VOLUME III

GENERAL SPECIFICATIONS – CIVIL WORKS

General Civil Specifications for the works to be carried out form an integral part of these specifications and contractor shall conform to these specifications.

1.0 General :

a. Design of all reinforced concrete structures shall be as per IS:456, of pre-stressed concrete structures as per IS:1343. The structural safety of all foundations on soil shall, in general be based on IS:1904.
b. For calculation purpose “Limit state Design” methods according to IS:456-2000 shall generally be adopted, except for water retaining structures where IS:3370 (PartI-IV) shall be referred and other special cases requiring design by working stress method.
c. All grouting below machine/equipment bases, and pockets shall be non-shrinking grout of adequate thickness and minimum grade of M35 with 6mm and down aggregates. Grouting below structural column bases shall be minimum grade of M30 with 6mm and down aggregates.
d. PCC grade M15 – Apron, plinth protection, screed concrete, foundation below masonry walls, encasing of underground pipes & conduits, ground floor at plinth level, toilet, rest room, etc.
e. All foundations and concrete structures shall be designed to resist full operating dead and live loads, with appropriate combination of wind and seismic forces and with due allowance for impact, inertia loading, vibration, unbalanced dynamic loads, etc. as secondary effect of live loads, erection loads, temperature variation etc. While designing structures and foundations either the effect of seismic forces or wind loads, whichever produces the worst effect, shall be considered along with usual load conditions. Apart from the installation and operating loads indicated by the equipment manufacturers, the design of buildings and structures shall be based on dead and imposed loads calculated according to IS:875. All structures shall be designed for sesimic load as per IS1893 2002/latest in teh catgeogry one above the satted in the specified code.
f. Concentrated and uniformly distributed live load on floors and platforms shall be considered depending upon the usage and in accordance with maximum expected process requirements, to be indicated by the equipment manufactures. When the loads are movable, they shall be so placed as to get worst effect in moment & shear, axial load etc. for which the elements shall be designed. The effect of concentrated load
g. shall not be reduced. Due allowance shall be made, wherever necessary, for installation and operation of any equipment as per equipment manufacturer’s data and recommendations. The design shall be based on the maximum loading due to uniform live load and/or equipment loading including impact, vibration, unbalanced operating forces, etc.
h. Foundations for structures and equipment shall be proportioned to resist the worst combination of loading and shall generally be designed as per the provision of IS:1904 for open foundations on soil and IS: 2911 for foundations on piles.

2 DEFINITIONS- EXCAVATION IN ALL TYPES OF SOILS EXCLUDING ROCK

The works under this head shall comprise of the following and shall have the meanings hereby assigned to them:

a) "Excavation" means excavation in open cut (excluding trench excavation outside buildings / structures) down to levels required as per approved drawings or otherwise as being the general levels after completion of excavation.

b) “Trench excavation" means excavation (ouside buildings / structures) of trenches into which pipes (of all types and sizes upto 2000mm) and cables are to be laid to levels and limits as required as per approved drawings or otherwise. This shall also include miscellaneous isolated lengths of trenches beneath or adjacent to other structures.

The term "excavation" is deemed to include for disposing excavated material within 500M in any of the following ways :

Back-filling to excavations and completed structures within the site using suitable excavated material and including placing in temporary spoil tips and any double handling required all as specified hereafter.

Or transporting and placing approved excavated material in permanent spoil tips, including the shaping and drainage of such tips all as specified hereafter.

Or transporting selected excavated material to locations within the site where embankments are to be constructed or where filling around structures is specified to be constructed as embankment including tipping ready for spreading and compacting.

2.1 EXCAVATION

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 provided. The excavation shall include excavation in earth and murrum shall be carried out to the correct levels required and specified and no clearance, plus or minus (ie. no overcuts), shall be permitted. However, if any overcuts / depressions are formed due to fault of contractor, they shall be made good by filling with M-7.5 concrete up to the bottom layer of the footing/raft without any extra cost implication. When excavation has reached within 300 mm of the required formation level, further excavation shall be carried out carefully to avoid any overcuts / depressions.

2.2 EXCESS EXCAVATION (EXCLUDING OVERCUTS / DEPRESSIONS AS IN CL. 1.2) TO BE MADE GOOD

In case of excess excavation by the Contractor (beyond that specified in drawings), the contractor shall , at his own expense, if directed , remove from the pits all material resulting from excess excavation and shall make good the same with such kind of fill

material or in such class of concrete as may be reasonably required by Employer's Representative having regard to the circumstances.

The Contractor shall backfill such excess excavation with concrete, rubble, stone or rock fill as directed by the Employer's Representative/ PMC Consultant. 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.

2.3 SUPPORTING EXCAVATIONS

The Contractor shall well and effectually support the sides and ends of all excavations to prevent 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 excavation necessary to provide space for such support or other working space shall be carried out. 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 distributed. Where the Contractor elects and is permitted by the Employer's Representative / PMC Consultant 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.

2.4 TIMBER SHORING

Close timbering shall be done by completely covering the sides of the trenches and pits generally with short, upright members called 'rolling 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 wailings of strong wood at maximum 1.2 metres spacing and suitably strutted. If the soil is very soft and loose, the boards shall be placed horizontally against each side of the excavation and supported by vertical wailings, which in turn shall be suitably strutted. The lowest boards supporting the sides shall be taken 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 Employer's Representative in writing:

a) Planks - 5 cm x 25 cm
b) Waling pieces - 10 cm x 20 cm
c) Struts - 15 cm x 20 cm

Timber shoring shall be 'dose' or 'open' type, depending on the nature of soil and the depth of pit or trench. The type of timbering shall be as approved by Employer's Representative. 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 excavations 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 the Employer's Representative / PMC Consultant.

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 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 the Employer's Representative. In all other respect, the 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 or for any other reasons and where the planking across sides of excavation/ pits cannot be strutted against, suitable inclined struts supported on the excavated bed shall be provided. Load from such struts shall be suitably distributed on the bed to ensure no yielding of the strut.

2.5 TRIMMING EXCAVATIONS

When excavating to specified or required levels for the foundation of any structure or to specified or required limits for the face of any structure required to abut undisturbed ground, the Contractor shall not excavate the last 150 mm until immediately before commencing the constructional work, except where the Employer's Representative shall permit otherwise. Should the Contractor have excavated to within 150mm 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 Employer's Representative, excavate further so as to remove not less than 150mm of material immediately before commencing the constructional work. 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 rest on a solid and perfectly clean foundation or abuts against solid ground.

3.1 PIPE TRENCHES

Trench excavation (as previously defined) means excavation of trenches in to which pipes and cables are to laid and the term pipes shall mean pipes of all kinds and for whatever purpose.

The line and level of trenches shall be as shown on the drawings or as may be directed by the Employer's Representative/ PMC Consultant. Before commencing trench excavation,

the route of the trench shall be pegged out accurately and the natural ground levels shall be agreed with the Employer's Representative / PMC Consultant. Strong sight rails shall then be fixed and maintained at each change of gradient and at as many intermediate points as may be necessary. On these rails shall be marked the centre line and the level to which the excavation is to be carried out, such rails being not more than thirty meters apart.

3.2 TRENCH EXCAVATION GENERALLY

Trench excavation shall be carried out by such methods and to such lines, dimensions arid depths as shall allow for the proper construction of the works, provided always that, unless the Employer's Representative permits otherwise, no trench excavation shall be less than 500mm in width.

Any hard rock in trench excavation shall be so excavated that the clearance between the pipe when laid and the hard rock side and bottom of the trench is kept to the minimum limits necessary to provide for working space and tile specified thickness of bedding haunching and surround to the pipe.

The sides of trench excavation shall be vertical unless the Employer's Representative permits otherwise. Any widening or deepening of trench excavations necessary to accommodate curves, joints or bends in the pipe as required or when ordered by the Employer's Representative/ PMC Consultant shall be provided.

No length of trench excavation shall be started until the pipes to be laid in that length are available on the site.

3.3 TRENCH EXCAVATION IN ROADS AND FOOTPATHS

All trench excavation and other work carried out within the limits of any road shall be completed as rapidly as possible and not more than half of the with of the carriage way shall be obstructed at one time. Road drains and grips shall be kept free from obstruction. In any event the Contractor's shall take special precautions, which shall include the continuous support of the sides of the excavation is begun until the refilling of the trench is placed to ensure that there is no disturbance of the adjacent road or road foundation.

Where excavated material has temporarily been deposited on a grass margin or road pavement, the margin or road pavement shall on completion of refilling be entirely to its original condition and left free from loose stones.

3.4 TRENCH EXCAVATION IN FIELDS, ETC.

The term "fields" includes fields, moor lands, grass verges and the like and all private lands, and no length of trench excavation located in fields shall be commenced until suitable temporary fencing has been erected around that length unless the Employer's Representative permits otherwise. Temporary fencing shall not be removed without the Employer's Representative's permission, which will not normally be given until the trench

excavation had been refilled and reinstated to the original ground condition or as directed by the Employer's Representative.

3.5 SUPPORTING TRENCH EXCAVATIONS

The Contractor shall well and effectually support the sides of trench excavations to prevent any fall or run from any portion of the ground outside the excavation and to prevent settlement of or damage to structures adjacent to the excavation. The Contractor shall be deemed to have made his own allowance for any extra excavation necessary to provide space for such support and for any other working space. If for any reason any portion of trench excavation 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 and making good the same.

Where the Contractor elects and is permitted by the Employer's Representativeto execute trench excavations with battered sides instead of providing support as a foresaid they shall be excavated to stable slopes and heights.

3.6 TRIMMING TRENCH EXCAVATIONS

When excavating to required levels for trench excavations or to required limits from the face of any structure therein required to abut undisturbed ground, the Contractor shall not excavate the last 150 mm until immediately before commencing constructional work except where the Employer's Representative permits otherwise. Should the Contractor have excavated to within 150 mm above these required levels or to within 150 mm of these required limits before he is ready or able to commence the constructional work he shall, where required by the Employer's Representative, excavate further so as to remove not less than 150 mm of material immediately before commencing the constructional work.

Where no bedding material is required to be laid beneath the pipe, the bottom of trench excavations shall be carefully boned in and trimmed true to grade with the aid of a straight edge at least six metres long so as to ensure a continuous support for the pipes.

The trench bottom shall hen be pricked over with a fork and any stones or flints either likely to cause the pipe to bed unevenly or to damage the pipe and its coating or greater 5 than 20mm in size shall be picked out the pipe bed and any holes so formed shall be filled in with soft material and trimmed to the correct level.

Where no bedding material is required, all shattered and loose material shall be removed from the bottom of the trench excavation so that the bedding material rest on a solid and clean foundation.

3.7 TRENCHES NOT TO BE LEFT OPEN

Trench excavation shall be carried out expeditiously and, subject to any specific requirements of the Contract, the refilling and surface reinstatement of trench excavations

shall be commenced and completed as soon as reasonably practicable after the pipes have been laid and jointed.

Pipe laying shall follow closely upon the progress of trench excavation, and the Contractor shall not permit unreasonably excessive lengths of trench excavation to remain open while awaiting testing of the pipeline. The Contractor shall take precautions to prevent flotation of pipes in locations where open trench excavations may become flooded, and these precautions may include the partial refilling of the trench leaving pipe joints exposed while awaiting tests of the joints.

If the Employer's Representative / PMC Consultant considers that the Contractor is not complying with any of the foregoing requirements he may prohibit further trench excavation until he is satisfied with the progress of laying and testing of pipes and refilling of trench excavation.

3.8 REFILLING OF TRENCH EXCAVATIONS

Trench excavations shall be refilled using suitable materials selected from excavations carried out at site or borrow areas as directed by the Employer's Representative/ PMC Consultant.

Soft material (free from stones greater than 75 mm in size for pipes without bitumen sheathing and 20 mm in size for pipes with bitumen sheathing) shall be deposited in 150 mm layers and thoroughly rammed under and around the pipe with suitably shaped rammers working alterrnately on either side of the pipe (particular care being taken to avoid damage to the pipe and any sheathing) until the trench has been refilled upto the swell of the pipe, thereafter until the soft filling has been carried up at least 300mmabove the top of the pipe.

The remainder of the refilling may consist of coarse material (including broken rock from excavation in hard rock) free from boulders and clods of earth larger than 150 mm in size provided that the compacted backfill is, in the opinion of the Employer's Representative sufficiently dense to prevent material from the superimposed layers being washed into the voids in such backfill. This coarse material shall be spread in layers of not greater depth than 225 mm and be thoroughly rammed by an approved mechanical rammer. The coarse filling is to be carried up to the level at which (in roads and footpaths) surface reinstatement is to commence or (elsewhere) to such level as with the surface reinstatement of the whole of the topsoil will leave the finished work sufficiently "proud" to allow for future settlement to the original ground level.

Hard material such as broken rock and original road metalling shall normally be used only for the surface reinstatement of roads as. Specified but where it is suitable and available in sufficient quantity it may be used in place of or as well as the aforesaid coarse material.

Where necessary the Contractor shall adjust the moisture content of the refill material either by drying out or by adding water to assist the compaction of the material.

Should the material being placed as refilling, while acceptable at the time when approved, become unacceptable to the Employer's Representative due to exposure to weather conditions or due to flooding or have become puddle, 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. Where directed by the Employer's Representative/ PMC Consultant trench excavations shall be refilled with concrete.

4.1. SURFACE REINSTATEMENT IN FIELDS. ETC.

After he has refilled trench excavation in fields and grass verges in the manner and to the level specified, the Contractor shall replace all top soil previously removed and it shall be evenly distributed and leveled over the full extent of the stripped area. Such of the working areas occupied by the Contractor as were originally down to grass shall be sown with grass seed of equivalent quality and maintained until the new grass is properly established.

Other areas not originally down to grass shall be dressed with suitable fertilizers harrowed in so as to restore the original level of fertility.

4.2. SURFACE REINSTATEMENT IN ROADS AND FOOTPATHS

Surface reinstatement of refilled trench excavations in roads and footpaths shall consist of approved backfill material which has been well compacted and brought up to the sub grade level of the adjacent road surface. The balance portion shall be made good with similar material as that of adjacent road, and shall be so maintained (including topping up when necessary) until the end of the Defects Liability Period or until taken over for permanent reinstatement by the appropriate authority, whichever is sooner.

4.3. OTHER STRUCTURES IN THE PIPELINE

The Contractor shall carry out farther excavation as may be necessary to accommodate structures such as thrust blocks and valve chambers. Such excavation shall include for disposal of surplus material and, where appropriate, for backfilling around the structures**.**

4.4. EXISTING SERVICE

Where trench excavation is carried out close to or across the line of sewers, pipes, cables and other services, the Contractor shall, where necessary, provide temporary supports or slings and where such sewer, pipe, cable or other service is temporarily disturbed it shall be replaced.

