Fittings and Accessories

The following fitting and accessories shall be provided on the transformer.

i) Inspection manhole in the cover.
ii) Lifting lugs for both the transformer and the core.
iii) Two earthing terminals on opposite ends of the transformer tank.
iv) Name plate, rating plate and diagram plate.
v) Radiator banks with suitably located thermometer pockets for measuring inlet and outlet oil temperature.
vi) Conservator, complete with filling plug, sump and drain valves and a shut-off valve on the pipe connection between transformer tank and conservator, to permit removal of the conservator. The conservator shall be designed to maintain an oil seal up to a temperature of 100^0C.
vii) Oil temperature indicator with a range of minimum 30^oC up to the maximum operating temperature.
viii) Weatherproof dehydrating breather with activated alumina or silica gel as the dehydrating agent.
ix) Oil level indicator
x) Gas detector relays, with separate alarm and trip contacts, completewith shut-off valves.
xi) Separate drain valve, oil-sampling valve with plug and a top filter valve on the tank.
xii) Explosion vent with diaphragm. The device shall be rainproof. An equalizer pipe connecting the pressure relief device to the conservator shall be provided.
xiii) Separately mounted, waterproof and dustproof marshalling box (IP55) housing the oil temperature indicator with alarm and trip contacts and marshalling facilities for electrical devices mounted on the transformer.
xiv) Adequate number of air vents for relieving trapped air during oil filling and during maintenance.
xv) Thermometer pockets and sensing element mounted on the transformer tank cover for measuring top oil temperature.
xvi) Adequate amount of insulating oil required for first filling, plus 10% excess oil.

(e) Tolerance on Losses

The permissible tolerances on the guaranteed values of transformer losses shall be as per IS 2026. The values of load- losses and No-load losses shall be within the values given in latest edition of CBIP manual for transformers.

(f) Rejection

The Project Manager or the Project Manager's Representative reserves the right to reject the transformer if the same does not meet the specification requirement, subject to tolerances as per IS 2026. The rejected transformers shall be replaced by transformers complying with the requirements of this specification at the Contractor's cost.

If the commissioning of the project is likely to be delayed by the rejection of a transformer, the Project Manager's Representative reserves the right to accept the rejected transformer until

the replacement transformer is made available. Transporting the rejected and replacement transformers as well as installation and commissioning of both the transformers shall be at the Contractor's cost.

(g) Technical Particulars

- The specific technical particulars of the main transformer at RWPS shall be as given below:

Sr.	Description	Particulars	
1	Rated output (kVA)	315	
2	Transformer installation	Outdoor	
3	No load transformation ratio	33 kV / 433V	
4	Number of phases	Three	
5	Rated Frequency	50 Hz	
6	Impedance at principal tap	As per IS	
7	Number of windings / Material of conductor	Two / Copper	
8	Type of cooling	ONAN	
9	Vector group	Dyn 11	
10	LV neutral earthing	Solidly earthed	
11	Design ambient temperature.	45°C	
12	Winding temperature rise measured by resistance method	As per IS	
13	Oil temperature rise by thermometer	As per IS	
14	Tap changer	Full capacity, Off circuit tap changer on HV side with pad locking facility	
15	Tap range	+ 5 % to -5 %	
16	Tap step	2.5 %	
17	Terminal connection		
a)	HV bushing	Bushings suitable for overhead ACSR "DOG" conductor	
b)	LV cable box	Cable box suitable for terminating 1.1kV Grade Al. XLPE arm. 2 runs of size 3.5 Core x 240 sqmm	
c)	LV Neutral	LV neutral shall be through 1.1 kV rated bushings, both inside the cable box for forming the 3 Ph, 4-wire system and outside the cable box for direct connections to earth pits.	
18	Insulation of windings	**HV**	**LV**

Sr.	Description	Particulars	
a)	Nominal system voltage	33 kV	415 V
b)	Rated voltage	36kV	1.1 kV
c)	One minute power frequency withstand voltage (dry & wet)	70kV (rms)	3kV (rms)
d)	1.2/50 micro second full wave impulse withstand voltage	170kV (rms)	--
19	Insulation of bushings	**HV**	**LV (Line & Neutral)**
a)	Nominal system voltage	33 kV	415 V
b)	Rated voltage	36kV	1.1 kV
c)	One minute, wet and dry, power frequency withstand voltage	70kV (rms)	3 kV(rms)
d)	1.2/50 micro-second, full wave impulse withstand voltage	170kV (rms)	--
e)	Minimum creepage distance	31mm per kV	31mm per kV
20	Vacuum withstand capability of transformer main tank with bushings, radiators, fittings and accessories	250 mm of mercury	

- The specific technical particulars of the main transformer at CWPS shall be as given below:

Sr.	Description	Particulars
1	Rated output (kVA)	1000
2	Transformer installation	Outdoor
3	No load transformation ratio	33 kV / 433V
4	Number of phases	Three
5	Rated Frequency	50 Hz
6	Impedance at principal tap	As per IS
7	Number of windings / Material of conductor	Two / Copper
8	Type of cooling	ONAN
9	Vector group	Dyn 11
10	LV neutral earthing	Solidly earthed

Sr.	Description	Particulars	
11	Design ambient temperature.	45°C	
12	Winding temperature rise measured by resistance method	As per IS	
13	Oil temperature rise by thermometer	As per IS	
14	Tap changer	Full capacity, Off circuit tap changer on HV side with pad locking facility	
15	Tap range	+ 5 % to -5 %	
16	Tap step	2.5 %	
17	Terminal connection		
a)	HV bushing	Cable box suitable for terminating 1 no. 33kV earthed grade 3 Core x 95 sq. mm. Al. XLPE arm. cable	
b)	LV cable box	Busduct termination box suitable for terminating 1600A AL busduct	
c)	LV Neutral	LV neutral shall be through 1.1 kV rated bushings, both inside the cable box for forming the 3 Ph, 4-wire system and outside the cable box for direct connections to earth pits.	
18	Insulation of windings	**HV**	**LV**
a)	Nominal system voltage	33 kV	415 V
b)	Rated voltage	36kV	1.1 kV
c)	One minute power frequency withstand voltage (dry & wet)	70kV (rms)	3kV (rms)
d)	1.2/50 micro second full wave impulse withstand voltage	170kV (rms)	--
19	Insulation of bushings	**HV**	**LV (Line & Neutral)**
a)	Nominal system voltage	33 kV	415 V
b)	Rated voltage	36kV	1.1 kV
c)	One minute, wet and dry, power frequency withstand voltage	70kV (rms)	3 kV(rms)
d)	1.2/50 micro-second, full wave impulse withstand voltage	170kV (rms)	--
e)	Minimum creepage distance	31mm per kV	31mm per kV

Sr.	Description	Particulars
20	Vacuum withstand capability of transformer main tank with bushings, radiators, fittings and accessories	250 mm of mercury

(h) Tests

All tests required by the specification including repeated tests and inspection that may be necessary owing to the failure to meet any tests specified, shall be carried out at the Contractor's expense.

If the transformer fails to pass the tests specified, the Project Manager shall have the option to reject the unit. Additional tests shall be conducted to locate the failure and after rectification, all tests shall be repeated to prove that the rebuilt transformer meets the specification in all respects, all at the Contractor's expense.

The tests shall be carried out in the presence of the Project Manager / representative. The following tests shall be carried out on the assembled transformer during inspection at the manufacturer's works.

i) Measurement of resistance of windings at principal and extreme taps
ii) Ratio at each tap, polarity and phase relationships
iii) Measurement of impedance voltage at principal and extreme taps
iv) Measurement of no load current and no load losses at rated frequency and at both the rated voltage and 110 % rated voltage
v) Measurement of efficiency at ½, ¾ and full load
vi) Measurement of insulation resistance
vii) Induced over voltage withstand test
viii) Separate source voltage withstand test
ix) Magnetic unbalance test
x) Pressure Test for the tank

- **Impulse Test and Heat Run Test**

  In addition to the above tests, a withstand test with lightning impulse, chopped on the tail, shall be carried out on one limb of HV winding of the transformer if impulse test has not been already carried out on transformer of similar capacity in the last three years. Similarly heat run test shall also be carried out if the same has not been already carried out on transformer of similar capacity in the last three years. Type test certificate shall be submitted along with the bid, if such a test has been already carried out. If the type test has to be carried out, it shall be at the contractor's expense.

9.6.4 OUTDOOR HV SUBSTATION EQUIPMENT WITH STRUCTURE

(a) General

The scope of supply consists of a two pole galvanised steel (GS) structure fabricated out of ISMBs and ISMCs;Rail poles for drawing overhead line; GS structural sections for supporting and fixing various equipment; transformer, lightning arresters, disconnector, insulators and hardware, ASCR conductor, etc.; fixing accessories, and chain link fencing with padlock able gate.

The design, material, construction, manufacture, inspection and testing of all HV outdoor substation equipment and overhead line shall comply with the currently applicable statutes, regulations and safety codes in the locality where the equipment will be installed.

The equipment shall conform to applicable standards. All standards and code of practices shall be the latest editions including all official amendments and revisions.
The details of the steel structure and support sections/members shall be subject to approval of structural design calculations to be furnished by the contractor. Galvanizing shall be as per the details mentioned elsewhere in this specification.

(b) Disconnector

The disconnectors shall conform to IS 9921 and IEC 60129.
The disconnector switch shall be complete with all parts that are necessary for complete operation. Such parts shall be deemed to be within the scope of supply, whether specifically mentioned or not. Clamps/connectors shall also be supplied.
The disconnector design shall be such that it is free from visible corona discharge in both closed and open positions, at the visible discharge test voltages as per the applicable standards.
The disconnector shall be provided with high current carrying contacts on the hinge and jaw ends. All contact surfaces shall be silver faced copper.
The disconnector handle shall be provided with a padlocking facility to lock it in fully open or fully closed positions. Rust proof padlocks shall be supplied with the disconnectors.
Insulator used in the assembly of disconnector shall be of porcelain and of brown colour. Insulator cap and base shall be of high-grade cast steel or malleable steel casting and they shall be machine faced and galvanized.
Disconnector base shall be of galvanized steel.
Operating devices for disconnector shall be manually operable.
Operating mechanism shall provide a quick, simple and effective operation. One man shall be able to operate the disconnector without undue effort.
The manual operating handles shall be mounted on the base of the supporting structure. Guide bearings shall be provided at a height of 750 mm above grade level. All brackets, angles, guides, guide bearings or other members necessary for attaching the operating mechanism and the operating handles to the supporting structure shall be supplied as an integral part of the disconnector. Rustproof pins and bearings of bronze bushing, ball and roller type, shall be furnished. All bearings shall be weather protected by means of covers and grease retainers. Bearing pressures shall be kept low to ensure long life and ease of operation.
Disconnector and its operating mechanism shall be such that it cannot be dislodged from its open or closed positions by gravity, wind pressure, vibrations, shocks or accidental touching or breaking of the connecting rods or the operating mechanism.

- **Technical Particulars**

The specific technical particulars of disconnectors shall be as given below.

Description	**Unit**	**Particulars**
General		
Application		Outdoor
Type of disconnector		Double break with center pole rotating/ Center break

Description	Unit	Particulars
Type of mounting		Horizontal/ Vertical – for 33kV system
Execution of poles		Group operated three phases
Rated Values		
Rated voltage	kV	36
Rated normal current	A	As per single line diagram TCE.5925A-735-AU-3001
Rated frequency	Hz	50
Rated short time withstand current and time	kA (rms) / sec	16 kA for 1 sec
Rated peak withstand current	kA (peak)	40
Rated insulation levels		
Rated lightning impulse withstand voltage		
- Across the isolating distance	kV (peak)	195
- Phase to phase, between phases and across open switching devices	kV (peak)	170
One minute power frequency withstand voltage		
- Across the isolating distance	kV (rms)	80
- Phase to phase, between phases and across open switching devices	kV (rms)	70
Operating Mechanism		
Operating devices		Manual
Phase spacing	mm	1500 (preferable)
Support Insulators		
Number and type of insulators		Pedestal post
Nominal creepage distance	mm/kV	31

(c) Lightning Arrester

Lightning arrester (LA) shall be of outdoor, metal oxide (gapless) type and shall conform to IEC 60099.

LA shall be of hermitically sealed type and of self-supporting construction, suitable for

mounting on steel structures.

Housing of the LA shall be of porcelain, having adequate mechanical strength and rigidity for satisfactory operation under climatic conditions obtaining at site. Porcelain shall be finely glazed and shall be free from imperfections.

LA shall incorporate anti-contamination feature to prevent arrester failure, consequent to uneven voltage gradient in the event of contamination of the arrester housing.

LAs shall be complete with insulating base with a provision for bolting to flat surface of supporting structure.

LA shall be complete with line and earth terminals. The terminal clamps/connectors on the earth terminal of the arresters and the discharge counter incoming and outgoing terminals shall also be provided.

- Technical Particulars

The specific technical particulars of the LA shall be as given in the table below.

Description	**Unit**	**Particulars**
General		
Application		Outdoor
Type of Arrester		Metal Oxide (Without gaps)
Rated frequency	Hz	50
Rated Values		
Rated voltage	kV	30
Nominal discharge current	kA (peak)	10
Max. residual voltage at nominal discharge current	kV (peak)	72
Pressure relief class		20 (B)
Continuous operating voltage	kV (rms)	Approx. 24
Long duration current impulse		
- Line discharge class		3
- High current impulse	kA	100 (4/10 μsec)
Arrester housing		
- Material of housing		Porcelain
- Creepage	mm/kV	31
- Primary terminal		Suitable for 'DOG' ACSR conductor for 33kV system

Description	Unit	Particulars
Withstand test of voltages		
- One minute power frequency withstand voltage	kV (rms)	As per IEC-60099-4 and 60099-5
- Impulse withstand voltage	kV (peak)	As per IEC-60099-4 and 60099-5

(d) Insulators

The porcelain post insulators shall conform to IS 2544 and IEC 60273, the insulators for overhead lines shall conform to IS 731 and IEC 60305, 433 and the insulator fittings shall conform to IS 2486.

Porcelain used for the manufacture of insulators shall be homogeneous, free from flaws or imperfections that might affect the mechanical or dielectric quality. They shall be thoroughly vitrified, tough and impervious to moisture. The glazing of the porcelain shall be of uniform brown colour, free from blisters, burns and other similar defects. The porcelain shall be sound, free from defects and smoothly glazed. Insulators shall have compression type glaze with a good lustre.

Insulators shall be designed to avoid excessive concentration of electrical stresses in any section or across leakage surfaces. Design features, which increase radio influence level, shall be avoided.

All metal parts shall be made of commercial grade malleable iron or open hearth or electric furnace steel, hot dip galvanised to relevant standards. Castings, if any shall be free from blow holes, cracks and such other defects.

- Technical Particulars

The specific technical particulars of insulator shall be as given in the table below.

Description	Unit	Particulars
String Insulators		
Type of insulators		Porcelain, ball and socket type
Highest system voltage	kV	36
No. of units per stack	Nos.	3 nos. of 12kV
Mechanical characteristics		
- Electromechanical or mechanical failing load	kN	70
- Nominal creepage distance	mm/kV	31
Post Insulators		
Type of insulators		Porcelain, Pedestal post
No. of units per stack	Nos.	2 nos. of 24 kV or Solid stack
One minute power frequency withstand voltage of stack	kV (rms)	70

Description	Unit	Particulars
lightning impulse withstand voltage of stack	kV (peak)	170
al creepage distance of each insulator	mm/kV	31

- ACSR Conductors

The overhead / exposed connections shall be made by ACSR (Aluminium Conductor Steel Reinforced) Wolf conductor and shall conform to IS 398.

Aluminium strands of ASCR conductor shall be hard drawn from 99.5 % pure electrolytic aluminium rods with 60 % IACS conductivity.

The surface of conductor shall be clean and dry and free from any excess grease that may be used in its construction. The surface strands shall be smooth and free from burrs and other projections.

No joints shall be present in aluminium and steel wires.

The steel wire strands shall be hot dip galvanised. Zinc coating shall be even and uniform.

- Drop-out Fuses

Drop-out fuse assembly shall be complete with fuse carrier, post insulator, jaw and hinge, live parts, terminals, channel base, fixing bolts, nuts and washers. Fuse links shall also be supplied.

All materials used in the manufacture of drop-out fuses shall be suitable for conditions specified and shall withstand variations of temperature and atmospheric conditions without deterioration or distortion of any kind in any part. All non-metallic parts of fuse carrier shall be of tough, non-ignitable insulating materials.

Mounting of drop-out fuses shall be such that its isolation/removal/replacement is easy. It shall have positive guides for this purpose.

Bird proof constructional features shall be provided.

It shall be possible to adjust spring pressure of the top contact to ensure consistent performance

All current carrying parts shall be of copper alloy. The contacts shall be of gun metal brass or phosphor bronze. The contact surface shall be silver plated to ensure low contact resistance.

Fuse links shall be of such construction as to prevent danger from overheating, arcing and scattering of hot metal or powder or emission of flame, when operating in service.

When the fuse link ruptures or when the fuse carrier is pulled downwards, the carrier shall swing free to an inverted position. The carrier shall be brought to a cushioning stop to eliminate shock on the carrier and lower insulator unit.

The base channel and all ferrous parts shall be hot-dip galvanised as per the applicable standards.

Drop-out fuse base channel shall bear a name plate describing the major technical particulars. Fuse base, fuse link and fuse carrier shall bear the markings as per IS.

An operating rod with provision at the top for switching and removing fuse carrier shall be provided. The rod shall be minimum 6.0 metre long unless otherwise stated.

Multi-bolt (bi-metallic) terminal clamps shall be provided at the top and bottom of fuse base contacts suitable for connection to the ACSR conductor.

Fuse kit shall be supplied, consisting of fuse-link assembly, refusing tool and any other item necessary to restore the fuse units to service after an operation.

Drop-out fuse frame shall have two earthing terminals.

9.6.5 33kV SWITCHBOARD

a) General Constructional Features

33kV Switchboard

Description	Unit	Particulars
General		
Type		al enclosed, compartmentalized, draw-out type
Rated voltage, no. of phases and rated frequency	kV / - / Hz	36 kV, 3 Phase, 50Hz
System neutral earthing		V system earthed within plant premises.
Rated Insulation Levels		
- Rated short duration power frequency withstand voltage	kV (rms)	
- Rated lightning impulse withstand voltage	(peak)	
Rated normal current of bus bars under design ambient temperature of 500C and material of busbar		minium - suitable for 100% load
Rated short-time withstand current and time	(rms) / sec	kA for 1 sec
namic rating	(peak)	
nstructional Requirements		
Minimum thickness of sheet steel in mm Cold rolled (Frame/ Enclosure/ Covers)	Mm	ne – 2.5 ors/Covers – 2.0
Degree of protection of enclosure		4X
Color finish shade		
- Interior		ssy White
- Exterior		nt Grey Semi Glossy
Cable connection		tom entry and exit
Circuit Breakers		
Type		uum / SF6
Rated current inside the cubicle under design ambient temperature at 50°C	A	per attached single line diagram TCE.5925A-735-AU-3001
Rated operating sequence		3 Min–CO-3 Min-CO
Rated short time breaking current	kA (rms)	

Description	Unit	Particulars
ed short time making current	kA (peak)	
ed short-time withstand current and time	(rms) / sec	kA for 1 sec
ed peak withstand current	kA (peak)	
. no. of auxiliary contacts		NO + 6 NC after internal use by manufacturer
e of operating mechanism		
rmal		ng charging for closing and tripping
nergency		nual and Spring charged for closing and tripping
iliary control voltage		
osing coil / Tripping coil	V	V DC
ring charging motor	V	V DC
ace heater and lighting	V	V AC
hing switch		uired
rrent and Voltage Transformers		
ails of ratio, taps, burden, accuracy		per Single Line Diagram TCE.5925A-735-AU-3001
tective Relays		
e		nventional
iliary supply	V	V DC
ails of protective relays		per Single Line Diagram TCE.5925A-735-AU-3001
ulation levels		
ed lightning impulse withstand voltage		
ross the isolating distance	kV (peak)	
ase to phase, between phases and across open switching devices	kV (peak)	
ed short duration power frequency withstand voltage		
ross the isolating distance	kV(rms)	
ase to phase, between phases and across	kV(rms)	

Description	Unit	Particulars
open switching devices		
erating mechanism		
osing and opening		ng charged
ntrol voltage	V	V DC
hing switch		uired

b) <u>Circuit Breaker</u>

Circuit breakers shall be vacuum type. Circuit breaker along with its operating mechanism shall be mounted on a wheeled carriage moving on guides, designed to align correctly and allow easy movement. Plugs and sockets for power circuits shall be silver faced and shall be insulated with suitable insulating material shrouds. All corresponding components of circuit breaker cubicles of same rating shall be interchangeable with one another.

There shall be ‘Service’, ‘Test’ ‘Fully withdrawn’ positions for the breakers. In the ‘Test’ position the circuit breaker shall be capable of being tested for operation without energizing the power circuits, i.e. the control circuits shall remain undisturbed while the power contacts shall remain disconnected. Separate limit switches, each having a minimum of 2 ‘NO’ + 2 ‘NC’ contacts, shall be provided for both ‘Service’ and ‘Test’ positions of the circuit breakers.

Electrical tripping shall be performed by shunt trip coils. “Local / Remote” selector switch lockable in “Local” position shall be provided on the cubicle door. ‘Red’ and ‘Green’ indicating lamps shall be provided on cubicle door to indicate breaker close and open positions. Breaker “Service” and “Test” positions shall be indicated by separate indicating lamps on the cubicle door, in case mechanical indication of “Service” and “Test” positions are not available on the cubicle door.

Connection of the control / interlocking circuits between the fixed portion of the cubicle and the breaker carriage shall be preferably by means of plug socket arrangement.

Operating mechanism control

I. Circuit breakers shall be operated by a motor spring charging type of mechanism. The mechanism shall be complete with motor, opening spring, closing spring and all accessories to make the mechanism a complete operating unit

II. Operating mechanism shall normally be operated from the breaker cubicle itself.

III. The tripping spring shall be charged by the closing action, to enable quick tripping. Closing of the circuit breaker shall automatically initiate recharging of the springs to enable the mechanism to be ready for the next closing stroke. Charging time for the springs shall not exceed 30 seconds. It shall be possible to manually charge the springs in an emergency. Transfer from motor to manual charging shall automatically disconnect the charging motor. All operating mechanisms shall be provided with "ON" - "OFF" mechanical indication. The charging mechanism shall be provided with mechanical indicators to show "charged" and "discharged" conditions of the spring. Failure of any spring, vibration or mechanical shock shall not cause tripping or closing of the circuit breaker.

IV. Only one closing operation of the circuit breaker shall result from each closing impulse (manual or electrical), even if the breaker trips while the control device (manual or electrical) is being held in the "close" position.

V. The circuit breaker mechanism shall make one complete closing operation, once the push button (PB) or control switch has been operated and the first device in the control scheme has responded, even though the PB or control switch is released before the closing operation is complete, subject to the condition that there is no counter- impulse for tripping.

VI. Means shall be provided to manually open and close the breakers slowly, when the operating power is not available, for maintenance and adjustments. A local manual trip device shall also be provided on the operating mechanism.

VII. Circuit breaker control shall be on 110 V DC. Closing coils and other auxiliary devices shall operate satisfactorily at all voltages between 85-110 % of the control voltage. Trip coils shall operate satisfactorily between 70 -110 % the rated control voltage.

c) <u>Safety interlocks and features</u>

i. Withdrawal or engagement of a circuit breaker / switch disconnector shall not be possible unless it is in the open position.

ii. Operation of a circuit breaker / switch disconnector shall not be possible unless it is in service position, withdrawn to test position or fully drawn out. It shall not be possible to close the circuit breaker electrically in the service position, without completing the auxiliary circuit between the fixed and moving portions.

iii. Circuit breaker / switch disconnector cubicles shall be provided with safety shutters operated automatically by the movement of the circuit breaker / switch disconnector carriage to cover the stationary isolated contacts when the breaker / switch disconnector is withdrawn. Padlocking facilities shall be provided for locking the shutters positively in the closed position. It shall, however, be possible to open the shutters intentionally against spring pressure for testing purposes.

iv. The circuit breaker / switch disconnector carriage shall be earthed before the circuit breaker / switch disconnector reaches the test position from fully withdrawn position. In case of breakers / switch disconnector with automatic disconnecting type of auxiliary disconnects, the carriage shall be earthed before the auxiliary disconnects are made and the carriage

v. earthing shall break only after the auxiliary disconnects break.

vi. Caution nameplate, “Caution Live Terminals” shall be provided at all points where the terminals are likely to remain live and isolation is possible only at remote end, i.e. incomer to the switchboard. Suitable interlock shall be wired for the purpose.

d) <u>Constructional Features of Switchboard</u>

Switchboard design shall comprise metal enclosed, fully compartmental execution having separate sections for each circuit. Compartments with doors for access to operating mechanism shall be so arranged as not to expose high voltage circuits. Switchboard cubicle shall be provided with hinged door on the front with facility for locking door handle. Switchboard shall be dust and vermin-proof and shall have a degree of protection of enclosure of IP 4X. All removable covers shall be gasketed all around with neoprene or superior gaskets.

Instruments, relays and control devices shall be flush-mounted on hinged door of the metering compartment located in the front portion of cubicle. The metering compartment shall be properly shielded to prevent mal-operation of electronic equipment such as numerical / static relays due to electro-magnetic fields. Separate signal earth shall be provided for such

devices, if necessary.

Each switchboard cubicle shall be fitted with a label on the front and rear of the cubicle. Each switchboard shall also be fitted with label indicating the switchboard designation, rating and duty. Each relay, instrument, switch, fuse and other devices shall be provided with separate label.

Sheet steel used for fabrication of switchboards, control cabinets, marshalling boxes, etc shall be cold rolled. All panels, cabinets, kiosks and boards shall comprise rigid welded structural frames made of structural steel sections or of pressed and formed cold rolled sheet steel of thickness not less than 2.5 mm. The frames shall be enclosed by sheet steel of at least 2 mm thickness. Stiffeners shall be provided wherever necessary. All doors, removable covers, gland plates, etc. shall be of at least 2 mm thickness and shall be gasketed all round the perimeter. All doors shall be supported by strong hinges of the disappearing or internal type and braced in such a manner as to ensure freedom from sagging, bending and general distortion of panel or hinged parts. All floor mounted panels / boards shall be provided with a channel base frame. It shall be possible to extend the switchboard on both sides.

The fully draw-out modules shall have all the circuit components mounted on withdraw able type steel chassis. All power and control connections shall be of the draw out type. It shall be possible to withdraw the chassis mounted circuit components without disconnecting any connections. All draw-out contacts shall be of silver plated copper.

In case of circuit breaker compartments, suitable barriers shall be provided between breaker and all control, protective and indication circuit equipment including instrument transformers such that no live parts are accessible. External cable connections shall be through separate cable compartments for power and control cables.

One metal sheet shall be provided between two adjacent vertical sections running to the full height of the switchboard except for the horizontal busbar compartment. However, each shipping section shall have metal sheets at both ends. After isolation of the power and control connections of a circuit, it shall be possible to carry out maintenance in a compartment safely, with the bus bars and adjacent circuits alive.

e) Earthing

A aluminum earthing bus shall be provided and extended throughout the length of the switchboard. It shall be bolted to the framework of each unit and brazed to each breaker earthing contact bar. It shall be located at the bottom of the board. The earth bus shall have sufficient cross section to carry the momentary short circuit and short time fault current for at least 1 second or higher without exceeding maximum allowable temperature rise. The earth bus shall be properly supported to withstand stresses induced by the momentary short circuit current.

Suitable clamp type terminals at each end of the earth bus shall be provided to suit the size of the earthing conductors. Bolted joints, slices, tap, etc. to the earth bus shall be made with at least two bolts. Positive earthing of circuit breaker frame shall be maintained when it is in the connected position and in all other positions whilst the auxiliary circuits are not totally disconnected.

Hinged doors shall be earthed through flexible earthing braid of adequate cross section. All non-current carrying metal work of the switchboard shall be effectively bonded to the earth bus.

Positive connection of the frames of all the equipment mounted in the switchboard to the earth busbar shall be maintained through insulated conductors of size equal to the earth busbar or the load current carrying conductor, whichever is smaller.

All instrument and relay cases shall be connected to earth busbar by means of 1100V grade, green colored, PVC insulated, stranded, tinned copper, 2.5 sq. mm conductor looped through each of the earth terminals.

f) Circuit / Busbar Earthing Facility

It shall be possible to connect each circuit or set of 3 phase bus bars of the switchboard to earth through earthing switches. Earthing switches / earthing devices shall be mechanically interlocked with the associated breakers / switch disconnector to prevent accidental earthing of live circuit or bus bars. In case the earthing facility comprises earthing trucks to be inserted in place of circuit breakers, separate earthing trucks shall be supplied for each type / size of breaker. The earthing facilities proposed to be provided by the Bidder shall be clearly detailed in the Bid and shall be subject to Employer's approval. Auxiliary contacts (min. 2 NO + 2 NC) shall be provided on each earth switch / earthing device and shall be wired to the terminal block for interlocking purpose.

g) Annunciators:

Annunciator shall be of facia type with translucent plastic window for each alarm point. Annunciator facia plates shall be engraved in block lettering with respective alarm inscriptions. The inscriptions shall be clearly readable and visible when the respective facia light is lighted. Each annunciation window shall be provided with two lamps to provide redundancy against lamp failure. Lamps shall be replaceable from the front. Lamps shall be of clustered LED type.