Where, in the opinion of the Employer's Representative/ / PMC Consultant, construction of the pipeline cannot reasonably be carried out unless the sewer, pipe, cable or other service is permanently severed or permanently diverted or permanently supported by concrete he shall order the Contractor to undertake such work.

Notwithstanding any relevant information furnished by the Employer's Representative, the Contractor shall be responsible for ascertaining from his own inspection of the site and from the respective supply authorities and other public bodies the position of all mains, pipes and cables whether underground or overhead, within or near the site.

4.5. HEDGES, FENCES AND WALLS

Where the trench excavation crosses barriers such as hedges, fences and walls, the Contractor, as a temporary measure during construction of the pipeline, shall provide temporary fencing for any parts of such barriers as have had to be removed.

After trench excavation has been reinstated, the Contractor shall carry out such work as the Employer's Representative may order for permanent restoration of such barriers.

4.6. CROSSING WATERCOURSES. ETC.

Where the pipeline crosses rivers, culverts and other water-courses, the Contractor shall be deemed to have allowed for all the additional measures necessary for the proper construction of the pipeline at these crossings including maintaining the full flow of water across the trench.

4.7. INSPECTION of Works BY THE Employer's Representative/PMC Consultant

When the specified levels or limits of excavation are reached, the Employer's Representative / PMC Consultant 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 Employer's Representative.

Should the material forming the bottom of any excavation, while acceptable to the Employer's Representativeat the time of his inspection, subsequently become unacceptable to him due to exposure to weather conditions or due to flooding or have become puddle, soft, or loose during the progress of the works, the Contractor shall remove such damaged, softened or loosened material and excavate further by hand. Where ever works inspection is involved either Employer's Representative / PMC Consultant shall do the same and shall be recorded and any procedureal changes required for fulfilment of the system shall be done by the contractor at no extar cost.

4.8. EMBANKMENTS

4.8.1. EARTHWORK IN EMBANKMENT

- **Stripping**

The entire area to be occupied by the embankment shall be stripped to a sufficient depth, as determined by the Employer's Representative to remove all materials unsuitable and objectionable for incorporation in embankment.

All excavations below the ground level arising out of the removal of trees, stumps, etc., shall be filled with suitable material and compacted thoroughly all as specified for the

embankment fill material, so as to make the surface at these points conform to the surrounding area.

4.8.2. SETTING OUT

After the site has been cleared the limit of embankments shall be set out true to lines as shown on the drawings.

4.8.3. EMBANKMENT CONSTRUCTION

The material used in embankment shall be earth, obtained as indicated in Clause 9.29 and approved by the Employer's Representative. The size of the coarse material in the earth shall not exceed 50mm. Such material shall be free of logs, brush, stumps, roots rubbish, organic matter, humus, or any other unsuitable material likely to deteriorate or affect the stability of the embankment.

The limits of embankments shall be marked by, fixing batten pegs at regular intervals as guides before, commencing the earthwork. It is desirable to fix the pegs about 0.5metre back from the actual limits of the fill and to paint them in a distinctive colour.

In all cases, the original ground under the embankments shall be prepared by scarifying, by ploughing, or by harrows or rakes or by any suitable method, all clods broken and, then moistening in the, range of+1 to -2 % of optimum moisture content and rolling, as directed by the Employer's Representative.

The embankment material shall be spread uniformly over the entire width of the embankment in horizontal layers not exceeding 230 mm and 150 mm in loose thickness, when sheep foot rollers and smooth wheeled rollers respectively are used for compaction. Successive layers of embankment shall not be placed until the layer under construction has been thoroughly compacted to the requirements set down hereunder:

i) Moisture content of the material shall be checked at the source of supply and -if- found less than that specified for compaction, the same shall be made good either at the source or after spreading the soil in loose thickness for compaction, in the latter case, water shall be sprinkled directly from a hose line or from a track-mounted water tank, and flooding shall not be permitted under any circumstances. Moisture content shall be distributed uniformly throughout each layer of the material.

ii) If the material is too wet, it shall be dried, by aeration and exposure to the sun, till the moisture content is acceptable for compaction.

iii) Moisture content of each layer of soil shall be so adjusted (making due allowance for evaporation losses) that at the time of compaction it is in the range of 1 percent above to 2 percent below the optimum moisture content determined in accordance with IS : 2720 (Part 7).

iv) After adding the required amount of the water, the soil shall be processed by means of harrows, or as otherwise approved by the Employer's Representative until the layer is uniformly wet.

Clods or hard lumps of earth shall be broken to have maximum size of 50mm when being placed in the lower layers of the embankment and a maximum size of 25 mm when being placed in the top 0.5-meter portion of the embankment.

Only compaction equipment approved by the Employer's Representative shall be employed. If directed by the Employer's Representativethe Contractor shall demonstrate the efficacy of the plant he intends to use by carrying out compaction trials.

Each layer of the material shall be thoroughly compacted to field dry density of not less than 95% of maximum laboratory dry density as per IS : 2720 (Part 7). Frequent laboratory tests to determine optimum moisture content and maximum laboratory dry density for different soil samples being used for embankment construction shall be made. Subsequent layers shall be placed only after the finished layer has been tested, as specified herein after, and accepted by the Employer's Representative. If in the opinion of the Employer's Representativethe surface of the prepared foundation or the compacted surface of any layer of earth fill is too dry or smooth to bond properly with the layer of material to be placed thereon, it shall be moistened properly with the layer of material to be placed thereon, it shall be moistened and/or worked with harrow, scarifies, or other suitable equipment, "in an approved manner to a sufficient depth to provide a satisfactory bonding surface before the next succeeding layer of earth fill material is placed. If in the opinion of the Employer's Representativethe compacted surface of any layer of the earth fill in place is too wet for proper compaction of the layer of earth fill material to be placed thereon, it "shall be removed; allowed to dry or be worked with harrow, scarifies or other suitable equipment to reduce the moisture content to the required amount and then it shall be re-compacted before the next succeeding layer of earth fill material is placed.

When field density measurements reveal any soft areas in the embankment, further compaction shall be carried out as directed by the Employer's Representative. If in spite of that, the specified compaction is not achieved, the material in the soft areas shall be removed and replaced by approved material compacted to the density requirements. The Contractor shall be entitled to no additional allowance above the prices bid in the schedule by reason of any work required due to above conditions.

4.9. DRAINAGE

The surface of the embankment at all times during construction shall be maintained at such a cross-fall as will shed water and prevent flooding. All rainwater shall be drained away from the toe of the embankment. The Contractor shall maintain the embankment in an approved manner till the end of Defects Liability Period.

4.10. PLYING OF CONSTRUCTION TRAFFIC

Construction traffic shall not use the prepared surface of the embankment without the prior permission of the Employer's Representative. Any damage arising cut of such use shall, however, be made good by the Contractor at his own expense**.**

4.11. DISPOSAL OF EXCAVATED MATERIAL (IN EXCESS OF 500M)

All excavated material shall remain the property of . The disposal of excavated material within the plant premises upto a distance of 500M shall, unless the Employer's

Representativeorders otherwise, be at the Contractor's discretion but shall be so arranged as to suit the overall requirements for the construction of the works. This disposal within 500M is covered under the rates for Excavation.

The Contractor shall ensure that no excavated material which is suitable for and is required for re-use in the works is transported unless so ordered by the Employer's Representative.

Excavated materials which are not required for or are unsuitable for reuse in the work shall be disposed to any tipping location designated by the Employer's Representative, all as specified, at a distance from the place of excavation not exceeding ten kilometers by the most direct practicable route. Material disposed off at an Employer's Representativetip at a distance greater than ten kilometers shall qualify for additional payment as decided by the Employer's Representativeat such instance. Material so deposited shall be shaped up or spread and leveled as directed by the Employer's Representative. Any necessary work to provide access to the Employer's Representative tips or other preliminary work in connection there with shall be carried out by the Contractor to the Approval of the Employer's Representative.

4.12. BACK FILLING, GENERAL SITE GRADING & SAND FILLING

i) Fill Material

All fill material whether such material in brought from outside borrow areas or excavation within the site, will be subject to Employer's Representative's approval. Notwithstanding any approval given to the fill material or borrow areas from which fill materials is proposed to be brought, the Employer's Representativereserves 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 the Contractor's responsibility to locate suitable borrow areas for borrowing fill material. Such areas will be inspected by Employer's Representativeand approved before Contractor makes arrangements to borrow the fill material. The top soil which may contain vegetation, rubbish, slush etc. shall not be used. If requested by the Employer's Representative, the Contractor shall arrange to have trial pits of specified dimensions and numbers dug at locations specified, for the Employer's Representativeto examine and nature and type of material likely to be obtained from the borrow areas.

The borrowed soil shall be generally granular, and non-cohesive. It shall consist of sand, silty and murrum, ordinary soil, gravel and shingle. Dredged material, free from clayey deposit, may be accepted. Fill material shall also be free from sulphate, salts, organic, foreign and other harmful or objectionable materials. Any material rejected by the Employer's Representative shall be removed from the site immediately.

Roads, of a 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. Such access roads shall be maintained in good condition during all seasons to ensure completion of the work according to the time schedule.

ii) 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 Employer's Representative. 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 ninety-five percent of the maximum dry density obtained by the test in Part 7 of I.S. 2720 or to such higher density as it specified hereinafter. During compaction the backfill shall have a uniform moisture content equal to or a little above the optimum moisture content recorded in the LS 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.

Should the material being placed as backfilling, while acceptable at the time of selection, become unacceptable to the Employer's Representativedue 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 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 as defined in the contract. 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 by backfilling to the specified levels. As a rule material to be backfilled shall be stacked temporarily within the basic lead of 500 metres unless otherwise directed by the Employer's Representative.

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 I.S. specification. It shall be ensured however that the minimum compacted dry density is not less than 16 KN/cum. As the work progress field density tests shall be conducted on each layer at the rate of one test for every 1000 square metres to check whether desired compaction has actually been achieved.

iii) General Site Grading

Site grading shall be carried out as directed by the Employer's Representative. Excavation shall be carried out as specified in the specification. Filling and compaction shall, be carried out as specified under (ii) of this Clause, unless otherwise indicated 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.

To ensure that the fill has been compacted as specified, field and laboratory tests shall be carried out by the Contractor. Field compaction test shall be carried out 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 materials and make good the slip.

The fill shall be carried out to such dimensions and levels as directed by the Employer's Representative, after the stipulated compaction. The fill will be considered as inoculate if the desired compaction has not been obtained.

If specifically permitted by Employer's Representative, 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 the Contractor to demonstrate that the desired/specified compaction has been achieved. In order that the fill may be reasonably uniform layers. Traffic over the fill shall then be so routed to contact the area uniformly throughout.

If so specified, the rock as obtained from the excavation may be used for filling and leveling to indicated grades without further breaking. In such 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 rockfill shall be filled with finer materials such as earth, broken stone etc. and the area flooded so that the finer fill material does not get washed out. Over the layer, so filled, a 100 mm thick mixed layer of broken material an earth shall be laid and consolidation carried out by a 12 tonnes roller. Not less than twelve passes of the roller shall be accepted before subsequent similar operations are taken up.

iv) Sand filling below Plinth and Other Places

Backfilling shall be carried out with sand at places as directed by the Employer's Representative. The sand used shall be clean, medium grained and free from impurities. The filled-in sand shall be kept flooded with water for 24 hours to ensure maximum consolidation. Any temporary work required to contain sand under flooded condition shall be to the Contractor's account. The surface of the consolidated sand shall be dressed to the required level or slope. Construction of floors or other structures on sand fill shall not be started until the Employer's Representative has inspected and approved the fill.

4.13. CONCRETE AND ALLIED WORKS

4.13.1. GENERAL

The quality of materials and method and control of manufacture and transportation of all concrete work irrespective of mix, whether reinforced or otherwise, shall conform to the applicable portions of this specification.

The Employer's Representative shall have the right to inspect the source/s of material/s, the layout and operation of procurement and storage of materials, the concrete batching and mixing equipment and the quality control system. Such an inspection shall be arranged and Employer's Representativeapproval obtained, prior to starting of concrete work.

4.13.2. MATERIALS FOR STANDARD CONCRETE

The ingredients to be used in the manufacture of concrete shall consist solely of Portland cement, clean sand, natural coarse aggregate, clean water and admixtures, if specifically called for on drawings or specifications, or to the approval of the Employer's Representativeif conditions at site warrant its use.

a) Cement

Unless otherwise specified in the Specification or called for by the Employer's Representative, cement shall be ordinary Portland cement (OPC-43 grade) Bags conforming to IS:269 unless specifically defined. The use of bulk cement will be permitted only with the approval of the Employer's Representative. Changing of brands or type of cement within the same structure should be avoided as far as possible.

However cement for all works submerged under water shall be Portland Slag cement 43 grade in 50 kg. Bags conforming to IS:269 unless specifically defined. The use of bulk cement will be permitted only with the approval of the Employer's Representative. Changing of brands or type of cement within the same structure should be avoided as far as possible.

Sample shall be tested at approved Laboratory at Contractor's cost from each lot of cement delivered at site.

The Contractor will have to make his own arrangements for the supply and storage of an adequate quantity of cement. Employer will not supply cement. It will be the responsibility of the Contractor to ensure adequate and proper storage and complete protection from dampness, contamination and minimize caking and false set. Cement bags shall be stored in a dry enclosed shed (storage under tarpaulins will not be permitted), well away from the outer walls, and insulated from the floor to avoid contact with moisture from the ground and so arranged as to provide ready access. Damaged or reclaimed or partly set cement will not be permitted to be used and shall be removed from the site. The storage arrangement shall be such there is no dead storage. Not more than 12 bags shall be stacked in any tier. The Employer's Representative shall approve the storage arrangement. Consignments cement shall be stored as received and shall be consumed in the order of their delivery.

Cement held in storage for a period of ninety (90) days or longer shall be tested. Should at any time the Employer's Representative have reasons to consider that any cement is defective, then irrespective of it origin, date of manufacture and/or manufacture's test certificate, such cement shall be tested immediately at the Contractor's cost at the approved laboratory and until the results of such tests are found satisfactory, it shall not be used in any work. The Contractor shall not be entitled to any claim of any nature on this account.

b) Aggregates

i) General

'Aggregate" in general designates both fine and coarse inert materials is used in the manufacture of concrete.

"Fine Aggregate" is aggregate most of which passes through 4.75 mm IS sieve.

"Coarse Aggregate" is aggregate most of which is retained on 4.75 mm IS sieve.

All fine and coarse aggregates proposed for use in the Works shall be subject to the Employer's Representative's approval and after specific materials have been accepted, the source of supply of such materials shall not be changed without prior approval of the Employer's Representative.
Aggregates shall, except as noted above, consist of natural sands, crushed stone and gravel from a source known to produce satisfactory aggregate for concrete and shall be chemically inert, strong, hard, durable against weathering, of limited porosity and free from deleterious materials that may cause corrosion of the reinforcement or may impair the strength shall such as to produce a dense concrete of specified strength and consistency that will work readily into position without segregation and shall be based on the "mix design" and preliminary tests on concrete specified later.

ii) Sampling and Testing

Samples of the aggregates for mix design and determination of suitability shall be taken under the supervision of Employer's Representative and delivered to the laboratory, well in advance of the scheduled placing of concrete. Records of tests which have been made on proposed aggregates and on concrete made from this source of aggregates shall be furnished to Employer's Representative in advance of the work for use in determining aggregate suitability. The costs of all such tests, sampling, etc., shall be borne me by Contractor.

iii) Storage of Aggregates

All coarse and fine aggregates shall be stacked separately in stock piles in the material yard near the work site in bins properly constructed to avoid inter mixing of different aggregates. Contamination with foreign material and earth during storage and while heaping the materials shall be avoided. The aggregate must be of specified quality not only at the time of receiving at site but more so at the time of loading into mixer. Rakers

shall be used for lifting the coarse aggregates from bins or stockpiles. Coarse aggregate shall be piled in layers not exceeding 1.20 meters in height to prevent coning or segregation. Each layers shall cover the entire area of the stock pile before succeeding layers are started. Aggregates that have become segregated shall be rejected. Rejected material after remixing may be accepted, if subsequent tests demonstrate conformance with required gradation.

iv) Specific Gravity

Aggregates having a specific gravity below 2.6 (saturated surface dry basis) shall not be used without special permission of the Employer's Representative.

4.13.3. FINE AGGREGATE

Fine aggregate shall consist of natural or crushed sand conforming to I.S. 383. The sand shall be clean, sharp, hard strong and durable and shall be free from dust, vegetable substances, adherent coating, clay, alkali, organic matter, mica, salt, or other deleterious substances, which can be injurious to the setting qualities/strength/durability of concrete.

a) Machine-made Sand

Machine-made sand will be acceptable, provided the constituent rock gravel composition shall be sound, hard, dense, non-organic, uncoated and durable against weathering.

b) Screening and Washing

Sand shall be prepared for use by such screening or washing, or both, as necessary, to remove all objectionable foreign matter while separating the sand grains to the required size tractions.

c) Foreign Material Limitations

The percentage of deleterious substance in sand delivered to, the mixer shall not exceed the following:

Table 4.1

		Percent by weight	
		Uncrushed	Crushed
i)	Material finer than 75 micron I.S sieve	3.00	15.00
ii)	Shale	1.00	---
iii)	Coal and lignite	1.00	1.00
iv)	Clay lumps	1.00	1.00
v)	Total of all above substances including items (i) to (iv) for uncrushed sand and items (iii) and (iv) for Crushed sand	5.00	2.00

d) Gradation

Unless otherwise directed or approved by the Employer's Representative, the grading of sand shall be within the limits indicated hereunder.

Table 4.2

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

Where the grading falls outside the limits of any particular grading zone of sieves, other than 600 micron I.S. sieve, by total amount not exceeding 5 percent, it shall be regarded as falling within that grading zone. This tolerance shall not be applied to percentage passing the 600 micron IS. sieve or to percentage passing any other sieve size on the coarser limit of Grading Zone I or the finer limit of Grading Zone IV. Fine aggregates conforming to Grading Zone IV shall be used unless mix designs and preliminary tests shall show its suitability for producing concrete of specified strength and workability.

e) Fineness Modulus

The sand shall have a fineness modulus of not less than 2.2 or more than 3.2. The fineness modulus is determined by adding the cumulative percentages retained on the following I.S. sieve sizes (4.75mm, 2.36mm, 1.18mm, 600micron, 300micron and 150micron) and dividing the sum by 100.

4.13.4. COARSE AGGREGATE

Coarse aggregate for concrete, except as noted above, shall conform to IS: 383. This shall consist of natural or crushed stone and gravel, and shall be clean, and free from elongated, flaky or laminated pieces, adhering coatings, clay lumps, coal residue, clinkers, slag, alkali, mica, organic matter or other deleterious matter.

a) Screening and Washing

Natural gravel and crushed rock shall be screened and/or washed for the removal of dirt or dust coating, if so directed by the Employer's Representative.

b) Grading

Coarse aggregate shall be either in single size or graded, in both cases the grading shall be within the following limits :

Table 4.3

I.S Sieve Desig-nation	Percentage passing for single sized aggregate of nominal size					Percentage passing for Graded aggregate of nominal size			
	40 mm	20mm	16mm	12.5mm	10mm	40mm	20mm	16mm	12.5mm
63 mm	100	--	--	--	--	100	--	--	--
40 mm	85-100	100	--	--	--	95-100	100	--	--
20 mm	0-20	85-100	100	--	--	30-70	95-100	100	--
16 mm	--	--	85-100	100	--	--	--	90-100	--
12.5 mm	--	--	--	85-100	100	--	--	--	90-100
10 mm	0-5	0-20	0-30	0-45	85-100	10-35	25-55	30-70	40-85
4.75 mm	--	0-5	0-5	0-10	0-20	0-5	0-10	0-10	0-10
2.36 mm	--	--	--	--	0-5	--	--	--	--

The pieces shall be angular in shape and shall have granular or crystalline surfaces. Friable, flaky and laminated pieces, mica and shale, if present, shall be only in such quantities that will not, in the opinion of the Employer's Representative, affect adversely the strength and/or durability of concrete. The maximum size of coarse shall be the maximum size specified above, but in no case greater than 1/4 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. Plums above 160 mm and upto any reasonable size can be used in plain mass concrete work of large dimensions upto a maximum limit of 20% by volume of concrete when specifically approved by Employer's Representative. For heavily reinforced concrete members, the nominal maximum size of the aggregate shall be 5 mm less than the minimum clear distance between the reinforcing main bars or 5 mm less than the minimum cover to the reinforcement whichever is smaller. The amount of fine particles occurring in the free state or as loose adherent shall not exceed 1% when determined by laboratory sedimentation tests as per I.S, 2386. After 24 hours immersion in water, a previously dried sample shall not have gained more than 10% of its oven dry weight in air, as determined by I.S. 2386.

c) Foreign Material Limitations

The percentage of deleterious substances in the aggregate delivered to the mixer shall not exceed the following:

TABLE 4.4 :

S.N.	Foreign Material	Percent by weight	
		Uncrushed	Crushed
i)	Material finer than 75 micron I.S Sieve	3.00	3.00

ii)	Coal and lignite	1.00	1.00
iii)	Clay lumps	1.00	1.00
iv)	Soft fragments	3.00	----
v)	Total of all the above substances	5.00	5.00

4.13.5. WATER

Water used for both mixing and curing, shall be free from injurious amounts of deleterious materials. Potable water is generally satisfactory for mixing and curing concrete.

In case of doubt, the suitability of water for making concrete shall be ascertained by the compressive strength and initial setting time test specified in I.S. 456. The sample of water for testing shall be typical of the water proposed to be used for concreting, due account being paid to seasonal variation. The sample shall not receive any treatment before testing other than that envisaged in the regular supply of water proposed for use in concrete. The sample shall be stored in a clean container previously rinsed out with similar water.

Average 28 day compressive strength of at least three 15 cm concrete cubes prepared with water proposed to be used shall not less than 90% of the average strength of three similar concrete cubes prepared with distilled water. The cubes shall be prepared, cured and tested in accordance with the requirements of I.S. 516.

The initial setting time of test block made with the appropriate test cement and the water proposed to be used shall not be less than 30 minutes and shall not differ by more than ±30 minutes from the initial setting time of control test block prepared with the appropriate test cement and distilled water. The test blocks shall be prepared and tested in accordance with the requirements of I.S. 4031.

Where water can be shown to contain an excess of acid, alkali, sugar or salt, Employer's Representative may refuse to permit its use. As a guide, the following concentrations represent the maximum permissible values:

(a) To neutralize 200 ml, sample of water, using Phenolphthalein as indicator, it should not require more than 2 ml. of 0.1 Normal NaOH. The details of test shall be as given in I.S: 3025.

(b) To neutralize 200-ml. sample of water, using methyl orange, as an indicator should not require more than 10 ml. of 0.1 Normal HCL. The details of test shall be as given in I.S: 3025.

(c) Percentage of solids, when tested in accordance with the method indicated below, shall not exceed the following:

TABLE 4.5 :

Solids	Percent	Method of Test

		(Ref. to Cause No. In IS :3025)
Organic	0.02	10 and 11 (organic solids = total solids minus ignited residue)
Inorganic	0.30	11 (ignited residue)
Sulphates (as SO4)	0.05	20
Alkali Chloride (As Cl)	0.20	24
Suspended matter	0.20	12

4.14. STEEL MEMBERS ENCASED IN CONCRETE

Structural steel columns, beams, girders and bracings to be encased in concrete shall be unpainted. The encasing shall be done in concrete with 10 mm maximum size aggregate and works cube strength not less than 15 N/mm2 at 28 days unless otherwise specified. The steel member shall be wrapped with galvanised wire mesh of adequate size.

All stell members in the floor level in tanks contact with water shall be embeed in concrete for min. 450 mm above the fished floor level.

The galvanised wire mesh shall be at 20 mm from the edge or surface of the steel member and shall be held in position securely. The steel, member will have a minimum cover of 50 mm unless otherwise indicated on the drawings. Where the clear cover to steel is more than 75mm, mild steel bar and concrete with 20 mm coarse aggregate can be used.

4.14.1. CONTROLLED CONCRETE

All concrete in the works shall be "controlled concrete" as defined in IS 456, except for M7.5 and M10 for which nominal mix concrete shall be used. Whether reinforced or otherwise, all concrete works to be carried out under this specification shall be divide into the following classification:

TABLE 4.6 :

MINIMUM COMPRESSIVE STRENGTH OF 15 CM. CUBES AT 7 AND 28 DAYS AFTER MIXING CONDUCTED IN ACCORDANCE WITH IS : 516

Class	Preliminary test N/mm2		Works test N/mm2		Maximum size of aggregate	Locations for use
	At 7 days	At 28 days	At 7 days	At 28 days		
M40	33.5	50.0	27.0	40.0	20	As indicated in the specificaitons or as required.
M35	30.0	44.0	23.5	35.0	20	-do-
M30	25.0	38.0	20.0	30.0	40 or 20	-do-

M25	22.0	32.0	17.0	25.0	40 or 20	-do-
M20	17.5	26.0	13.5	20.0	40 or 20	-do-
M15	13.5	20.0	10.0	15.0	40 or 20	-do-

Notes: It shall be very clearly understood that whenever the concrete such M 20, etc. is specified it shall be Contractor's responsibility to ensure that minimum crushing strength stipulated for the respective grade of concrete is obtained at works.

Minimum cement content in the concrete used for liquid/ water retaining structure shall be 360 kg/m3 for 20 mm downgraded aggregate and 325 kg/m3 for 40 mm downgraded aggregate.

4.14.2. MIX DESIGN

a) General

This is to investigate the grading of aggregates, water cement ratio, workability and the quantity of cement required to give preliminary and works cubes of the minimum strengths specified. The proportions of the mix shall be determined by weight. Adjustment of aggregate proportions due to moisture present in the aggregate shall be made.

Determination of mix proportions shall be carried out according to "Recommended Guidelines for Concrete Mix Design' conforming to IS: 10262.

Whenever there is change either in required strength of concrete, or water-cement ratio or workability or the source of aggregates and/or cement, preliminary tests shall be repeated to determine the revised proportions of the mix to suit the altered conditions. While designing mix proportions, over-wet mixes shall always be avoided.
While fixing the value for water/cement ratio for preliminary mixes, assistance maybe derived from IS: 456.

b) Preliminary Tests

Test specimens shall be prepared with at least two different water/cement ratios for each class of concrete, consistent with workability required for the nature of the work.

The materials and proportions used in making preliminary tests shall be similar in all respects to those to be actually employed in the works as the object of these tests is to determine the proportions of cement, aggregates and water necessary to produce concrete of required consistency and to give the specified strength. It will be Contractor's sole responsibility to carry out these tests and he shall therefore furnish to Employer’s Representative a statement of proportions proposed to be used for the various concrete mixes. For preliminary tests, the following procedure shall be followed :

Materials shall be brought to the room temperature and all materials shall be in a dry condition. The quantities of water, cement and aggregates for each batch shall be determined by weight to an accuracy of 1 part in 1000 parts.

(i) Mixing Concrete

It shall be done by hand or in a small batch mixer as per I.S. 516 in such a manner as to avoid loss of water. The cement and fine aggregate shall first be mixed dry until the mixture is uniform in colour. The coarse aggregate shall then be added, mixed and water added and the whole batch mixed thoroughly for a period of not less than two minute until the resulting concrete is uniform in appearance. Each batch of, concrete shall be of such a size as to leave about 10% excess concrete, after moulding the desired number of test specimens.

(ii) Consistency

The consistency of each batch of concrete shall be measured immediately after mixing, by the slump test in accordance with I.S.1199. If in the slump test, care is taken to ensure that no water or other material is lost, the material used for the slump test may be remixed with the remainder of the concrete for making the specimen test cubes. The period of re-mixing shall be as short as possible yet sufficient to produce a homogeneous mass.

(iii) Size of Test Cubes

Compression tests of concrete cubes shall be made as per I.S.516 on 15 cm. cubes. Each mould shall be provided with a metal base plate having a plain surface so as to support the mould during filling without leakage.

The base plate shall be preferably attached to the mould when assembled shall be positively and rigidly held together. Before placing concrete, the mould and base plate shall be cleaned and oiled. The dimensions and internal faces of the mould shall be accurate within the following limits:

Height and distance between the opposite faces of the mould shall be of specified size +0.2 mm. The angle between the adjacent internal faces and between internal faces and top and bottom faces of mould shall be 90 +_ 0.5°. The interior faces of the mould shall be plain surface with a permissible variation of 0.03 mm.

(iv) Compacting

Concrete test cubes shall be moulded by placing fresh concrete in the mould and compacted as specified in I.S. 516.

(v) Curing

Curing shall be as specified in I.S.516. The cubes shall be kept in moist air of at least 90% relative humidity at a temperature of 27° ±_2° C for 24 hours ±1/2 hour from the time of adding water to the dry ingredients. Thereafter they shall be removed from the moulds and kept immersed in clean, fresh water and kept at 27° ± 2° C temperature "until required for test. Curing water shall be renewed every seven days. A record of maximum temperatures at the place of-storage of the cubes shall be maintained during the period they remain in storage.