All facia annunciator points shall be suitable to accept external contacts of either 'NO' or 'NC' self or hand reset type for initiating the annunciation sequence. Annunciators shall be suitable for accepting fleeting faults of duration as less as 15 millisecond.

For static annunciator schemes, special precaution shall be taken by the Contractor to ensure that Munduli, Bhubaneswar alarm conditions do not appear due to influence of external magnetic fields on the annunciator wiring and switching disturbances from the neighboring circuits within the panels / desks.

A "Lamp Test" push button shall be provided for each individual panel's group of annunciators to limit the sudden drain on the battery. Provision of testing facilities for flasher and audible alarm circuits of annunciators is desirable. The Contractor shall give the details of the offered scheme.

Annunciator shall have following features:

I. Suitable for annunciating subsequent faults immediately after the sound cancel of the previous fault.

II. During lamp test, if a fault occurs, the corresponding lamp circuit shall be automatically disconnected from the "lamp test" circuit and shall start flashing.

III. Designed to prevent mal-operation of the scheme or sequence when the push buttons are pressed incorrectly or in the wrong order.

IV. "Alarm Supply Failure" Alarm scheme similar to the normal annunciation sequence, but shall operate on a different DC supply or on AC auxiliary supply.

h) Instruments

All electrical instruments and meters shall comply with IEC 60051, 61010 and IS 722, 1248. All indicating and recording instruments shall be flush mounted in dust proof cases complying with IEC 60068 and dimensions to IEC 61554.

Indicating Instruments

I. Electrical indicating instruments shall be 144mm x 144mm square with 2400 scale. Taut band type of instruments is preferred. Taut band moving coil instruments for use on AC systems shall incorporate built-in transducers.

II. Instrument dials shall be white with black numbers and lettering. A red line shall be drawn on each scale to represent rated conditions.

III. Normal maximum meter reading shall be of the order of 60 % normal full scale deflection. Ammeters for motor feeders shall have suppressed scale to show current from full load up to six times the full load current.

IV. Instruments shall have accuracy class of 1.0 or better. The design of the scales shall be such that it can read to a resolution corresponding to 50% of the accuracy class index.

V. Ammeters and current coils of Watt meters and Voltmeters shall continuously withstand 120% of rated current and 10 times the rated current for 0.5 sec., without loss of accuracy. Voltmeters and potential coils of Watt meters and Varmeters shall withstand 120% of rated voltage continuously and twice the rated voltage for 0.5 sec. without loss of accuracy.

VI. Alternatively, instruments can be electronic / digital type with LCD display. These instruments should have high performance ratio and can be equipped with digital output (for alarms) or with interfacing facilities for communication and remote reading of parameters.

Metering instruments

I. Watt-hour meters shall be of the induction type and shall be provided with reverse running stops.

II. Watt-hour and Varhour meters shall be of the three phase two element type of accuracy class 1.0, suitable for measurement of unbalanced loads in three phase three wire circuits. Watt-hour and Varhour meters shall be suitable for operation from the secondary of CTs and VTs. They shall be provided with a separate 3 phase 4 wire type test blocks for the testing of the meters without disturbing the CT and VT secondary connections. Alternatively, instruments can be electronic / digital type with LCD display. These instruments should have high performance ratio and can be equipped with digital output (for alarms).

i) <u>Control and Selector Switches</u>

Control and instrument switches shall be rotary type, provided with escutcheon plates clearly marked to show operating position and suitable for semi-flush mounting with only the switch front plate and operating handle projecting out. The connections shall be from the back. The contact assembly at the back of the switch shall be enclosed in dust tight

removable covers.
The control switches shall be 3 position, spring return to neutral type. They shall be provided with contacts to close in 'normal after close' and 'normal after trip' position. Each switch shall have external red and green indicating lamps, (except when discrepancy type switches are called for). In addition, a semaphore indicator shall be provided for earthing switch.
Contacts of the switches shall be spring assisted and contact faces shall be of silver / silver alloy. Springs shall not be used as current carrying parts. Contact rating and configurations of the switches shall be adequate for the functions desired.
Instrument selector switches shall be of the maintained (stay-put) type. Ammeter selector switches shall have make-before-break type contacts so as to prevent open circuiting of CT secondary when changing the position of the switch.
Lockable type switches, which can be locked in a particular position, shall be provided, if required.
Emergency stop buttons, if any, shall incorporate 'stay-put' features with independent reset facilities.

j) <u>Indicating Lamps / Pilot Lights</u>

Indicating lamp shall be of the double contact, bayonet cap type rated for operation at either 230 V AC or at the specified DC system voltage as applicable. Lamps shall be provided with translucent lamp covers.
Clustered LED type lamps shall be provided. Lenses shall be glass or plastic in standard colors, red, green, blue, white and amber, in accordance with IEC 60073. Bulbs and lenses shall be interchangeable and easily replaceable from the front of the panel. Tools, if any, which are required for replacing the bulbs and lenses, shall also be included in the scope of supply.
Miniature pilot lamps may be provided with plastic marking plate contained inside square (or rectangular) front lens to provide indication of legend or symbols engraved on the marking plate.
The basis of colors shall be as follows:

Red	:	Flow of energy.
Green	:	No flow of energy.
White	:	Supervision of power available, relay coil healthy, etc.
Amber	:	Disagreement with original condition, 'abnormal' condition or
	'	Sequence–on' condition.

k) <u>Push Buttons</u>

Push buttons shall be of momentary contact type with rear terminal connections. The color of the push button actuator shall be red for 'OPEN / STOP' and green for 'CLOSE / START'. The push button knob shall be suitably shrouded to prevent inadvertent operation. The push buttons shall be provided with integral inscription plates engraved with their designation.
All push buttons shall have independent, potential free, 2NO + 2NC contacts. The contact faces shall be of silver / silver alloy. The contacts shall be rated 10A and capable of breaking inductive load of 5A at 110V DC.

l) <u>Space Heaters</u>

Adequately rated anti-condensation space heaters shall be provided for each switchboard / cubicle. Space heater shall be of the industrial strip continuous duty type, rated for operation on a 230 V, 1 phase, 50 Hz, AC system. Space heater shall be provided with a single pole MCB with overload and short circuit release, a neutral link and a thermostat to cut off the heaters at 35 degree C.

m) Cubicle Lighting / Receptacle

Each cubicle shall be provided with interior lighting by means of 18 W fluorescent tube lighting fixture. An MCB shall be provided for the lighting circuit. The lighting fixture shall be suitable for operation from a 230 V, 1 ph, 50 Hz, AC supply. A 230 V, 1 phase, AC receptacle (socket) plug point shall be provided in the interior of each panel with an MCB.

n) Power and Control Cable Terminations

Terminals for power connections shall be complete with adequate phase segregating insulating barriers, shrouds and suitable crimping type of lugs for terminating the cables.
Double compression type glands with armour and bonding clamps for the termination of all solid dielectric multicore cables shall be provided. They shall be designed to secure the armour wires to provide electrical continuity between the armour and the threaded fixing component of the gland and to provide watertight seals between the cable outer sheath and gland and between the inner sheath and threaded fixing component. The gland shall preferably project above the gland plate to avoid entry of moisture.
Earthing connectors between cable armour and earth shall be routed outside the cable gland in an approved manner. Gland insulation shall be capable of withstanding test for appropriate high voltage for one minute.
Cable terminations for HV / MV cables shall be heat / cold shrinkable type. Adequately sized shrouds / bolts shall be provided at connections to completely cover the terminations.
Where core-balance type current transformers are provided on the feeder cables for earth fault protection, glands for cables shall be insulated from earth in an approved manner.

o) Wiring for Control and Protective Circuits

All low voltage wiring for control, protection and indication circuits shall be carried out with 1100 V grade, PVC insulated cable with stranded, tinned copper conductor of minimum 1.5 sq. mm size. The size of conductor for CT circuits shall be minimum 2.5 sq. mm.
All wiring shall be run on the sides of panels and shall be neatly bunched and cleated without affecting access to equipment mounted in the panel. The wiring shall be bound and supported by clamping, roughing or lacing. Spiral wrapping will not be accepted. Wireways shall not be more than 50% full. Adequate slack wire shall be provided to allow for one restripping and reconnection at the end of each wire. When screened cables or wires are necessary, an insulating sheath shall be included. Wiring and supports shall be of fire resistant material.
Wiring shall only be jointed or teed at terminals. Terminals of the clamp type shall not have more than two wires connected.

p) Terminations and Ferrules

Engraved core identification ferrules, marked to correspond with the wiring diagram, shall be fitted to each wire and each core of multicore cables terminated on the panels.
Moisture and oil resisting insulating material shall be used. The ferrules shall be of the interlocking type and shall grip the insulation firmly without falling off when the wire is removed.
All wires forming part of a tripping circuit shall be distinctively marked. Spare auxiliary contacts of electrical equipment shall be wired to terminal blocks.

q) Control Wiring Terminal Blocks

Terminal blocks shall be of 1000 V grade and stud type. Brass stud of at least 6 mm dia. with fine threads shall be used and securely locked within the mounting base to prevent turning. Each terminal shall comprise two threaded studs, with a link between them, washers, and matching nuts and locknuts for each stud. Connections to the terminals shall be at the front.
Terminals shall be numbered for identification, grouped according to function. Engraved 'black on-white' labels shall be provided on the terminal blocks describing the function of the circuit.
Terminals for circuits with voltage exceeding 110 V shall be shrouded. Terminal blocks at different voltages shall be segregated into groups and distinctively labeled. Terminals used for connecting current transformer secondary leads shall be 'disconnecting and shorting' type with a facility for earthing the secondary.
Terminal blocks shall be arranged with 100 mm clearance, between any two sets. Separate terminal stems shall be provided for internal and external wiring respectively. All wiring shall be terminated on terminal blocks, using crimping type lugs or claw type of terminations.

r) Busbars

The phase and neutral busbars shall be of rating indicated in the corresponding one line diagram. Busbars shall be of aluminum type and shall be provided with minimum clearances as specified.
All busbars and bus taps shall be insulated with close fitting sleeve of hard, smooth, dust and dirt free, heat shrunk PVC insulation of high dielectric strength, to provide a permanent non-ageing and non-tracking protection, impervious to water, tropical conditions and fungi. The insulation shall be non-inflammable and self-extinguishing type and in fast colours to indicate phases. The dielectric strength and properties shall hold good for the temperature range of 0 to 95 degree centigrade. If the insulating sleeve is not coloured, bus bars shall be colour coded with coloured PVC tape at suitable intervals.
Busbar joints shall be of the bolted type. Spring washers shall be provided to ensure good contact at the joints. Busbars shall be thoroughly cleaned at the joints and suitable contact grease shall be applied just before making a joint.

Direct access to, or accidental contact with busbars and primary connections shall not be possible. All apertures and slots shall be protected by baffles to prevent accidental shorting of busbars due to insertion of maintenance tools.
Sequence of red, yellow and blue phases and neutral for four-pole equipment shall be left to right and top to bottom, for horizontal and vertical layouts respectively.
The following HV/ MV switchboards are being procured under the present scope of works

with following protections systems:

33kV indoor VCB panel containing a single breaker
(a) IDMT over current and earth fault protection for incomer
(b) Transformer auxiliary protection (e.g. WTI, OTI, Buchhloz, etc. Alarm as well as tripping)

s) Over current / Earth Fault Protection

I. This relay shall be of the multi-characteristics type which has a flexible mode selection facility so that it is possible to select one mode for the over current elements and another for the earth fault element.
II. Phase current range shall cover at least 50-300% of 'In' in steps of not more than 10% while the earth current range shall cover at least 5-100% of 'In' in steps of not more than 5%.
III. The time setting range of the definite time mode shall not be less than 5 seconds in steps of 0.1 second each.
IV. The time multiplier setting for the inverse time-current characteristic modes shall have a range not less than 0.05- 1.6 in steps of 0.05.
V. Over current and earth fault relays shall have separate timers and operation indicators.
VI. The high set element shall have a range of 2 - 15 times the nominal current in steps of 'In' and shall be of low transient overreach, with a tripping time of less than 25 ms and possible to be selected on "blocked" position. Reset time shall be not more than 50 ms for both elements.
VII. The relays that are installed on the transformer neutral side shall be of single phase version, but they shall have the same characteristics as the phase side relays.

t) Under voltage relays

(a) Suitable voltage operated relays for sensing loss of voltage shall be provided. The relay shall have a drop off to pick up ratio of the order 90%. The relays shall be fast operating type and shall be fitted with operation indication. The indication shall come on drop off or loss of voltage.
(b) Additional potential free contacts for all the relay outputs i.e. trip as well as alarm signals shall be provided for connection.

u) Motor Protection Relay

The main 0.415kV motors are required to have Comprehensive Motor Protection Relays. These relays shall provide the following features.

(a) It shall be designed to protect the motor against thermal overload, locked rotor, over current, current unbalance, and earth fault protection, under voltage, over voltage, phase loss/reversal and negative sequence. Protection for repeated and prolonged starts, restart inhibition, no load running etc. shall also be provided.

(b) Thermal setting range shall cover at least 50% to 200% of 'In' in steps of not more than 5 % of 'In'.
(c) Phase current range shall cover at least 5-200% of 'In' in steps of not more than 1% while the earth current range shall cover at least 1-100% of 'In' in steps of not more than 5%.

In case CTMM relay, as existing in New Treatment Plant, is provided, additional relays required shall also be provided to achieve comprehensive motor protection providing all the above features. The cost of all such relays for comprehensive motor protection, if procured individually, shall be clubbed and quoted as a single rate under 'Comprehensive Motor protection Relay' in the schedule of prices.

The type / makes and the comprehensive motor protection philosophy shall be exactly identical for the old and the new treatment plants. Different type of relays, numerical or conventional for comprehensive motor protection, at the two different sites is not acceptable.

v) Auxiliary Relays and Timers

A. Following auxiliary relays shall be provided on each breaker cubicle:

i. Trip circuit supervision relay

ii. Anti- pumping relay

B. Hand reset type lockout (tripping) relays and timers shall be provided as required in addition to the protection relays given in the single line diagram.

C. Auxiliary relays and timers shall be rated to operate satisfactorily between 70 % and 110 % of the rated voltage.

D. Voltage operated relays with sufficient contacts to initiate tripping, alarm, annunciation for various trip functions like Buchholz relay operation, high oil temperature, high winding temperature, pressure relief device (PRD) operation etc. shall be provided. Each relay shall have four (4) pairs of self-reset contacts except for Buchholz and "PRD" trip which shall have hand-reset contact. The relays shall have hand-reset operation indicators.

E. Voltage operated relays with sufficient contacts to initiate alarm and data logging for various alarm functions for transformers, etc. shall be provided. Each relay shall have four (4) normally open self reset contacts. The auxiliary relay for Buchholz alarm shall be slugged to have delay on drop off at 100 ms. The relays shall have hand reset operation indicator.

w) Component Identification

A. A component reference number shall be marked adjacent to each component. Where this is impossible, components shall be identifiable from the layout drawings provided.

B. The following shall be marked in all instances:

I. Fuses: The rating and the circuit identification of each fuse shall be marked adjacent to the fuse base.

II. Control, Protection and Indication Devices: The function of each control, protection and indication device shall be marked. The caption and its arrangement shall be subject to the approval of the Employer's Representative.

III. Preset Controls: The circuit reference and if possible, the function shall be marked adjacent to each preset control in a position where it will be clearly visible while the adjustment is being made.

IV. Connectors: The diagram reference number shall be marked on or adjacent to each connector.

C. Test points shall be individually marked with the diagram reference number.The polarity of any polarized devices (e.g. diodes) shall be marked.

x) Test Terminal Blocks

Test terminal blocks, if any, shall be provided for secondary injection and testing of relays. A suitable metering block shall be provided for the connection of a portable precision instrument to be operated when required for specific plant testing purposes.

y) Tests

The following routine tests shall be carried out on the assembled switchboard / panel during inspection at the manufacturer's works in addition to other tests as per applicable standards.

I. Primary injection tests to ensure correct ratios and polarity of current and voltage transformers and of the current operated protection relays and direct acting coils, over their full range of settings.
II. Balance earth fault stability test by primary current injection. Care must be taken to reproduce accurately the burdens of interconnecting cables. A further test to ensure correct polarity must be made after assembly.Tests on auxiliary relays at normal operating voltages by operation of associated remote relays.
III. Correct operation of sequencing and control circuits at normal operating voltages by operation of local control switches, and simulation of operation from remote control positions.
IV. Carry out functionality tests, check interfacing status contacts and instrumentation.
V. Checking of Differential protection relay.One minute power-frequency voltage dry withstand tests on the main circuits
VI. One minute power-frequency voltage dry withstand tests on auxiliary circuits
VII. Insulation resistance tests
VIII. All circuit breakers shall be subject to the following tests:
IX. Routine tests including HV pressure test, milli-volt drop tests and mechanical tests.
X. To ensure the operation of the dc closing coil and satisfactory closing of the circuit breaker with the voltage of the coil down to 80% of its rated voltage, and that mal-operation does not occur with a voltage on the coil of 120% of its rated voltage.

Inter changeability of withdraw-able identically equipped circuit breakers, and checking of all mechanical and electrical interlocks.

Type test figures for heat test runs performed on identical panel types shall be made available.

HV and MV indoor switchboard shall comply with the following Standards, including those referred to therein: IEC 60044, 60186, 60255, 60265, 60282, 60298, 60466, 60529, 60694, 60787, 62271 IEC/TR2 61233 and IS 9046, 9920, 9921, 13118, 31307, 13037, 2156, 2705, 3156, 10118, 722, 13118.

z) Applicable Standards

The design, manufacture and performance of equipment shall conform to the latest standards specified below. In case of conflict between standards and this specification, this specification shall govern.

Metal enclosed switchgear	:	IS:31307
Current transformers	:	IS:2705/BS:7626
Arrangement for switchgear busbars,	:	IS:5578/IS:11353

main connections and auxiliary wiring		
Busbar support insulators	:	IS:2544/BS:3297/IEC:273
Degree of protection	:	IS:13947 (Part I) /BSEN: 60529/ IEC:947-1
Electrical relays for power system protection	:	IS:3231/BS:1130/IEC:255
Electrical indicating instruments	:	IS:1248/BS:89/IEC:51
A.C. electricity meters	:	IS:722/BS:2692
Specification for copper rods and bars for electrical purposes	:	IS:613
Code of practice for phosphating iron and steel	:	IS:6005/BS:3189

9.6.6 LV SWITCH BOARD

The following clauses shall be deemed to apply for CWPS PMCC,CWPS Auxiliary MCC,WTP & Chemical House MCC, RWPS PMCC, RWPS Auxiliary MCC, Feeder Piller-1,2,3, Lighting panels, marshalling boxes, control cabinets/panels, etc...

(a) General Constructional Features

Sheet steel used for fabrication of switchboards, control cabinets, marshalling boxes, etc shall be cold rolled.

All panels, cabinets, kiosks and boards shall comprise rigid welded structural frames made of structural steel sections or of pressed and formed cold rolled sheet steel of thickness not less than 2 mm. The frames shall be enclosed by sheet steel of at least 2 mm thickness. Stiffeners shall be provided wherever necessary.

All doors, removable covers, gland plates, etc. shall be of at least 1.6 mm thickness and shall be gasketed all round the perimeter.

All doors shall be supported by strong hinges of the disappearing or internal type and braced in such a manner as to ensure freedom from sagging, bending and general distortion of panel or hinged parts.

All floor mounted panels/boards shall be provided with a channel base frame. Total height of all floor mounted cubicles/panels shall not be greater than 2300 mm. Where steel pedestals for mounting of boards/panels are specified, the total height including that of the pedestal shall exceed 2300 mm.

Switchboard/control cabinet/panel shall be dust and vermin proof. Degree of protection of the enclosure shall be IP 54 for indoor installations and IP 55 for outdoor installations.

(b) LV Switchboard

Separate, segregated metal clad compartments shall be provided for main and auxiliary bus bars, each feeder and cable alleys. Metal clad cubicles/modules shall be provided with hinged doors in the front, with facility for padlocking door handles. More than one module may be arranged in the same vertical section. Circuits not controlled by air circuit breaker (ACB) shall be of the fixed type. The switchboard enclosure shall conform to “Form – 4” as per IS-8623. It shall be possible to extend the switchboard on both sides.

ACB, if any, shall be fully draw-out type. The breaker carriage shall be fitted with positive guides to ensure proper alignment. All corresponding components of circuit breaker cubicles of same rating shall be interchangeable with one another.

The fully draw-out modules shall have all the circuit components mounted on withdrawable type steel chassis. All power and control connections shall be of the draw out type. It shall be possible to withdraw the chassis mounted circuit components without disconnecting any connections. All draw-out contacts shall be of silver plated copper.

In case of circuit breaker compartments, suitable barriers shall be provided between breaker and all control, protective and indication circuit equipment including instrument transformers. External cable connections shall be through separate cable compartments for power and control cables.

The fixed type module shall have all the circuit components mounted in the compartment, with bolted type power and control connections. It shall be possible to remove all circuit components after removing the connections and the component fixing bolts.

Instruments, relays and control devices shall be mounted flush on hinged door of the cubicles. Switchboard shall be complete with inter-panel wiring.

Each switchboard shall also be fitted with a label indicating its title. Each cubicle shall be fitted with a label on the front and rear of the cubicle. Each relay, instrument, switch, fuse, contactor and MCCB/MCB shall be provided with a separate label.

One metal sheet shall be provided between two adjacent vertical sections running to the full height of the switchboard except for the horizontal busbar compartment. However, each shipping sections shall have metal sheets at both ends.

After isolation of the power and control connections of a circuit, it shall be possible to carry out maintenance in a compartment safely, with the busbars and adjacent circuits alive.

The current rating of outgoing feeders of any switchboard shall not be less than 10% of that of the incoming feeder. Deviation from this requirement shall be subject to the approval of the Project Manager.

(c) Busbars

The phase and neutral busbars shall be of rating indicated in the corresponding one line diagram. Busbars shall be of aluminium and shall be provided with minimum clearances as specified.

All busbars and bus taps shall be insulated with close fitting sleeve of hard, smooth, dust and dirt free, heat shrunk PVC insulation of high dielectric strength, to provide a permanent non-ageing and non-tracking protection, impervious to water, tropical conditions and fungi. The insulation shall be non-inflammable and self extinguishing type and in fast colours to indicate phases. The dielectric strength and properties shall hold good for the temperature range of 0 to 95 degree centigrade. If the insulating sleeve is not coloured, bus bars shall be colour coded with coloured PVC tape at suitable intervals.

Busbar joints shall be of the bolted type. Spring washers shall be provided to ensure good contact at the joints. Busbars shall be thoroughly cleaned at the joints and suitable contact grease shall be applied just before making a joint.

Direct access to, or accidental contact with busbars and primary connections shall not be possible. All apertures and slots shall be protected by baffles to prevent accidental shorting of busbars due to insertion of maintenance tools.

Sequence of red, yellow and blue phases and neutral for four-pole equipment shall be left to right and top to bottom, for horizontal and vertical layouts respectively.

(d) Circuit Breakers

- Air Circuit Breaker (ACB)

i) Circuit breakers shall be operated by a motor spring charging type of mechanism. The tripping spring shall be charged by the closing action, to enable quick tripping. Closing of the circuit breaker shall automatically initiate recharging of the springs to enable the mechanism to be ready for the next closing stroke. Charging time for the springs shall not exceed 30 seconds. It shall be possible to manually charge the springs in an emergency. Transfer from motor to manual charging shall automatically disconnect the charging

motor. The charging mechanism shall be provided with mechanical indicators to show "charged" and "discharged" conditions of the spring. Failure of any spring, vibration or mechanical shock shall not cause tripping or closing of the circuit breaker.

ii) Only one closing operation of the circuit breaker shall result from each closing impulse (manual or electrical), even if the breaker trips while the control device (manual or electrical) is being held in the "close" position.

iii) The circuit breaker mechanism shall make one complete closing operation, once the push button has been operated and the first device in the control scheme has responded, even though the PB is released before the closing operation is complete, subject to the condition that there is no counter- impulse for tripping.

iv) Means shall be provided to manually open and close the breakers slowly, when the operating power is not available, for maintenance and adjustments. A local manual trip device shall be provided on the operating mechanism.

v) All operating mechanisms shall be provided with "ON" - "OFF" mechanical indication.

vi) Closing coils and other auxiliary devices shall operate satisfactorily at all voltages between 85-110 % of the control voltage. Trip coils shall operate satisfactorily between 70 -110 % the rated control voltage.

- Moulded Case Circuit Breaker (MCCB)

i) MCCBs shall be of the air break, quick make, quick break and trip free type and shall be totally enclosed in a heat resistant, moulded, insulating material housing.

ii) MCCBs shall have an ultimate short circuit capacity not less than the prospective short circuit current at the point of installation.

iii) MCCBs shall have a service short circuit breaking capacity equal to the ultimate short-circuit capacity.

iv) Each pole of MCCB shall be fitted with a bi-metallic thermal element for inverse time delay protection and a magnetic element for short circuit protection. Alternatively, they shall be fitted with a solid state protection system. Such a protection system shall be fully self-contained, needing no separate power supply to operate the circuit breaker tripping mechanism. Thermal element shall be adjustable. Adjustments shall be made simultaneously on all poles from a common facility. Thermal elements shall be ambient temperature compensated.

v) The MCCBs shall be provided with the following features.

- Common trip bar for simultaneous tripping of all poles
- Shrouded terminals
- Time for clearing short circuit current of 20 msec.
- 2 NO + 2 NC auxiliary contacts

- Miniature Circuit Breaker (MCB)

i) MCB shall be hand operated, air break, quick make, quick break type.

ii) Operating mechanisms shall be mechanically trip-free from the operating knob to prevent the contacts being held closed under overload or short-circuit conditions.

iii) Each pole shall be fitted with a bi-metallic element for overload protection and a magnetic element for short-circuit protection. Multiple pole MCBs shall be mechanically linked such that tripping of one pole simultaneously trips all the other poles. The magnetic element tripping current classification shall be of the type suitable for the connected load. Where this is not specified, it shall be Type C.

iv) The short circuit rating shall be not less than that of the system to which they are connected.

(e) <u>Contactors</u>

The power contactors used in the switchboard shall be of, air break, single throw, triple

pole, electromagnetic type. Contactors shall be suitable for uninterrupted duty and rated for Class AC3 duty in accordance with the latest edition of IS 13947.

Operating coils of all contactors shall be suitable for operation on 240 V, single phase, 50 Hz supply.

Contactors shall be provided with at least two pairs of NO and NC auxiliary contacts.

Contactors shall not drop out at voltages down to 70 % of coil rated voltage.

Contactors shall be provided with a three element, positive acting, ambient temperature compensated, time lagged, hand reset type thermal overload relay with adjustable settings. The hand reset button shall be flush with the front door of the control module, and shall be suitable for resetting the overload relay with the module door closed. Relays shall be either direct connected or CT operated. Overload relay and reset button shall be independent of the "Start" and "Stop" push buttons. All contactor shall all be provided with single phasing preventer (SPP).

Motor starters shall be complete with auxiliary relays, timers and necessary indications.

(f) Switch Disconnectors and Fuses

LV switch disconnectors shall be of the load break, fault make, group operated type. For use on 3-phase systems, the switches shall be of the triple pole type with a link for neutral wire. For use on single phase system and DC systems, the switches shall be of the two pole type.

Switch disconnectors shall be of the heavy duty, quick make and quick break type. Their contacts shall be silver plated, and contact springs shall be of stainless steel. Their handles shall have provision for locking in both fully open and fully closed positions. Mechanical ON-OFF indication shall be provided.

Switch disconnectors for controlling motor circuits shall be of the load break, fault make type, and shall be capable of breaking locked rotor current of the associated motor.

Where combination units of switch disconnector and fuses are used, the following interlocks shall be incorporated.

- The fuses should not be accessible unless the switch disconnector is in fully open condition.
- It should not be possible to close the switch disconnector when the fuse cover is open, but an authorised person may override the interlock and operate the switch disconnector. After such an operation, the cover shall be prevented from closing if the switch disconnector is left in the "ON" position.

All fuses shall be of the HRC cartridge type, mounted on plug-in type of fuse bases. Fuses shall be provided with visible indicators to show that they have operated. Current vs. time characteristics of all types of fuses shall be furnished to the Project Manager.

Fuses and links functionally associated with the same circuit shall be mounted side by side.

An adequate number of spare fuse cartridges of each rating shall be supplied and fitted in clips inside the panel.

(g) Instrument Transformers

Current transformer (CT) shall have polarity markings indelibly marked on each transformer and at the lead terminations at the associated terminal block.

CT shall be able to withstand the thermal and mechanical stresses resulting from the maximum short circuit current.

CT core laminations shall be of high grade silicon steel.

Secondary winding of voltage transformer (VT) shall be rated for a three phase line to line voltage of 110 V.

Identification labels giving type, ratio, output and serial numbers shall be provided.

(h) Relays

Main protective relays shall be Numerical / Static type.

All relays shall be enclosed in rectangular shaped, dustproof cases and shall be suitable for flush mounting.

All relays shall be accessible from the front for setting and resetting. Access to setting devices shall be possible only after the front covers of the relays are removed. Resetting facilities shall however be accessible external to the relay case.

All protective relays shall be of the draw-out type and shall be provided with operation indicators visible from the front.

Auxiliary relays and timers shall be rated to operate satisfactorily between 70 % and 110 % of the rated voltage.

(i) Control and Selector Switches

Control and selector switches shall be of the rotary type, having enclosed contacts, which are accessible by the removal of the cover. Control and selector switches for instruments shall be flush mounted on the front of the panels and desks.