(v) Testing of Specimens

The strength shall be determined based on not less that five cube test specimens for each age and each water cement ratio. All these laboratory test results shall be

tabulated and furnished to the Employer's Representative. The test results shall be accepted by the Employer's Representativeif the average compressive strength of the specimens tested is not less than the compressive strength specified for the age at which specimens are tested subject to the condition that only one out of the five consecutive tests may give a value less than the specified strength for that age. The Employer's Representativemay direct the Contractor to repeat the tests if the results are not satisfactory and also make such changes as he considers necessary to meet the requirement specified. All there preliminary tests shall be conducted by the Contractor at his own cost in approved laboratory.

4.14.3. PROPORTIONING, CONSISTENCY, BATCHING AND MIXING OF CONCRETE

a) Proportioning

(i) Aggregate

The proportions which shall be decided by conducting preliminary tests shall be by weight. These proportions of cement, fine and coarse aggregates shall be maintained during subsequent concrete batching by means of weigh batchers conforming to I.S. 2722 capable of controlling the weights within one percent of the desired value. Except where it can be shown to the satisfaction of the Employer's Representative that supply of properly graded aggregate of uniform quality can be maintained over the period of work, the grading of aggregate shall be controlled by obtaining the coarse aggregate in different sizes and blending them in the right proportions.

The different sizes shall be stocked in separate stock piles. The grading of coarse and fine aggregate shall be checked as frequently as possible, as determined by the Employer's Representative, to ensure maintaining of grading in accordance with the samples used in preliminary mix design. The material shall be stock piles well in advance of use.

(ii) Cement

Cement shall be measured by weight.

(iii) Water

Only such quantity of water shall be added to the cement and aggregates in the concrete mix as to ensure dense concrete, specified surface finish satisfactory workability, consistent with the strength stipulated for each class of concrete. The water added to the mix shall be such as not to cause aggregation of materials or the collection of excessive free water on the surface of the concrete.

(iv) Definition of Water/ Cement Ratio

The water cement (W/C) ratio is defined as the weight of water in the mix (including the surface moisture of the aggregates) divided by the weight of cement in the mix.

(v) Water/ Cement Ratio

The actual water cement ratio to be adopted shall be determined in each instance by the Contractor and approved by the Employer's Representative.

(vi) Proportioning by Water/ Cement Ratio

The W/C ratio specified for use by the Employer's Representativeshall be maintained. The Contractor shall determine the water content of the aggregates as frequently as directed by the Employer's Representativeas the work progresses and as specified in I.S. 2386 (Part ID) and the amount of mixing water added at the mixer shall be adjusted as directed by the Employer's Representative so as to maintain the specified W/C ratio. To allow for the variation in weight of aggregates due to variation in their moisture content, suitable adjustments in the weights of aggregates shall also be made,

b) Consistency and Slump

Concrete shall be of consistency and workability suitable for the conditions of the job. After the amount of water required is determined, the consistency of the mix shall be maintained throughout the progress of the corresponding parts of the work and approved tests e.g. slump tests, compacting factor tests, in accordance with I.S.1199, shall be conducted from time to time to ensure the maintenance of such consistency.

The following tabulation gives a range of slumps which shall generally be used for various types of construction unless otherwise instructed by the Employer's Representative:

TABLE 4.7 :
SLUMPS FOR VARIOUS TYPES OF CONSTRUCTION

Works Details	Slump in millimeters	
	Maximum	Minimum
Reinforced foundation walls and footings	75	25
Plain footings and substructure walls	75	25
Slabs, Beams and reinforced walls	100	25
Pumps & Miscellaneous Equipment foundations	75	25
Building Columns	100	25
Pavements	50	25
Heavy Mass Construction	50	25

c) Batching and Mixing of Concrete

The materials and proportions of concrete materials as established by the preliminary tests for the mix designs shall be rigidly followed for all concrete on the Works and shall not be changed except when specifically permitted by the Employer's Representative.

Concrete shall be produced only by weigh batching the ingredients. The mixer and weigh batchers shall be maintained in clean, serviceable condition. The accuracy of weigh batchers shall be periodically checked. They shall be set up level on a firm base and the hopper is empty. Fine and coarse aggregates shall be weighed separately. Volume batching will not be permitted. However, the Employer's Representative may permit

volume batching by subsequent conversion of the weights of the aggregate into their equivalent volumes knowing their bulk densities, only in the case of small and less important pours involving weigh batching are not likely to be taken up. Concrete shall be of strength stipulated in the respective items. All concrete shall be mixed in mechanically operated batch mixers complying with I.S.1791 and of the approved make with suitable provision for correctly controlling the water delivered to the drum. The quantity of water actually entering the drum shall be checked with the reading of the gauge or valve setting, when starting a job. The test should be made while the mixer is running. The volume of the mixed material shall not exceed the manufacturer's rated mixer capacity. The batch shall be charged into the mixer so that some water will enter the drum in advance of cement and aggregates. All water shall be in the drum by the end of the first 15 seconds of the specified mixing time.

Each batch shall be mixed until the concrete is uniform in colour, for a minimum period of two minutes after all the materials and water are in the drum. The entire contents of the drum shall be discharged in one operation before the raw materials for the succeeding batches are fed into the drum. Each time the work stops, the mixer shall be cleaned out and when next commencing the mixing, the first batch shall have 10% additional cement to allow for sticking in the drum.

4.15. MIX DESIGN REINFORCED CONCRETE – M15, M20, M30,M35,M40

- All water reating structures shall be designed as per IS3370 part I to IV.
- The works under this head covers all acitivities including raw materials, transportation to site, Reinforced Cement Concrete grades M15, M20, M30 shall be mix design as specified in General Specifications. In case WPC is required to be added (if specified), same shall conform with general specifications in all respects. Admixtures, as specified in General Specifications, shall be added, if directed by Employer's Representative depending on grade of concrete and construction requirements without any extra cost implication. Minimum M 25 grade for buildings and M-30 for Water Reating Structures shall be used, no grade below the said is permissible.
- Only Natural sand is allowed, no crushed sand is permissible.
- Suplhur Resitant cenemt to be used in contrction of RCC manholes.

- Contractor shall comply with all testing requirements as specified in General Specifications for raw materials and concrete (for all grades of concrete).

4.15.1. NOMINAL MIX CONCRETE – M10

- Nominal mix concrete, used in plain concrete works, shall be of grade M10. The Nominal mix concrete shall conform to the requirements of General specifications in all respects.

4.15.2. SAMPLING AND TESTING CONCRETE IN THE FIELD

As per **FQP**

4.15.3. ADMIXTURES

a) General

Admixtures may be used in concrete where required, only with the approval of the Employer's Representative based upon evidence that, with the passage of time, neither the compressive strength not its durability reduced.

Calcium chloride shall not be used for accelerating set of the cement for concrete containing reinforcement, or embedded steel parts. When calcium chloride is permitted to be used, such as in mass concrete works, it shall be dissolved in water and added to the mixing water in an amount not to exceed 1 1/2 % of the weight of the cement in each batch of concrete. When admixtures are used, the designed concrete mix shall be corrected accordingly. Admixtures shall be used as per manufacturer's instructions and in the manner and with the control specified by the Employer's Representative.

b) Air Entraining Agents

Neutralized vinsol resin or any other approved air entraining agent may be used to produce the specified amount of air in the concrete mix and these agents shall conform to the requirements of ASTM standard 6-20. Air entraining admixtures for concrete. The recommended total air content of the concrete is 4% ± 1%. The method of measuring air content shall be as per IS: 1199.

c) Water Reducing Admixtures

Water reducing lignosulfonate admixture may be added in quantities approved by the Employer's Representative. The admixtures shall be added in the form of a solution.

d) Retarding Admixtures

Retarding agents may be added to the concrete mix in quantities approved by the Employer's Representative.

e) Water-Proofing Compound

i) As directed by the Employer's Representative, the Contractor shall use approved waterproofing compound made by manufacturers as per list of makes in Section-X, Volume-2, Employers requirement. In the reinforced concrete works. The quantity to be used shall be two percent by weight of cement or shall be in accordance with the manufacturer's instructions subject however to the approval of the Employer's Representative. The compound shall not contain calcium chloride and shall conform to IS: 2645.

ii) Mixing water proofing compound with cement. The compound should be mixed thoroughly with the cement by hand before the cement is mixed with aggregate. Thorough mixing is essential. The two materials should be heaped on a mixing board thoroughly turned over several times with a shovel and finally passed through a fine sieve. If labour is unsatisfactory the sieving should be done twice to ensure maximum dispersal of the compound throughout the cement.

iii) **Mixing the concrete**

The mixture of water proofing compound and cement should then be added to the aggregate, the dry materials turned over twice and the correct amount of water then added through a rose spray, A further thorough mixing by spade should immediately follow. Only the minimum quantity of water necessary to give workability should be used such that it will make the concrete just sufficiently plastic for purposes of placing and thorough consolidation without affecting its strength.

f) Corrosion Inhibators

Corrosion Inhibators shall be added to concreting for water reating structures in contact with water as well for use of concrete to embeed the structural steel.

4.15.4. CONCRETE IN ALKALI SOILS AND ALKALINE WATER

Where concrete is vulnerable to attack from alkali salts or alkaline water, special cements containing low amount of tricalcium aluminate shall be used, if so specified or directed. Such concrete shall have a minimum 28 days compressive strength of 25 N/mm2 and shall contain not less than 3.7 KN of cement per cubic metre of concrete in place. If specified, additional protection shall be obtained by the use of chemically resistant stone facing or a layer of Plaster of Paris covered with suitable fabric, such as jute thoroughly impregnated with tar.

4.15.5. PREPARATION PRIOR TO CONCRETE PLACEMENT. FINAL INSPECTION AND APPROVAL

Before the concrete is actually placed in position, the insides of the formwork shall be inspected to see that they have been cleaned and oiled. Temporary openings shall be provided to facilitate inspection, especially of bottoms of columns and wall forms, to permit removal of saw dust wood shavings, binding wire, rubbish, dirt, etc. Openings shall be placed or holes drilled so that these materials and water can be removed. Such openings/holes shall be later suitably plugged. The various trades shall be permitted ample time to install drainage and plumbing lines, floor and trench drains, conduits, hangers, anchors, inserts, sleeves, bolts, frames and other miscellaneous embedded to be cat in the concrete as specified or required or as is necessary for the proper execution of the work.

All embedded parts, inserts, etc., supplied by the Corporation or the Contractor shall be correctly positioned and securely held in the forms, to prevent displacement during depositing and vibrating of concrete.

All anchor bolts shall be positioned and kept in place with the help of properly manufactured templates unless specifically waived in writing by the Employer's Representative.

Slots, openings, holes, pockets, etc., shall be provided in concrete work in the positions specified or required or as directed by the Employer's Representative.

Reinforcement and other items to be cast in concrete shall have clean surfaces that will not impair bond.

Prior to concrete placement all work shall be inspected and approved by the Employer's Representative and if found unsatisfactory, concrete shall not be poured until all defects have been corrected.

Approval by the Employer's Representative of any and all materials and work as stated herein shall not relieve the Contractor from his obligation to produce finished concrete in accordance with the requirements of the specification.

a) Rain or Wash Water

No concrete shall be placed in wet weather or on a water covered surface. Any concrete that has been washed by heavy rains shall entirely removed, if there is any sign of cement and sand having been washed away from the concrete mixture. To guard against damage which may be used by rains, the works shall be covered with tarpaulins immediately after the concrete has been placed and compacted before leaving the work ended. Any water accumulating on the surface of the newly placed concrete shall be removed by approved means and no further concrete shall be placed thereon until such is removed. To avoid flow of water over/around freshly placed concrete, suitable drains .and sumps shall be provided.

b) Bonding Mortar

Immediately before concrete placement begins, prepared surfaces except formwork, which will come in contact with the concrete to be placed, shall be covered with a bonding mortar as specified.

5.1 TRANSPORTATION

a) General

All buckets, containers or conveyors used for transporting concrete shall be mortar-tight. Irrespective of the method of transportation adopted, concrete shall be delivered with the required consistency and plasticity without segregation or loss of slump. However, chutes shall not be used for transport of concrete without the written permission of the Employer's Representative and concrete shall not be re-handled before placing.

b) Re tempered or Contaminated Concrete

Concrete must be placed in its final position before it becomes too stiff to work. On no account, water shall be added after the initial mixing. Concrete which has become stiff or has been contaminated with foreign materials shall be rejected and disposed off as directed by the Employer's Representative.

c) Cleaning of Equipment

All equipment used for mixing, transporting and placing of concrete shall be maintained in clean condition. All pans, buckets, hoppers, chutes, pipelines and other equipment shall be thoroughly cleaned after each period of placement.

4.16. PROCEDURE FOR PLACING OF CONCRETE

a) Employer's Representative's Approval for Equipment & Methods

Before any concrete is placed, the entire placing programme, consisting of equipment, layout, proposed procedures and methods shall be submitted to the Employer's Representative for approval if so demanded by the Employer's Representativeand no concrete shall be placed until Employer's Representative approval has been received equipment for conveying concrete shall be of such size and design as to ensure a practically continuous flow of concrete during depositing without segregation of materials, considering the size of the job and placement location.

b) Time Interval between Mixing and Placing

Concrete shall be placed in its final position before the cement reaches its initial set and concrete shall normally be compacted in its final position within Ninety minutes of leaving the mixer, and once compacted it shall not be disturbed.

c) Avoiding Segregation

Concrete shall in all cases, be deposited as nearly as practicable directly in its final position, and shall not be re-handled or caused to flow in a manner which will cause segregation, loss of materials, displacement of reinforcement, shuttering or embedded inserts, or impair its strength. For locations where direct placement is not possible, and in narrow forms, the Contractor shall provide suitable drop and "Elephant Trunks" to confine the movement of concrete. Special care shall be taken when concrete is dropped from a height, especially if reinforcement is in the way, particularly in columns and thin walls.

d) Placing of Manual Labour

Except when otherwise approved by the Employer's Representative, concrete shall be placed in the shuttering by shovels or other approved implements, and shall not be dropped from a height more than 1.0 m or handled in a manner which will cause segregation.

e) Placing by Mechanical Equipment

The following specification shall apply when placing of concrete by use of mechanical equipment is warranted considering the nature of work involved.

The control of placing shall begin at the mixer discharge. Concrete shall be discharge by a vertical drop into the middle of the bucket or hopper and the principle of a vertical discharge of concrete shall be adhered to throughout all stages of delivery until the concrete comes to rest in its final position.

i) Type of Buckets

Central-bottom-dump buckets of a type that provides for positive regulation of the amount and rate of deposition of concrete in all dumping positions, shall be employed.

ii) Operation of Bucket

In placing concrete in large open areas, the bucket shall be spotted directly over the position designated and then lowered for dumping. The open bucket shall clear the concrete already in place and the height of drop shall not exceed 1.0 m. the bucket shall

be opened slowly to avoid high vertical bounce. Dumping of buckets on the swing or in any manner which results in separation if ingredients or disturbance of previously placed concrete will not be permitted.

f) Placement in Restricted Forms

Concrete placed in restricted forms by barrows, buggies, cars, short chutes or hand shovelling shall be subject to the requirement for vertical delivery of limited height to avoid segregation and shall be deposited as nearly as practicable in its final position.

g) Chuting

Where it is necessary to use transfer chutes, specific approval of Employer's Representative must be obtained to type, length, slopes, baffles, vertical terminals and timing of operations. These shall be so arranged that an almost continuous flow of concrete is obtained at the discharge end without segregation. To allow for the loss of mortar against the sides of the chutes, the first mixes shall have less coarse aggregate. During cleaning of chutes, the waste water shall be kept clear of the forms. Concrete shall not be permitted to fall from the end of the chutes by more than 1.0 m. chutes, when approved for use, shall have slopes not flatter than 1 vert : 3 horiz. And not steeper than 1 vert : 2 horiz. Chutes shall be of metal or metal lined and of rounded cross section. The slopes of all chute sections shall be approximately the same. The discharge end of the chutes shall be maintained above the surface of the concrete in the forms.

h) Placing by Pumping / Pneumatic Placers

Concrete may be conveyed and placed by mechanically operated equipment e.g. pumps or pneumatic placers only with the written permission of the Employer's Representative. The slump shall be held to the minimum necessary for conveying concrete by this method.

When pumping is adopted, before pumping of concrete is started, the pipeline shall be lubricated with one or two batches of mortar composed of one part cement and two parts sand. The concrete mix shall be specially designed to suit pumping. Care shall be taken to avoid stoppages in work once pumping has started.

When a pneumatic placer is used, the manufacturer's advice on layout of the pipeline shall be followed to avoid blockages and excessive wear. Restraint shall be provided at the discharge box to cater for the reaction at this end.

Manufacturer's recommendations shall be followed regarding concrete quality and all other related matters when pumping/ pneumatic placing equipment is used.

i) Concrete In Layers

Concreting, once started, shall be continuous until the pour is completed. Concrete shall be placed in successive horizontal layers of uniform thickness ranging from 15 cm to 90 cm as directed by Employer's Representative. These shall be placed as rapidly practicable to prevent the formation of cold joints or places of weakness between each

succeeding layer within the pour. The thickness of each layer shall be such that it can be deposited before the previous layer has stiffened. The bucket loads or other units of deposit, shall be spotted progressively along the face of the layer with such overlap as will facilitate spreading the layer to uniform depth arid texture with a minimum of shovelling. Any tendency to segregation shall be corrected by shovelling stones into mortar rather than mortar on to stones. Such a 'condition' shall be corrected by redesign of mix or other means, as directed by the Employer's Representative.

j) Bedding of Layers

The top surface of each pour and bedding planes shall be approximately horizontal unless otherwise instructed.

k) Compaction

Concrete shall be compacted during placing, with approved vibrating equipment until the concrete has been consolidated to the maximum practical density, is free of pockets of coarse aggregate fits tightly against all form surfaces, reinforcement an embedded fixtures. Particular care shall be taken to ensure that all concrete placed against the form faces and into comers of forms or against hardened concrete at joints is free from voids or cavities. The use of vibrators shall be consistent with the concrete mix and caution exercised not to over vibrate the concrete to the point that segregation results.

i) Type of Vibrators

Vibrators shall conform to IS specifications. Type of vibrator to be used shall depend on the structure where concrete is to be placed. Shutter vibrators to be effective, shall be firmly secured to the formwork which must be sufficiently rigid to transmit the vibration and strong enough not to be damaged by it. Immersion vibrators shall have "no load" frequency, amplitude and acceleration as per IS: 2505 depending on the size of the vibrator. Immersion vibrators in sufficient numbers and each of adequate size shall be used to properly consolidate all concrete. Tapping or external vibrating of forms by hand tools or immersion vibrators will not be permitted.

ii) Use of Vibrators

The exact manner of application and the most suitable machines for the purpose must be carefully considered and operated by experienced men. Immersion vibrators shall be inserted vertically at points not more than 450 mm apart and withdrawn when air bubbles cease to come to the surface. Immersion vibrators shall be withdrawn very slowly. In no case shall immersion vibrators be used to transport concrete inside the forms. Particular attention shall be paid to vibration at the top of a lift e.g. in a column or wall.

iii) Melding successive Batches

When placing concrete in layers, which are advancing horizontally as the work progresses, great care shall be exercised to ensure adequate vibration, blending and melding of the concrete between the succeeding layers.

iv) Penetration of Vibrator

The immersion vibrator shall penetrate the layer being placed and also penetrate the layer below while the under layer is still plastic to ensure good bond and homogeneity between the two layers and prevent the formation of cold joints.

v) Vibrating against Reinforcement

Care shall be taken to prevent contact of immersion vibrators against reinforcement steel. Immersion vibrators shall not be allowed to come in contact with reinforcement steel after start of initial set. They shall also not be allowed to come in contact with forms or finished surfaces.

vi) Use of Form Attached Vibrators

Form attached vibrator shall be used only with specific authorization of the Employer's Representative.

vii) Use of Surface Vibrators

The use of surface vibrators will not be permitted under normal conditions. However, for thin slabs, such as highways, runways and similar construction, surface vibration by specially designed vibrators, may be permitted, upon approval of Employer's Representative.

viii) Stone Pockets and Mortar Pondages

The formation of stone pockets or mortar pondages in corners and against faces of forms shall not be permitted. Should these occur, they shall be dug out, reformed and refilled to sufficient depth and shape for through bonding, as directed by the Employer's Representative.

l) Placement Interval

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 and before the start of a subsequent placement.

m) Special Provision in Placing

When placing concrete in walls with openings, in floor of integral slab and beam construction and other similar conditions, the placing shall stop when the concrete reaches the top of the opening in walls or bottom horizontal surface of the slab, as the case may be. Placing shall be resumed before the concrete in place takes initial set, but not until it has had time to settle as determined by the Employer's Representative.

n) Placing Concrete through Reinforcing Steel

When placing concrete through reinforcing steel, care shall be taken to prevent segregation of the coarse aggregate. Where the congestion of steel makes placing difficult, it may be necessary to temporarily move the top steel aside to get proper placement and restore reinforcing steel to design position and the Employer's Representative's approval shall be obtained prior to adopting this method.

o) Bleeding

Bleeding or free water on top of concrete being deposited into the forms, shall be cause to stop the concrete pour and the conditions causing this defect corrected before any further concreting is resumed.

4.17. BONDING OF NEW AND OLD CONCRETE

a) General

Epoxy resins may be used to bond fresh concrete to concrete that is fully cured, to give a monolithic bond capable of transmitting high stresses when traditional bonding agents such as cement slurry cannot always be relied upon to provide good adhesion which is particularly the case when large areas are involved.

The formulation shall be applied to a suitably prepared concrete substrata and the fresh concrete poured as soon as possible, but always during the 'open time' of the adhesive. Material used shall be of best quality and approved by .the Employer's Representative. Manufacturer's instruction shall be followed in all respects.

Prefeablly a Acrylic emulsion cement modifier shall be used.

b) Application

i) Preparation of the Substrata

To obtain good adhesion it is necessary to have a clean and sound substrata. Preparation can be carried out using a variety of techniques including chemical treatment and mechanical methods such as grinding, milling abrading, planning and sand blasting. Dust and loose particles resulting from the pre-treatment should be removed by vacuum cleaning or oil-free air blast.

ii) Mixing

The resin and hardener should be thoroughly mixed before mixing in the dry filler. The mixed, ready to use adhesive should not contain lumps of unwetted filler and should be of a uniform colour. For a total weight of 1 kilogram or less, hand mixing should be sufficient. For quantities in excess of 1 kilogram, the use of a mechanical mixer is recommended.

iii) Pot life and 'Open Time'

The pot life is the period during which the ready to use Araldite based formulation must be applied. After this period the mix can no longer be worked and will have begun to set in its container. The table below indicates the pot life at different temperatures :

Table 4.8

Max. temperature ^{0}C	Pot life in minutes
25	90
30	60
35	45

The 'open time' is the maximum period of time allowable between application of the ARALDITE adhesive and pouring the fresh concrete. Exceeding the 'open time' would result in considerably reduced adhesion.

The adhesive should be applied to the pre-treated substrata as soon as the components have been mixed and fresh concrete poured immediately afterwards.

Accurate knowledge of the 'open time' is essential in case the work in interrupted.

Table 4.9

Substrate temperature ^{0}C	Open Time
35	30 Minutes
30	1 Hour
25	1.75 Hours
23	3 Hours

Table 9.9 gives the 'open time' of ARALDITE base formulations as a function of substrata temperature. In all cases the adhesives shall be applied immediately after mixing. Any delay between mixing and application will reduce the 'open time'. Fresh concrete must be poured before the adhesive begins to gel. New to old concrete bonding is not recommended at temperatures below 5°C as adequate curing cannot be assured under these circumstances.

iv) Methods of Application

The shape and size of the concrete structure will determine the method of application used. The ARALDITE based adhesive may be applied by hand using brushes, brooms or any other suitable applicator.

v) Suitability of the Fresh Concrete

Best results are obtained when the water/cement ratio of the new concrete is as low as is practicable.

vi) Coverage

One kilogram of the mixed ARALDITE adhesive including hardeners and thinner covers an area of 2.3 sq. metres when applied with a stiff nylon bristle brush. However, the coverage is very much dependent on the finish in the concrete.

c) Handling Precautions

Epoxy resins can cause irritation of the skin of the persons if incorrectly handled. Certain safety precautions must therefore be observed and those handling the resins and hardeners should be given suitable instructions. Those working with epoxy resins should, above all, be instructed that personal cleanliness at the place of work is essential. The resin and hardener should not be allowed to come into direct contact with the skin. The most effective protection is achieved by wearing rubber or polythene gloves, the later

having the advantage that they can be replaced when dirty. They are most pleasant to wear if cotton gloves are worn underneath. Parts of the skin which have come into contact with the resin or hardener should be washed with lukewarm water and a mild soap. Special cleaning creams have also proved to be highly suitable.

4.18. CONSTRUCTION JOINTS

A construction joint is defined as a joint in the concrete introduced for convenience in construction at which special measures are taken to achieve subsequent continuity without provision for further relative movement.

All the drawings submitted for the Employer's Representative's approval shall indicate position of all construction joints and lifts. No concreting shall be started until the Employer's Representative has approved the method of placing, the positions and form of the construction joints and lifts. The construction joints shall be so located as not to impair the strength of the structure. Rebates, keys or notches shall be formed and water stops inserted as the Employer's Representative may require. The position of construction joints and the size of the formwork panels shall be so coordinate that where possible the line of any construction joints coincides with the line of a formwork joint and that in any case all construction joint lines and formwork joint lines appear as a regular and uniform series. For all exposed horizontal joints and purposely inclined joints, a uniform joint shall be formed with a batten of approved dimensions to give a straight and neat joint line.

Concrete placed to form the face of a construction joint shall have all laitance removed and the aggregate exposed prior to the placing of fresh concrete. The laitance shall wherever practicable be removed by spraying the concrete surface with water under pressure and brushing while the concrete is still green. Where the laitance cannot be removed while the concrete is still green the whole of the concrete surface forming part of the joint shall be hacked to expose the aggregate. Where aggregate is damaged during hacking it shall be removed from the concrete face by further hacking. All loose matter shall be removed and the exposed surface thoroughly cleaned by wire brushing, air blasting or washing, leaving the surface clean and damp. Immediately before fresh concrete is placed a 12 mm thick layer of sand/ cement mortar mixed in the same proportions as in the concrete shall be spread in the horizontal face of the construction joint. A drier mix shall be used for the top lift of horizontal pours to avoid laitance. The new concrete shall be well worked against the prepared face before the mortar sets. Special care shall be taken to obtain through compaction and to avoid segregation of the concrete along the joint plain.

4.19. MOVEMENT JOINTS

Movement joints are defined as all joints intended to accommodate relative movement between adjoining parts of a structure, special provision being made where necessary for maintaining the water tightness of the joint. The Contractor shall comply with the instructions of manufacturers of proprietary jointing materials and shall, if required by the Employer's Representative, demonstrate that the jointing materials can be applied satisfactorily.

The Contractor shall show locations of all movement joints and details thereof on drawings submitted for the Employer's Representative's approval.

The surface of set concrete in a movement joint shall, as shown on the Drawings, be painted with two coats of bituminous paint and new concrete shall be placed against it only when the paint is dry. Expansion joints shall be formed by a separating strip of approved performed joint filler. Caulking grooves shall be provided. At all joints where a caulking groove is formed, immediately prior to caulking, the groove shall be wire brushed and loose material removed and blown out by compressed air. After the groove has dried, it shall be primed and caulked with approved sealing compound applied in accordance with the manufacturer's instructions. At all caulked joints, the face of the caulking strip and a 50 mm width of concrete on either side shall be painted with two coats of paint having the same base as the sealing compound.

4.20. WATER STOPS AND JOINT FILLERS

At all vertical construction joints in walls of water retaining structures and all expansion joints in the water retaining structures and wherever specified or directed by the Employer's Representative, water stops shall be provided. The water stops shall be of synthetic grade rubber and shall be as follows:

i)	Tensile strength not less than	20 N per sq.mm
ii)	Elongation at break not less than	500%
iii)	Modulus at 300% elongation	5.1 N per sq.mm
iv)	Specific gravity	1.12
v)	Compression set / constant deflection percent of original deflection at 70^0C for 22 hrs.	24% max.
vi)	Change in weight water immersion (2 days at 70^0C)	1.6% max.
vii)	Tensile strength and elongation at break as % of original, after oxygen pressure test 48 hours, 70^0C, 21.1 kgf per sq.cm before ageing	
	Tensile strength	85% min.
	Elongation at break	83% min.

Water stops shall not be exposed to direct sunlight for long periods. Before being concreted, water stops shall be cleaned of all foreign materials. Wherever provided, water stops shall be placed in such a manner that they are embedded in the adjacent sections of the panels for equal width.

The storage, fixing in position, splicing of water stops shall be as per manufacturer's instructions.