All control switches shall be of the spring return to normal type and shall have momentary contacts. Selector switches shall be of the stay-put, maintained contact type.

(j) Indicating Instruments & Meters

Electrical indicating instruments shall be 110 mm square with 2400 scale. Taut band type of instruments is preferred. Taut band moving coil instruments for use on AC systems shall incorporate built-in transducers.

Instrument dials shall be white with black numbers and lettering.

Normal maximum meter reading shall be of the order of 60 % normal full scale deflection.

Ammeters for motor feeders shall have suppressed scale to show current from full load up to six times the full load current.

Watt hour meters shall be of the induction type and shall be provided with reverse running stops.

Instruments shall have an accuracy of Class 1.0.

(k) Indicating lamps

Indicating lamps shall be of the cluster LED type, with low watt consumption. Indicating lamp shall be of the double contact, bayonet cap type rated for operation at either 240 V AC or at the specified DC system voltage as applicable. Lamps shall be provided with translucent lamp covers.

Bulbs and lenses shall be interchangeable and easily replaceable from the front.

(l) Push Buttons

"Start" and "Stop" push buttons shall be coloured green and red respectively. Stop Push Button shall be lockable stay-put type with Mushroom head.

(m) Space Heaters

Adequately rated anti-condensation space heaters shall be provided, one for each control panel, for each switchboard and for each marshalling kiosk.

Space heater shall be of the industrial strip continuous duty type, rated for operation on a 240 V, 1 phase, 50 Hz, AC system.

Each space heater shall be provided with a single pole MCB with overload and short circuit release, a neutral link and a control thermostat to cut off the heaters at 450 C.

(n) Cubicle Lighting/Receptacle

Each control panel, control cabinet, marshalling box, etc. shall be provided with interior lighting by means of a 20 W fluorescent tube lighting fixture. A MCB shall be provided for the lighting circuit. The lighting fixture shall be suitable for operation from a 240 V, 1 ph, 50 Hz, AC supply.

A 240 V, 1 phase, AC receptacle (socket) plug point shall be provided in the interior of each panel with a MCB for connection of hand lamp.

(o) Safety Arrangements

All terminals, connections and other components, which may be “live” when front access door is open, shall be adequately screened. It shall not be possible to obtain access to an adjacent cubicle or module when any door is opened.

Components within the cubicles shall be labelled to facilitate testing.

(p) Power and Control Cable Terminations

Equipment terminal blocks for power connections shall be complete with adequate phase segregating insulating barriers, shrouds and suitable crimping type of lugs for terminating the cables. Double compression type cable glands shall be provided for all power and control cables.

Earthing connectors between cable armour and earth shall be routed outside the cable gland in an approved manner. Gland insulation shall be capable of withstanding a high voltage test of 3000 V for one minute.

(q) Wiring for Control and Protective Circuits

All wiring for control, protection and indication circuits shall be carried out with 650 V grade, PVC insulated cable with stranded, tinned copper conductor of minimum 1.5 sq. mm size. The size of conductor for CT circuits shall be minimum 2.5 sq. mm.

All wiring shall be run on the sides of panels and shall be neatly bunched and cleated without affecting access to equipment mounted in the panel. All wiring shall be taken to terminal blocks without joints or tees in their runs.

All wiring shall be colour coded as given below.

Instrument Transformer circuit	: Red, Yellow or Blue determined by the phase with which the wire is associated
A C phase wire	: White
A C neutral	: Black
D C circuits	: Grey
Earth connections	: Green

Engraved core identification ferrules, marked to correspond with the wiring diagram, shall be fitted to each wire and each core of multicore cables terminated on the panels. Ferrules shall fit tightly on wires, without falling off when the wire is removed. Ferrules shall be of yellow colour with black lettering.

All wires forming part of a tripping circuit shall be provided with an additional red ferrule marked 'T'. Each wire shall be identified by a letter to denote its function followed by a number to denote its identity, at both ends. Unused core of multicore cables shall be ferruled U1, U2 etc., at both ends, and connected to spare terminals.

Spare auxiliary contacts of electrical equipment shall be wired to terminal blocks.

(r) Control Wiring Terminal Blocks

Terminal blocks shall be of the 650 V grade and stud type. Brass stud of at least 6 mm dia. with fine threads shall be used and securely locked within the mounting base to prevent turning. Each terminal shall comprise two threaded studs, with a link between them, washers, and matching nuts and locknuts for each stud. Connections to the terminals shall be at the front.

Terminals shall be numbered for identification, grouped according to function. Engraved ‘black on-white’ labels shall be provided on the terminal blocks describing the function of the circuit.

Terminals for circuits with voltage exceeding 110 V shall be shrouded. Terminal blocks at different voltages shall be segregated into groups and distinctively labelled.

Terminals used for connecting current transformer secondary leads shall be ‘disconnecting and shorting’ type with a facility grounding the secondary.

Terminal blocks shall be arranged with 100 mm clearance, between any two sets.

Separate terminal stems shall be provided for internal and external wiring respectively.

All wiring shall be terminated on terminal blocks, using crimping type lugs or claw type of terminations.

(s) Test Terminal Blocks

Test terminal blocks, if any, shall be provided for secondary injection and testing of relays. A suitable metering block shall be provided where specified for the connection of a portable precision instrument to be operated when required for specific plant testing purposes.

(t) Earthing of Switchboards/Panels

Each switchboard, control panel, etc. shall be provided with an earth busbar running along its entire length. The earth busbar shall be located at the bottom of the board/panel.

Earth busbars shall be of copper and shall be rated to carry the rated symmetrical short circuit current of the associated board/panel for one second, unless otherwise specified. Earth busbars shall be properly supported to withstand stresses induced by the momentary short circuit current of value equal to the momentary short circuit rating of the associated switchboard/panel.

Positive connection of the frames of all the equipment mounted in the switchboard to the earth busbar shall be maintained through insulated conductors of size equal to the earth busbar or the load current carrying conductor, whichever is smaller.

All instrument and relay cases shall be connected to earth busbar by means of 650 V grade, green coloured, PVC insulated, stranded, tinned copper, 2.5 sq. mm conductor looped through the case earth terminals.

(u) Applicable Standards

The following standards and codes of practice shall be applicable. These shall be the latest editions including all official amendments and revisions. The standards referred to therein shall also be applicable.

Air break switches, MCCBs, etc. for voltage not exceeding 1000 V AC or 1200 V DC	:	IS 13947
Current transformer	:	IS 2705 / IEC 60044
Voltage transformer	:	IS 3156 / IEC 44, 60186
Electrical Relays	:	IS 3231, 38130 / IEC 60255
Contactors for voltage not exceeding 1000 V AC	:	IS 13947 / IEC 60947
Control Switches	:	IS 6875 / IEC 60947
High Voltage Fuses	:	IS 9385 / IEC 60282
Low voltage Fuse	:	IS 13703 / IEC 60269
Electrical direct acting indicating instruments	:	IS 1248 / IEC60051
AC electricity meters of of induction type for voltage greater than 1000 volts	:	IS 722, 8530 / IEC 60145, IEC 60211
Porcelain post insulators for system with nominal voltages greater than 1000 volts	:	IS 2544
Specification for copper rods and bars for electrical purposes	:	IS 613
Specification for low voltage switchgear and control gear	:	IS 13947 / IEC 60947

Degree of protection provided by enclosures for low voltage switchgear and control gear	:	IS 13947 / IEC 60947
Marking and arrangement for switchgear, busbars, main connections and auxiliary wiring	:	IS 5578 / IS 11353
Code of practice for selection, installation and maintenance of switchgear and control gear	:	IS 10118
Miniature Circuit Breakers	:	IS 8828 / IEC 60898
Control Switches/ Push buttons	:	IS 6875

(v) Technical Particulars

The specific technical particulars of switchboard shall be as given below:

Sr.	**Description**	**Particulars**
1	Rated voltage, Phases and Frequency	415 V, 3 Ph, 50 Hz
2	Type of Construction	Single front, fixed type (except for CB)
3	Maximum system voltage	476 V
4	One minute Power Frequency withstand voltage	
a)	Power circuit	3000 V (rms)
b)	Control Circuit	2000 V (rms)
c)	Auxiliary circuit connection to secondary of CTs	2000 V (rms)
5	Current rating of busbars over design ambient temperature of 45^{o}C	As per single line diagram TCE.5925A-735-AU-3001
6	Short circuit withstand for main and auxiliary busbars (1 sec.)	As per single line diagram TCE.5925A-735-AU-3001
7	Maximum temperature of main and auxiliary busbars at continuous rated current rating under site design ambient temperature of 50^{o}C	85^{o}C
8	Colour finish shade as per IS:5	
a)	Interior	Glossy white
b)	Exterior	Light grey, semi-glossy, shade 631 of IS 5
9	Earthing bus material and size	Copper, 25 x 6 mm
10	Clearances in air of live parts	25.4 mm
11	Power contactors	
a)	Contactor rated duty	AC3
b)	Utilisation category	Uninterrupted
12	Motor Starters	For motor $\leq$ 5 kW – DOL For motor > 5 kW – Star-Delta up to

Sr.	Description	Particulars
		250kW
13	Type of Mounting	Floor
14	Cable Entry	As per single line diagram TCE.5925A-735-AU-3001

(w) Tests

The following routine tests shall be carried out on the assembled switchboard/panel during inspection at the manufacturer's works in addition to other tests.

- One minute power-frequency voltage dry withstand tests on the main circuits
- One minute power-frequency voltage dry withstand tests on the auxiliary circuits

9.6.7 L.V Capacitors Banks with APFCR and MV Capacitor banks

(a) L.V Capacitor Banks

- General

The capacitor bank shall be complete with all parts that are necessary or essential for efficient operation. Such parts shall be deemed to be within the scope of supply whether specifically mentioned or not. It shall be complete with the required capacitors along with the supporting post insulators, steel rack assembly, copper bus bars, copper connecting strips, foundation channels, fuses, fuse clips, etc. The steel rack assembly shall be hot dip galvanised.

The capacitor bank may comprise of suitable number of single phase units in series parallel combination. However, the number of parallel units in each of the series racks shall be such that failure of one unit shall not create an over voltage on the units in parallel with it, which will result in the failure of the parallel units. The assembly of the banks shall be such that it provides sufficient ventilation for each unit.

Each capacitor case and the cubicle shall be earthed to a separate earth bus.

Capacitor shall conform to IS 13925. Capacitors shall be of mixed dielectric or APP type. Each unit shall satisfactorily operate at 135 % of rated kVAR including factors of overvoltage, harmonic currents and manufacturing tolerance. The units shall be capable of continuously withstanding satisfactorily any overvoltage up to a maximum of 10 % above the rated voltage, excluding transients.

Each capacitor unit/bank shall be fitted with directly connected continuously rated, low loss discharge device to discharge the capacitors to reduce the voltage to 50 volts within one minute upon disconnection, in accordance with the provisions of the latest edition of IS:13925.

- Unit Protection

Each capacitor unit shall be individually protected by a HRC fuse suitably rated for load current and interrupting capacity, so that only the faulty capacitor unit will be disconnected without causing the bank to be disconnected.

An operated fuse shall give visual indication so that it may be detected during periodic inspection. The fuse breaking time shall co-ordinate with the pressure built up within the unit to avoid explosion.

Mounting of the individual fuse should be internal to the capacitor case.

Tests and Test Reports

All tests shall be conducted in accordance with the latest edition of IS: 13925 and as

applicable for the controls. Type test certificates for similar capacitor units shall be furnished.

- Constructional features

Each capacitor bank shall comprise of 3 nos. of single phase units and shall be complete with all parts that are necessary or essential for efficient operation. Such parts shall be deemed to be within the scope of supply whether specifically mentioned or not.

Disconnector (Off load isolator) shall be provided to facilitate removal of the capacitor bank for maintenance or for running the motor on no load.

The complete bank with its accessories, series reactor and disconnector shall be placed in a free standing, floor mounted steel structural assembly and enclosed by wire mesh on all sides and at bottom and 14 gauge sheet on top. Wire mesh opening shall not be more than 6 mm x 6 mm. The bank shall be floor mounting with sufficient bottom clearance and shall be free standing type.

The enclosure shall be compartmentalised, with separate compartments for disconnector, capacitor bank and reactor.

Lamp indication to indicate "Capacitor Bank Live" shall be provided on the enclosure through auxiliary contact of the vacuum contactor.

The assembly of the bank shall be such that it provides sufficient ventilation for the unit.

Each capacitor case and the cubicle shall be earthed to a separate earth bus in the cubicle. Facility shall be provided to connect the earth bus inside the cubicle to purchaser's earthing system. The size of earth bus shall be 50 x 6 mm GI flat. Each capacitor bank/unit shall be fitted with directly connected continuously rated, low loss discharge device to discharge the capacitors to reduce the voltage to 50 volts within one minute in accordance with the provisions of relevant IS.

(b) Capacitor Bank

Capacitors shall be All Polypropylene (APP) type. Each unit shall be non-inflammable dielectric immersed, self cooled and hermetically sealed. The dielectric shall of All polypropylene (APP) type. Each bank shall satisfactorily operate at 135% of rated kVAR including factors of over voltage, harmonic currents and manufacturing tolerance. The units shall be capable of continuously withstanding satisfactorily any over voltage up to a maximum of 10% above the rated voltage.

When building up capacitor banks from individual capacitor units, care shall be taken to avoid over voltages due to difference in capacitance between the units.

(c) Bank protection

Each phase of the bank shall be protected by a built in current limiting fuse suitably rated for load current and interrupting capacity. The fuses shall provide local visual indication.

All switching and protective devices and connections supplied with the capacitor banks shall be designed to withstand the electro dynamic and thermal stresses caused by transient over currents of high amplitude and frequency which are likely to occur during switching on of the capacitor banks. Switching devices when supplied with the capacitor banks shall be re-strike free.

(d) Tests and test reports

All routine tests shall be conducted in accordance with the latest edition of relevant IS in the presence of Engineer's representative at the manufacturer's works.

Type test certificates for similar capacitor units and reactors shall be furnished with after award of Contract for approval.

(e) Drawing

A general arrangement drawing showing overall dimension of capacitor banks/housing, details of housing, sizing calculation for capacitor and reactor based on the finally procured motor details, bill of material, sectional view foundation arrangement, weight etc.

shall be submitted for approval after the award of contract.

(f) Technical Particulars

The specific technical particulars of capacitors shall be as given in the table below.

Sr.	Description	Particulars
1	Rated Capacity	As per Single line diagram TCE.5925A-735-AU-3001
2	Type of Capacitor	APP
3	Rated voltage, frequency and phases	415V, 3 Phase, 50 Hz
4	Insulation level	3 kV (rms)
5	Capacitor bank connection	Delta
6	Control	Connected across the bus and control through automatic Power factor Correction Relay
7	Min. Steps of Control	16
8	Capacitor Bank Enclosure	
a)	Type	Floor mounted inside APFC panel
b)	Colour finish / shade	Light grey, semi glossy, shade 631 of IS 5

9.6.8 Local Push Button Stations

(a) Constructional features

The constructional features of the local push button stations shall be as follows.

i) They shall be metal enclosed, weather proof and suitable for mounting on wall or steel structures. The enclosure shall be of die cast aluminium or GS sheet of 2 mm thickness.

ii) Outdoor type push button stations shall be completely weather, dust and vermin proof and shall be provided with canopy. They shall have a degree of protection shall be IP 55. Indoor type push button stations shall have a degree of protection shall be IP 54.

iii) They shall be provided with inscription plates of rear engraved Perspex with white letters on black background. The letter size shall be 6 mm.

iv) They shall be provided with two earthing terminals suitable for 14 SWG GI wire.

v) They shall be provided with removable undrilled gland plate and cable glands for appropriate sizes of cable. The cable entry shall be from the bottom.

(b) Push buttons

All push buttons shall be

i) fitted with two (2) each normally open and normally closed contacts rated to carry and break 10 Amps at 415 Volts;

ii) provided with integral escutcheon plates marked with its function;

iii) the momentary contact push shall be green in colour;

iv) lockable stay put type with mushroom knob and shall be red in colour in case of “Stop” PB; and with contacts designed to be robust for both mechanical and electrical operation. Mechanical life shall exceed 10 million switching operations.

9.6.9 Non-Segregated Bus Duct

a) Bus Enclosure

- The enclosure shall be made of steel or aluminum alloy, the grade of steel or aluminum alloy.
- The entire bus duct shall be designed for indoor/outdoor installation, with a dust and vermin-proof construction. Bus duct installations meant for outdoor application shall be of weather proof construction and shall have degree of protection better than or equal to IP-55. Outdoor portion of bus duct shall be provided with rain hood.
- The inside of the bus enclosure shall be treated with a matt paint of dark colour, preferably black to facilitate efficient heat dissipation. The bare enclosure with above painting shall be designed so as not to exceed the temperature specified in IS: 8084.
- Joints consisting of metallic expansion bellows shall be provided on the bus enclosure at following points :

a) **At terminations at transformers**
b) **At terminations at switchgear cubicles**
c) **In the run of the bus duct in case of long lengths as required.**

- Flexible expansion joints for the enclosure shall be provided wherever deemed necessary. The flexible joints shall take care of expansion and contraction due to temperature variations and fault conditions.
- Necessary bonding shall be provided at the above expansion joints if joints are made of insulating material.
- Three-phase terminal enclosures shall be provided with flanged ends with drilling dimensions to suit the flange at equipment terminals.
- The flanges shall be provided with gaskets, nuts, bolts etc.
- Provision shall be made for periodic inspection of insulators by means of inspection covers. The inspection covers shall be provided at the bottom with quick-acting stainless steel clamps and shall have gaskets. There shall be no joints or fixing bolts on the top surface through which water could seep through.
- The drain plugs shall be easily removable for cleaning purposes.
- The gasket material and thickness shall be so selected as to satisfy the operating conditions imposed by temperature, weathering, durability, etc. Care shall be exercised to ensure that covers fit easily, that the required compression of the gaskets can be obtained without damage to the inspection covers by bolts and that covers do not bend after this compression has been applied. Over-compression of the gaskets shall be avoided.
- The material of the gasket shall preferably be neoprene closed-cell sponge rubber or equivalent.
- Flange gaskets shall be provided at the equipment terminal connections.
- The bus duct shall not have any through bolts. All nuts and bolts shall be mild steel hot dip galvanized. GS spring washers shall be provided for making satisfactory joints. Clamps, splice plates etc. shall be provided wherever necessary.
- Whenever the outdoor portion of the bus duct is of flanged construction but of bolted type a continuous hood made of non-magnetic material shall be provided over the entire length of the outdoor portion of the bus duct to prevent ingress of water particles due to heavy rain fall directly on bus duct enclosure. This hood shall be mounted on bus duct

supporting structures and all hardware and accessories required for mounting the hood shall be included in scope of supply.

b) Bus Conductor

- The material of the conductor shall be of aluminum alloy.
- The temperature rise of conductor shall be as per IS: 8084. Also the temperature of the bus shall not exceed 250°C while carrying the specified short circuit current for one second when a fault occurs at the operating temperature.
- The bus conductor shall be given a coat of matt black paint to facilitate heat dissipation. The bare conductor with above painting shall be designed to carry the normal rated current without exceeding temperature rise as specified in IS:8084
- Flexible aluminum connectors welded to the main busbars shall be provided wherever deemed necessary.
- The connectors shall be of the same material as the conductor and joints shall be silver-plated to ensure an efficient connection. The bolting schedule and contact pressure shall conform to accepted codes of practice.
- Flexible braided copper connections shall be provided at the equipment terminal connections. Bimetallic connectors shall be provided between the busbar and the copper flexible if the bus conductor is of aluminum alloy. The joints shall be capable of 25 mm settlement of the equipment mounting pads. The joints shall be suitably designed to take care of the vibration at the terminals as well as the expansion and contraction of the busbars.
- Expansion joints made of aluminum strips shall be provided wherever deemed necessary, to take care of expansion and contraction of the busbars under normal operating conditions.
- All the above joints shall be tested for temperature rise to prove the adequacy of the design. The maximum temperature rise at the joints shall be less than the specified temperature rise for the busbars.
- The busbar clamps at insulators shall be designed to withstand the forces due to momentary short circuit current. They shall permit free longitudinal movement of the bus bars during expansion and contraction. The material of the clamps shall be aluminum alloy. Suitable aluminum spacers shall be provided wherever necessary.
- All bolts, nuts and lock washers used in the bus assembly shall be of high tensile steel, plated for corrosion resistance. Spring washers of “Beleville” type or equivalent shall be used.
- Suitable splice plates and bimetallic connectors shall be provided wherever necessary.
- Disconnecting links with rating same as that of the main busbars shall be provided in the run of the bus duct to facilitate disconnection of the busbars during testing and maintenance. The separation of the busbar sections with the bolted links removed shall be sufficient to withstand the rated voltage of the bus duct.
- Shorting jumpers, for the purpose of drying out the equipment before commissioning or for carrying out short circuit test on the equipment, rated for the main bus current shall be supplied for shorting the bus duct at a location, adjacent to the disconnecting links.
- The shorting links shall have drilling dimensions matching those of the main bus disconnecting links. Suitable supporting structures and support insulators for the shorting links if necessary shall also be offered.

c) Phase Barriers

- In segregated phase bus duct if metal barriers are provided, the material shall be same as that of the bus duct enclosure material.

- Insulated phase barriers, when specified, shall be made of non-hygroscope insulating material such as fibre glass.

d) Bus Support Insulators

- Within the bus duct the bus shall be mounted and supported on insulators. The insulators shall be mounted on resilient pads provided in the bus enclosure.
- The insulators shall be either porcelain or resin cast.
- For bus ducts with voltage rating upto 1100 Volt, Fibre glass/FRP or equivalent type of non-hygroscope insulating supports are acceptable.

e) Wall Frame Assembly And Seal – off Bushing

- Wherever the bus duct passes through the plant building wall, from indoors to outdoors, a wall frame assembly with seal-off bushings shall be provided to prevent any leakage of rain water, infiltration of dust and air temperature variations from indoors to outdoors. The wall frame shall be fabricated out of aluminum angles and sheet and shall be suitable for grouting in the wall. It shall be provided with flanges on both sides to receive the bus duct flanges. A suitable size breather shall be provided for the two sections of the
- between the wall frame assembly.
- The bus duct shall be equipped wherever necessary with seal-off bushings to prevent interchange of air at different temperatures. The seal-off bushings shall be flanged type.
- The insulator for wall frame assembly and seal-off bushings shall be of porcelain. Also the bushings shall be designed for thermal expansion/contraction due to temperature differential for outdoor/indoor use.

f) Bus Duct Supports

- The supporting structure shall be fabricated from standard steel sections and shall be hot dip galvanized after fabrication. The hot dip galvanizing shall be in accordance with standards.
- Calculations shall be furnished to substantiate the strength support structure to withstand the various static and dynamic loadings.
- The supporting structures shall include supporting members, brackets, hangers, longitudinal beams, channels, nuts, bolts, washers and all other hardware which are necessary for the erection and support of the entire bus duct installation. All the accessories and hardware of ferrous material shall be hot dip galvanised.
- Studs, nuts, bolts and tapped holes shall conform to the relevant standards. Only hexagonal nuts shall be used. All bolt holes shall be spot faced for nuts.
- Castings and forgings shall conform to respective material specifications and shall be free from flaws. They shall be machined true as per good workshop practice. Welding shall be performed in accordance with relevant recognised standards.
- All threaded pipe connections and fittings, pipe flanges and tube fittings shall comply with relevant standards.
- Indoor portion of the bus duct may be supported from the floor or ceiling beams.
- Outdoor portion of the bus duct shall be supported from ground below on suitable foundation in the ground.
- The foundations and structures in outdoor area shall clear the transformers, transformer foundations, cable trenches.
- Each supporting structure shall be securely connected at two points to the station earthing bus. Earthing of enclosure to support structures shall be securely connected at two ends of busduct. All necessary hardware, such as clamps, connectors, etc. required for this purpose shall be furnished by the BIDDER.

9.6.10 Power/Control cables

All existing undamaged / un-jointed cables having adequate length, meeting the requirements of the new designs, will be utilised in the new installations. The existing cables with ratings same or more than the requirement would be HV tested / IR tested during the execution of the project and decided accordingly. It will be checked whether the voltage drop of such cables will be limited to 2.5 % at rated equipment current rating.

General Requirements

1.1.1 IS 1554, 7098, 8130, 5831, 3975, IEC 60183, 60227, 60502, 60885

Technical Data Sheet

Sl.	Description	Particulars	
1	Voltage grade of cable	36kV	1100V
2	Permissible voltage variation	+ 10%	+ 10%
3	Permissible frequency variation	+ 5%	+ 5%
4	Material of conductor	Aluminium, H4-grade, Class-2	Aluminium, H4-grade, Class-2
5	Type of conductor	Stranded	Stranded
6	Material of insulation	Extruded XLPE	Extruded PVC, Type-A / XLPE
7	Material of inner sheath	Extruded thermoplastic or unvulcanized rubber	Extruded thermoplastic or unvulcanized rubber
8	Material of armour	Galvanized steel	Galvanized steel
9	Material of outer sheath	Extruded PVC, Type-ST 2	Extruded PVC, Type-ST 2
10	Core identification	Required	Required

(a) Conductor

The conductor shall be composed of electrical Munduli, Bhubaneswar material of aluminum or copper wires as mentioned in the drawings and shall comply with IS: 8130. The aluminium conductor shall be stranded, H4-grade and Class-2 type. The copper conductor shall be annealed, stranded and Class-2 type.

(b) Insulation

The insulation for PVC cables shall be of extruded sheath of Type-A, PVC compound conforming the requirements of IS 5831. The insulation for XLPE cables shall be of extruded sheath XLPE compound conforming to the requirements of IS 7098.

(c) Inner Sheath

For all cables having two or more cores, a common covering (inner sheath) shall be applied over the laid up cores by extruded sheath of thermoplastic material or unvulcanized rubber. The material shall be compatible with temperature ratings of the cable and shall have no deleterious effect on any other component of the cable.

(d) Armouring

For multi core cables, armouring shall be applied over the inner sheath and over the insulation in case of single core cable. Where the calculated diameter below armouring does not exceed 13mm, the armour shall consist of galvanized round steel wires while in case of calculated diameter below armouring is greater than 13mm, the armour shall consist of galvanized steel strips. For single core armoured cables non magnetic armouring is provided over the insulation. The galvanized steel wires/strips shall conform to the requirements of the latest version of IS 3975.

(e) Outer Sheath

The material of outer sheath for up to 1100V grade PVC or XLPE cables shall be of extruded sheath of Type-ST 2, PVC compound conforming the requirements of IS 5831. The material of outer sheath for more than 1100V grade XLPE cables shall be have extruded sheath of Type-ST 2, PVC compound conforming the requirements of IS 5831. The colour of the outer sheath shall be black.

(f) Core Identification

Core shall be identified by different colouring of insulation as indicated in IS 1554

(g) Inspection

All meters and other reference devices used for testing shall have valid calibration certificate from reputed national laboratories / institutes. Following tests shall be carried out on each Cable at manufacturers work in presence of the Project Manager:

- Tests on conductor

i) Measurement of resistance at 20 deg C in all phases.
ii) Annealing test (for copper)
iii) Tensile test (for aluminium)
iv) Wrapping test (for aluminium)

- Test on insulation

i) Measurement of thickness in all phases
ii) Measurement of volume resistivity at 27 deg C & 70 deg C
iii) Measurement of tensile strength
iv) Measurement of % elongation at break
v) Hot set test (for XLPE)

- Hot set elongation (175% maxi.)
- Permanent set (5% maxi.)

- Test on inner sheath

i) Measurement of thickness

- Test on armouring

i) Measurement of dimensions

- Test on outer sheath

i) Measurement of thickness
ii) Measurement of tensile strength before ageing
iii) Measurement of % elongation at break before ageing

- High voltage test at room temperature

i) Measurement of overall diameter

All the test results shall be jointly signed by both the manufacturer's representative and the Project Manager's representative. The Project Manager's representative shall issue the dispatch clearance for the equipment only after giving the approval for successful test results.

9.6.11 LIGHTING SYSTEM

(a) Lighting Fixtures

The lighting fixtures offered shall comply with the following requirements and typical drawing TCE-5925A -815-GL-3003.

i) The fixtures shall be suitable for operation on a nominal supply of 240 V, single phase, 50 Hz, AC with a voltage variation of +/- 10 %.
ii) All lighting fixtures shall be supplied complete with lamps and all necessary accessories such as ballast, capacitor, etc. for their satisfactory operation.
iii) Starter of the fluorescent/ HPSV / light fixture shall be replaceable without disturbing the reflector or lamps and without the use of any tool.
iv) The capacitor of the HPSV / lighting fixture shall have adequate value of capacitance to correct the power factor of its fixture to 0.98 lag.
v) Lamp holders for fluorescent tubes shall be of the spring loaded, low contact resistance, bi-pin rotor type, resistant to wear and suitable for operation at the specified temperature, without deterioration in insulation value, contact resistance or lamp holding quality.
vi) Lighting fixture reflectors shall generally be manufactured from steel or aluminium sheet of not less than 20 SWG thickness.
vii) Each fixture shall be complete with a four way terminal block for connection and looping of incoming and outgoing cables. Each terminal shall be able to accept two 2.5 mm2 copper stranded conductors.
viii) Each lighting fixture shall be provided with an earthing terminal suitable for connecting 16 SWG copper stranded conductor.
ix) All metal or metal enclosed parts of the housing shall be bonded and connected to the earth terminal to ensure satisfactory earthing continuity throughout the fixture.
x) All reflectors and louvers shall be finished to the same standard as the fixture housing.
xi) 1200mm sweep ceiling fans shall be provided in areas such as offices, etc. as indicated in the drawings. Adequate ventilation arrangements shall be made for enclosed areas where ceiling fans are not proposed to be installed or cannot be provided. Power supply for the ceiling fans shall be derived from lighting circuits. Ceiling fans shall be complete with all accessories. Regulators shall be conventional resistance type.
xii) 450mm heavy duty exhaust fans shall be provided as directed. The fans shall have built in power factor capacitor, supports for mounting / fixing and cowls to prevent entry of birds. Power supply to the exhaust fans shall be from a 5A switched socket supplied from the lighting panels.