Water stops shall be fully supported in the form work, free of nails and clear of reinforcement and other fixtures. Damaged water stops shall be replaced and during concreting care shall be taken to place concrete so that water stops do not bend or distort

The different type of water stops to be used in liquid retaining structures shall be as follows:

TABLE 4.10

	Type of Joint	Type of Water Stops
1.	Partial / complete contraction joint in walls and slabs	150 mm wide, ribbed with hollow centre bulb and 5 mm minimum thickness
2.	Expansion joints in walls and slabs	225 ram wide, ribbed with hollow centre bulb and 9 mm minimum thickness
3.	Construction joint in raft	225 mm wide, ribbed with hollow centre bulb and 5 mm minimum thickness
4.	Construction joint in wall	150 mm wide, ribbed with hollow centre bulb and 5 mm minimum thickness
5.	Partial/ complete contraction joint in raft	225 mm wide, ribbed with hollow centre bulb and 5 mm minimum thickness
6.	Expansion joint in raft	225 mm wide, ribbed with hollow centre bulb and 5 mm minimum thickness

4.21. JOINT FILLERS

Joint fillers shall be of durable, compressible, and non-extruding material. The joint filler shall be thermocole TF quality of thickness 25 mm. The side face of reinforced concrete member shall be thoroughly cleaned with wire brush and 85/25 industrial grade hot bitumen, conforming to IS: 702 shall be applied uniformly over the surface at the rate of 1.5 kg/sq.m.

Thermocole boards (TF quality) of 25 mm thickness shall be stuck means of the same grade of hot bitumen. The joints of the boards shall be sealed with bitumen. Holes in joint filler to accommodate the dowel bars shall be accurately done to produce a sliding fit on the dowel bars.

4.22. BITUMEN PAINT

The material shall be of the best quality unpig mented bituminous base paint of such a composition as to satisfy the requirements of IS: 9862 where total volatile matter contained in the paint shall not exceed 55% by weight.

At least 95% of the solid materials shall be soluble, in carbon di-sulphide or in benzene, and the closed flash point as determined in Abel's apparatus shall not be less than (86°F)30°C. The paint shall remain liquid and retain its consistency at the ordinary atmospheric temperature when packed in suitable containers. The drying time shall not be less than 2 hours and not more than 8 hours and after drying, the paint shall not show any surface cracks, tendency to powder or discoloration due to weathering action or expansion and contraction, It shall also be able to resist the action of acids and alkalis. It shall soften under the action of mineral turpentine.

The film resulting from brushing the material on a strip of tinned iron, 30 standard wire gauge after being allowed to dry at room temperature not below (65°F) 18.3°C for 48 hours shall not when bent do1.lble over a (quarter inch) 6 mm dia rod, shown any signs of flaking or cracking. The time occupied for the actual bending shall not exceed" one second. When the paint has dried hard, a 4 H pencil should not be capable of scratching it. The weight of the paint shall be from 0.83 to 1.25 kg per litre, the component of the paint shall be such as not to react the water chlorinated or otherwise and develop poisonous or harmful elements thereto.

The paint shall be of Indian manufacture of approved make and quality.

4.23. BITUMENT KRAFT PAPER

The Bitumen Kraft paper shall comprise of two plies or kraft paper laminated with bitumen. It shall conform to type 1 of IS: 1398. It shall be free of cracks. The adhesion between the plies shall be such that they cannot be separated by pulling apart with hands after conditioning as per Clause 2.1 of IS: 1060 Part I without damaging the paper. Its minimum bursting strength should be 2.3 kgs / sq / cms. Its tensile strength shall be as per IS: 1398.

4.24. SEALING COMPOUND

The sealing compound shall satisfy the following requirements.

(a) To seal the joints against passage of water.
(b) To prevent ingress of grit or other foreign matters and
(c) To provide protection to the joint filler where necessary.

The various characteristic properties of the sealing compound those require consideration are adhesion, good extensibility, resistance to flow, resistance to ingress of foreign matter, resistance to weathering and resistance to oil, fuel and fat.

For application of, the sealing compounds the concrete shall be in dry condition. The subsequent climatic conditions after construction shall also be considered in selection of proper sealing compounds and its application so that the sealing compound is able to withstand the stress and maintain its adhesive bond with the concrete. After allowing the concrete to dry, the sealing cavity shall be cleaned and exposed to atmosphere for some time till it is dry.

While applying compounds, the manufacturer's advice may be followed with regard to application of primer, if necessary. The application of primer shall be such as to cover the

sealing cavity to the full depth. No excess primer shall be applied. Sufficient time shall be allowed after the application of primer so that it dries completely before the application of sealing compound.

4.25. TOLERANCES IN CONCRETE SURFACES

Concrete surfaces for the various classes of unformed and formed finished specified in various Clauses shall comply with the tolerances shown in Table 9.11 hereunder, except where different tolerances are expressly required by the specification.

In Table 9.11 'line and level' and 'dimension' shall mean the lines, levels and cross-sectional dimensions as specified and required.

Surface irregularities shall be classified as 'abrupt' or 'gradual'. Abrupt irregularities include but shall not be limited to, offsets and fins caused by displaced or misplaced formwork, loose knots and other defects in formwork materials, and shall be tested by direct measurement. Gradual irregularities shall be tested by means of a straight template for plain surfaces or its suitable equivalent for curved surfaces, the template being 3 m long for unformed surfaces and 1.5 m long for formed surfaces.

TABLE 4.11

Class of Finish	Maximum tolerances 9mm) in :			
	Line and Level	Abrupt irregularity	Gradual irregularity	Dimension
U1	±12	6	±6	---
U2	±6	3	±3	---
U3	±6	3	±3	---
F1	±12	6	±6	+12 – 6
F2	±6	6	±6	+12 – 6
F3	±3	3	±6	+6

4.26. UNFORMED SURFACES - CLASS OF FINISH

Finishes to unformed surfaces of concrete shall be classified as U1, U2, U3, 'spaded" or 'bonded concrete'. Where the class of finish is not specified the concrete shall be finished to Class U1.

Where a bonded concrete surface is specified, the laitance shall be removed from the Class U1 finished surface and the aggregate exposed while the concrete is still green.

A spaded finish shall be a surface free from voids and brought to reasonably uniform appearance by the use of shovels as it is placed in the works.

Class U2 finish shall be a wood float finish. Floating shall be done after the initial set of the concrete has taken place and the surface had hardened sufficiently. The concrete shall be worked no more than is necessary to produce a uniform surface free from screed marks.

Class U3 finish shall be a hard smooth steel-trowelled finish. Trowelling shall not commence until the moisture film has disappeared and the concrete has hardened sufficiently to prevent excess laitance from being worked into the surface. The surfaces shall be trowelled under firm pressure and left free from trowel marks.

The addition of dry cement, mortar or water shall not be permitted during any of the above operations,

4.27. CURING, PROTECTING. REPAIRING & FINISHING

a) Curing

All concrete shall be cured by keeping it continuously damp for a period of time required for complete hydration and hardening to take place. Preference shall be given to the use of continuous sprays, or ponded water, continuously saturated coverings of sacking, canvas, hessian or other absorbent materials, or approved effective curing compounds applied with spraying equipment capable of producing a smooth, even textured coat. Extra precautions shall be exercised in curing concrete during cold and hot weather as outlined hereinafter. The quality of curing water shall be the same as that used for mixing concrete.

Certain types of finish or preparation for overlaying concrete must be done at certain stages of the curing process and special treatment maybe required for specific concrete surface finish.

Curing of concretes made of high alumina cement and super sulphated cement shall be carried out as directed by the Employer's Representative.

i) Curing with Water

Fresh concrete shall be kept continuously wet for a minimum period of 10 days from the date of placing of concrete, following a lapse 12 to 14 hours after laying concrete. The curing of horizontal surfaces exposed to the drying winds shall however begin as soon as the concrete has hardened. Water shall be applied to formed surfaces immediately upon removal of forms. Quantity of water applied shall be controlled so as to prevent erosion of freshly a placed concrete.

ii) Continuous Spraying

Curing shall be assured by use of an ample water supply under pressure in pipes, with all necessary appliances of hose, sprinklers, and spraying devices. Continuous fine mist spraying or sprinkling shall be used, unless otherwise specified or approved by the Employer's Representative.

iii) Alternate Curing Methods

Whenever in the opinion of the Employer's Representative, it is necessary to omit the continuous spray method, a covering of clean sand or other proved means such as wet gunny bags which will prevent loss of moisture from the concrete may be used. No

type of covering will be approved which would stain or damage the concrete during or after the curing period. Covering shall be kept continuously wet during the curing period.

For curing of concrete in pavements, sidewalks, floor, flat roofs or other level surfaces, the ponding method of curing is preferred. The method of containing the ponded water shall be approved by the Employer's Representative. Special attention shall be given to edges and comers of the slabs to ensure proper protection to these areas. The ponded areas shall be kept continuously filled with water during the curing period.

iv) Curing Compounds

Surface coating type curing compounds shall be used only by special permission of Employer's Representative. Curing compounds shall be liquid type white pigmented, conforming to U.S. Bureau of Reclamation specification. No curing compound shall be used on surfaces where future blending with concrete, water or acid proof membrane, or painting is specified.

v) Curing Equipment

All equipment and materials required for curing shall be on hand and ready for use before concrete is placed.

b) Protecting Fresh Concrete

Fresh concrete shall be protected from defacements and damage due to construction operations by leaving forms in place for an ample period as specified later in these specifications. Newly placed concrete shall be protected by approved means such as tarpaulins from rain, sun and winds. Steps as approved by the Employer's Representative shall also be taken to protect immature concrete from damage by debris, excessive loading, vibration, abrasion or contact with other materials etc., that may impair the strength and/or durability of the concrete. Workmen shall be warned against and prevented from disturbing green concrete during its setting period. If it is necessary that workmen enter the area of freshly placed concrete, the Employer's Representative may require that bridges be placed over the area.

c) Repair and Replacement of Unsatisfactory Concrete

Immediately after the shuttering is removed, the surface of concrete shall be very carefully gone over and all defectives areas called for the attention of the Employer's Representative who may permit patching of the defective areas or also reject the concrete unit either partially or its entirely. Rejected concrete shall be removed and replaced by the Contractor. Holes left by form bolts etc., shall be filled up and made good with mortar composed of one part of cement to one and half parts of sand passing 2,36 mm I.S. sieve shall be struck off flash at the fare of the concrete. Concrete surfaces shall be finished as described in specifications or as directed by the Employer's Representative.

Superficial honeycombed surfaces and rough patches shall be similarly made good immediately after removal of shuttering, in the presence of the Employer's Representativeand superficial water and air holes shall be filled in. The mortar shall be well worked into the surface with a wooden float. Excess water shall be avoided. Unless

instructed otherwise by the Employer's Representative, the surface of the exposed concrete placed against shuttering shall be rubbed down immediately on removal of shuttering to remove fine or other irregularities, care being taken to avoid damaging the surfaces. Surface irregularities shall be removed from grinding.

If reinforcement is exposed or the honeycombing occurs at vulnerable positions e.g. ends of beams or columns it may be necessary to cut out the member completely or in part and reconstruct. The decision of the Employer's Representative shall be final in this regard. If only patching is necessary, the defective concrete shall be cut out until solid concrete is reached or to a minimum depth of 25mm whichever is greater., the edges being cut perpendicular to the affected surface or with a small undercut if possible. Anchors, tees or dovetail slots shall be provided whenever necessary to attach the new concrete securely in place. An area extending several centimeters beyond the edges and the surfaces of the prepared voids shall be saturated with water for 24 hours immediately before the patching material is placed.

i) Use of Epoxy

The use of epoxy for bonding fresh concrete used for repairs will be permitted upon written approval of the Employer's Representative. Epoxies shall be applied in strict accordance with the instructions of the manufacturer.

ii) Method of Repair

Small sizes holes having surface dimensions about equal to the depth of the hole, holes left after removal of from bolts, grout insert holes and slots cut for repair of cracks shall be repaired as follows. The hole to be patched shall be roughened and thoroughly soaked with clean water absorption stops.

A 5 mm thick layer of grout of equal parts of cement and sand shall be well brushed into the surface to be patched, followed immediately by the patching concrete which shall be well consolidated with a wooden float and left slightly proud of the surrounding surface. The concrete patch shall be built up in 10 mm thick layers. After an hour or more, depending upon weather conditions, it shall be worked off flush with a wooden float and a smooth finish obtained by wiping with Hessian. A steel trowel shall be used for this purpose. The mix for patching shall be of the same materials and in the same proportion as that used in the concrete being repaired, although some reduction in the maximum size of the coarse aggregates may be necessary and the mix shall be kept as dry as possible.

Mortar filling by air pressure (guniting) shall be used for repair of areas too large and/or too shallow for patching with mortar. Patched surfaces shall be given a final treatment to match the colour and texture of the surrounding concrete. White cement shall be substituted for " ordinary cement, if so directed by the Employer's Representative, to match the shade of the patch with the original concrete. Also whereas as required for constinuation of reinforcement Hiliti can be used with prior approval of Employers representative.

iii) Curing of Patched Work

The patched area shall be covered immediately with an approved non-staining, water-saturated material such as gunny bags which shall be kept continuously wet and protected against sun and wind for a period 24 hours. Thereafter, the patched area shall be kept wet continuously by a fine spray, or sprinkling for not less than 10 days. All fillings shall be lightly bonded to the concrete and shall be sound, free form shrinkage cracks after the fillings have been cured, and dried.

iv) Approval by the Employer's Representative

All materials, procedures and operations used in the repair of concrete and also the finished repair work shall be subject to the approval of the Employer's Representative.

d) Finishing

The type of finish for formed concrete surfaces shall be as follows, unless varied by the Employer's Representative.

When the structure is in service all the surfaces shall receive no special finish, except repair of damaged or defective concrete, removal of fins and abrupt irregularities, filling of holes left by form ties and rods and clean up of loose or adhering debris.
Surfaces which will be exposed to the weather and which would normally be level, shall be sloped for drainage. Unless a horizontal surface or the slope required is specified, the tops of narrow surfaces such as stair treads, walls curbs and parapets shall be sloped across the width approximately 1 in 30. Broader surfaces such as walkways, roads parking areas and platforms shall be sloped about 1 in 50.

Surfaces that will be covered by backfill or concrete, sub-floors to be covered with concrete topping, such as outside decks, floors of galleries and sumps, parapets, gutters, side-walks, floors and slabs, shall be consolidated, screeded and floated. Excess water and laitance shall be removed before final finishing. Floating may be done with hand or power tools and started as soon as the screeded surface has attained a stiffness to permit finishing operations and these shall be minimum required to produce a surface uniform in texture and free from screed marks or other imperfections. Joints and edges shall be tooled as specified or as directed by the Employer's Representative.

Finishes

Interior Wall:

All interior walls should be painted approved quality of distemper.

Exterior Wall:

The type of finishing & the color scheme of the external surfaces to be as preapproval of the Employer's Representative. However it shall be sand faced cement plaster in CM (1:4) 20 mm thick followed by water proofing cement based paint. This shall be of approved shade & brand to give even shade on the work in 3 or more coats.

i) Standard Finish for Exposed Concrete

Exposed concrete shall mean any concrete, other than floors or slabs, exposed to view upon completion of the works. Unless otherwise specified, the standard finish for exposed concrete shall be a smooth finish. A smooth finish shall be obtained with the

use of lined or plywood forms having smooth and even surfaces and edges. Panels of forms shall be of uniform size and be as large as practicable and installed with closed joints. Upon removal of forms the joint marks shall be smoothed off and all blemishes, projection, etc., removed leaving the surfaces smooth.

ii) Integral Cement Concrete Finish

When specified, an integral cement concrete finish of specified thickness for floors and slabs shall be applied either monolithic or bonded, as specified or directed by the Employer's Representative. The surface shall be tested with a straight edge and any high and low spots eliminated. Floating or trowelling of the finish shall be permitted only after all surface water has evaporated. Dry cement or a mixture of dry cement finish to absorb moisture or to stiffen the mix.

iii) Rubbed Finish

A rubbed finish shall be provided only on exposed concrete surfaces. Upon removal of forms, all fins and other projections on the surfaces shall be carefully removed, offsets leveled and voids and/ or damaged sections immediately saturated with water and repaired by filling with a concrete or mortar of the same composition as was used in the surface. The surfaces shall then be thoroughly wetted and rubbed with carborundum or other abrasive. Cement mortar may be used in the rubbing, but the finished surfaces shall not be brush coated with either cement or rout after rubbing the finished surfaces shall present a uniform and smooth appearance.

e) Protection

The Employer's Representative shall protect all concrete against damage until final acceptance.

4.28. PREPARATION OF EARTH STRATA FOR FOUNDATION

a) General

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, yielding soil shall be removed and replaced with suitable earth well compacted or lean concrete as directed by the Employer's Representative. Where specified, lean concrete shall be provided on the earth stratum for receiving concrete. The surface of absorptive soils against which concrete is to be placed shall be moistened thoroughly so that no moisture will be drawn from the freshly placed concrete and later shall help to cure the concrete.

b) Preparation of Concrete Surface

The preparation of concrete surfaces upon which additional concrete is to be placed later, shall preferably be done by scarifying and cleaning while the concrete is between its initial and final set. This method shall be used wherever practicable and shall consist of cutting the surface with picks and stiff brooms and by use of an approved combination of air and water jet as directed by the Employer's Representative. Great care shall be taken in performing this work to avoid removal of too much mortar the weakening of the surface by

loosening of aggregate. When it is not practicable to follow the above method, it will be necessary to employ air tools to remove laitance and roughen the surface.

The final required result shall be a pitted surface from which all dirt, unsound concrete, laitance and glazed mortar have been removed.

c) Bonding Treatment (Mortar)

After rock or concrete surfaces upon which new concrete is to be placed have been scarified, cleaned and wetted as specified herein, they shall receive a bonding treatment, immediately before placement of the concrete.

The bonding medium shall be a coat of cement-sand mortar shall have the same cement-sand proportions as the concrete which shall be placed on it. The water-cement ratio shall be determined by placing conditions and as approved by the Employer's Representative.

Bonding mortar shall be placed in sufficient quantity to completely cover the surface, about 10mm thick for rock surface and about 5mm thick for concrete surfaces. It shall be brushed or broomed over the surface and worked thoroughly in to all cracks, crevices and depressions. Accumulations or puddles or mortar shall not be allowed to settle on depressions and shall be brushed out to a satisfactory degree, as determined by the Employer's Representative.

Mortar shall be placed at such rate that it can be brushed over the surface just in advance of the placement of concrete. Only as much area shall be covered with mortar as can be covered with concrete before initial set in the mortar takes place. The amount of mortar that will be permitted to be place at any one time, or the area which it is to cover, shall be in accordance with the Employer's Representative's directions.

d) Cleaning and Bonding Formed Construction Joints.

Vertical construction joints shall be cleaned as specified above or by other methods approved by the Employer's Representative, hi placing concrete against formed construction joints, the surfaces of the joints, where accessible, shall be coated thoroughly with the specified bed-joint bonding mortar immediately before they are covered with concrete or by scrubbing with wire brooms dipped into the fresh concrete. Where it is impracticable to apply such a mortar coating, special precautions shall be taken to ensure that the new concrete is brought into intimate contact with the surface of the joint by careful puddling and spading with the aid of vibrators and suitable tools.

e) Expansion and Contraction Joints

Provision shall be made for expansion and contraction in concrete by use of special type joints located wherever necessary and as shown on approved drawings.

4.29. HOT WEATHER REQUIREMENTS

All concrete work performed in hot weather shall be in accordance with IS: 456, except as herein modified.

Admixtures may be used only when approved by the Employer's Representative.

Adequate provisions shall be made to lower concrete temperatures by cool ingredients, eliminating excessive mixing, preventing exposure of mixers and conveyors to direct sunlight and the use of effective paint on mixers, etc. The temperature of the freshly placed concrete shall not be permitted to exceed 38°C.

Consideration shall be given to shading aggregate stockpiles from direct rays of the sun and spraying stockpiles with water, use of cold water when available, and burying, insulating, shading and/ or painting white the pipelines and water storage tanks and conveyances.

In order to reduce loss of mixing water, the aggregates, wooden forms, subgrade adjacent concrete and other moisture absorbing surfaces shall be well wetted prior to concreting. Placement and finishing shall be done as quickly as possible.

Extra precautions shall be taken for the protection and curing of concrete. Consideration shall be given to continuous water curing and protection against high temperatures and drying hot winds for a period of at least 7 days immediately after concrete has set and after which normal curing procedures may be resumed.

4.30. PLACING CONCRETE UNDERWATER

Under all ordinary conditions all foundations shall be completely dewatered and concrete placed in the dry. However, when concrete placement underwater is necessary, all work shall conform to IS: 456 and the procedure shall be as follows:

i) Method of Placement

Concrete shall be deposited underwater by means of tremies, or drop bottom buckets of approved type.

ii) Discretion, Inspection and Approval

All work requiring placement of concrete underwater shall be designed, directed and inspected with due regard to local circumstances and purposes. All underwater concrete shall be placed according to the plans or specifications approved by the Employer's Representative.

4.31. PRECAST CONCRETE

a) General

Precast concrete units, whether manufactured on or off site, shall comply in every way with the provisions of the Contract for in situ concrete. Pre-cast units shall be hydraulically pressed or cast on vibrating table.

When ready for incorporation in the works, precast units shall be laid, bedded, jointed and fixed to the lines and levels as specified or required. Mortar for bedding and jointing shall consist of one part by volume of Portland cement and two parts by volume of natural sand or equivalent crusher fines.

All precast units shall be cast on a suitable bed or platform with firm foundation and free from wind. The Contractor shall be responsible for the accuracy of the level or shape of the bed or platform. A suitable serial number and the date of casting shall be impressed or painted on each unit.

b) Striking Form

Side shutters shall not be struck in less than 24 hours after depositing concrete and no precast unit shall be lifted until the concrete reaches strength of at least twice the stress to which the concrete may be subjected to at the time of lifting.

c) Precast Units

The lifting and removal of precast units shall be undertaken without causing shock, vibration or undue bending stresses to or in the units. Before lifting and removal takes place, Contractor shall satisfy the Employer's Representative or his representative that the methods he proposes to adopt for these operations will not over-stress or otherwise effect seriously the strength of the precast units. The reinforced side of the units shall be distinctly marked.

d) Curing

All precast work shall be protected form the direct rays of the sun for at least 7 days after casting during that period each unit shall be kept constantly watered or preferably be completely immersed in water if the size of the unit so permits.

4.32. PRECAST CONCRETE POROUS PIPES

Concrete porous pipes shall be made in accordance with IS: 4350. The pipes shall be of uniform cross section and bore and not more than 1 meter in length with minimum wall thickness of 50 mm with 1:3 cement to coarse aggregate proportion. The pipes shall have ogee or rebated joints, the axial length of which shall not be less than (D/36 + 12) mm, where D is the nominal internal diameter of the pipe in millimeters.

The wall thickness shall be such that the pipe shall bear a load of 20,000 N/m applied radially and have a porosity of not less than 0.65 D litres/metre/min.

4.33. SLOTS, OPENINGS, ETC.

Slots, openings or holes, pockets, etc., shall be provided in the concrete work in the approved positions or as directed by the Employer's Representative. Any deviation from the approved drawings shall be made good by Contractor at his own expense, without damaging and other work. Sleeves, bolts, inserts, etc., shall also be provided in concrete work where so required.

4.34. GROUTING

a) Standard Grout

Grout shall be provided as specified herein below.

The proportions of grout shall be such as to produce a flowable mixture consistent with minimum water content and shrinkage. The grout proportions shall be limited as follows:

TABLE 4.12

Use	Grout thickness	Mix Proportions	W/C ratio (max.)
i) Fluid mix	Under 25 mm	One part Portland cement to one part sand	0.44
ii) General	25 mm and over but less than 50 mm	One part Portland cement to two parts of sand	0.53
iii) Stiff mix	50 mm and over	One part Portland cement to three parts of sand	0.53

I. i) Sand shall be such as to produce a flowable grout without any tendency to segregate.

ii) Sand, for general grouting purposes, shall be graded within the following limits.

Passing IS 2.36 mm sieve	95 to 100%
Passing IS 1.18 mm sieve	65 to 95%
Passing IS 300 micron sieve	10 to 30%
Passing IS 150 micron sieve	3 to 10%

iii) Sand for fluid grouts, shall have the fine material passing the 300 and 150 micron sieves at the upper limits specified above.

iv) Sand, for stiff grouts, shall meet the usual grading specifications for concrete,

II. i) Surfaces to be grouted shall be thoroughly roughened and cleaned of all foreign matter and laitance.

ii) Anchor bolts, anchor bolt holes and the bottoms of equipment and column base plates shall be Cleaned of all oil, grease, dirt and loose material. The use of hot, strong caustic solution for this purpose will be permitted.

III. i) Prior to grouting, the hardened concrete surfaces to be grouted shall be saturated with water.

ii) Water in anchor bolt holes shall be removed before grouting is started. Forms around base plates shall be reasonably tight to prevent leakage of the grout.

Adequate clearance shall be provided between forms and base plate to permit grout to be worked properly into place.

Grouting, once started, shall be done quickly and continuously to prevent segregation, bleeding and breakdown of initial set. Grout shall be worked from one side of one end to the other to prevent entrapment of air. To distribute the grout and to ensure more complete contact between base plate and foundation and to help release trapped air, link chains can be used to work the grout into place.

Grout through holes in base plates shall be by pressure grouting.

Variations in grout mixes and procedures shall be permitted if approved by the Employer's Representative.

b) Non-Shrinking Grout for Equipment Foundation

Non-shrinking grout shall be used for grouting of machine base plates, anchor bolts, other anchoring devices and at locations where ordinary grouts are ineffective due to shrinkage. It shall be composed a type of expansive hydraulic setting binder and select-graded aggregates. It shall have properties as mentioned below :

1. Maximum grain size - 6
2. Water % (for 80% flow) - 15.17
3. Density of hardened Grout gm/ml - 2.27-2.30
4. Compressive strength N/mm2
   Min. 3 days - 23
   7 days - 34
   28 days - 45
5. Expansion, %
   Free - 0.15-0.2
   Restrained - 0.08-0.12

Mixing, batching, cleaning, preparation of surface and curing of non-shrinking grout shall be done as per Manufacturer's instructions.

4.35. INSPECTION

All materials, workmanship and finished construction shall be subject to continuous inspection and approval of the Employer's Representative.

All materials supplied by the Contractor and all work or construction performed by the Contractor which is rejected as not being in conformity with the specifications and requirements, shall be immediately replaced.

Approvals of any preliminary materials or phase of work shall in no way relieve the Contractor from the responsibility of supplying concrete and/or producing finished concrete in accordance with specifications and requirements.

All finished concrete shall be protected against damage until final acceptance by the Employer's Representative.

4.36. CLEAN-UP

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

All debris, i.e. containers, scrap wood, etc., shall be removed to "dump" daily, or as directed by the Employer's Representative.

The finished concrete surfaces shall be left in a clean condition satisfactory to the Employer's Representative

4.37. RECORDS OF CONCRETING

An accurate and upto date record showing times, dates, weather and temperature conditions when various positions of all the concrete structures forming the works were concreted will be kept by the Employer's Representativeshall be countersigned by the Contractor. If the Contractor fails to sigh the Employer's Representativerecord, it shall nevertheless be regarded as correct and binding on the Contractor.

4.38. FOUNDATION BEDDING, BONDING AND JOINTING

All surfaces upon or against which concrete will be placed, shall be suitably prepared by thoroughly cleaning, washing and dewatering, as specified or as the Employer's Representative may direct, to meet the various situations encountered in the work.

Soft or spongy areas shall be cleaned out and backfilled with either a soil-cement mixture, lean concrete or clean sand fill compacted to minimum density of 90% Modified Proctor.

Prior to construction of formwork for any item where soil act as bottom form, approval shall be obtained from the Employer's Representative as to the suitability of the soil.

4.39. DEWATERING

Dewatering is process of removal of water from a foundation pit when it is situated below the ground water table or when it is surrounded by a cofferdam. The purpose of dewatering is to keep the excavation dry so that concreting can be done. Dewatering is temporary if it is done at the time of construction. It is followed by restoration to its original water table after the structure has been be completed. Dewatering may be done by sump and pump, but for deep excavtions such as in case of intake pump house, treated water sumps etc. Wellpoint systems are advised. Well points are either with braces or stainless steel screens and are made with either closed ends or self jetting types and spacing of the well points depends on the permeability of the soil and on the availability of the time to affect the drawdown. Further specially in case of intake pump house, being quite deep the well points must be installed in two or more stages and on the other hand, it is possible to avoid multi-well point stages by excavating don to water level before installing the pump and header or deep weel drainsge shall be used for dewatering.

4.40. PREPARATION OF ROCK STRATA FOR FOUNDATIONS

To provide tight bond with rock foundations, the rock surface shall be prepared and the following general requirements shall be observed.

Concrete shall not be deposited on large sloping rock surfaces. Where required by the Employer's Representative, the rock shall he cut to form rough steps or benches to provide roughness or a more suitable bearing surface.