(b) Receptacle units

1.1.2 Receptacle units of 5/15 A rating with switches shall be supplied. The units shall be suitable for mounting flush on GS sheet boxes. The receptacle shall be suitable for 240V, 1-Phase, (or 415 V, 3-Phase), 50 Hz AC supply.

- Applicable Standards

All standards and codes of practice referred to below shall be the latest edition including all official amendments and revisions.

i)	Industrial luminaires with metal reflector	:	IS 1777
ii)	Ballast for fluorescent lamp	:	IS 1534
iii)	3 pin plugs & sockets	:	IS 1293
iv)	General safety requirements for luminaires	:	IS 1913
v)	Luminaires for street lighting	:	IS 10322
vi)	Fitting for rigid steel conduits for electrical wiring	:	IS 2667
vii)	Code of practice for interior illumination	:	IS 3646 & IS 6665

viii) Switches for domestic & similar purposes	:	IS 3854
ix) Electric ceiling type fans & regulator	:	IS 374
x) Code of practice for electrical wiring installation (system voltage not exceeding 650 Volts)	:	IS 732

(c) Tests and Test Reports

Type tests, acceptance tests and routine tests for the lighting fixtures, accessories and receptacles covered by this specification shall be carried out as per the relevant standard.

Manufacturer's type and routine test certificates shall be submitted for tests conducted as per relevant standards for the fixtures, accessories and receptacles.

The following routine tests shall be conducted as per the relevant Indian Standards.

- Each fixture shall be tested at 1500 Volts (rms), 50 Hz, AC for one minute and no flash over or breakdown shall occur between current carrying parts and ground.
- Insulation resistance of each fixture shall be tested at 500 V DC and the insulation resistance so measured shall not be less than 2 mega-ohms between all current carrying parts and ground.
- All luminaires provided with glass covers shall be subjected to thermal shock-proof test. A test shall be conducted to ensure that the cover glass will withstand sudden variation in surface temperature due to rainfall or splashing water when the lighting fixture is lit. The cover glass shall be heated in an oven to attain a steady temperature of 100^0 C and then plunged into cold water. No crack should develop.
- Contractor shall ensure use of calibrated test equipment having valid calibration test certificates from standard laboratories traceable to National Standards.

9.6.12 LIGHTING SYSTEM INSTALLATION

The Contractor shall supply, install, test and commission the complete system of lighting and receptacles in accordance with the approved lighting drawings and documents and in accordance with relevant Indian Standards, codes of practice, Indian Electricity rules and safety codes in the locality where the equipment/system is to be installed. Nothing in this specification shall be construed to relieve the contractor of this responsibility.

(a) Installation of Lighting Panel, Lighting fixtures & Receptacles.

The scope of installation work shall include mounting of lighting panel, lighting fixtures and receptacles at locations as per the approved drawings. All work associated with installation such as providing and fixing of wooden blocks, ball sockets, hooks, etc., as required, drilling holes in walls, ceilings, etc., or any civil work including scaffolding, provision of ladders, etc., together with supply of hardware shall form part of the Contractor's work. All work items necessary for completing earthing connections shall be included in the scope of work.

(b) Wiring

The work shall comprise wiring in heavy gauge (minimum 16 SWG) GI conduits, fixed and supported at intervals of 300 mm on walls, ceiling etc.; installation of light control switches and receptacles housed in GS boxes; earthing with 16 SWG copper wire run along the conduit and clamped to it at every 300 mm; and termination of cables/wires at lighting panels, light control switches, receptacles, lighting fixtures etc., as required. The minimum size of conduit shall be 20 mm. Space factor (ratio of total wire area to internal conduit area) shall be 40 %.

Supply of all the items of work detailed above including 650 V grade, 2.5/4 sq. mm stranded copper conductor PVC insulated cables; 5 / 15A switches; GS conduits and accessories (such as junction boxes, tees, elbows, etc); 16 SWG GS boxes complete with gasket, knockouts for conduit entries, earthing terminal with bolts, nuts and washers; 16 SWG aluminium earthing wire; flexible conduit etc. shall be included in the Contractor's scope. All work necessary for fixing boxes, conduits etc., together with supply of necessary accessories hardware, shall also be included in the Contractor's work.

All light control switches and receptacle units (connected on the same phase) at one location (such as room entrance), shall be housed in one common GS sheet steel box.

Receptacle and lighting fixtures shall be fed from different circuits and wiring for the same shall be done in different conduits. The maximum load on any circuit shall not exceed 1800 Watts.

Wires belonging to different phases shall not be run in the same conduit. However, more than one circuit on the same phase can be run in the same conduit. For every phase wire, a separate neutral wire shall be run. Neutral wire for different phases shall not be looped.

Size of wire chosen shall be such as to limit the voltage drop to within 3 %. Minimum area of conductor shall be 1.5 sq mm stranded copper for lighting and 2.5 sq mm / 4 sq mm for 5A / 15A receptacle circuits respectively, and current density shall not exceed 2.5 A/sq mm. Generally, not more than 8 to 10 lighting points shall be wired in one circuit. For calculating connected loads of various circuits, a multiplying factor of 1.25 shall be assumed on the rated lamp wattage for sodium vapour and fluorescent lamp fixtures to take into account the losses in the ballast. A loading of 100 watts and 500 watts shall be assumed for each, single phase 5 amps and 15 amps receptacles respectively.

(c) Estimation for point wiring (Electrical)

Wiring of all lighting fixtures, fans and receptacles and earthing wiring shall be on point wiring basis. Insulated green coloured earthing wire shall also be run in conduits. Indian TNS type of distribution (as per IS 3043) shall be followed. Neutral of the circuits shall not be looped.

(d) Mains Wiring upto switchboards

Mains wiring consist of wiring from lighting panel to first point of switch board (where provided) of the circuit. Where no switchboard is provided (switching is directly from MCB on the lighting panel), no “mains wiring” is applicable.

Mains wiring work shall consist of supply, installation and testing commissioning of wiring with 4 sq mm copper PVC wires and their terminations including supply of 19/25 mm (16G) GI conduits with all accessories (e.g. bends, reducers, coupler, junction boxes, 16 SWG green copper wire for earthing, etc.) from lighting panel to first point of the circuit (switches for control are excluded).

The mains wiring shall be classified into the following lengths:

i) Short point – from 0 to 5m
ii) Medium Point – 5 to 10m
iii) Long Point – 10 to 20m
iv) Extra long point – more than 20m

- Point wiring for lighting and fans

Primary point (GI) shall consist of supply, installation and testing commissioning of lighting system / fan system including supply of 19/25 mm (16G) GI conduits with all accessories (e.g. bends, reducers, couplers, switches for control, junction boxes, 16 SWG green copper wire for earthing, etc.) with 1.5 sq. mm. copper PVC wires and their termination etc.

The point wiring for lighting and fans shall be classified into the following lengths:

i) Short point – from 0 to 5m

ii) Medium Point – 5 to 10m
iii) Long Point – 10 to 20m
iv) Extra long point – more than 20m

- Point wiring for receptacles (5A)

Primary point (GI) shall consist of supply, installation and testing commissioning of 5A receptacle including supply of 19/ 25 mm (16G) GI conduits with all accessories (e.g. bends, reducers, couplers, switches for control, junction boxes, 16 SWG green copper wire for earthing, etc.) with 2.5 sq. mm. copper PVC wires and their termination etc.

The point wiring for 5A receptacles shall be classified into the following lengths:

i) Short point – from 0 to 5m
ii) Medium Point – 5 to 10m
iii) Long Point – 10 to 20m
iv) Extra long point – more than 20m

- Point wiring for receptacles (15A)

Primary point (GI) shall consist of supply, installation and testing commissioning of 15A receptacle including supply of 19/ 25 mm (16G) GI conduits with all accessories (e.g. bends, reducers, couplers, switches for control, junction boxes, 16 SWG green copper wire for earthing, etc.) with 4.0 sq. mm. copper PVC wires and their termination etc.

The point wiring for 15A receptacles shall be classified into the following lengths:

i) Short point – from 0 to 5m
ii) Medium Point – 5 to 10m
iii) Long Point – 10 to 20m
iv) Extra long point – more than 20m

9.6.13 EARTHING SYSTEM

(a) Scope

The scope includes supply of earthing conductors, earth electrode pits and their installation including associated civil work as per the specifications and approved drawings, to the satisfaction of the Project Manager's representative and the Electrical Inspector.

Earthing system shall be provided to ensure equipment safety, personnel safety and to facilitate designed operation of protective devices during earth fault conditions in the associated system.

All work such as cutting, bending, supporting, painting/coating, drilling, welding, clamping, bolting and connection to structures, equipment frames, terminals, etc. shall be in the Contractor's scope of work. All incidental hardware and consumables such as fixing cleats/clamps, anchor fasteners, lugs, bolts, nuts, washers, bituminous compound, welding rods, anti-corrosive paint as required for the complete work shall be deemed to be included by the Contractor as part of the installation work.

The earthing shall be done as typical tender document TCE-5925A -816-GL-3005.

(b) Earthing Protection System Installation

Earthing protection system (wherever required) shall conform to the latest edition including all official amendments and revisions of IS: 3043/ IS: 2309 and Indian Electricity Rules, 1956. All materials and fittings used in the earthing installation shall conform to the relevant Indian Standards or shall be as approved by the Project Manager's Representative. Installation work shall be in accordance with approved earthing layout drawings and any change in routing, size of conductors etc. shall be subject to the prior approval of the Project Manager's Representative.

Installation of earth conductors in outdoor areas, buried in ground, shall include excavation of trench of size 600 mm deep and 450 mm wide, laying of conductor at 600 mm depth, welding as required of main grid conductor joints; as well as provision of risers up to 500

mm above ground at required locations and then backfilling of excavated area by material that is free from stones and other harmful mixtures. Backfill shall be placed in layers of 150 mm, uniformly spread along the trench and compacted by approved means. If the excavated soil is found unsuitable for backfilling, the Contractor shall arrange for suitable material from outside.

Metallic frames of all electrical equipment shall be earthed by two separate and distinct leads and then connected with earthing system.

Cable sheaths and armour shall be bonded to the earthing system. Metal pipes and cable conduits shall be effectively bonded and earthed.

Neutral connection shall never be used for equipment earthing.

The work of embedment of earthing conductor in RCC floors/walls along with provision of earth plate inserts/pads/earth risers shall be done by the contractor preferably before the floors/columns/walls are cast. The embedded conductors shall be connected to reinforcing rods wherever necessary.

The scope of installation of earthing leads to the equipment and risers on steel structures/walls shall include laying the conductors, welding / cleating at specified intervals, welding to the main earth grids, risers, bolting at equipment terminals and coating welded joints by bituminous paint. Galvanised conductors shall be touched up with zinc-rich paint, when holes have to be drilled in them at site for bolting to equipment/structure.

Wherever earthing conductor passes through walls, GS sleeves shall be provided for the passage of earthing conductor. The pipe ends shall be sealed by suitable water-proof compound. Water stops shall be provided where earthing conductor enters the building from outside, below grade level.

The lightning protection system for the structures shall be installed by forming a grid of exposed continuous earth conductors and taking down-comers along the walls / supports of the structure and terminating the same at earth pits. The lightning protection system earth pits shall be inter-connected to form the safety earthing grid provided for the building / structure. The safety earthing grid shall be connected to the mains grid of the switch yard.

(c) Connections

All connections between the earth conductors buried in earth / concrete and between earth conductor and earth leads shall be of welded type. Connection between MS conductor buried in ground and GS conductor above ground shall be welded type made by bringing the MS conductor above ground.

Connection between earth leads and electrical equipment/distribution boards / lighting panels, etc. shall be of bolted type. Lighting panel shall be earthed by 8 SWG GI wires and distribution Board shall be earthed by 25x6mm GI strip as applicable.

(d) Earth Electrode Pits

Electrodes shall, as far as practicable, be embedded below permanent moisture level.

Test pits with concrete covers shall be provided for periodic testing of earth resistance. Installation of pipe electrodes in test pits shall be suitable for watering. The necessary materials required for installation of test pits shall be supplied and installed by Contractor. The installation work shall also include civil works such as excavation/drilling and connection to main earth grid.

Treated earth pits shall be treated with salt and charcoal, if average electrical resistivity of soil is more than 20 ohm metre.

Soil, salt and charcoal placed around the electrode shall be finely graded, free from stones and other harmful mixtures. Backfill shall be placed in layers of 250 mm thick uniformly spread and compacted. If excavated soil is found unsuitable for backfilling, the Contractor

shall arrange for a suitable soil from outside.

(e) Minimum sizes

Following are the minimum sizes of various components of earthing system

Sr. No.	**Description**	**Size & Material**	**No. of Leads**
1	CWPS PMCC	32 x6 mm GI flat	2
2	RWPS PMCC,RWPS Auxiliary MCC, Sub-DB & Capacitor Control Panel	25 x6 mm GI flat	2
3	Cable tray support	25 X 6 mm GI flat	2
4	Local PB station	14 SWG - GS	1
5	Motors		
a)	Small motors (motor ratings up to 7.5kW)	8 SWG GI wire	2
b)	Main motors	25 X 3 mm GI flat	2
6	Transformer	Body - 25x6 mm GI flat Neutral - 25x3 mm GI flat	4(2 nos for neutral earthing and 2 Nos for body earthing)
7	Lightning Arrestor Set,Isolator	50 X 6mm GI flat	2
8	Earth Electrode	40 mm dia., 3 M long, heavy duty GI pipe electrode	-
9	Plate earthing	Plate earthing with 600 x 600 x 3mm copper plate	-
10	Internal Earthing Grid	25x6 mm GI flat	-
11	Main grid buried in ground	50 x 6 mm GI flat	-

Applicable standards:

All standards and codes of practice referred to below shall be the latest edition including all official amendments and revisions.

- Code of practice for earthing : IS 3043
- Lightning protection : IS 2309

9.6.14 CABLING SYSTEM

(a) General

The cabling system covers the supply of cables, supports and associated accessories, hardware and their installation. It shall be the responsibility of the contractor to complete the cabling system in all respects.

The various components of cabling system shall be provided as per typical drawing number TCE.5924A- 818-CT-3008.

(b) Installation of Cables

The Contractor shall install, test and commission the cables in the specification in accordance with the approved drawings, and instructions issued by Project Manager's Representative. Cables shall be laid directly buried in earth, on cable racks, in built up trenches and supports, on trays, in conduits and ducts or bare on walls, ceiling etc. as per approved drawings. Contractor's scope of work includes unloading, laying, fixing, jointing, bending,

and termination of the cables. The Contractor shall also supply the necessary materials and equipment required for jointing and termination or the cables.

After pulling the cable, the Contractor shall record cable identification with date pulled neatly with waterproof ink in linen tags / aluminium tags and shall securely attach such identification tags. Identification tags shall be attached to each end of each cable with non-corrosive wire. The said wire must be non-ferrous material on single conductor power cable. Tags may further be required at intervals on long runs of cables on cable trays and in pull boxes. Cable and joint markers and RCC warning covers shall be provided wherever required.

Sharp bends and kinks in cables shall be avoided. The bending radii for various types of cables shall not be less than 15 times the overall diameter of the cable.

Cables laid in ground shall be laid on a 75 mm riddled earth bed. The cables shall then be covered on top and at their sides with riddled earth of depth of about 150 mm. This should be then filled up to a depth of about 100 mm above the top of uppermost cable to provide bedding for the protective cable covers which shall be placed centrally over the cables. The RCC covers shall have one hole at each end, to tie them to each other with GI wires to prevent displacement. The trench should be then backfilled with the excavated soil and well rammed in successive layers of not more than 300 mm thick, with the trenches being watered to improve consolidation wherever necessary. To allow for subsidence, a crown of earth not less than 50 mm in the centre and tapering towards the sides of the trench should be provided.

In each cable run, some extra length shall be kept at a suitable point to enable one or two ‘straight through joints’ to be made, should the cable develop a fault at a latter date.

Cables splices shall not be used except where permitted by the Project Manager's Representative. Splices shall be made by Contractor for each type of wire or cable in accordance with the instructions issued by cable manufacturers and the Project Manager's Representative. Before splicing, insulated cables shall have conductor insulation stepped and bound or pencilled for recommended distance back from splices to provide a long leakage path. After splicing, insulation equal to that on the spliced conductors shall be applied at each splice.

At cable terminal points, where the conductor and cable insulation will be terminated, terminations shall be made in a neat, skilful and approved manner by specially trained staff. Terminations shall be made by the Contractor for each type of wire or cable in accordance with instructions issued by cable manufacturers or the Project Manager's Representative.

Cable seals shall be examined to ascertain if they are intact and that cable ends are not damaged. If the seals are found to be broken the cable ends shall not be jointed until after due examination and testing under supervision of the Project Manager's Representative. Before jointing is commenced, insulation resistance of both sections of cables to be jointed shall be checked by megger.

Metal sheath and armour of the cable shall be bonded to the earthing system of the station. The size of conductor for bonding shall be appropriate with the system fault current.

All cables shall be tested for insulation resistance before jointing. After jointing is completed, all cables shall be tested again by a 1000 volt megger.

Cable core shall be tested for

v) Continuity;
vi) Absence of cross phasing;
vii) Insulation resistance to earth; and
viii) Insulation resistance between conductors.

Contractor shall furnish testing kits and instruments required for field testing.

9.6.15 DC Equipment

DC equipment shall comply with IEC 60896 including those standards referred to therein.

Requirements

Following items shall be covered in the Contract:

a) One no. 110 V Nickel Cadmium type Battery (Minimum capacity of Battery – 75AH)

b) One no. Float-cum-boost charger for 110 V battery

c) DC distribution board.

All connections between battery, battery chargers and DC distribution board shall be designed for effective segregation between positive and negative leads.

9.6.16 Battery

Battery offered shall be Nickel Cadmium (Ni-Cd) type. Nickel hydroxide and Cadmium hydroxide shall be used for positive and negative electrode respectively. Aqueous solution of Potassium hydroxide with small quantities of lithium hydroxide shall be used as electrolyte. It shall be used only for ion transfer and shall not chemically change during charging/ discharging.

The containers shall be transparent and preferably be made of toughened glass or plastic and provided with acid level indicator. The battery shall be rated on 5-hour basis and for the specified ambient temperature. The battery shall have maximum recharge time of 8 hours.

Terminal posts shall be designed to accommodate external bolted connection conveniently and positively. Each terminal post shall have two bolt holes of the same diameter, preferably at right angles to each other. The bottom hole shall be used to terminate the inter-cell connection. The top hole shall be left for external terminal connections. Bolts, heads and nuts, except seal nuts, shall be hexagonal and shall be lead covered. The junction between terminal posts and cover, and between cover and container shall be so sealed as to prevent any seepage of electrolyte.

Required quantity of electrolyte for first filling with 10% extra shall be supplied in non-returnable containers.

Each battery shall be complete with following accessories, as applicable, that include, but are not limited to:

a) Battery racks

b) Porcelain insulators, rubber pads, etc.

c) Set of inter-cell, inter-tier and inter-bank connectors as required for the complete installation.

d) Electrolyte for first filling + 10% extra.

1 set of accessories for testing and maintenance shall also be provided suitable for all the three battery banks.

One	-	-3, 0, +3 volts DC voltmeter with built-in discharging resistor and suitable leads for measuring cell voltage.
One	-	Filler hole thermometer fitted with plug and cap and having specific gravity correction scale.

Three	-	Pocket thermometers
Two	-	Cell lifting straps
One set	-	Terminals and cable boxes with glands for connecting cable as required.
Each of		Spare connectors Spare vent plugs Spare nuts and bolts Suitable set of spanners

Each battery shall be mounted in a manner that permits easy accessibility to any cell. The racks shall be suitable for fixing on flat concrete floor. The complete racks shall be suitable for bolting end to end.

It shall be the responsibility of the Contractor to provide batteries of adequate capacities to meet specified requirements pertaining to control, indication, annunciation, etc. and emergency lighting. For computing battery capacity, it shall be assumed that the battery is fully charged at the beginning of loading cycle and is discharged to a voltage of 1.2 volts per cell at the end of the loading cycle.

The battery shall have minimal difference (approx. 0.3 V per cell) between float and boost charging voltages.

9.6.17 Battery Charger

The float-cum-boost type battery charger shall comprise silicon controlled rectifiers (SCRs) connected in a full wave bridge circuit. Each battery charger shall be suitable for float charging the battery under normal conditions and boost charging the battery when it has discharged during service conditions. The changeover from float to boost mode and vice versa shall be automatic.

The rectifier transformer shall be dry type and double wound with required number of taps. The DC output voltage during float charging shall be stabilized within + 1% of the set DC bus voltage for AC input voltage variation of +10%, frequency variation of + 5% and DC load variation from 0 - 100%. The voltage regulation shall be achieved by a constant voltage regulator having fast response SCR control. The ripple content shall be within 1% of DC output nominal voltage with battery disconnected and shall be designed to have voltage regulation of 1%. Also in any mode of operation, the maximum harmonics in the charger output shall not exceed 5%.The setting of the output DC bus voltage shall be adjustable between + 10% of nominal rated voltage. There shall be provision for manual control if auto mode fails. Line surge suppressers shall be provided.

For boost charging the discharged battery after a mains failure, the rectifier shall charge the battery at high rate limited to the maximum boost charging voltage. The boost charging shall come on only when selected for boost mode manually. In auto control, the DC output current shall be stabilized within +2% for AC input voltage and frequency variation of + 10% and + 5% respectively. There shall be provision for manual control if auto-mode

fails. Boost charging time for charging the battery to full capacity from fully discharged condition shall not exceed 8 hours.

In the float charging mode, the charger shall be designed for supplying:

a) The DC loads of control, indication and annunciation circuits that remain energized during normal operation and the momentary closing and trip coil loads of circuit breakers, vacuum contactors; and
b) The float charging current of the battery.
c) 25% margin over the above load

Battery charging equipment complete with all accessories shall be housed in a free standing sheet steel cubicle having degree of protection of IP 5X. Sheet steel used for construction shall be 2 mm thick. The units shall be wired using 1100 V grade, PVC insulated, stranded copper conductor cables.

Each battery charger shall be provided with accessories that include, but not limited to the following:

a) Silicon controlled rectifiers connected in full wave bridge circuit with ripple control devices and transient suppression network.

b) 230 V AC compact fluorescent lamp fixture for internal lighting with MCB
c) Automatic voltage regulator unit with manual / auto control switch
d) Coarse and fine control potentiometers for manual control
e) Selector switch for mode of charging i.e. float charging / boost charging
f) Off-load tap changing switch for changing the taps of the transformer
g) DC voltmeter with fuses and a three position selector switch
h) DC ammeter with shunt
i) AC ammeter with selector switch for incoming AC power
j) AC voltmeter with selector switch for incoming AC power
k) MCB for incoming AC supply along with surge suppressers
l) Switch-fuse / MCB on DC output side with kick fuses and alarm contacts
m) Voltage dropping diodes in load circuit during boost charging mode
n) DC undervoltage relay and earth fault relay
o) AC / DC switching relays for alarm and indication circuits including buzzer
p) Cubicle space heater suitable for 230 V AC, 1 ph, 50 Hz supply, with MCB and thermostat

Each battery charger shall be provided with the following alarms / indications:

a) AC and DC supply 'ON'
b) AC and DC supply fail
c) Modes of charging
d) Over voltage
e) Under voltage on DC side
f) Earth fault on DC side
g) AC / DC MCB trip

The DC circuit switching shall be through DC MCBs only.

9.6.18 DC Distribution Board (DB)

The distribution board shall be of floor mounting design. Entry for incoming and outgoing cables shall be from the bottom. Bus bars shall be of copper. Incomers, bus coupler and outgoing circuits shall be controlled by suitably rated double pole MCBs type suitable for

DC application. Contractor shall furnish proposed single line diagram of the board along with the Bid.

Constructional features, pre-treatment, painting and other aspects shall comply with the specifications for LV switchboard.
An earth busbar of 25x3 mm copper flat shall be provided along the length of the DB at the bottom. Two nos. earthing terminals shall be provided on the external face of the board for connection to the earthing grid.

9.6.19 Tests

The batteries, chargers and distribution boards and their components shall be subjected to routine/ acceptance tests as per the applicable standards. For battery, following tests are also to be carried out:

- Capacity test
- Test for voltage charging and discharging
- Ampere-hour and watt-hour efficiency test

Certificates of type tests carried out on similar equipment shall be furnished

9.6.20 LIST OF APPROVED MAKES

Following is the list of makes that shall be strictly adhered to by the bidder:

LV Switchgear	L&T (including Hagar) / Siemens / Schneider (including Telemecanique and Merlin Gerin) / ABB / MDS (Legrand)
Motors	Crompton Greaves / Bharat Bijlee / Siemens / Jyoti / Kirloskar / ABB / Alstom (AREVA)
Relays	Siemens / Alstom (AREVA) / L&T / Easun Reyrolle / ABB / GE
Meters	AE / Rishabh/ Meco / Enercon / IMP / L&T
Cables and Wires	Polycab / Universal / Nicco / Fort Gloster / Finolex / CCI
Lighting Fixtures	Crompton Greaves / Philips / Wipro / Bajaj
Fans	Crompton Greaves / Bajaj / Usha / Orient / Almonard / Unique
Indicating Lamps	Vaishno / Tecknic / Raas / Siemens
Push Buttons	Siemens / Vaishno / Tecknic / Raas
Glands	Comet / Dowell
Insulators	BHEL / WS / Jayashree
Transformers	Bharat Bijlee / Voltamp / Crompton Greaves / Kirloskar / EMCO / BHEL/Universal
Lightning Arresters	WS / Jayashree / Elpro / Oblum
Relays	Siemens / Alstom (AREVA) / L&T / Easun Reyrolle / ABB / GE
Capacitors	L&T / Manohar / Madhav / Shreem / Epcos / Universal

9.6.21 TESTING AND COMMISSIONING

The Contractor shall carry out commissioning tests in the presence of the Project Manager's representative. The evaluation of test results and decision passed by the Project Manager's representative regarding the test results will be final and binding on the Contractor. Any additional tests or repetition of tests to establish satisfactory operation of any equipment shall be carried out by the Contractor, if so desired by the Project Manager's representative

at no extra cost.

The completion checks and commissioning tests to be carried out shall include, but not be limited to, those described in subsequent paragraphs, as applicable to the individual equipment/system.

All checks and tests shall be as per the Manufacturer's drawing manuals, relevant codes of installation and commissioning checklists described in subsequent paragraphs.

Among other commissioning tests, the following shall be carried out at site after completion of installation. Contractor shall ensure to use calibrated test equipment having valid calibration test certificates from standard laboratories traceable to National Standards / International Standards. All tests to be carried out in the presence of Project Manager's representatives.

(a) Switchboard

Power frequency high voltage test, IR test, operation tests

(b) Relays

Check internal wiring, relay settings

(c) Cables

All new cables shall be megger tested before terminating / jointing. Afterterminations / joints shall be megger tested by 1000V megger.

Cable core shall be tested for

i) Continuity
ii) Absence of cross phasing
iii) Insulation resistance to earth
iv) Insulation resistance between conductors

(d) Earthing System

Continuity of all conductors and joints. The Project Manager's representatives may ask for earth continuity tests, earth resistance measurements and other tests, which in his opinion are necessary, to prove that the system is in accordance with design, specification, code of practice and electricity rules. Earth resistance value should be not greater than one (1) ohm.

(e) Lighting System

Commissioning tests stipulated in applicable standards and code of practice covering all lighting system equipment

The Contractor shall carry out insulation resistance tests by a megger of following rating

i) Control circuits up to 220 V 500 V megger
ii) Power circuits up to 1.1 kV 1000 V megger

(f) General

In general, the following checks shall be carried out on all the equipment / systems, as applicable.

i) Name plate details according to approved drawings/ specifications
ii) Any physical damage or defect and cleanliness
iii) Tightness of all bolts, clamps and connections
iv) Oil leakages and oil level
v) Condition of accessories and their completeness
vi) Clearances
vii) Earthing connections
viii) Correctness of installation with respect to approved drawings/specifications

ix) Lubrication of moving parts
x) Alignment
xi) Correctness and condition of connections

(g) Commissioning Tests

The following commissioning tests are to be carried out on all the equipment/systems, as applicable.

i) Insulation resistance measurement of equipment, accessories, cabling/wiring etc.
ii) Dielectric tests on equipment, accessories, cabling/ wires etc.
iii) Phase sequence and polarity
iv) Voltage and current ratios
v) Vector group
vi) Resistance measurement of winding, contacts etc.
vii) Continuity tests
viii) Calibration of indicators, meters, relays, etc.
ix) Control and interlock checks
x) Settings of equipment and accessories
xi) Checking of accuracy/error
xii) Checking of operating characteristics, pick-up voltages and currents, etc.
xiii) Operational and functional tests on equipment, accessories, control schemes, alarm/trip/indication circuits, etc.
xiv) Measurement of guaranteed/approved design values including lighting levels, earth resistance measurement, etc.
xv) Complete commissioning checks of the system

9.6.22 SAFETY PROCEDURE AND PRACTICE

Following safety procedure and practice should be provided by electrical Contractor in switchboard room/substation as per latest edition of I.S. 5216.

i) Rubber matting in front of LV switchboard and other panels in substation room, Filter house, Clear water Pump house MCC room etc
ii) One shock treatment chart in substation room, Filter house, Clear water Pump house MCC room etc
iii) Caution/Danger Board on all panels, MCC , Switchgear, switchyard fencing etc Sand buckets at substation room, Filter house, Clear water Pump house MCC room, outdoor switch yard etc
iv) Fire extinguisher at substation room, Filter house, Clear water Pump house MCC room, outdoor switch yard etc
v) One set of hand gloves at substation room
vi) Fire Safety
vii) The requirement of hand appliance in switchboard room, electrical equipment room shall be as per the latest edition of Fire Protection Manual by Regional Tariff Committee.
viii) Contractor's Licence

The Contractor shall obtain the necessary Licence/Authorisation from the Licensing Board of the locality/State for carrying out the installation work. The persons deputed by the Contractor's firm should also hold valid permits issued/recognised by the Licensing Board of the locality/State in which the work is to be done.

The electrical installation work shall be carried out by licensed electricians only and approved by appropriate authorities. It is the responsibility of Contractor to get approval of complete system from the appropriate authority.

9.6.23 DRAWINGS, TEST CERTIFICATES AND O & M MANUALS

(a) Drawings

- General

i) Separate drawings shall be prepared and submitted for each equipment/system.

ii) All drawings to be furnished by the Contractor shall be in standard size of sheets with maximum size being A0. Drawings shall contain the following particulars in the title block at lower right hand corner in addition to the Contractor's name, date, scale, drawing number, drawing title etc.

- Client Name
- Project Title
- Project Manager’s / Project Manager’s Representative’s Name

iii) A blank space of approx. size 100 mm x 100 mm shall preferably be provided for the approval stamp of the Project Manager's representative and provision shall also be made by way of a block for details of revisions to be recorded. The drawing no. shall be marked with a subsequent revision no. every time the drawing is revised. The drawing title shall also identify name of the substation/site.

iv) The equipment and systems, which are to be bought out from the sub-vendors, are also required to be approved by the Project Manager's representative prior to manufacture. The relevant technical literature and drawings pertaining to such equipment and systems shall contain information detailed above and shall be submitted for approval. In addition, drawings submitted by sub-vendor/sub-contractor shall carry Contractor's approval stamp and the Contractor shall be responsible for their contents, accuracy and completeness.

v) Contractor shall ensure that the contents on copies of drawings are legible and are complete with all details. Drawings that are not legible or are incomplete will not be reviewed.

vi) One copy of reviewed/approved drawings will be furnished to the Contractor. Drawings returned not approved/approved with comments shall be resubmitted for review/approval until the final approval is obtained. Delays caused by submission of incomplete/incorrect drawings shall be to Contractor's account.

- Detailed Drawings/Documents

i) The Contractor shall submit to the Project Manager the design calculations for various equipment/systems, all working drawings, equipment data and detailed drawings. These shall include general arrangement, details of equipment, foundations, cable routing, openings in walls and floors, wiring diagrams, cable schedules, interconnection diagrams, etc. necessary for the erection of plant. These drawings/data having been corrected or amended as necessary based on the Project Manager's comments shall become the 'Approved' drawings/data to be used for manufacture and erection of plant.

ii) Minimum details required on drawings of different categories are given below.

- List of Drawings

  A detailed list of drawings, which the Contractor proposes to prepare for each substation/site, indicating therein drawing nos. and titles.

Type of drawing		**Minimum details required**
One line diagrams	:	All equipment with ratings, polarities, protection and metering details etc. Cable details for all circuits Details of relays, meters and major components associated with each circuit

Type of drawing		Minimum details required
		Busbar details, makes of equipment/ components etc Reference drawings
General	:	Dimensional layout drawings covering complete layout of equipment and cabling, earthing, lightning protection, lighting systems, etc. Plans and sections as required showing details, access space/ clearances etc. Details of foundations, cut-outs, openings, supporting/ mounting details etc. Installation details Bill of material and identification of components/ rooms/areas etc. Reference drawings

In addition to the above, the contractor shall also submit adequate copies of all relevant literature, catalogues, etc.

- Record Drawings

  Within eight (8) weeks of successful commissioning tests, the Contractor shall furnish 'Record' drawings. Submission to and approval by the Project Manager of the 'Record' drawings shall be pre-requisite for the 'Taking Over' Certificate. The drawings shall show the whole Plant as installed and shall include electrical components with schematic and wiring diagrams for all items of electrical equipment included in the Works. The record drawings shall be furnished in neatly bound volumes. Reduced copies of the relevant drawings shall be included in the operating and maintenance manual.

- Specific Requirements

  i) Following drawings shall be enclosed with the bid.

  ii) Dimensioned general arrangement drawings showing plan, elevation and sections together with identification of parts/accessories etc. for the major items, viz. outdoor transformer and equipment, LV switchboard, control panels, lighting equipment along with manufacturer's catalogues / literature etc.

Following information/drawings shall be submitted after the award of Contract for approval of the Project Manager.

- Detailed design calculations for electrical equipment such as sizing of transformer, cables, LV switchboard, capacitors, etc. and for systems such as cabling, earthing and lighting.

- <u>Transformers</u>

  General arrangement drawing showing plan, front and side elevations and all accessories and fittings. Detailed dimensions, net weights, crane lift for untanking, size of lifting lugs and eyes, clearances between HV terminals, LV terminals and to ground, identification for fittings and accessories, centre lines in both the directions, details of anti-earthquake clamping device, details of HV/LV bushings, LV box, foundation details, detailed manufacturer's catalogues/literature of accessories actually being supplied.

  Rating and terminal marking plate, showing polarity, vector group and other details

- <u>Equipment/systems/area</u>

  Detailed dimensioned plan and sections indicating therein salient features of equipment, detailed bill of material for equipment, identification of clamps and connectors etc.

  Cabling, lighting, earthing and lightning protection system drawings

  Detailed drawings for the HV substation structures, equipment and clamps/ connectors.

  Foundation details

Control and protection schematic diagrams
Detailed one line diagrams
Block logic diagrams
Cable schedules and interconnection wiring diagrams
Typical installation detailed drawings
Manufacturer's catalogues/literature etc. of equipment being supplied

- Switchboards/Panels

Complete assembly drawing of the switchgear showing plan, elevation, and location of cable terminations and control cable terminal blocks for external wiring connections as well as sectional view of each type of panel.
Foundation plan showing the location of channel sills, foundation bolts and floor openings.
Schematic diagram (AC and DC) for control, protection, indication, alarm and trip circuits, relays, instruments, space heaters etc. for each type of feeder.
Single line diagram with details of busbars, components, cable sizes and detailed bill of material etc. for each feeder.
Complete wiring diagrams including terminal wiring designation
Cable termination details with dimensions
Manufacturer's catalogues/literature etc.

- Lighting System

Layout drawings for indoor and outdoor areas showing lighting fixtures, conduit/cables, lighting circuit distribution scheme, complete bill of material, locations of control switches, receptacles etc. and mounting details for fixtures, switches and receptacles including installation details. Manufacturer's catalogues/literature shall also be furnished.

- Earthing and Lightning Protection System

Layout drawings for earthing and lightning protection systems showing earthing grid, locations of earth electrodes, routes of conductors, interconnections, earth leads to various equipments, bill of material etc. including installation details.

- Cabling System

Layout drawings showing cable route, laying method, trench, tray and pipe/conduit layout, clamping, etc. including installation details.

(b) Test Certificates

- Type Test Certificates

Type test certificates for the following equipment shall be furnished.

i) Transformers
ii) Switchboards, disconnectors, insulators/bushings, LAs and drop-out fuses etc.
iii) Cables
iv) Induction motor

Certificates shall be furnished for type tests carried out on similar type/design of equipment during the last three years only.

- Routine Test Certificates

i) Routine test certificates for all equipment and accessories shall be furnished.
ii) Routine test certificates shall be furnished in addition to test reports, which will be collected at the time of inspection.

iii) Routine test certificates shall be furnished for review by the Project Manager after completion of inspection of relevant equipment or as instructed by the Project Manager in case of equipment for which witnessing of tests is waived.

- Other Documents

i) Technical catalogues, descriptive literature, characteristic curves, write-up on schemes where required in support of relevant control/indication drawings etc. shall be furnished for all the items of plant and accessories/components.

ii) Documents pertaining to cables shall in addition, include current ratings, derating factors, physical and electrical data, recommended bending radii etc.

iii) Documents in respect of lighting system equipment shall include data in respect of each type of lighting fixture/switch, receptacles/miniature circuit breaker and wires to be used in circuit wiring. Data on lighting fixtures shall include dimensional drawings, cable entry facility, mounting details and weight, light distribution diagrams, light absorption and utilisation factors, lamp data etc.

iv) Contractor shall note that the documents mentioned above shall be made available along with relevant drawings listed above of equipment/systems as supporting documents to facilitate expeditious review of such drawings.

(c) Operating and Maintenance Manuals

i) The Contractor shall provide adequate sets of approved manuals. All descriptive leaflets, instruction sheets, charts, lists, pamphlets and other documents that are used in compiling each manual shall be contained in one or more binders designed to prevent loss of contents. Each binding shall be titled with the name of the Employer, the name of the project, the Contract number, the name of the Contractor and with information to identify the subject matter and shall include a detailed index to all the literature contained therein.

ii) The manuals will be initially approved in draft form by the Project Manager and shall cover all items of the Works. For this purpose, adequate number of draft copies shall be submitted to the Project Manager. Final submission of manuals shall be done after satisfactory completion of commissioning tests. A mere collection of manufacturers' descriptive leaflets will not be acceptable in satisfaction of this Clause. Information pertaining to items selected for this project shall be clearly indicated in such leaflets. The manuals shall comprise both operating instructions and maintenance instructions. The Operating manual should also highlight operation of the Plant in conjunction with the system. Thus, a general tie-up between system and equipment shall be available in the manuals.

iii) A separate section of a manual shall be devoted to each size and type of equipment. It shall contain a detailed description of its construction and operation and shall include all relevant pamphlets and a list of parts with procedure for ordering spares. Operation of electrical equipment shall be described systematically giving the complete sequence of operation. The detailed sections of the manual, if necessary, shall contain further maintenance instructions and fault location charts.

iv) The manuals shall be printed on A4 size sheets and shall be bound. Reduced copies of record drawings shall also be included in the manuals.

v) The operating instructions shall include the following.

- Step by step directions on setting the plant to work, listing all adjustments and settings necessary for the correct functioning of the plant.
- List of plant alarms giving possible causes for alarm initiation and sequence of remedial actions to be taken.
- Instructions on monitoring of plant performance and sample log sheets for each plant item, to be filled by operators on a routine basis.

- "Do's" and "Don'ts" in plant operations. Operators' attention shall be drawn to all operations considered to be dangerous to operators or likely to cause damage to the plant.

vi) The maintenance instructions shall include the following.

- Checking, testing and replacement procedures to be carried out on all plant items on a daily, weekly and monthly basis or at longer intervals to ensure trouble-free operation.
- Fault locations and remedy charts to facilitate tracing the cause of malfunctions or breakdown and correcting faults.
- A 'spares schedule', which shall consist of a complete list of itemised spares for all plant items with ordering references and part numbers.
- A complete list of manufacturer's instructions for operation and maintenance of all bought-out equipment. The list shall be tabulated in alphabetical order giving the name of supplier/manufacturer, identification of the plant item giving the model number and the literature provided including instruction leaflets and drawing numbers.
- Full instructions to cover the complete dismantling and re-assembly of all items of plant.
- Part-list and drawings or exploded diagrams for such items of plant showing manufacturing tolerances, matching clearances between machined components at the time of supply, maximum wear and clearances permitted to facilitate replacement.
- Complete list of recommended lubricants and lubricating chart, insulating oil and insulation checking/ replacement chart.

9.7 INSPECTION AND TESTING REQUIREMENTS

9.7.1 TESTS ON COMPLETION

General

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

- Site Acceptance Test Documents;
- As-Built Drawings;
- Operation and Maintenance Manuals.

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

The charges of oil, grease etc. necessary for Tests on Completion shall be provided by the Contractor. Chemicals required for Tests on Completion will be provided by the Contractor. The Contractor shall provide adequate notice of his raw water requirements prior to commencement of the Tests on Completion involving its use.

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

9.7.2 DRY TEST REQUIREMENTS

General

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

- A general inspection to check for correct assembly and quality of workmanship;
- A check on the presence of lubricant, cooling medium, electrolyte, etc.:
- A check on adequacy and security of plant fixing arrangements;

- A general check to ensure that all covers, access ladders, water proofing, guard railings etc are in place;
- A check on damp-proofing, rust-proofing and vermin-proofing and particularly the sealing of apertures between building structures, chambers etc and the outside;

9.7.3 Civil and Building Works

As a minimum requirement presence of foreign bodies in pipe work and structures shall be checked.

9.7.4 Mechanical Works

As a minimum requirement preliminary running checks shall be carried out on all the mechanical works as far is permitted by circumstances in order to ensure smooth operation of Plant.

GENERAL

All items of plant shall be liable to inspection and testing before despatch. Unless otherwise authorised by the Engineer's Representative, the Contractor shall arrange routine and functional tests to demonstrate to the Engineer's Representative, conformity with the Specification and appropriate standards.

The Contractor shall inform the Engineer in writing at least 15 days in advance regarding readiness for carrying out inspection of equipment/material etc. at manufacturer's works or at places of inspection. The programme for inspection shall be finalised by the Engineer after the receipt of the above. In case inspection cannot be carried out due to non-readiness of equipment/material etc. a subsequent date shall be finalised for carrying out the inspection in which event all expenses incurred by the Corporation for such visits shall be recovered from the Contractor. In case equipment/material etc. is found not to comply with the specification, dates for re-inspection shall be finalised and expenses incurred by the Corporation for such visits shall also be recovered from the Contractor. Contractor's Representatives shall essentially be present during all inspections. The following information shall be given in the inspection call letter mentioned above:

(a) Name of manufacturer/supplier;

(b) Address of place where inspection is to be carried out;

(c) Proposed date/s and equipment to be inspected;

(d) Name/s of contact personnel at manufacturer's/ supplier/s works with their telephone and fax numbers.

(e) Name of Contractor's Representative who will be present during the inspection.

(f) Confirmation that internal testing has been completed.

The Contractor shall provide all the necessary instruments to carry out the tests after assembly. All instruments used for such tests shall be calibrated and certified by and approved by an independent testing authority not more than one month prior to the tests in which they are used. Calibration certificates for instruments used for such tests shall be

produced for the approval of the Engineer's Representative and if necessary, instruments shall be recalibrated before the commencement of the tests.

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

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

The Employer's Representative reserves the right to be present during the testing of all Plant items.

Factory Acceptance Test Document

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

- unpriced copy of the Contractors order for the Plant item concerned:
- Details of the inspection and test procedures to be carried out.

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

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

- motors;
- pumps;
- instruments;
- gear boxes;
- electrical switchgear rated in excess of 250 A;
- integral control and switchgear panels;
- valve gear;
- castings.

Where witness tests are not required the test certificates and curves etc. shall be forwarded to the Employer's Representative within two weeks of the tests being completed.

The Contractor shall not deliver Plant to Site without the Employer's Representatives approval in writing. This permission will not be given unless amongst other things a valid Contractors test certificate and completed FAT document for the item of Plant concerned is in the possession of the Employer's Representative.

Inspection and Testing Programme

The Contractor shall submit to the Employer's Representative not later than 56 days prior to the commencement of the first inspection and test during manufacture a programme detailing the inspection dates for all Plant. Those items of Plant that the Employer's

Representative has specifically identified for witness testing test shall be highlighted in the programme.
The Contractor shall keep the Employer's Representative informed of any changes to the programme.
The Employer's Representative shall not be requested to inspect an item of Plant until the Contractor has satisfied himself that the equipment meets all requirements of the Employer's Requirements.

Manufacturer's Works Acceptance Tests on Mechanical Equipment

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

Pumps

Manufacturers standards test certificates will be acceptable for small pumps rated for powers of 25 kW or less.
All other pumps shall be tested individually in accordance with the relevant international standard. Site conditions shall be simulated as near as possible including the NPSH condition. Pumps shall be tested with their own prime movers. Where it is impractical to include the full length of the connecting shaft, the Contractor shall state the allowances to be made for the losses incurred by its omission and shall demonstrate the accuracy of the allowances to the satisfaction of the Employer's Representative.

Each pump shall be tested at its guaranteed duty point and over its full working range from its closed valve condition to 20% in excess of the specified quantity at minimum head. Tests shall provide information for performance curves to be drawn for: head/quantity, efficiency/quantity, power absorbed/quantity and net positive suction head/quantity.

Pump casings shall be subject to a pressure test at 1.5 times the pressure obtained with the delivery valve closed. The positive suction head shall be taken into account in determining this pressure.

In addition to confirming the hydraulic performance of the pumpset as specified, the test shall demonstrate that vibration is within the specified limits and that the mechanical performance is satisfactory.

Valves

Type test certificates will be acceptable for valves sized 300 mm diameter or less.

All valve bodies shall be hydraulically tested closed ended to 1.5 times the rated pressure in accordance with the appropriate standards.

Butterfly valves with rubber seats shall be tested to the maximum differential pressure, at which pressure they shall be drop-tight.
Butterfly valves with metal seats shall be tested to the maximum differential pressure and the permissible leakage rate shall not exceed 0.10 litres/hour per 100 mm of the diameter with on-seat pressure.
Filter outlet valve type testing shall be witnessed.

Penstocks

Check for smoothness of operation and integrity of seal. Leakage tests shall also be carried out.

Pipework

The inspection and testing of all pipework shall be carried out in accordance with the appropriate standards approved by the Employer's Representative.

Cranes

Cranes shall be completely assembled and tested for all operations in accordance the relevant international standard.

Compressors and Blowers

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

Process Plant Items

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

Manufacturer's Works Acceptance Tests on Electrical Equipment

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

Switchgear and Motor Control gear Assemblies

Switchgear and control gear shall be witness tested as complete assemblies.

The following tests shall be carried out:

1. Dielectric tests at an approved voltage/s.
2. Primary injection tests to ensure correct ratings and polarity of current and voltage transformers and of the current operated protection relays and direct acting coils, over their full range of settings.
3. Tests on auxiliary relays at normal operating voltages by operation of associated remote relays.
4. Correct operation of sequencing and control circuits at normal operating voltages by operation of local control switches, and simulation of operation from remote control positions.
5. Correct functionality of the equipment in all modes of control.

Transformers

Transformers shall be subject to works routine tests as defined in the relevant standard.
Type test certificates shall be provided for the following:

- Impulse voltage withstand;
- Temperature rise.

Cables

All cables and armoured cables shall be subject to routine tests in accordance with the relevant Indian Standards.
Test certificates shall be provided against each drum and/or cable length.
The tests carried out on every cable length and/or drum at manufacturer's premises shall

include:

- high voltage dc insulation pressure test, between cores, each core to earth, metallic sheath or armour as applicable.
- insulation resistance test.
- core continuity and identification.
- conductor resistance test.

Motors

The manufacturer's type test certificate will be accepted for motors rated at less than 55 kW. A type test certificate and an individual motor test certificate shall be provided for all other motors.

Manufacturer's Works Acceptance Tests on Standby Generator Sets

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

- functionality check;
- manufacturers standard tests;
- run set for 2 hours at full load;
- step load acceptance and rejection tests using the maximum step loads plus 20 % to be applied in use at the water treatment plant.

9.7.5 Electrical Works

The following commissioning tests are to be carried out on all the equipment/systems, as applicable.

- Insulation resistance measurement of equipment, accessories, cabling/wiring etc.
- Dielectric tests on equipment, accessories, cabling/ wires etc.
- Phase sequence and polarity
- Voltage and current ratios
- Vector group
- Resistance measurement of winding, contacts etc.
- Continuity tests
- Calibration of indicators, meters, relays, etc.
- Control and interlock checks
- Settings of equipment and accessories
- Checking of accuracy/error

- Checking of operating characteristics, pick-up voltages and currents, etc.

- Operational and functional tests on equipment, accessories, control schemes, alarm/trip/indication circuits, etc.

- Measurement of guaranteed/approved design values including lighting levels, earth resistance measurement, etc.

- Complete commissioning checks of the system

9.7.6 Instrumentation & Control System

The following dry tests shall be carried out on the instrumentation & control system:

- Continuity check on all signal/ control/ power supply cables.
- Check instrument loop integrity, functionality and calibration; A written report on each instrument in the format required by the Engineer/ Purchaser shall be provided certifying that the instruments have been calibrated to published specified accuracy.
- Check functionality of the instrument control panels/ consoles.

9.7.7 HYDRAULIC WET TEST REQUIREMENTS

Hydraulic wet tests shall be carried out on completion of dry tests.Raw water or treated water (if available) shall be used for hydraulic wet tests. The purpose of the tests is to prove as far as practical the hydraulic performance of the Works. In order to demonstrate this, the Contractor shall ensure that each part of the Works is hydraulically loaded to its rated throughput for a period of at least four hours.

In order to remove doubt, the following tests inter alias shall be carried out:

- Pressure testing of all piped systems laid direct in ground in accordance with the relevant standards;
- Fill all structures and check for leaks;
- Filling of all storage vessels to check for leaks and distortion;
- Running of all pumped systems in order to check for:
    - Correct functionality;
    - Absence of leaks;
    - Correct running temperatures
    - Smoothness of running and the absence of undue vibration or stress;
- Check drive running currents.
- Carry out calibration of instruments where appropriate;
- Hydraulic testing of primary/ impulse tubing.
- Demonstrate correct functionality of electrical, control and instrumentation systems.

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

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

9.7.8 FILTER WET TESTS

The Contractor shall carry out the following tests on each of the filters after completion of

hydraulic test:

Air Distribution Test

The empty filter shall be filled with water to a level of 50 - 100 mm above the top of laterals. Air shall be introduced into the system at such a rate that the system can be seen to pass air through the pores of laterals over the whole filter area. Any discrepancies in distribution over the filter shall be rectified and the test repeated until the Employer's Representative is satisfied that the air distribution is uniform over the entire filter.

Combined Air Scour and Backwash Distribution Test

The filter shall be tested for combined air and water scour at the design rates in the same manner as described above for the air distribution test. Air shall be brought on first and allowed to fully develop before the water is introduced. Any discrepancy in distribution over the filter shall be rectified and the test repeated until the Employer's Representative is satisfied that the distribution is uniform over the entire filter.

As soon as possible after satisfactory completion of the above tests the filter shall be charged with filter media.

9.7.9 SAFETY AUDIT

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

9.7.10 PLANT STERILISATION

On approval of the safety audit document the Contractor shall carry out sterilisation of the wetted parts of the Works. In order to remove doubt this shall also include the wetted surfaces of water treatment chemical storage and dosing systems.

The sterilisation process shall be carried out by completely filling the item or items concerned with water containing not less than 30 mg/l of free chlorine and leaving it to stand for not less than 2 hours. On draining down the Contractor shall demonstrate that the chlorine residual has not fallen below 20 mg/l of free chlorine. If this is not true the sterilisation process shall be repeated until this condition is met.

The Contractor shall be responsible for the disposal of the sterilisation solution. The Contractor shall take the necessary measures to ensure that the free chlorine residual of the solution for disposal is not greater than 1 mg/l before discharge to the environment.

The Contractor shall give 2 weeks notice to the Employer's Representative and the Employer of the proposed date for carrying out sterilisation.

The Contractor shall advise the Employer's Representative and the Employer in writing when all wetted parts of Plant and civil structures have been sterilised.

If the Contractor carries out any new work that invades a previously sterilised area the Contractor shall be required to carry out re-sterilisation of that area to the approval of the Employer's Representative.

9.7.11 PROCESS WET TESTS

On approval of the sterilisation process the Contractor shall carry out process wet tests.

Raw water shall be used as the primary feed stock for process wet tests. These tests shall

be carried out to demonstrate the process performance of the Works. In order to demonstrate this, the Contractor shall ensure that each part of the Works is loaded to its rated throughput (including a period of overload if required in order to demonstrate compliance with the Employer's Requirements) for a continuous stable operating period of not less 48 hours.

The following tests shall be carried out:

- Check for leaks on vessels, structures, pumps and pipe work;
- Running of all pumped systems in order to check for:
- Correct functionality;
- Absence of leaks;
- Correct running temperatures
- Smoothness of running and the absence of undue vibration or stress;
- Check drive running currents where the solution pumped is different from that pumped during hydraulic wet tests;
- Carry out calibration of water quality instruments;
- Carry out valving, diversions etc. To full hydraulic load (or where there is a requirement to withstand an over load) each process element;
- Demonstrate correct functionality of electrical, control and instrumentation systems

On completion of the tests on the various parts of the works the Contractor shall run the plant as a whole in order to demonstrate the full functionality and performance of the Works at various throughput rates for a continuous period of not less than 5 days.

During the various process tests the Contractor shall take samples and carry out water quality analysis at not greater than one hourly intervals in order to demonstrate to the Employer's Representative that the Works is functioning in accordance with the Employer's Requirements. Each sample shall comprise two 1 litre (minimum) quantities and shall be labelled to identify the contents, where taken and time and date. One sample shall be used by the Contractor for his analysis, the other shall be handed over to the Employer's Representative.

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

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

9.7.12 WATER QUALITY CRITERIA FOR PASSING THE TESTS ON COMPLETION

The Works shall be considered to have achieved the required water quality standards for passing Tests On Completion if all samples taken during a 5 day continuous operational period comply with the criteria set down for the passing the Tests After Completion. including that criteria relating to the reliability of the plant.

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

9.7.13 TESTS AFTER COMMISSIONING

General

On successful completion of Test on Completion the Contractor shall carry out over a period of time not exceeding one year two separate 20 day operational tests. These tests shall be used to prove the operation of the Works at varying flows and with varying raw water quality. During these tests water produced by the Works will be entering the public supply

network.

The timing of the tests shall be determined by the Employer who shall give notice to the Contractor in accordance with the General Conditions of Contract. The total time for carrying out the tests shall not be less than six calendar months, of which one of the tests for each part shall be carried out in a period of high raw water turbidity.
During the tests the Contractor shall take samples to demonstrate that the part of the Works is performing in accordance with the Employer's Requirements. The procedure for taking the samples shall follow the pattern adopted for Test on Completion. Samples shall be taken at locations and intervals as directed by Engineer. The results of the Tests after Completion shall be compared and evaluated by the Employer and Contractor.

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

The Contractor shall be required reasonably to co-operate and co-ordinate his activities with those of the Employer and other contractors.

CRITERIA FOR PASSING THE TEST AFTER COMPLETION

Treated Water Quality Criteria

The Works shall be considered to have passed the 20 Day Test for treated water quality if all samples taken during the 20 day period comply with the criteria set out below in Table below

Treated Water Quality Criteria

Turbidity Al pH Taste and Odour	<1 NTU < 0.2 mg/l 7.0 to 8.5 Unobjectionable
Faecal Coli forms Coliform Organisms	0/100 ml 0/100 ml
Free available Chlorine residual at Plant Outlet	1mg/l

The treated water quality criterion is an absolute requirement. i.e. the stated water quality standards must be achieved.

Water Quantity Criteria

The Works shall have fulfilled the treated water quantity criteria if the Works have demonstrated that this can provide the quantity of treated water detailed in the Contractors Functional Guarantee over a sustained and continuous period during the Tests After Completion.
The treated water quantity criterion is an absolute requirement. i.e. the guaranteed treated water quantity must be achieved.

Plant Reliability Criteria

A part of the Works shall be deemed to have failed its test if:
a single item of Plant fails more than twice during the test;
more than four individual Plant items fail during test.

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

PERFORMANCE CERTIFICATE

The conditions for issuance of a Performance Certificate shall comprise:

- The completion of the one year's operation of the Works to the satisfaction of the Employer's Representative;
- The O & M Manuals have been updated following one year operational experience and approved by the Employer's Representative;
- All defects identified prior to Taking Over and defects identified during the one year's operation of the Works have been rectified;
- All Tests After Completion have been completed to the satisfaction of the Employer's Representative;
- All training detailed in the Employer's Requirements has been completed.

9.8 DRAWINGS, TEST CERTIFICATES AND O & M MANUALS

9.8.1 Drawings

General

a) Separate drawings shall be prepared and submitted for each equipment/system.

b) All drawings to be furnished by the Contractor shall be in standard size of sheets with maximum size being A0. Drawings shall contain the following particulars in the title block at lower right hand corner in addition to the Contractor's name, date, scale, drawing number, drawing title etc.

- Client Name
- Project Title
- Engineer's / Engineer's Representative's Name

c) A blank space of appx. size 100 mm x 100 mm shall preferably be provided for the approval stamp of the Engineer's representative and provision shall also be made by way of a block for details of revisions to be recorded. The drawing no. shall be marked with a subsequent revision no. every time the drawing is revised. The drawing title shall also identify name of the substation/site.

d) The equipment and systems, which are to be bought out from the sub-vendors, are also required to be approved by the Engineer's representative prior to manufacture. The relevant technical literature and drawings pertaining to such equipment and systems shall contain information detailed above and shall be submitted for approval. In addition, drawings submitted by sub-vendor/sub-contractor shall carry Contractor's approval stamp and the Contractor shall be responsible for their contents, accuracy and completeness.

e) Contractor shall ensure that the contents on copies of drawings are legible and are complete with all details. Drawings that are not legible or are incomplete will not be reviewed.

f) One copy of reviewed/approved drawings will be furnished to the Contractor. Drawings returned not approved/approved with comments shall be resubmitted for review/approval until the final approval is obtained. Delays caused by submission of incomplete/incorrect drawings shall be to Contractor's account.

9.8.2 Detailed Drawings/Documents

a) The Contractor shall submit to the Engineer's representative, the design calculations for various equipment/systems, all working drawings, equipment data and detailed drawings. These shall include general arrangement, details of equipment, foundations, cable routing, openings in walls and floors, wiring diagrams, cable schedules, interconnection diagrams, etc. necessary for the erection of plant. These drawings/data having been corrected or amended as necessary based on the Engineer's comments shall become the 'Approved' drawings/data to be used for manufacture and erection of plant.

b) Minimum details required on drawings of different categories are given below.
List of Drawings : A detailed list of drawings, which the Contractor proposes to prepare for each substation/site, indicating therein drawing nos. and titles.

Type of Drawing		Minimum Details Required
One line diagrams	:	All equipment with ratings, polarities, protection and metering details etc.
Cable details for all circuits		
Details of relays, meters and major components associated with each circuit		
Busbar details, makes of equipment/ components etc.		
Reference drawings		
General	:	Dimensional layout drawings covering complete layout of equipment and cabling, earthing, lightning protection, lighting systems, etc.)
		Plans and sections as required showing details, access space/ clearances etc.
		Details of foundations, cutouts, openings, supporting/ mounting details etc.
		Installation details
		Bill of material and identification of components/ rooms/areas etc.
		Reference drawings

In addition to the above, the contractor shall also submit adequate copies of all relevant literature, catalogues, etc.

9.8.3 Record Drawings

a) Within eight (8) weeks of successful commissioning tests, the Contractor shall furnish 'Record' drawings. Submission to and approval by the Engineer's representative of the 'Record' drawings shall be pre-requisite for the 'Taking Over' Certificate. The drawings shall show the whole Plant as installed and shall include electrical components with schematic and wiring diagrams for all items of electrical equipment included in the Works. The record drawings shall be furnished in neatly bound volumes. Reduced copies of the relevant drawings shall be included in the operating and maintenance manual.

9.8.4 Test Certificates

Type Test Certificates

Type test certificates for the following equipment shall be furnished.

a) Transformers

b) Switchboards, disconnectors, insulators/bushings, LAs and drop-out fuses etc.

c) Cables

d) Induction motor

Certificates shall be furnished for type tests carried out on similar type/design of equipment during the last three years only.

9.8.5 Routine Test Certificates

a) Routine test certificates for all equipment and accessories shall be furnished.

b) Routine test certificates shall be furnished in addition to test reports, which will be collected at the time of inspection.

c) Routine test certificates shall be furnished for review by the Engineer's representative after completion of inspection of relevant equipment or as instructed by the Engineer's representative in case of equipment for which witnessing of tests is waived.

9.8.6 Other Documents

Technical catalogues, descriptive literature, characteristic curves, write-up on schemes where required in support of relevant control/indication drawings etc. shall be furnished for all the items of plant and accessories/components.

Documents pertaining to cables shall in addition, include current ratings, derating factors, physical and electrical data, recommended bending radii etc.

Documents in respect of lighting system equipment shall include data in respect of each

type of lighting fixture/switch, receptacles/miniature circuit breaker and wires to be used in circuit wiring. Data on lighting fixtures shall include dimensional drawings, cable entry facility, mounting details and weight, light distribution diagrams, light absorption and utilisation factors, lamp data etc.

Contractor shall note that the documents mentioned above shall be made available along with relevant drawings listed above of equipment/systems as supporting documents to facilitate expeditious review of such drawings.

9.9 TRAINING AND ADVISORY REQUIREMENTS

Training Requirements

General

The Contractor shall provide comprehensive training for the different categories of the Employers operation and maintenance staff. Training shall fall into two main types which are 'off the job' and 'on the job'. Off the job training shall take place in the class room on the job training shall be carried out on the running plant.

Off The Job Training

The Contractor shall prepare formal training documentation for distribution to the trainees. Visual aids shall be used where possible to illustrate the points being made and to make the training programme as interesting and enjoyable as possible for the participants.

The off the job training shall comprise the following:

1. Off the Job Training Programme for all Trainees

To provide training:

a) on the simple chemistry and process principles involved in the operation of the Works;
b) health and safety;
c) plant safety procedures;

2. Off the Job Process Training Programme for Operators

To provide training:

a) on the operation of individual items of plant and sections of the Works including automatic operation and manual operation in the event of say automatic control failure;
b) on the day to day operation of the Works and procedures;
c) on a comprehensive list of 'what if' scenarios dealing with the actions to be taken in the event of potential process problems, alarms, plant failures overflows, power failures etc.;
d) on first line mechanical maintenance;
e) safe methods of work general;
f) on safety procedures to be followed in operating, maintaining and cleaning the plant;

g) special precautions to be followed in the event of a chlorine leak.

3. Off the Job Training Programme for Electrical Maintenance Staff

To provide training:

a) on the configuration, construction and operation of the electrical Plant;
b) on the electrical maintenance requirements of the Works;
c) on the switching and safety procedures to be followed;
d) safe methods of working;
e) on fault finding and repair procedures.

4. Off the Job Training Programme for Control and Instrumentation Maintenance Staff

To provide training:

a) on the configuration, construction and operation of the Plant;
b) on the control and instrumentation maintenance requirements of the Works;
c) on fault finding and repair procedures;
d) safe methods of working;
e) special training on the use of the PC and associated programming software for fault finding on PLC based control systems;
f) special training on the use and performance of the other specialist hardware and software systems used on the plant;

5. Off the Job Training Programme for Mechanical Maintenance Staff

To provide training:

a) on the routine mechanical maintenance requirements of the Works;
b) on lubrication requirements of the Works;
c) on fault finding, repair and overhaul procedures;
d) safe methods of working.

6. Off the Job Training Programme for Water Treatment Management Staff

To provide training:

a) water treatment process management techniques;
b) water treatment plant cost management;
c) water treatment plant laboratory management;
d) safe methods of work general;
e) on safety procedures to be followed in operating, maintaining and cleaning the plant.

On The Job Training

The Contractor shall utilise the Operations and Maintenance Manuals as the primary training aid in carrying out the on the job training. Short comings, omissions and errors identified in the O & M Manuals during the training shall be rectified prior to final acceptance of the O & M Manuals.

1. On the Job Training Programme for all Trainees

To provide training:

a) plant familiarization tour;
b) health and safety;
c) identify areas where special safety precautions are necessary.

2. On the Job Process Training Programme for Operators

To provide training:

a) under operational conditions on the operation of individual items of plant and sections of the Works including automatic operation and manual operation in the event of say automatic control failure;
b) illustrate by example the day to day operation of the Works and procedures;
c) illustrate by example the actions to be taken in the event of potential process problems, alarms, plant failures overflows, power failures etc. (as identified in the 'what if' scenario off the job training);
d) illustrate by example the first line mechanical maintenance;
e) illustrate by example safety procedures to be followed in operation, maintenance and cleaning of the Works.

3. On the Job Training Programme for Electrical Maintenance Staff

To provide training:

a) carry out detail tour of the electrical plant;
b) illustrate by example the operation of the electrical Plant;
c) illustrate by example the electrical isolation and maintenance procedures;
d) illustrate by example fault finding and repair procedures;
e) illustrate by example switching and safety procedures to be followed;
f) illustrate by example safe systems of work.

4. On the Job Training Programme for Control and Instrumentation Maintenance Staff

To provide training:

a) illustrate by example the operation of the Works;
b) illustrate by example the control and instrumentation maintenance requirements of the Works;
c) illustrate by example fault finding and repair procedures
d) illustrate by example fault finding on PLC based control systems, SCADA hardware and software and other specialist hardware and software systems used on the plant;;
e) illustrate by example safe systems of work.

5. On the Job Training Programme for Mechanical Maintenance Staff

To provide training:

a) illustrate by example the routine mechanical maintenance requirements of the Works;
b) illustrate by example lubrication procedures;
c) illustrate by example fault finding, repair and overhaul procedures.
f) illustrate by example safe systems of work.

Training Programme

Off the job training shall be carried out prior to Taking Over of the Works or any section of the Works.

On the job training shall be carried out primarily after Taking Over of the Works or any section of the Works. However where it is possible to do so without reducing the effectiveness of the training and with the permission of the Employers Representative and the Employer on the job training may be carried out prior to Taking Over.
The training day shall be assumed to be not less than 6 hours split into two sessions. The off the job training rooms shall be provided by the Employer at the Site in the existing buildings. The Contractor shall provide facilities for training which shall include inter alia tables and chairs, projectors, white/black boards, training aids etc.

Where trainees of a given category can all be released from their Works operational duties simultaneously they may be trained together. Where this is not possible the Contractor shall repeat the complete course for those who could not attend.

Training Personnel

The Contractor shall provide suitably qualified trainers to carry out the off the job and on the job training.

The trainers are to be experienced in treatment plant management, operation and maintenance in their relevant discipline and in the training of skilled and unskilled staff.

Operation manual & As-Built Drawings

Operation manual

The Contractor has to submit an operation manual after the physical completion of the Work. This manual will be submitted as draft at the date of physical completion and as final version 1(one) month after commissioning, including all the experiences made during the tests and the training given to the operators during the commissioning period. This manual will be established by the Contractor in cooperation with his suppliers and subcontractors and after consultation with the Engineer in Charge for the detailed contents. It will contain at least:

General description of the plant and its functioning
Step-by step procedures for all operation requirements and adjustments
Architectural, mechanical, electrical, instrumentation, piping drawings, sections, details, charts
Nomenclature and nomenclature schedule of all the equipment (mechanical, electrical, instrumentation, power and signal cables, electrical and sanitary fixtures)
For each item of the equipment:
drawing, section, exploded drawing operation instructions calibration charts (if required) fault identification and location guides and charts repair instructions (if repair by operators is possible)
maintenance instructions including type and quantity of lubricants spare parts list with addresses and procedures for ordering.
Preventive maintenance schedules for all the equipment, showing the type and frequency of maintenance of different items.
Type and quantity of the recommended consumables (lubricants, fuels, etc.)
Emergency management for specimen emergency situations which might occur due to external or internal factors

Logs for the operators of the system operating hours, salient indicators of the operation, maintenance operations faults and actions taken other events.

Address and telephone number (Hotline) to contact in case of operation problems

The operation manual shall be bound in one or several loose leaf binders designed to prevent loss and damage of the contents. The binders shall be titled, numbered and have a table of contents of all information contained.

As-Built Drawings

The Contractor shall submit to the Engineer within two months of actual completion, "Completion" Drawings as specials below. These Drawings shall be accurate and correct in all respects and shall be shown to and approved by the Engineer.

Completion Drawings as below on two prints and one polyester film shall be supplied by the contractor, along with a soft copy in CD. These drawings shall be developed in Auto CAD and shall be of standard size for below.

a. Site plan showing all features existing and as constructed under this contract with all external dimensions, dimensions of clear spaces among those, diameter and materials of pipeline etc. complete.
b. Architectural, Civil and Structural details of all components of the plant including plans at different levels, elevations from all sides as well as sectional etc. complete with all dimensions including structural Thickness, concrete grade, reinforcement details, finishing details, schedules of doors and windows, details of associated fittings and features complete.
c. All piping, plumbing and electrical details with dimensions, diameters etc. complete at specific cases isometric views of piping may be necessary.
d. Dimensioned details of all electrical, mechanical and instrumentation equipments including accessories along with arrangement inside the buildings or enclosures, connected piping and cabling layout etc. all complete.
e. Dimensioned details of all control and measuring devices lined weirs, V-notches, probes, valves, gates, consoles, panels, switch boards, cable layouts etc. for the complete proposed plant. Fine diagrams/ Circuit diagrams shall be used wherever applicable.
f. L-sections for pipelines laid externally, showing pipe profile, ground profile, soil condition, bedding, location of specials, valves and other accessories complete.
g. Dimensioned details of all site development works such as roads, drainage, cables pipelines, landscaping etc. complete with layout, cross-sections, levels etc. complete.
h. All drawings shall be prepared in appropriate scale and with adequate notes, legends, titles etc. for clarity.

Annex - I
(Schedule-E)

Rectification of Defects and Deficiencies

Sl. No.	Name of defect or deficiencies	Time limit for repair/rectification
1.	**Pumps, Motors & Control Panels**	Up to 250 HP – 7 days Above 600 HP-15 days
2.	**Transformers/Sub-stations**	Minor repair -24 Hrs. Major repair – 3 days
3.	**Raw Water/Clear Water Rising/ Gravity Mains**	24 Hrs.
4.	**Distribution Systems**	24 Hrs.
5.	**WTP – Mechanical/ Electrical Equipments, Instrumentations & Control System (excluding items covered in Sl.No.1 to 4 above)**	24 Hrs.
6.	**Determination of Chemical dosing rate**	Thrice daily (Shift wise)
7.	**Water sample testing**	Daily test as per Operation and Maintenance Manual of CPHEEO
8.	**Preventive Maintenance as detailed in Clause No.19.3.8. of EPC Agreement.**	**Monthly, Quarterly, Semi-Annually (Half Yearly), Annually and Bi-Annually**

Annex - II

(Schedule-E)

Check List for Operation & Maintenance

Name of Water supply Project		:	**Construction of 130MLD Water Treatment Plant and its Ancillary Structures for Improvement of Water Supply to Bhubaneswar City on Engineering, Procurement & Construction (EPC) Contract Including Operation & Maintenance for a Period of Five Years.**	
Name of the contractor		:		
District/ Division		:	**WATCO Division-I, Bhubaneswar**	
Name of ULB		:	**Bhubaneswar Municipal Corporation**	
Date of commission of the scheme		:		
Agreement No.		:		
Operation & Maintenance period		:	from …… to ……	
Date of inspection/ reporting		:		
Name of person inspected/ reported		:		
Designation (not below the rank of JE/ AE)		:		
1.	**Pumps, Motors, Control Panels, Circuit Breakers, etc.**	:		
	a) If Daily checks are done	:	Yes	No
	b) On detection of defects, if steps taken to rectify	:	Yes	No
2.	**Transformer & Sub-stations**	:		
	a) If Daily checks are done	:	Yes	No
	b) On detection of defects, if steps taken to rectify	:	Yes	No
3.	**Raw Water/ Clear Water Rising/ Gravity Mains**	:		
	a) If Daily checks are done	:	Yes	No
	b) No. of leakages detected during site inspection and/or through complaint received	:	Nos. (Received)	Nos. (Attended within 24 Hrs.)
4.	**Distribution Systems**	:		
	a) If Daily checks are undertaken to	:	Yes	No

	detect leakages			
	b) No. of leakages detected during site inspection and/or through complaint received	:	Nos. (Received)	Nos. (Attended within 24 Hrs.)
5.	**WTP – Mechanical/ Electrical Equipments, Instrumentations & Control System (excluding items covered in Sl.No.1 to 4 above)**	:		
	a) If Daily checks are done	:	Yes	No
	b) On detection of defects, if steps taken to rectify	:	Yes	No
6.	**Water Treatment & Water Quality Monitoring**	:		
	a) If Daily checks on chemical dosing are done in each shift	:	Yes	No
	b) Whether required Water sample testings are conducted during the day as per recommendations in the CPHEEO manual	:	Yes	No

Signature of JE/ AE

Verified & found correct & recommended for payment:

Signature of AEE/ DEE

Accepted for payment:

Signature of EE

NB: *In case JE/ AE/ AEE/ DEE do not agree to the report, then he shall return the report to the reporting officer with reason.*

Annex - III
(Schedule-E)

ESTIMATE FOR OPERATION & MAINTENANCE OF THE WORK "130 MLD Water Treatment Plant and its Ancillary Structures for Improvement of Water Supply to Bhubaneswar City" FOR 5 YEARS

A] Estimated Construction Cost of the Project : Rs.26000.00 lakh

B] Estimated Annual Operation & Maintenance Cost :

1.	**Annual Cost of Manpower (Calculated basing on present labour rate)**	**: Rs. 68.84lakh**
2.	**Annual Cost of Chemicals, Consumables and Other Materials & Spare parts required for Operation & Maintenance (Excluding energy charges) (Calculated basing on present rate of chemicals & materials etc.)**	**: Rs. 274.68 lakh**
3.	**Annual cost of Energy charges 99.55 lakh units (KWh) @ Rs.7.00/KWh**	**: Rs. 696.83 lakh**
	Total O&M Cost/Year	**: Rs.1040.35 lakh**
	O&M Cost for 5 years (Rs.1040.35 lakh x 5 year)	**: Rs.5201.75 lakh**

Or Say Rs. 5200.00 Lakh

REQUIREMENT OF MANPOWER FOR OPERATION AND MAINTENANCE OF STAFF AS PER YARD STICK for the work "130 MLD Water Treatment Plant and its Ancillary Structures for Improvement of Water Supply to Bhubaneswar City"

Sl. No.	System component as per flowline	Pump Driver	Khalasi	Fitter Mistry	Filter Operator	Meter reader	Meter Ledger Clerk	Bill Clerk	Mechanic	Watch-man	Analyst	Lab. Asst.
1	2	3	4	5	6	7	8	9	10	11	12	13
1	Intake well 130 MLD Capacity at in on river "Mahanadi" at Mundali (4 x 400 HP VT Pumps)	2	3	-	-	-	-	-	-	-	-	-
2	Raw water rising main **1420 mm(OD)** size **S.W.M.S** (12mm thick) from intake well to WTP & clear water rising main from WTP to proposed MBR = 21.00 KM)	-	2	2	-	-	-	-	-	-	-	-
3	Water Treatment Plant of 130 MLD Capacity	-	4	-	2	-	-	-	-	3	1	1
4	Clear water pump house near WTP and at MBR (**6 x 350 HP** capacity and **4 x 250 HP Centrifugal Pump sets**)	3	3	1	-	-	-	-	-	-	-	-
5	**2 x 3.00 ML capacity RCC Elevated Storage Reservoir**	-	2	2	-	-	-	-	-	-	-	-
6	For Billing and service connections & House connection.	-	-	-	-	1	-	-	-	-	-	-
7	Telephone booths for receiving complain.	-	1	-	-	-	-	-	-	-	-	-
8	Mechanical Staff.	-	-	-	-	-	-	-	2	-	-	-
Total:		**5**	**15**	**5**	**2**	**1**	**0**	**0**	**2**	**3**	**1**	**1**
											Total :	**35**

Annual Cost for Engagement of Man Power

Sl. No.	Man power	Nos.	Category	Remuneration per day (Rs.)	Annual Cost (In Rs.)
1	Analyst + Mechanic	1	Highly Skilled	430.00	1,56,950.00
2	Pump Driver+ Fitter Mistry+ Filter Operator+ Meter Reader+ Meter Ledger Clerk+ Bill clerk + Lab Asst.	24	Skilled	370.00	32,41,200.00
3	Khalasi	19	Semi Skilled	320.00	22,19,200.00
4	Watch Man	3	Unskilled	280.00	3,06,600.00
	Total:	**47**			**59,23,950.00**

(I) **Annual Cost of Manpower :**

(i)	Annual Remuneration of Manpower.	= Rs.	59,23,950.00
(ii)	Contribution towards EPF @ 13.61% on item (i)	= Rs.	806249.60
(iii)	Contribution towards E.S.I. @ 4.75% on item (i)	= Rs.	281387.63
(iv)	**Sub-Total:**	**= Rs.**	**70,11,587.22**
(v)	Overhead charges & Contractor's profit on item (i) @ 7.5% each (15%)	= Rs.	1051738.08
(vi)	**Total: (iv) + (v)**	**= Rs.**	**80,63,325.30**
	Add Labour Cess @ 1% on item (vi)		80633.25
	Grand Total:		**81,43,958.56**
		Or Say Rs.	**81.44** **Lakhs**

YEARWISE CONSUMPTION OF WATER

Year	Water requirement in MLD
1	**2**
2025	100.00
2026	106.00
2027	112.00
2028	118.00
2029	124.00
Total	**560.00**
Yearly Average	**112**

Average Daily Demand		=	112.00	MLD			
Annual Consumption of Chlorine (4.08 x 365 @ 3ppm)		=	122.64	MT	Say	123.00	MT
Annual Consumption of Alum (Grade-IV) = (4.08 @ 7 MT/MLD)		=	392.00	MT	Say	29.00	MT
Annual Consumption of PAC towards 50% of Alum		=	196.00	MT	Say	196.00	MT
Annual Consumption of Lime (1/3rd of Alum)		=	130.67	MT	Say	131.00	MT

Annual Cost of Chemicals

Sl. No.	Name of Chemicals	Quantity in MT required	Rate per MT in Rs.	Total amount (in Rs.)
1	Alum	392.00	8502.01	3332787.92
2	Lime	131.00	5851.01	766482.31
3	PAC	196.00	9529.01	1867685.96
4	Liquid Chlorine (Gas Cylinder (Tonner)	123.00	9826.79	1208695.17
			TOTAL:	**71,75,651.36**
			Or Say Rs.	**71,75,650.00**

(2) Annual Cost of Chemicals, Consumables & Maintenance including Spare Parts:

(i)	Annual cost of Chemicals (Base Year : 2023-24):	= Rs.	71,75,650.00
(ii)	Annual cost of repair and replacement including Spare parts and supervision etc. @ 2.0 times of cost of chemicals (w.r.t. Para 2.3.13 of O&M Manual of W/S System of CPHEEO)	= Rs.	1,43,51,300.00
(iii)	**Sub-Total:**	**= Rs.**	2,15,26,950.00
	Add Labour Cess @ 1% on item (iii)	= Rs.	2,15,270.00
	Overhead charges & Contractor's profit on item (i) @ 7.5% each (15%) on item (iii)	= Rs.	32,29,043.00
	Total cost for the year (2024-25)	**= Rs.**	**2,49,71,263.00**
	Add 10% increase during construction period of two years (i.e. from 2019-20 to 2020-21) @ 5% per annum	= Rs.	24,97,126.00
	Total cost for the year (2025-26) i.e., 1st year of Maintenance	**= Rs.**	**2,74,68,389.00**

Or Say Rs. 274.68 Lakhs

Cost Analysis of Chemicals/M.T.

Distance		
Rairangpur to Cuttack =	272	KM
Rairangpur to Ganjam =	438	KM

Basic Rate (in Rs.)	
Alum:	8151.00
Lime:	5500.00
Chlorine Gas:	8400.00

GST	Distance in KM			Rate in Rs.
18%	438	272	272	
	5	5	5	161.72
	45	45	45	8.23
	388	222	222	6.99

ALUM

Sl. No.	Item.	Quantity	Rate	Unit	Amount	Carriage	GST (18%) (6+7) x 18%	Total	Remarks
1	2	3	4	5	6	7	8	9	10
1	Alum	01 M.T.	8151.00	M.T.	8151.00	2083.85	1842.27	**12077.12**	

LIME

Sl. No.	Item	Quantity	Rate	Unit	Amount	Carriage	GST (18%) (6+7) x 18%	Total	Remarks
1	2	3	4	5	6	7	8	9	10
1	Lime	01 M.T.	5500.00	M.T.	5500.00	2083.85	1365.09	**8948.94**	

CHLORINE GAS CYLINDER

Sl. No.	Item	Quantity	Rate	Unit	Amount	Carriage	GST (18%) (6+7) x 18%	Total	Remarks
1	2	3	4	5	6	7	8	9	10
1	Chlorine Gas Cylinder	01 M.T.	8400.00	M.T.	8400.00	3244.19	2095.95	**13740.14**	

TRANSPORTATION (CHLORINE CYLINDER):

1ST 5 KM	…Rs.	161.72
Rate for 45 KM	…Rs.	370.35
Rate for Rest KM	…Rs.	2712.12
Total: (/MT)	**…Rs.**	**3244.19**

TRANSPORTATION (ALUM)

1ST 5 KM	… Rs.	161.72
Rate for 45 KM	… Rs.	370.35
Rate for Rest KM	… Rs.	1551.78
Total: (/MT)	**… Rs.**	**2083.85**

TRANSPORTATION (LIME)

1ST 5 KM	…Rs.	161.72
Rate for 45 KM	…Rs.	370.35
Rate for Rest KM	…Rs.	1551.78
Total: (/MT)	**…Rs.**	**2083.85**

Energy Charges

HP x 0.746 KW

Sl. No.	Description of item	HP	Total KW	No. of Working Hours/Day		Monthly KW-Hr.	Tariff in Rs./ KW-Hr.	Amount per Month
1	Raw water pump sets (HT Connection) – KW	800	596.80	22	Hr./day	358080.00	7.00	25,06,560.00
2	WTP & CWR Pump House (HT Connection) – KW	700	522.20	22	Hr./day	313320.00	7.00	21,93,240.00
3	Clear water pump sets at MBR (HT Connection) – KW	500	373.00	13.82	Hr./day	156660.00	7.00	10,96,620.00
5	Other loadings in (LT) for Office/Store/Yard lighting etc. – KW		5.00	12	Hr./day	1500.00	7.00	10,500.00
6	Others, if any		-	-	-	-	-	-
Total power charges per Month:						**42,719**	**8,29,560.00**	
Total power charges per Annum:							**Or Say Rs.**	**6,96,83,040.00**

Or Say Rs. 696.83 Lakh

SCHEDULE – E

(See Clauses 2.1 and 14.2)

OPERATION & MAINTENANCE REQUIREMENTS

1. Operation & Maintenance Requirements

1.1 The Contractor shall, at all times operate & maintain the Water Supply Projects in accordance with the provisions of this Agreement, Applicable Laws and Applicable Permits.

1.2 The Contractor shall repair or rectify any Defect or deficiency set forth in Paragraph 2 of this Schedule-E within the time limit specified therein and any failure in this behalf shall constitute non-fulfillment of the Operation & Maintenance obligations by the Contractor. Upon occurrence of any breach hereunder, the Authority shall be entitled to effect reduction in monthly lump sum payment as set forth in Clause 14.6 of this Agreement, without prejudice to the rights of the Authority under this Agreement, including Termination thereof.

1.3 All Materials, works and construction operation &Maintenance shall conform to the relevant IS specification and CPHEEO Manual of MoUD publications. Where the specifications for a work are not given, Good Industry Practice shall be adopted. [Specify all the relevant documents]

2. Repair/rectification of Defects and deficiencies

The obligations of the Contractor in respect of Operation & Maintenance Requirements shall include repair and rectification of the Defects and deficiencies specified in Annex - I of this Schedule-E within the time limit set forth therein.

3. Other Defects and deficiencies

In respect of any Defect or deficiency not specified in Annex - I of this Schedule-E, the Authority's Engineer may, in conformity with Good Industry Practice, specify the permissible limit of deviation or deterioration with reference to the Specifications and Standards, and any deviation or deterioration beyond the permissible limit shall be repaired or rectified by the Contractor within the time limit specified by the Authority's Engineer.

4 Extension of time limit

Notwithstanding anything to the contrary specified in this Schedule-E, if the nature and extent of any Defect or deficiency justifies more time for its repair or rectification than the time specified herein, the Contractor shall be entitled to additional time in conformity with Good Industry Practice. Such additional time shall be determined by the Authority's Engineer and conveyed to the Contractor and the Authority with reasons thereof.

5 Emergency repairs/restoration

Notwithstanding anything to the contrary contained in this Schedule-E, if any Defect, deficiency or deterioration in the Water Supply Projects poses a hazard to safety or risk of damage to property, the Contractor shall promptly take all reasonable measures for eliminating or minimizing such danger.

6 Daily inspection by the Contractor

The Contractor shall, through its engineer, undertake a daily visual inspection of the Water Supply Projects and maintain a record thereof in a register to be kept in such form and manner as the Authority may specify. Such record shall be kept in safe custody of the Contractor and shall be open to inspection by the

Authority at any time during office hours.

7. Pre-monsoon inspection / Post-monsoon inspection

Deleted

8. Repairs on account of natural calamities

All damages occurring to the Water Supply Projects on account of a Force Majeure Event or default or neglect of the Authority shall be undertaken by the Authority at its own cost. The Authority may instruct the Contractor to undertake the repairs at the rates agreed between the Parties.

SCHEDULE - F

(See Clause 3.1.7(a))

APPLICABLE PERMITS

1 Applicable Permits

1.1 The Contractor shall obtain permits and clearances as required under the Applicable Laws for smooth execution of works:

1.2 Applicable Permits, as required, relating to environmental protection and conservation shall have been procured by the Authority in accordance with the provisions of this Agreement.

1.3 The Contractor shall be solely responsible for obtaining the required permits and the Authority will not be liable for payment of compensation on any account for failure in the part of the Contractor to obtain any such permits. However the authority will facilitate to obtain permits/clearances from the concerned Department.

SCHEDULE-G

(See Clauses 7.1.1, 7.5.3 and 19.2)

FORM OF BANK GUARANTEE

Annex-I

(See Clause 7.1.1)

Performance Security

The Chief Executive Officer,
WATCO, Odisha, Bhubaneswar.

WHEREAS:

(A) _____[name and address of contractor] (hereinafter called the "**Contractor**") has executed an agreement (hereinafter called the "Agreement") with the [General Manager, WATCO Division-I, Bhubaneswar representing the Chief Executive Officer, WATCO, Odisha], (hereinafter called the "**Authority**") for the construction of the work **"Construction of 130MLD Water Treatment Plant and its Ancillary Structures for Improvement of Water Supply to Bhubaneswar City including Operation & Maintenance for a Period of Five Years"** on Engineering, Procurement and Construction (the "**EPC**") basis, subject to and in accordance with the provisions of the Agreement.

(B) The Agreement requires the Contractor to furnish a Performance Security for due and faithful performance of its obligations, under and in accordance with the Agreement, during the {Construction Period/ Defects Liability Periodand operation maintenance period}(as defined in the Agreement) in a sum of Rs…… cr. (Rupees ……..….. crore) (the "**Guarantee Amount**").

(C) We, …….. through our branch at ……. (the "**Bank**") have agreed to furnish this bank guarantee (*hereinafter called the* **"Guarantee**") by way of Performance Security.

NOW, THEREFORE, the Bank hereby, unconditionally and irrevocably, guarantees and affirms as follows:

1. The Bank hereby unconditionally and irrevocably guarantees the due and faithful performance of the Contractor's obligations during the {Construction Period/ Defects Liability Period and Operation & Maintenance period} under and in accordance with the Agreement, and agrees and undertakes to pay to the Authority, upon its mere first written demand, and without any demur, reservation, recourse, contest or protest, and without any reference to the Contractor, such sum or sums up to an aggregate sum of the Guarantee Amount as the Authority shall claim, without the Authority being required to prove or to show grounds or reasons for its demand and/or for the sum specified therein.
2. A letter from the Authority, under the hand of an officer not below the rank of **[General Manager, WATCO Division-I, Bhubaneswar],** that the Contractor has committed default in the due and faithful performance of all or any of its obligations under and in accordance with the Agreement shall be conclusive, final and binding on the Bank. The Bank further agrees that the Authority shall be the sole judge as to whether the Contractor is in default in due and faithful

performance of its obligations during and under the Agreement and its decision that the Contractor is in default shall be final and binding on the Bank, notwithstanding any differences between the Authority and the Contractor, or any dispute between them pending before any court, tribunal, arbitrators or any other authority or body, or by the discharge of the Contractor for any reason whatsoever.

3. In order to give effect to this Guarantee, the Authority shall be entitled to act as if the Bank were the principal debtor and any change in the constitution of the Contractor and/or the Bank, whether by their absorption with any other body or corporation or otherwise, shall not in any way or manner affect the liability or obligation of the Bank under this Guarantee.
4. It shall not be necessary, and the Bank hereby waives any necessity, for the Authority to proceed against the Contractor before presenting to the Bank its demand under this Guarantee.
5. The Authority shall have the liberty, without affecting in any manner the liability of the Bank under this Guarantee, to vary at any time, the terms and conditions of the Agreement or to extend the time or period for the compliance with, fulfillment and/ or performance of all or any of the obligations of the Contractor contained in the Agreement or to postpone for any time, and from time to time, any of the rights and powers exercisable by the Authority against the Contractor, and either to enforce or forbear from enforcing any of the terms and conditions contained in the Agreement and/or the securities available to the Authority, and the Bank shall not be released from its liability and obligation under these presents by any exercise by the Authority of the liberty with reference to the matters aforesaid or by reason of time being given to the Contractor or any other forbearance, indulgence, act or omission on the part of the Authority or of any other matter or thing whatsoever which under any law relating to sureties and guarantors would but for this provision have the effect of releasing the Bank from its liability and obligation under this Guarantee and the Bank hereby waives all of its rights under any such law.
6. This Guarantee is in addition to and not in substitution of any other guarantee or security now or which may hereafter be held by the Authority in respect of or relating to the Agreement or for the fulfilment, compliance and/or performance of all or any of the obligations of the Contractor under the Agreement.
7. Notwithstanding anything contained hereinbefore, the liability of the Bank under this Guarantee is restricted to the Guarantee Amount and this Guarantee will remain in force for the period specified in paragraph 8 below and unless a demand or claim in writing is made by the Authority on the Bank under this Guarantee all rights of the Authority under this Guarantee shall be forfeited and the Bank shall be relieved from its liabilities hereunder.
8. The Guarantee shall cease to be in force and effect on ****[$]. Unless a demand or claim under this Guarantee is made in writing before expiry of the Guarantee, the Bank shall be discharged from its liabilities hereunder.
9. The Bank undertakes not to revoke this Guarantee during its currency, except

[$]Insert date being 2 (two) years from the date of issuance of this Guarantee (in accordance with Clause 7.2 of the Agreement).

with the previous express consent of the Authority in writing, and declares and warrants that it has the power to issue this Guarantee and the undersigned has full powers to do so on behalf of the Bank.

10. Any notice by way of request, demand or otherwise hereunder may be sent by post addressed to the Bank at its above referred branch, which shall be deemed to have been duly authorized to receive such notice and to effect payment thereof forthwith, and if sent by post it shall be deemed to have been given at the time when it ought to have been delivered in due course of post and in proving such notice, when given by post, it shall be sufficient to prove that the envelope containing the notice was posted and a certificate signed by an officer of the Authority that the envelope was so posted shall be conclusive.

11. This Guarantee shall come into force with immediate effect and shall remain in force and effect for up to the date specified in paragraph 8 above or until it is released earlier by the Authority pursuant to the provisions of the Agreement.

Signed and sealed this ……. day of …….., 20…… at ……..

SIGNED, SEALED AND DELIVERED

For and on behalf of the Bank by:

(Signature)

(Name)

(Designation)

(Code Number)

(Address)

NOTES:

(i) The bank guarantee should contain the name, designation and code number of the officer(s) signing the guarantee.

(ii) The address, telephone number and other details of the head office of the Bank as well as of issuing branch should be mentioned on the covering letter of issuing branch.

(iii) The stamp papers of appropriate value shall be purchased in the name of bank who issues the "Bank Guarantee".

(iv) The bank guarantee shall be from a Nationalised/Scheduled Indian Bank with counter guaranteed by its branch at **Bhubaneswar**.

Annex – II
(Schedule - G)
(See Clause 7.5.3)

Form for Guarantee for Withdrawal of Retention Money

The Chief Executive Officer,
WATCO, Odisha, Bhubaneswar.

WHEREAS:

(A) [name and address of contractor] (hereinafter called the "**Contractor**") has executed an agreement (hereinafter called the "Agreement") with the [General Manager, WATCO Division-I, Bhubaneswar representing the Chief Executive Officer, WATCO, Odisha], (hereinafter called the "**Authority**") for the construction of the work "**Construction of 130MLD Water Treatment Plant and its Ancillary Structures for Improvement of Water Supply to Bhubaneswar City including Operation & Maintenance for a Period of Five Years"** on Engineering, Procurement and Construction (the "**EPC**") basis, subject to and in accordance with the provisions of the Agreement.

(B) In accordance with Clause 7.5.3 of the Agreement, the Contractor may withdraw the retention money (hereinafter called the "**Retention Money**") after furnishing to the Authority a bank guarantee for an amount equal to the proposed withdrawal.

(C) We, …….. through our branch at ……. (the "**Bank**") have agreed to furnish this bank guarantee (hereinafter called the "**Guarantee**") for the amount of Rs. --------- cr. (Rs.----------crore) (the "**Guarantee Amount**").

NOW, THEREFORE, the Bank hereby unconditionally and irrevocably guarantees and affirms as follows:

1. The Bank hereby unconditionally and irrevocably undertakes to pay to the Authority, upon its mere first written demand, and without any demur, reservation, recourse, contest or protest, and without any reference to the Contractor, such sum or sums up to an aggregate sum of the Guarantee Amount as the Authority shall claim, without the Authority being required to prove or to show grounds or reasons for its demand and/or for the sum specified therein.
2. A letter from the Authority, under the hand of an officer not below the rank of **[General Manager, WATCO Division-I, Bhubaneswar],,** that the Contractor has committed default in the due and faithful performance of all or any of its obligations for under and in accordance with the Agreement shall be conclusive, final and binding on the Bank. The Bank further agrees that the Authority shall be the sole judge as to whether the Contractor is in default in due and faithful performance of its obligations during and under the Agreement and its decision that the Contractor is in default shall be final, and binding on the Bank, notwithstanding any differences between the Authority and the Contractor, or any dispute between them pending before any court, tribunal, arbitrators or any other authority or body, or by the discharge of the Contractor for any reason

whatsoever.

3. In order to give effect to this Guarantee, the Authority shall be entitled to act as if the Bank were the principal debtor and any change in the constitution of the Contractor and/or the Bank, whether by their absorption with any other body or corporation or otherwise, shall not in any way or manner affect the liability or obligation of the Bank under this Guarantee.
4. It shall not be necessary, and the Bank hereby waives any necessity, for the Authority to proceed against the Contractor before presenting to the Bank its demand under this Guarantee.
5. The Authority shall have the liberty, without affecting in any manner the liability of the Bank under this Guarantee, to vary at any time, the terms and conditions of the Retention Money and any of the rights and powers exercisable by the Authority against the Contractor, and either to enforce or forbear from enforcing any of the terms and conditions contained in the Agreement and/or the securities available to the Authority, and the Bank shall not be released from its liability and obligation under these presents by any exercise by the Authority of the liberty with reference to the matters aforesaid or by reason of time being given to the Contractor or any other forbearance, indulgence, act or omission on the part of the Authority or of any other matter or thing whatsoever which under any law relating to sureties and guarantors would but for this provision have the effect of releasing the Bank from its liability and obligation under this Guarantee and the Bank hereby waives all of its rights under any such law.
6. This Guarantee is in addition to and not in substitution of any other guarantee or security now or which may hereafter be held by the Authority in respect of or relating to the Retention Money.
7. Notwithstanding anything contained hereinbefore, the liability of the Bank under this Guarantee is restricted to the Guarantee Amount and this Guarantee will remain in force for the period specified in paragraph 8 below and unless a demand or claim in writing is made by the Authority on the Bank under this Guarantee all rights of the Authority under this Guarantee shall be forfeited and the Bank shall be relieved from its liabilities hereunder.
8. The Guarantee shall cease to be in force and effect 90 (ninety) days after the date of the Completion Certificate specified in Clause 12.4 of the Agreement.
9. The Bank undertakes not to revoke this Guarantee during its currency, except with the previous express consent of the Authority in writing, and declares and warrants that it has the power to issue this Guarantee and the undersigned has full powers to do so on behalf of the Bank.
10. Any notice by way of request, demand or otherwise hereunder may be sent by post addressed to the Bank at its above referred branch, which shall be deemed to have been duly authorized to receive such notice and to effect payment thereof forthwith, and if sent by post it shall be deemed to have been given at the time when it ought to have been delivered in due course of post and in proving such notice, when given by post, it shall be sufficient to prove that the envelope containing the notice was posted and a certificate signed by an officer of the Authority that the envelope was so posted shall be conclusive.
11. This Guarantee shall come into force with immediate effect and shall remain in force and effect up to the date specified in paragraph 8 above or until it is released earlier by the Authority pursuant to the provisions of the Agreement.

Signed and sealed this ……. day of ……., 20…… at ……..

SIGNED, SEALED AND DELIVERED

For and on behalf of the Bank by:
(Signature)
(Name)
(Designation)
(Code Number)
(Address)

NOTES:

(i) The bank guarantee should contain the name, designation and code number of the officer(s) signing the guarantee.

(ii) The address, telephone number and other details of the head office of the Bank as well as of issuing branch should be mentioned on the covering letter of issuing branch.

(iii) The stamp papers of appropriate value shall be purchased in the name of bank who issues the "Bank Guarantee".

(v) The bank guarantee shall be from a Nationalised/Scheduled Indian Bank with counter guaranteed by its branch at **Bhubaneswar**.

Annex–III
(Schedule - G)
(See Clause 19.2)

Form for Guarantee for Advance Payment

The Chief Executive Officer,
WATCO, Odisha, Bhubaneswar

WHEREAS:

(A) [name and address of contractor] (hereinafter called the "**Contractor**") has executed an agreement (hereinafter called the "Agreement") with the General Manager, WATCO Division-I, Bhubaneswar representing the Chief Executive Officer, WATCO, Odisha],, (hereinafter called the "**Authority**") for the construction of the work **"Construction of 130MLD Water Treatment Plant and its Ancillary Structures for Improvement of Water Supply to Bhubaneswar City including Operation & Maintenance for a Period of Five Years"**)on Engineering, Procurement and Construction (the "**EPC**") basis, subject to and in accordance with the provisions of the Agreement.

(B) In accordance with Clause 19.2 of the Agreement, the Authority shall make to the Contractor an interest bearing advance payment @10% per Annum (herein after called "**Advance Payment**") equal to 10% (ten per cent) of the Contract Price; and that the Advance Payment shall be made in fourinstallments subject to the Contractor furnishing an irrevocable and unconditional guarantee by a Nationalised Bank, counter guaranteed by its branch at Bhubaneswar for an amount equivalent to 110% (one hundred and ten percent) of suchinstallment to remain effective till the complete and full repayment of the installment of the Advance Payment as security for compliance with its obligations in accordance with the Agreement.The amount of {first/second/third/fourth}installment of the Advance Payment is Rs. ------ cr. (Rupees ------ crore) andthe amount of this Guarantee is Rs. ------- cr. (Rupees ------ crore)(the**"Guarantee Amount")**[$]**.**

(C) We, …….. through our branch at ……. (the "Bank") have agreed to furnish this bank guarantee (hereinafter called the "Guarantee") for the Guarantee Amount.

NOW, THEREFORE, the Bank hereby, unconditionally and irrevocably, guarantees and affirms as follows:

1. The Bank hereby unconditionally and irrevocably guarantees the due and faithful repayment on time of the aforesaid instalment of the Advance Payment under and in accordance with the Agreement, and agrees and undertakes to pay to the Authority, upon its mere first written demand, and without any demur, reservation, recourse, contest or protest, and without any reference to the Contractor, such sum or sums up to an aggregate sum of the Guarantee Amount as

[$] The Guarantee Amount should be equivalent to 110% of the value of the applicable instalment.

the Authority shall claim, without the Authority being required to prove or to show grounds or reasons for its demand and/or for the sum specified therein.

2. A letter from the Authority, under the hand of an officer not below the rank of **[General Manager, WATCO Division-I, Bhubaneswar]**, that the Contractor has committed default in the due and faithful performance of all or any of its obligations for the repayment of the instalment of the Advance Payment under and in accordance with the Agreement shall be conclusive, final and binding on the Bank. The Bank further agrees that the Authority shall be the sole judge as to whether the Contractor is in default in due and faithful performance of its obligations during and under the Agreement and its decision that the Contractor is in default shall be final and binding on the Bank, notwithstanding any differences between the Authority and the Contractor, or any dispute between them pending before any court, tribunal, arbitrators or any other authority or body, or by the discharge of the Contractor for any reason whatsoever.

3. In order to give effect to this Guarantee, the Authority shall be entitled to act as if the Bank were the principal debtor and any change in the constitution of the Contractor and/or the Bank, whether by their absorption with any other body or corporation or otherwise, shall not in any way or manner affect the liability or obligation of the Bank under this Guarantee.

4. It shall not be necessary, and the Bank hereby waives any necessity, for the Authority to proceed against the Contractor before presenting to the Bank its demand under this Guarantee.

5. The Authority shall have the liberty, without affecting in any manner the liability of the Bank under this Guarantee, to vary at any time, the terms and conditions of the Advance Payment or to extend the time or period of its repayment or to postpone for any time, and from time to time, any of the rights and powers exercisable by the Authority against the Contractor, and either to enforce or forbear from enforcing any of the terms and conditions contained in the Agreement and/or the securities available to the Authority, and the Bank shall not be released from its liability and obligation under these presents by any exercise by the Authority of the liberty with reference to the matters aforesaid or by reason of time being given to the Contractor or any other forbearance, indulgence, act or omission on the part of the Authority or of any other matter or thing whatsoever which under any law relating to sureties and guarantors would but for this provision have the effect of releasing the Bank from its liability and obligation under this Guarantee and the Bank hereby waives all of its rights under any such law.

6. This Guarantee is in addition to and not in substitution of any other guarantee or security now or which may hereafter be held by the Authority in respect of or relating to the Advance Payment.

7. Notwithstanding anything contained hereinbefore, the liability of the Bank under this Guarantee is restricted to the Guarantee Amount and this Guarantee will remain in force for the period specified in paragraph 8 below and unless a demand or claim in writing is made by the Authority on the Bank under this Guarantee all rights of the Authority under this Guarantee shall be forfeited and the Bank shall be relieved from its liabilities hereunder.

8. The Guarantee shall cease to be in force and effect on ****.[$] Unless a demand or

[$] Insert a date being 90 (ninety) days after the end of one year from the date of payment of theAdvance payment to the Contractor (in accordance with Clause 19.2 of the Agreement).

claim under this Guarantee is made in writing on or before the aforesaid date, the Bank shall be discharged from its liabilities hereunder.

9. The Bank undertakes not to revoke this Guarantee during its currency, except with the previous express consent of the Authority in writing, and declares and warrants that it has the power to issue this Guarantee and the undersigned has full powers to do so on behalf of the Bank.

10. Any notice by way of request, demand or otherwise hereunder may be sent by post addressed to the Bank at its above referred branch, which shall be deemed to have been duly authorised to receive such notice and to effect payment thereof forthwith, and if sent by post it shall be deemed to have been given at the time when it ought to have been delivered in due course of post and in proving such notice, when given by post, it shall be sufficient to prove that the envelope containing the notice was posted and a certificate signed by an officer of the Authority that the envelope was so posted shall be conclusive.

11. This Guarantee shall come into force with immediate effect and shall remain in force and effect up to the date specified in paragraph 8 above or until it is released earlier by the Authority pursuant to the provisions of the Agreement.

Signed and sealed this ……. day of ……., 20…… at ……..

SIGNED, SEALED AND DELIVERED

For and on behalf of the Bank by:

(Signature)

(Name)

(Designation)

(Code Number)

(Address)

NOTES:

(i) The bank guarantee should contain the name, designation and code number of the officer(s) signing the guarantee.

(ii) The address, telephone number and other details of the head office of the Bank as well as of issuing branch should be mentioned on the covering letter of issuing branch.

(iii) The stamp papers of appropriate value shall be purchased in the name of bank who issues the "Bank Guarantee".

(iv) The bank guarantee shall be from a Nationalised/Scheduled Indian Bank with counter guaranteed by its branch at **Bhubaneswar**.

———

SCHEDULE - H

(See Clauses10.1.4 and 19.3)

Contract Price Weightage

1.1 The Contract Price for this Agreement is Rs. ******

1.2 Proportions of the Contract Price for different stages of Construction of the Project shall be as specified below:

(**In order to closely monitor the execution of the project and to ensure quality, cost and time of the project without compromising in any manner, the contractor shall provide work programme in such a realistic manner so that there will be balance between financial & physical progress with reference to cost & completion time.)**

(A) WATER SUPLY PROJECT WISE PAYMENT BREAK-UP SCHEDULE IN PERCENTAGE

Sl No	Description of Item	Mundali, Bhubaneswar in Rs.	% to Agreement Price
1	**Construction Cost**	**2,60,00,00,000.00**	83.33
2	**Operation & Maintenance Cost for five year excluding Energy Charges**	16,90,00,000.00	5.42
3	**Energy Charges for Five Years**	35,10,00,000.00	11.25
		3,12,00,00,000.00	

(B) WATER SUPLY PROJECT COMPONENT-WISE PAYMENT BREAK-UP SCHEDULE IN PERCENTAGE FOR MAJOR COMPONENTS OF WORK FOR CONSTRUCTION

Sl No.	Description of Item (Mundali, Bhubaneswar)	% to Total Project Cost
1	Intake arrangement with Electrical & Mechanical units with Supply & Installation of Silent DG Sets	7.04
2	130 MLD Water Treatment Plant, Wash Water Recirculation & Sludge removal arrangement with Electrical & Mechanical units	34.15
3	Raw Water/Clear water rising main	28.90
4	MBR & ESRs with Electrical & Mechanical units	11.44
5	HT Cabling & constrution of Cable Trench	2.12
6	Supply & Installation of AC Server (2W+1S) for Data Communication & Syncronise Panel (6Nos) for DG sets with breaker	0.38
7	Complete SCADA & Automation system for Intake, WTP & MBR site & construction of PLC Cotrol Room & Battery Bank, UPS etc	7.77
8	Electrical Hoisting Arrangement and Industrial Grade Yard Lighting with Tower for Intake, WTP & MBR site	3.88
9	Boundary Wall with Gate & site development etc	0.78
10	4 Nos Ground Storage reservoir for Diesel fuel	0.16
11	Detailed Survey & Investigation and preparation of Base Data	0.98
12	Provision for Temporary W/S, Power Supply to Intake, WTP, MBR Site, Obtaining Boiler & Explosive liscence. Provision Towards all risk (CAR) & Safety Handling	1.64
13	Electrical feeder Bay extension at Existing WTP with provision of VCB & stringing of 33KV OH lineincluding Isolator on Both side.	0.76
	Total	**100.00**

(C) SCHEDULE OF BREAK-DOWN PAYMENT AGINST MAJOR COMPONENTS OF WORKS UNDER ITEM A & B ABOVE.

[To be furnished by the Successful Bidder after due approval of the construction schedule for the period of 24 months as per Schedule-J by the authority. The decision of the authority i.e., PHEO is final & binding on the proposal of the successful bidder regarding break-down payment schedule]

If payment is on a periodic basis according to pre-estimated construction progress.

Month	Description	Type of Payment	Amount for INR Portion			
			Civil works	Design & Documentation	Plant &Equipment	Total
1st 2nd 3rd 24th						
Total						

Note:

*(i) The Employer and the Contractor may make necessary **Approval and adjustments** to the payment schedule if the progress of work is substantially ahead of or behind the program.*

*(ii) The Contractor shall make necessary break down of Civil works for Payment Schedule with reference to the Table **A0.***

Table A0 Break Down of Civil Works Payment Schedule for Interim Valuations		
Major Work Category	**Type of Payment**	**Payment (in % of Total Price)**
1.Water Retaining Structure Units		
(i) Up to Base slab	LS	15%
(ii) Walls	LS	
(a) Half Stage of Design Height		25%
(b) Full Stage Design Height		25%
(iii) Platform, Handrail and other Miscellaneous Works	LS	25%
(iv) Hydraulic Testing	LS	5%
(v) On successful Testing, Commissioning & Stabilization	LS	5%
2. Other Units		
(i) Up to Base Slab / Foundation	LS	25%
(ii) Walls	LS	50%
(iii) Platform, Handrail and other Miscellaneous Works	LS	15%
(iv) On successful Testing, Commissioning & Stabilization	LS	10%
3. Buildings (Single Storeyed)		
(i) Up to Plinth Level	LS	15%
(ii) Up to Roof Slab(including Roof Slab)	LS	25%
(iii) Brick work, Internal & External Plastering	LS	20%
(iv) Flooring, Plastering, Doors, Windows, Painting, Waterproofing & other Miscellaneous Works	LS	30%
(v) On successful Testing, Commissioning	LS	10%
4. Buildings (Double Storied)		
(i) Up to Plinth Level	LS	10%
(ii) Up to Ground floor Roof Slab(including Roof Slab)	LS	15%
(iii) Up to First floor Roof Slab(including Roof Slab)	LS	15%
(iv) Brick work, Internal & External Plastering	LS	20%
(v) Flooring, Plastering, Doors, Windows, Painting, Waterproofing & other Miscellaneous Works	LS	30%
(vi) On successful Testing, Commissioning	LS	10%
5. Boundary Wall Complete		
(i) On completion per meter	P	90%
(ii) On successful Commissioning	LS	10%

Table A0 Break Down of Civil Works Payment Schedule for Interim Valuations		
Major Work Category	**Type of Payment**	**Payment (in % of Total Price)**
6. Landscaping Complete		
(i) Hard Landscaping On completion per Square meter	P	30%
(ii) Soft Landscaping On completion per Square meter	P	30%
(iii) Planting of Trees, Shrubs	P	20%
(iv) Completion	LS	20%
7. Roads, Pavements Complete		
(i) On completion per square meter	P	90%
(ii) On successful Commissioning	LS	10%
8. **Supplying & Laying of Spirally welded M.S. Pipelines**		
(i) On Delivery of DI Pipe duly inspected by Third Party Inspection as per the work schedule approved by Engineer-in-Charge with responsibility of contractor for safely stacking, storing, handling, watch & ward etc till completion in all respect (%age to be paid on the item brought to the site)	P	75%
(ii) On completion of laying of pipeline	P	15%
(iii) Testing & Commissioning	LS	10%
9. **Supplying & installation of pump sets**		
(i) On Delivery of pump sets duly inspected by Third Party Inspection as per the work schedule approved by Engineer-in-Charge with responsibility of contractor for safely storing, handling, watch & ward etc till completion in all respect (%age to be paid on the item brought to the site)	P	70%
(ii) On completion of installation	P	20%
(iii) Testing & Commissioning	LS	10%

SCHEDULE OF PRICES

Name of Work	**Construction of 130MLD Water Treatment Plant and its Ancillary Structures for Improvement of Water Supply to Bhubaneswar City including Operation & Maintenance for a Period of Five Years on Engineering, Procurement & Construction (EPC) Contract**

Note: Described full name of work listed in PREAMBLE of Schedules of Rates and Prices

A1 Design, Drawings and Documentation

Item	Description	Unit	Quantity	Unit Rate		Total Price	
					Local Currency Portion (INR)		Local (INR)
Total (to Schedule A-5-a Summary of Work)							

A2 Plant & Equipment including mandatory spare parts, to be supplied from within India

Item	Description	Unit	Quantity	Ex-Factory Price (INR)	GST (INR)	Freight & Insurance (INR)	Total Price (INR)
						Total (to Schedule A-5-a Summary of Work)	

A3 Civil Works, Installation and Other Services

Item	Description	Unit	Quantity	Unit Rate		Total Price	
					Local Currency Portion (INR)		Local (INR)
Total (to Schedule A-5-a Summary of Work)							

A4-(a) Summary of Work

Name of Work	**Construction of 130MLD Water Treatment Plant and its Ancillary Structures for Improvement of Water Supply to Bhubaneswar City including Operation & Maintenance for a Period of Five Years on Engineering, Procurement & Construction (EPC) Contract.**

Note: Described full name of work listed in PREAMBLE of Schedules of Rates and Prices

Item	Description	Total Price	
			Local
A-1	Total Schedule A-1: Design, Drawings and Documentation		
A-2	Total Schedule A-2: Plant and Equipment, including Mandatory spare parts, supplied from within the Employer's Country		
A-3	Total Schedule A-3: Civil Works, Installation and Other Services		
	Total (to Schedule A-5-b Grand Summary)		

A4-(b) Grand Summary

Construction of New Treatment Plants & Pumping Stations in **(Package no. Mundali Bhubaneswar)**			
Item	Description	Total Price	
			Local
(i)	Total Schedule A-5 1..Intake Arrangement at **. Mundali Bhubaneswar**		
Ii	1..Raw water pumping system at **. Mundali Bhubaneswar**		
(iii)	Total Schedule A-5: 2.Raw & Clear water rising pipe line at **Mundali Bhubaneswar**		
(iv)	Total Schedule A-5 3.130 MLDWater Treatment Plant at **Mundali Bhubaneswar**		
v	Zonal Pumping Stations with MBR & ESR at **Mundali Bhubaneswar**		
vi	Power supply to Intake ,WTP & Zonal pumping station of **Mundali Bhubaneswar**.		
	Total (to Letter of Price Bid)		

A-5 Schedule of Operation and Maintenance Requirements

Requirements for operation and maintenance of the Water Treatment Plant & Pumping Stations, Pipelines etc. for an initial Five year period following completion of the Works.

Name of Work	

Note: Described full name of work listed in PREAMBLE of Schedules of Rates and Prices

Description of Operation	**Recommended Frequency of Operation (Daily, Weekly, Monthly, Yearly, etc.)**	**Annual Consumption/ Requirement**	**Unit Rate(2017 – 2018 rates)**	**Yearly Fixed Charges (2017 – 2018 rates)**	**Yearly Variable Cost (2017 – 2018 rates)**
Year 1 (a) a-.Routine operating costs Electricity Energy (with details of HP, KVA,KWH) Fuel Oil b- Chemicals Other inputs Labour (i) (ii) (iii) c-Periodic maintenance costs(as per manufacturer's maintenance schedule) Servicing (Labour) Cost of oil, chemicals, lubricants, etc. d-Others (a) Repair and Replacement Replacements: (i) (ii) (iii) Repairs (b) Miscellaneous (Others) (i) Sludge Disposal (ii) (iii)					
Total (a)+(b)+(c)+(d)(goes to "Summary of Operation and Maintenance")					

Note: (The Bidder shall provide complete details on all aspects of the operating and maintenance requirements relating to his proposed facilities in the above form or in any other form and detail as may be required for the Employer to properly evaluate the annual costs of operating the facilities with due regard to the particular items of Plant and equipment which the Bidder proposes to supply under the Contract. In preparing this schedule the Bidder shall consider that the Plant and facilities will operate for 22 hours per day, 365 days per year, and shall be operating at the specified design capacity throughout the entire period. Quantities and costs shall be estimated based on the current rates for such activity (i.e. 2016-2017 costs), but the Year in which such expenditure is to be incurred shall be clearly identified.)

A 6 (a) Summary of Operation and Maintenance by Work

Name of Work	**Construction of 130MLD Water Treatment Plant and its Ancillary Structures for Improvement of Water Supply to Bhubaneswar City including Operation & Maintenance for a Period of Five Years on Engineering, Procurement & Construction (EPC) Contract**

Note: Described full name of work listed in PREAMBLE of Schedules of Rates and Prices

O&M Year	Yearly Expenditure (as Base Year _____)		
	Fixed Charge	Variable Cost	Total Cost
Year 1			
Year 2			
Year3			
Year 4			
Year 5			
Total for Operation and Maintenance(carried forward to Grand Summary)	In Figure	In Figure	In Figure
	In Words	In Words	In Words

O&M cost: 5 yr. Operation & Maintenance (O&M)

A 6 (b) Grand Summary of Operation and Maintenance

O&M Year	Yearly Expenditure (as Base Year _____)							
							Reserve Fund For Major Maintenance, Repair and replacement	Total Cost
Year-1								
Year 2								
Year 3								
Year 4								
Year 5								
Total for Operation and Maintenance (carried forward to letter of Price Bid)								In Figure
	Total Cost In Words							

O&M cost: 5 yr. Operation & Maintenance (O&M)

Reserve Fund for Major Maintenance, Repair and replacement: minimum 5% of the Fixed component of annual O&M cost for each year.

SCHEDULE -I

(See Clause 10.2.4)

DRAWINGS

1 Drawings

In compliance of the obligations set forth in Clause 10.2 of this Agreement, the Contractor shall furnish to the Authority's Engineer, free of cost, all Drawings listed in Annex-I of this Schedule-I.

2 Additional Drawings

If the Authority's Engineer determines that for discharging its duties and functions under this Agreement, it requires any drawings other than those listed in Annex-I, it may by notice require the Contractor to prepare and furnish such drawings forthwith. Upon receiving a requisition to this effect, the Contractor shall promptly prepare and furnish such drawings to the Authority's Engineer, as if such drawings formed part of Annex-I of this Schedule-I.

Annex-I

(Schedule-I)

List of Drawings

The contractor is required to furnish the following drawing to the Authority's Engineer free of cost under clause 10.2 including the details as attached in the Annexure herewith describing the scope of work during survey, investigation and design stage.

- Project Lay out Plans starting from intake arrangement to distribution system at consumer end.
- General arrangement & Structural details of Intake arrangement, boosting pumping stations.
- Hydraulic flow diagram of WTP
- General arrangement & Structural details of each component of WTP
- Structural details of all UGRs and ESRs.
- Plan and structural details of all the building units.
- Any other drawings as required by the authority's Engineer relating to the project.

SCHEDULE - J

(See Clause 10.3.2)

PROJECT COMPLETION SCHEDULE

[In order to closely monitor the execution of the project and to ensure quality, cost and time of the project are not compromised in any manner, the contractor shall provide bar chart & PERT Chart in such a realistic manner so that there will be balance between financial & physical progress with reference to cost & completion time.]

1 Project Completion Schedule

During Construction period, the Contractor shall comply with the requirements set forth in this Schedule-J for each of the Project Milestones and the **Scheduled Completion Date**. Within 15 (fifteen) days of the date of each Project Milestone, the Contractor shall notify the Authority of such compliance along with necessary particulars thereof.

2 Project Milestone-I

2.1 Project Milestone-I shall occur on the date falling on the 4th* month from the Appointed Date (the "**Project Milestone-I**").

2.2 Prior to the occurrence of Project Milestone-I, the Contractor shall have commenced construction of the Water Supply Project and submitted to the Authority duly and validly prepared Stage Payment Statements for an amount not less than 15% (fifteen percent) of the Contract Price.

3 Project Milestone-II

3.1 Project Milestone-II shall occur on the date falling on the 8th* month from the Appointed Date (the "**Project Milestone-II**").

3.2 Prior to the occurrence of Project Milestone-II, the Contractor shall have continued with construction of the Water Supply Project and submitted to the Authority duly and validly prepared Stage Payment Statements for an amount not less than 30% (Thirty per cent) of the Contract Price.

4 Project Milestone-III

4.1 Project Milestone-III shall occur on the date falling on the 12th*month from the Appointed Date (the "**Project Milestone-III**").

4.2 Prior to the occurrence of Project Milestone-III, the Contractor shall have continued with construction of the Water Supply Project and submitted to the Authority duly and validly prepared Stage Payment Statements for an amount not less than 50% (Fifty per cent) of the Contract Price.

5 Project Milestone-IV

5.1 Project Milestone-III shall occur on the date falling on the 16th*month from the Appointed Date (the "**Project Milestone-IV**").

5.2 Prior to the occurrence of Project Milestone-III, the Contractor shall have continued with construction of the Water Supply Project and submitted to the Authority duly and validly prepared Stage Payment Statements for an amount not less than 70% (seventy per cent) of the Contract Price.

6 Project Milestone-V

6.1 Project Milestone-III shall occur on the date falling on the 20th*month from the Appointed Date (the "**Project Milestone-V**").

6.2 Prior to the occurrence of Project Milestone-III, the Contractor shall have continued with construction of the Water Supply Project and submitted to the Authority duly and validly prepared Stage Payment Statements for an amount not less than 90% (Ninety per cent) of the Contract Price.

* The milestone has to be proportionately fixed considering the period of completion.

7 Scheduled Completion Date

7.1 The Scheduled Completion Date shall occur on the 24th** month from the Appointed Date.

7.2 On or before the Scheduled Completion Date, the Contractor shall have completed construction in accordance with this Agreement.

8 Extension of time

Upon extension of any or all of the aforesaid Project Milestones or the Scheduled Completion Date, as the case may be, under and in accordance with the provisions of this Agreement, the Project Completion Schedule shall be deemed to have been amended accordingly.

** Period of completion.

SCHEDULE -K

(See Clause 12.1.2)

Tests on Completion

1 Schedule for Tests

1.1 The Contractor shall, no later than 30 (thirty) days prior to the likely completion of construction, notify the Authority's Engineer and the Authority of its intent to subject the Water Supply Project to Tests, and no later than 10 (ten) days prior to the actual date of Tests, furnish to the Authority's Engineer and the Authority detailed inventory and particulars of all works and equipment forming part of Works.

1.2 The Contractor shall notify the Authority's Engineer of its readiness to subject the Water Supply Project to Tests at any time after 10 (ten) days from the date of such notice, and upon receipt of such notice, the Authority's Engineer shall, in consultation with the Contractor, determine the date and time for each Test and notify the same to the Authority who may designate its representative to witness the Tests. The Authority's Engineer shall thereupon conduct the Tests itself or cause any of the Tests to be conducted in accordance with Article 12 and this Schedule-K.

2 Tests

2.1 Visual and physical test: The Authority's Engineer shall conduct a visual and physical check of construction to determine that all works and equipment forming part thereof conform to the provisions of this Agreement. The physical tests shall include hydraulic test of pipelines, water tightness of water retaining structures, duty of pump sets, flow measurement and head loss test, operation of valves and any other physical tests required as per scope of work.

2.2 Water quality test: Raw Water& Clear water quality shall be checked according to CPHEEO standard.

2.3 Tests for Pipe lines: Rising main and distribution networks shall be subjected to the tests to be conducted as per relevant IS specification.

2.4 Other tests: The Authority's Engineer may require the Contractor to carry out or cause to be carried additional tests, in accordance with Good Industry Practice, for determining the compliance of the Water Supply Project with Specifications and Standards.

2.5 Environmental audit: The Authority's Engineer shall carry out a check to determine conformity of the Water Supply Project with the environmental requirements set forth in Applicable Laws and Applicable Permits.

2.6 Safety Audit: The Authority's Engineer shall carry out, or cause to be carried out, a safety audit to determine conformity of the Water Supply Projectwith the safety requirements and Good Industry Practice.

3 Agency for conducting Tests

All Tests set forth in this Schedule-K shall be conducted by the Authority's Engineer or such other agency or person as it may specify in consultation with the Authority.

4 Completion Certificate

Upon successful completion of Tests, the Authority's Engineer shall issue the Completion Certificate in accordance with the provisions of Article 12.

SCHEDULE-L

(See Clause 12.2 and 12.4)

PROVISIONAL CERTIFICATE

1 I, ……. (Name of the Authority's Engineer), acting as the Authority's Engineer, under and in accordance with the Agreement dated ……. (the **"Agreement"**), for construction of the work (Name of the Project)on Engineering, Procurement andConstruction (EPC) basis through …… (Name of Contractor), hereby certify that the Tests in accordance with Article 12 of the Agreement have been undertaken to determine compliance of the Water Supply Project with the provisions of the Agreement.

2 Works that are incomplete on account of Time Extension have been specified in the Punch List appended hereto, and the Contractor has agreed and accepted that it shall complete all such works in the time and manner set forth in the Agreement.In addition, certain minor works are incomplete and these are not likely to cause material inconvenience to the Users of the Water Supply Projector affect their safety. The Contractor has agreed and accepted that as a condition of this Provisional Certificate, it shall complete such minor works within 30 (thirty) days hereof. These minor works have also been specified in the aforesaid Punch List.

3 In view of the foregoing, I am satisfied that the Water Supply Projectcan be safely and reliably placed in service of the Users thereof, and in terms of the Agreement, the Water Supply Projectis hereby provisionally declared fit for entry into operation on this the …… day of …….. 20…...

ACCEPTED

SIGNED, SEALED AND DELIVERED For and on behalf of CONTRACTOR by:	SIGNED, SEALED AND DELIVERED For and on behalf of AUTHORITY'S ENGINEER by:
(Signature) (Name and Designation) (Address)	(Signature) (Name and Designation) (Address)

COMPLETION CERTIFICATE

1 I, ……. (Name of the Authority's Engineer), acting as the Authority's Engineer, under and in accordance with the Agreement dated …… (the "**Agreement**"), for construction of the work (Name of the Project) on Engineering, Procurement and Construction (EPC) basis through ……. (Name of Contractor), hereby certify that the Tests in accordance withArticle 12 of the Agreement have been successfully undertaken to determine compliance of the Water Supply Project with the provisions of the Agreement,and I am satisfied that the Water Supply Project can be safely and reliably placed in service of the Users thereof.

2 It is certified that, in terms of the aforesaid Agreement, all works forming part of Water Supply Project have been completed, and the Water Supply Project is hereby declared fit for entry into operation on this the …… day of …… 20…..

SIGNED, SEALED AND DELIVERED

For and on behalf of the Authority's Engineer by:

(Signature)

(Name)

(Designation)

(Address)

SCHEDULE -M

(See Clauses 14.6, 15.2 and 19.7)

PAYMENT REDUCTION FOR NON-COMPLIANCE

1. Payment reduction for non-compliance with the Operation & Maintenance Requirements

1.1 Monthly lump sum payments for Operation & maintenance shall be reduced in the case of non-compliance with the Operation & Maintenance Requirements set forth in Schedule-E.

1.2 Any deduction made on account of non-compliance with the Operation & Maintenance requirements shall not be paid even after compliance subsequently. The deductions shall continue to be made every month until compliance is done.

1.3 The Authority shall calculate the amount of payment reduction on the basis of weightage assigned to non-conforming items as given in Paragraph 2.

2. Reductions in lump sum payments

2.1 The following shall govern the payment reduction:

[A] For the quantity of clear water supplied:

1) If the quantity of treated Water taken in to clear water reservoir near WTP as well as Zonal Reservoirs on any particular day is less than that specified water requirement, price reduction shall be @ prevailing rate of water charges/m^3 for commercial consumption.

2) The reading (Cumulative) of flow meters at the outlet of the treatment plant before clear water reservoir and inlet of Zonal Reservoirs shall be taken at 10 AM or any mutually agreed time each day. The difference between the reading of successive day & previous day shall be considered as the output of the WTP and supply to different zonal reservoirs respectively. Difference if found less than the specified quantity of water shall be considered as the deficiency in water supply. If the quantity supplied is more, nothing extra shall be paid.

[B] For Water Loss:

1) The allowable Water Loss percentage is upto 5% in raw water transmission line from pumping station at intake to inlet ofRaw water sump at Boosting station and there to inlet of WTP.

2) The allowable Water Loss percentage is upto 5% in clear water transmission lines from WTP to different zonal reservoirs.

3) Any Water Loss greater than the allowable water losses shall attract Price Reduction from the payment due to the Contractor at the rate of prevailing water charges/m^3 for commercial consumption.

[C] For Quality Deterioration:

If the quality fails to meet the required parameters as per CPHEEO Manual, penalty of Rs.10,000.00 per day for up to 3 parameters and Rs.20,000.00 per day for more than 3 parameters shall be charged. The quality is to be restored within 8 hours from the time of deterioration and in case of failure a penalty of Rs.50,000.00 per day will be charged.

SCHEDULE - N

(See Clause 18.1.1)

SELECTION OF AUTHORITY'S ENGINEER

1 Selection of Authority's Engineer

1.1 The provisions of the Model Request for Proposal for Selection of Technical Consultants, issued by the Ministry of Finance in May 2009, or any substitute thereof shall apply for selection of an experienced firm to discharge the functions and duties of an Authority's Engineer.

1.2 In the event of termination of the Technical Consultants appointed in accordance with the provisions of Paragraph 1.1, the Authority shall appoint another firm of Technical Consultants forthwith and may engage a government-owned entity in accordance with the provisions of Paragraph 3 of this Schedule-N.

2 Terms of Reference

The Terms of Reference for the Authority's Engineer (the "**TOR**") shall substantially conform with Annex 1 to this Schedule N.

3 Appointment of Government entity as Authority's Engineer

Notwithstanding anything to the contrary contained in this Schedule, the Authority may in its discretion appoint a government-owned entity as the Authority's Engineer; provided that such entity shall be a body corporate having as one of its primary functions the provision of consulting, advisory and supervisory services for engineering projects; provided further that a government-owned entity which is owned or controlled by the Authorityshall not be eligible for appointment as Authority's Engineer.

Annex – I

(Schedule - N)

TERMS OF REFERENCE FOR AUTHORITY'S ENGINEER

1 Scope

1.1 These Terms of Reference (the "**TOR**") for the Authority's Engineer are being specified pursuant to the EPC Agreement dated ..... (the "**Agreement**), which has been entered into between the [name and address of the Authority] (the "**Authority**") and ..... (the "**Contractor**") for the work (Name of the Project) in the State of Odishaon Engineering, Procurement, Construction (EPC) basis, and a copy of which is annexed hereto and marked as Annex-A to form part of this TOR.

1.2 The TOR shall apply to construction and operation & Maintenance of the Water Supply Project.

2 Definitions and interpretation

2.1 The words and expressions beginning with or in capital letters and not defined herein but defined in the Agreement shall have, unless repugnant to the context, the meaning respectively assigned to them in the Agreement.

2.2 References to Articles, Clauses and Schedules in this TOR shall, except where the context otherwise requires, be deemed to be references to the Articles, Clauses and Schedules of the Agreement, and references to Paragraphs shall be deemed to be references to Paragraphs of this TOR.

2.3 The rules of interpretation stated in Clauses 1.2, 1.3 and 1.4 of the Agreement shall apply, *mutatis mutandis*, to this TOR.

3. General

3.1 The Authority'sEngineer shall discharge its duties in a fair, impartial and efficient manner, consistent with the highest standards of professional integrity and Good Industry Practice.

3.2 The Authority's Engineer shall perform the duties and exercise the authority in accordance with the provisions of this Agreement, but subject to obtaining prior written approval of the Authority before determining:

(a) any Time Extension;

(b) any additional cost to be paid by the Authority to the Contractor;

(c) the Termination Payment; or

(d) any other matter which is not specified in (a), (b) or (c) above and which creates an obligation or liability on either Party for a sum exceeding Rs. 5,000,000 (Rs. fifty lakh).

3.3 The Authority's Engineer shall submit regular periodic reports, at least once every month, to the Authority in respect of its duties and functions under this Agreement. Such reports shall be submitted by the Authority's Engineer within 10 (ten) days of the beginning of every month.

3.4 The Authority's Engineer shall inform the Contractor of any delegation of its duties and responsibilities to its suitably qualified and experienced personnel; provided, however, that it shall not delegate the authority to refer any matter for the Authority's prior approval in accordance with the provisions of Clause 18.2.

3.5 The Authority's Engineer shall aid and advise the Authority on any proposal for Change of Scope under Article 13.

3.6 In the event of any disagreement between the Parties regarding the meaning,

scope and nature of Good Industry Practice, as set forth in any provision of the Agreement, the Authority's Engineer shall specify such meaning, scope and nature by issuing a reasoned written statement relying on good industry practice and authentic literature.

4 **Construction Period**

4.1 During the Construction Period, the Authority's Engineer shall review the Drawings furnished by the Contractor along with supporting data, including the geo-technical and hydrological investigations, characteristics of materials from quarry sites, topographical surveys, and the recommendations of the Safety Consultant in accordance with the provisions of Clause 10.1.6. The Authority's Engineer shall complete such review and send its observations to the Authority and the Contractor within 15 (fifteen) days of receipt of such Drawings; provided, however that in case of a Major Structures, the aforesaid period of 15 (fifteen) days may be extended upto 30 (thirty) days. In particular, such comments shall specify the conformity or otherwise of such Drawings with the Scope of the Project and Specifications and Standards.

4.2 The Authority'sEngineer shall review any revised Drawings sent to it by the Contractor and furnish its comments within 10 (ten) days of receiving such Drawings.

4.3 The Authority's Engineer shall review the Quality Assurance Plan submitted by the Contractor and shall convey its comments to the Contractor within a period of 21 (twenty-one) days stating the modifications, if any, required thereto.

4.4 The Authority's Engineer shall complete the review of the methodology proposed to be adopted by the Contractor for executing the Works, and convey its comments to the Contractor within a period of 10 (ten) days from the date of receipt of the proposed methodology from the Contractor.

4.5 **Deleted.**

4.6 The Authority'sEngineer shall review the monthly progress report furnished by the Contractor and send its comments thereon to the Authority and the Contractor within 7 (seven) days of receipt of such report.

4.7 The Authority'sEngineer shall inspect the Construction Works ofthe Water Supply Projectand shall submit a monthly Inspection Report bringing out the results of inspections and the remedial action taken by the Contractor in respect of Defects or deficiencies. In particular, the Authority's Engineer shall include in its Inspection Report, the compliance of the recommendations made by the Safety Consultant.

4.8 The Authority's Engineer shall conduct the pre-construction review of manufacturer's test reports and standard samples of manufactured Materials, and such other Materials as the Authority's Engineer may require.

4.9 For determining that the Works conform to Specifications and Standards, the Authority's Engineer shall require the Contractor to carry out, or cause to be carried out, tests at such time and frequency and in such manner as specified in the Agreement and in accordance with Good Industry Practice for quality assurance. For purposes of this Paragraph 4.9, the tests specified in the relevant IS specification and CPHEEO manual on water supply issued byMoUD or any modification/substitution thereof shall be deemed to be tests conforming to Good Industry Practice for quality assurance.

4.10 The Authority's Engineer shall test check at least 20 (twenty) percent of the quantity or number of tests prescribed for each category or type of test for quality

control by the Contractor.

4.11 The timing of tests referred to in Paragraph 4.9, and the criteria for acceptance/ rejection of their results shall be determined by the Authority's Engineer in accordance with the Quality Control Manuals. The tests shall be undertaken on a random sample basis and shall be in addition to, and independent of, the tests that may be carried out by the Contractor for its own quality assurance in accordance with Good Industry Practice.

4.12 In the event that results of any tests conducted under Clause 11.10 establish any Defects or deficiencies in the Works, the Authority's Engineer shall require the Contractor to carry out remedial measures.

4.13 The Authority's Engineer may instruct the Contractor to execute any work which is urgently required for the safety of the Water Supply Project, whether because of an accident, unforeseeable event or otherwise; provided that in case of any work required on account of a Force Majeure Event, the provisions of Clause 21.6 shall apply.

4.14 In the event that the Contractor fails to achieve any of the Project Milestones, the Authority's Engineer shall undertake a review of the progress of construction and identify potential delays, if any. If the Authority's Engineer shall determine that completion of the Water Supply Projectis not feasible within the time specified in the Agreement, it shall require the Contractor to indicate within 15 (fifteen) days the steps proposed to be taken to expedite progress, and the period within which the Project Completion Date shall be achieved. Upon receipt of a report from the Contractor, the Authority's Engineer shall review the same and send its comments to the Authority and the Contractor forthwith.

4.15 The Authority's Engineer shall obtain from the Contractor a copy of all the Contractor's quality control records and documents before the Completion Certificate is issued pursuant to Clause 12.4.

4.16 Authority's Engineer may recommend to the Authority suspension of the whole or part of the Works if the work threatens the safety of the Users. After the Contractor has carried out remedial measure, the Authority's Engineer shall inspect such remedial measures forthwith and make a report to the Authority recommending whether or not the suspension hereunder may be revoked.

4.17 In the event that the Contractor carries out any remedial measures to secure the safety of suspended works and Users, and requires the Authority's Engineer to inspect such works, the Authority's Engineer shall inspect the suspended works within 3 (three) days of receiving such notice, and make a report to the Authority forthwith, recommending whether or not such suspension may be revoked by the Authority.

4.18 The Authority's Engineer shall carry out, or cause to be carried out, all the Tests specified in Schedule-K and issue a Completion Certificate or Provisional Certificate, as the case may be. For carrying out its functions under this Paragraph 4.18 and all matters incidental thereto, the Authority's Engineer shall act under and in accordance with the provisions of Article 12 and Schedule-K.

5. Operation &Maintenance Period

5.1 Deleted

5.2 Deleted

5.3 Deleted

5.4 Deleted

5.5 Deleted

6 Determination of costs and time

6.1 The Authority's Engineer shall determine the costs, and/or their reasonableness, that are required to be determined by it under the Agreement.

6.2 The Authority's Engineer shall determine the period of Time Extension that is required to be determined by it under the Agreement.

6.3 The Authority's Engineer shall consult each Party in every case of determination in accordance with the provisions of Clause 18.5.

7. Payments

7.1 The Authority's Engineer shall withhold payments for the affected works for which the Contractor fails to revise and resubmit the Drawings to the Authority's Engineer in accordance with the provisions of Clause 10.2.4 (d).

7.2 Authority's Engineer shall -

(a) within 10 (ten) days of receipt of the Stage Payment Statement from the Contractor pursuant to Clause 19.4, determine the amount due to the Contractor and recommend the release of 90 (ninety) percent of the amount so determined as part payment, pending issue of the Interim Payment Certificate; and

(b) within 15 (fifteen) days of the receipt of the Stage Payment Statement referred to in Clause 19.4, deliver to the Authority and the Contractor an Interim Payment Certificate certifying the amount due and payable to the Contractor, after adjustments in accordance with the provisions of Clause 19.10.

7.3Deleted

7.4 Deleted

8. Other duties and functions

The Authority's Engineer shall perform all other duties and functions as specified in the Agreement.

9. Miscellaneous

9.1 A copy of all communications, comments, instructions, Drawings or Documents sent by the Authority'sEngineer to the Contractor pursuant to this TOR, and a copy of all the test results with comments of the Authority'sEngineer thereon, shall be furnished by the Authority'sEngineer to the Authority forthwith.

9.2 The Authority'sEngineer shall retain at least one copy each of all Drawings and Documents received by it, including 'as-built' Drawings, and keep them in its safe custody.

9.3 Within 90 (ninety) days of the Project Completion Date, the Authority's Engineer shall obtain a complete set of as-built Drawings, in 2 (two) hard copies and in micro film form or in such other medium as may be acceptable to the Authority, reflecting the Water Supply Project as actually designed, engineered and constructed, including an as-built survey illustrating the layout of the Water Supply Project and setback lines, if any, of the buildings and structures forming part of Project Facilities; and shall hand them over to the Authority against receipt thereof.

9.4 The Authority's Engineer, if called upon by the Authority or the Contractor or both, shall mediate and assist the Parties in arriving at an amicable settlement of any Dispute between the Parties.

9.5 The Authority's Engineer shall inform the Authority and the Contractor of any event of Contractor's Default within one week of its occurrence.

SCHEDULE -O

(See Clauses 19.4.1, 19.6.1, and 19.8.1)

Forms of Payment Statements

1. Stage Payment Statement for Works

The Stage Payment Statement for Works shall state:

(a) the estimated amount for the Works executed in accordance with Clause 19.3.1 subsequent to the last claim;

(b) amounts reflecting adjustments in price for the aforesaid claim;

(c) the estimated amount of each Change of Scope Order executed subsequent to the last claim;

(d) amounts reflecting adjustment in price, if any, for (c) above in accordance with the provisions of Clause 13.2.3 (a);

(e) total of (a), (b), (c) and (d) above;

(f) Deductions:

  (i) Any amount to be deducted in accordance with the provisions of the Agreement except taxes;

  (ii) Any amount towards deduction of taxes; and

  (iii) Total of (i) and (ii) above.

(g) Net claim: (e) – (f) (iii);

(h) The amounts received by the Contractor upto the last claim:

  (i) For the Works executed (excluding Change of Scope orders);

  (ii) For Change of Scope Orders, and

  (iii) Taxes deducted

2. Monthly Operation &MaintenancePayment Statement

The monthly Statement for Operation & Maintenance Payment shall state:

(a) the monthly payment admissible in accordance with the provisions of the Agreement;

(b) the deductions for Operation & maintenance work not done;

(c) net payment for Operation & maintenance due, (a) minus (b);

(d) Deleted

(e) amount towards deduction of taxes

3. Contractor's claim for Damages

Note: The Contractor shall submit its claims in a form acceptable to the Authority.

SCHEDULE -P

(See Clause 20.1)

INSURANCE

1. Insurance during Construction Period

1.1 The Contractor shall effect and maintain at its own cost, from the Appointed Date till the date of Completion of Operation & Maintenance Period, the following insurances for any loss or damage occurring on account of Non Political Event of Force Majeure, malicious act, accidental damage, explosion, fire and terrorism:

(a) insurance of Works, Plant and Materials and an additional sum of [15 (fifteen)] per cent of such replacement cost to cover any additional costs of and incidental to the rectification of loss or damage including professional fees and the cost of demolishing and removing any part of the Works and of removing debris of whatsoever nature; and

(b) insurance for the Contractor's equipment and Documents brought onto the Site by the Contractor, for a sum sufficient to provide for their replacement at the Site.

1.2 The insurance under paragraph 1.1 (a) and (b) above shall cover the Authority and the Contractor against all loss or damage from any cause arising under paragraph 1.1 other than risks which are not insurable at commercial terms.

2. Insurance for Contractor's Defects Liability

The Contractor shall effect and maintain insurance cover for the Works from the date of issue of the Completion Certificate until the end of the Defects Liability Period for any loss or damage for which the Contractor is liable and which arises from a cause occurring prior to the issue of the Completion Certificate. The Contractor shall also maintain other insurances for maximum sums as may be required under the Applicable Laws and in accordance with Good Industry Practice.

3. Insurance against injury to persons and damage to property

3.1 The Contractor shall insure against its liability for any loss, damage, death or bodily injury, or damage to any property (except things insured under Paragraphs 1and 2 of this Schedule or to any person (except persons insured under Clause 720.9), which may arise out of the Contractor's performance of this Agreement. This insurance shall be for a limit per occurrence of not less than the amount stated below with no limit on the number of occurrences.

The insurance cover shall be not less than: Rs. [*****]

3.2 The insurance shall be extended to cover liability for all loss and damage to the Authority's property arising out of the Contractor’s performance of this Agreement excluding:

(a) the Authority's right to have the construction works executed on, over, under, in or through any land, and to occupy this land for the Works; and

(b) damage which is an unavoidable result of the Contractor's obligations to execute the Works.

4. **Insurance to be in joint names**

The insurance under paragraphs 1 to 3 above shall be in the joint names of the Contractor and the Authority.

SCHEDULE - Q

(See Clause 1.2.3. of RFP)

FEASIBILITY REPORT

The present scheme **"Construction of 130 MLD Water Treatment Plant and its Ancillary Structures for Improvement of Water Supply to Bhubaneswar City" on Engineering, Procurement & Construction (EPC) Contract Including Operation & Maintenance for a Period of Five Years"** has been prepared to cater water demand of the population for ultimate design year 2055 considering base year as 2025. The feasibility of the project is summarised below:

[A] Bhubaneswar

The present scheme has been prepared to cater water demand of population for ultimate design year 2055 taking 2025 as base year. The feasibility of the project is summarized below:

1. **Population (2011): 8,37,737**
2. Projected population of mid design year **2040** & ultimate design year **2055** are 18,14,300 & 20,86,500 respectively.
3. Projected water demand of mid design year 2040 & ultimate design year 2055 are 309.35 MLD & 355.75 MLD respectively.
4. The proposed capacity of WTP for mid design year has been considered as 130 MLD excluding existing WTP capacity.
5. **Source:** Mahanadi River (Mundali)
6. **Water quality of source :** Satisfactory
7. **Water availability of source:** Available
8. **Power Supply :** Available near intake arrangement, raw water boosting Point, WTP & all zonal pumping stations from which power supply can be extended.
9. **Land :** Land is available for Raw Water Intake, WTP, MBR and Zonal Reservoirs & Pumping Stations. Alienation/ acquisition of lands for WTP and intake is under process.
10. **Feasibility of laying of Raw Water & Clear Water Rising Mains:** The alignment of Raw water pipe lines from Intake well to 130 MLD proposed W.T.P and clear water pipelines from W.T.P. to Master Balancing Reservoir alignment are along the side of State roads for which permission will be processed from respective authorities & will be made available before start of the project. Other necessary permission, if any, from State Pollution Control Board, Works Department, Forest Department, Electrical Department, Water Resource Department, etc. will be obtained in due course.

Thus over all it is a feasible project and can be implemented smoothly.