Rock foundation stratum shall be prepared by picking, barring, wedging and similar methods which will leave the rock in an entirely sound and unsheltered condition.

Shortly before concrete is placed, the rock surface shall be cleaned with high pressure water and air jet even though it may have been previously cleaned in that manner.

Prior to placing concrete, the rock surface shall be kept wet for a period of 2 to 4 hours unless otherwise directed by the Employer's Representative.

Before placing concrete on rock surfaces all water shall be removed from depressions to permit through inspection and proper bonding of the concrete to the rock.

4.41. FORMWORK

4.41.1. FORMWORK - FIXING AND GENERAL

All formwork shall be constructed of timber, sheet metal or other approved material. It shall be firmly supported adequately strutted, braced and tied to withstand the placing and vibrating of concrete and the effects of weather. The tolerance on line and level shall not exceed 3 mm and the soffit of beams other than pre-stressed beams shall be in the absence of any specified camber, be erected with an upward camber of 6 mm for each 3 metres of span.

The Contractor shall be responsible for the calculations and design for the formwork, and if required, shall submit them to the Employer's Representative for approval before construction. On formwork to external faces, which will be permanently exposed, all horizontal and vertical formwork joints shall be so arranged that Joint lines will form a uniform pattern on the face of the concrete. Where the Contractor proposes to make up the formwork from standard sized manufactured formwork panels, the Employer's Representative shall approve the size of such panels before they are used in the construction of the works. The finished appearance of the entire elevation of the structure and adjoining structures shall be considered when planning the pattern of joint lines caused by formwork and by construction joint to ensure continuity of horizontal and vertical lines.

Faces of formwork in contact with concrete shall be free from adhering foreign matter, projecting nails and the like, splits or other defects, and all formwork shall be clean and free from standing water, dirt, shavings, chipping or other foreign matter. Joints shall be sufficiently watertight to prevent the escape or mortar or the formation of fine and other blemishes on the face of the concrete.

Formwork shall be provided for the top surfaces of sloping work where the slope exceeds fifteen degrees from the horizontal (except where such top surface is specified as spaded

finish) and shall be anchored to enable the concrete to be properly compacted and to prevent floatation, care being taken to prevent air being trapped.
Openings for inspection of the inside of the formwork and for the removal of water used for washing down shall be provided and so formed to be easily closed before placing concrete. Before placing concrete, all bolts, pipes or conduits or other fixtures which are to be built in shall be fixed in their correct positions, and cores and other devices for forming holes shall be held fast by fixing to the formwork or otherwise. Holes shall not cut in any concrete without approval of the Employer's Representative.

All exterior angles on the finished concrete of 90° or less shall be given 20 mm x 20 mm chamfers unless otherwise ordered by the Employer's Representative.

No ties or bolts or other device shall be built into the concrete for the purpose of supporting formwork without the prior approval of the Employer's Representative. The whole part of any such supports shall be capable of removal so that no part remaining embedded in the concrete shall be nearer than 50 mm from the surface in the case of reinforced concrete and 150 mm in the case of un-reinforced concrete. Holes left after removal of such supports shall be neatly filled with well-rammed dry-pack mortar (Clause 9.135).

Formwork in contact with the concrete shall be treated with a suitable non-staining mould oil to prevent adherence of the concrete except where the surface is subsequently to be rendered. Care shall be taken to prevent the oil from coming in contact with reinforcement or with concrete at construction joints. Surface retarding agents shall be used only where ordered by the Employer's Representative.

4.41.2. REMOVAL OF FORMWORK

Formwork shall be so designed as to permit any removal without resorting to hammering or levering against the surface of the concrete. The periods of time elapsing between the placing of the concrete and the striking of the formwork shall be as approved by the Employer's Representative after consideration of the loads likely to be imposed on the concrete and shall in any case be not less than the periods shown in Table 9.13 below. Where soffit formwork is constructed in a manner during and after such removal of a sufficient number of adequate supporting props in an undisturbed condition, the Contractor may with the agreement of the Employer's Representative, remove the formwork at the earlier times listed below provided that the props are left in position.

Notwithstanding the foregoing, the Contractor shall be held responsible for any damage arising from removal of formwork before the structure is capable of carrying its own weight and any incidental loading.

Striking shall be done slowly with utmost care to avoid damage to arises and projections and without shock or vibration, by gently easing the wedges. If after removing the formwork it is found that timber has been embedded in the concrete, it shall be removed and made good as specified earlier.

TABLE 4.13

Position of Formwork	Days for Striking
Walls	1
Side of beams and columns	2
Slabs (Props left under)	3
Props to slabs (span not exceeding 4.5 m)	7
Props to slabs (span exceeding 4.5 m)	14
Beams soffit (props left under)	7
Props to beams (span not exceeding 6 m)	14
Props to beams (span exceeding 6 m)	21

Notwithstanding the foregoing, the Contractor shall be held responsible for any damage arising from removal of formwork before the structure is capable of carrying its own weight and any incidental loading.

Striking shall be done slowly with utmost care to avoid damage to arises and projections and without shock or vibration, by gently easing the wedges. If after removing the formwork it is found that timber has been embedded in the concrete, it shall be removed and made good as specified earlier.

Reinforced temporary openings shall be provided, as directed by the Employer's Representative, to facilitate removal of formwork which otherwise may be inaccessible.

Tie rods, clamps, form bolts etc. which must be entirely removed from walls or similar structures shall be loosened not sooner than 24 hours nor later than 40 hours after the concrete has been deposited. Ties, except those required to hold forms in place, may be removed at the same time. Ties, withdrawn from walls and grade beams shall be pulled toward the inside face. Cutting ties back from the faces of the walls and grade beams will not be permitted.

For liquid retaining structures no sleeves for through bolts shall be used nor shall through bolts be removed as indicated above. The bolts, in this case, shall be cut at 25 mm depth or more from the surface and then the hole shall be made good by cement sand mortar of the same proportions as the concrete just after striking the formwork.

4.41.3. FORMED SURFACES - CLASSES OF FINISH

Finishes to form surfaces of concrete shall be classified as Fl, F2 or F3 or such other special finish as may be particularly specified. Where the class of finish is not specified the concrete shall be finished to Class Fl.

Formwork for Class F3 finish shall be lined with as large panels as possible of non staining material with a smooth unblemished surface such as sanded plywood or hard compressed

fibre board, arranged in uniform approved pattern and fixed to back formwork by oval nails. Un-faced wrought boarding or standard steel panels shall not be permitted.

Formwork for Class F2 finish shall be faced with wrought tongued and grooved boards or plywood or metal panels arranged in a uniform approved pattern free from defects likely to detract from the appearance of the surface.

Formwork for Class Fl finish shall be constructed in timber, sheet metal or any suitable materials, which will prevent loss of grout when the concrete is vibrated. Surfaces subsequently to be rendered, plastered and tiled shall be adequately scabbed or hacked as soon as the formwork is removed to reduce the irregularities to not more than half the thickness of such rendering, plastering or bedding for tiles and to provide a satisfactory key.

4.41.4. DEFECTS IN FORMED SURFACES

Workmanship in formwork and concreting shall be such that concrete shall normally require no making good, surface being properly compacted and smooth.

If any blemishes are revealed after removal of formwork, the Employer’s Representative's decisions concerning remedial measures shall be obtained immediately. These measures may include, but shall not be limited to the following:

Fins, pinhole bubbles, surface discolouration and minor defects may be rubbed down with sacking immediately after the formwork is removed.

Abrupt and gradual irregularities may be rubbed down with carborundum and water after the concrete has been fully cured. These and any other defects shall be remedied by methods approved by the Employer’s Representativewhich may include using a suitable epoxy resin or, where necessary, cutting out to a regular dovetailed shape at feast 75 mm deep and refilling with concrete over steel mesh reinforcement sprung into the dovetail.

4.41.5. HOLES TO BE FILLED

Holes formed in concrete surfaces by formwork supports or the like shall be filled with dry-pack mortar made from one part by weight of ordinary Portland cement and three parts fine aggregate passing IS sieve 1.18 mm. The mortar shall be mixed with only sufficient water to make the materials stick together when being moulded in the hands.

The Contractor shall thoroughly clean any hole that is to be filled with dry-pack mortar and where the surface has been damaged the Contractor shall break out any loose, broken or cracked concrete or aggregate. The concrete surrounding the hole shall then be thoroughly soaked after which the surface shall be dried so as to leave a small amount of free water on the surface. The surface shall then be dusted lightly with ordinary Portland cement by means of a small dry brush until the whole surface that will come into contact

with the dry-pack mortar has been covered and darkened by absorption of the free water by the cement Any dry cement in the hole shall be removed.

The dry-pack material shall then be placed and packed in layers having a compacted thickness not greater than 15 mm. The compaction shall be carried out by use of a hardwood stick and a hammer and shall extend over the full area of the layer, particular care being taken to compact the dry-pack against the sides of the hole. After compaction the surface of each layer shall be scratched before further loose material is added. The hole shall be finished by laying a hardwood block against the dry-pack fill and striking the block several times. Steel finishing tools shall not be used and water shall not be added to facilitate finishing.

4.42. TOLERANCES

Tolerances is a specified permissible variation from lines, grade or dimensions given in approved drawings. No tolerance specified for horizontal or vertical building lines or footings shall be construed to permit encroachment beyond the legal boundaries. Unless otherwise specified, the following tolerances will be permitted:

Tolerances for R.C. Building

i) Variation from the plumb -

a) In the lines and surfaces of columns, piers, walls and in arises

5 mm per 2.5 m or 25 mm, whichever is less.

b) For exposed comer columns and other conspicuous lines —

In any bay or 5 m maximum - 5 mm

In 10m or more - 10 mm

ii) Variation from the level or from the grades indicated on the approved drawings.

a) In slab soffit, ceilings, beam soffit, and in shard edges

In 2.5m 5 - 5mm

In any bay or 5 m maximum - 10 mm

In 10 m or more - 15mm

b) For exposed lintels, sills, parapets, horizontal grooves and other conspicuous lines-

In any bay or 5 m maximum - 5 mm

In 10 m or more - 10 mm

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

ln any bay or 5 m maximum - 10 mm

In 10 m or more - 20 mm

iv) Variation in the sizes and locations of sleeves, openings in walls and floors 5 mm except in the case of and for anchor bolts

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

Minus - 5 mm

Plus - 10 mm

vi) Footings

a) Variation in dimension in plan

Minus - 5 mm

Plus - 50mm

b) Misplacement or eccentricity

2% of footing width in the direction of misplacement but not more than 50 mm

c) Reduction in thickness

Minus - 5% of specified thickness subject to a maximum of 50mm

vii) Variation in steps -

a) In a flight of stairs

Rise - 3 mm

Tread - 5 mm

b) In consecutive steps

Rise - 1.5mm

Tread - 3 mm

Tolerances in other concrete structures

i) All structures

a) Variation of the constructed linear outline from established position in plan

ln 5 m - 10 mm

In 10 m or more - 15 mm

b) Variation of dimensions to individual structural features from established positions -

In 20 m or more - 25 mm

In buried construction - 50 mm

c) Variation from plumb, from specified batter or from curved surfaces of all structures

In 2.5 m - 10 mm

In 5 m - 15 mm

In 10 m or more - 25 mm

In buried construction - Twice the above amounts

d) Variation from level or grade indicated on approved drawings in slab, beams, soffit, horizontal grooves and visible arises -

In 2.5 m - 5 mm

Ln 7.5 m or more - 10 mm

In buried construction - Twice the above amounts

e) Variation in cross-sectional dimensions of columns, beams.buttresses, piers and similar members -

Minus - 5 mm

Plus - 10 mm

f) Variation in the thickness of slabs, walls, arm sections and similar members -

Minus - 5 mm

Plus - 10 mm

ii) Footings for columns, piers, walls, buttresses and similar members

a) Variation of dimensions in plan -

Minus - 10 mm

Plus - 50 mm

b) Misplacement or electricity -

2% of footing width in the direction of misplacement but not more than 50 mm

c) Reduction in thickness -

5% of specified thickness subject to a maximum of 50 mm

iii) Tolerances in other types of structures shall generally conform to those given in Clause 2.4 of Recommended Practice for Concrete Formwork (American Concrete Institute -Ad 347)

iv) Tolerances in fixing anchor bolts shall be as follows:

a) Anchor bolts without sleeves ±5 mm,

b) Anchor bolts with sleeves ± 5.0 mm for bolts upto 3.00 mm for bolts above 32 mm dia

c) Embedded parts ± 5 mm in all direction.

4.43. BRACINGS, STRUTS AND DROPS

Formwork shall be braced, strutted, propped and so supported that it shall not deform under weight and pressure of the concrete and also due top the movement of men and other materials. Bamboos shall not be used as proper cross bearers.

The formwork for beams and slabs shall be so erected that the formwork on the sides of the beams and under the soffit of slabs can be removed without disturbing the beam bottoms. Re-propping of beams shall not be done except when props have to be reinstated to take care of construction loads anticipated to be in excess of the design load. Vertical props shall be supported on wedges or other measures shall be taken whereby the props can be gently lowered vertically while striking the formwork.

If the formwork for a column is erected for the full height of the column, one side shall be left open and built up in sections as placing of the concrete proceeds, or windows may be left for pouring concrete from the sides to limit he drop of concrete to 1.0 m or as directed by the Employer's Representative.

4.44. REINFORCEMENT

4.44.1. GENERAL

Reinforcement shall be TMT deformed bars (Thermo Mechanical Treatment) Fe 500 as per IS: 1786. Wire mesh or fabric shall be in accordance with IS: 1566. Substitution of reinforcement will not be permitted.SHALL BE ONLY PROCURED from list of makes as per Section-X, Volume-2 Employers Requirement, using iron ore as the basic raw material and having an in house iron making facilities followed by production of liquid steel and crude steel with in house rolling.adopting BF-BOF route or DRI-EAF technology as per Ministry of Steel Government of India Guildlines. No re-rolled material/secondary steel will be acepted or allowed for any structural steel. As per Is 1786 :2008 under clause 4.2.3 Low alloyed/microalloyed/CRS steel can also be used by adding alloy elements like Cu,Cr,Ni, Mo and P either individually or in combination to improve allied product propoerties.however, the total content of these elements shall not be less than 0.40%.in such alloys when phosphorous is used, it shall not exceed 0.12%and the carabon shall be restiricted to max. 0.15%.Every lot shall be accompined by the manufactures certificate certifying the quality, grade and material and shall be tested in an independent laboratory to certify all propoerties as per IS 1786 and shall be TMT/CRS.

4.44.2. STORAGE

The reinforcement shall not be kept in direct contact with the ground but stacked on top of an arrangement of timber sleepers or the like.

If the reinforcing rods have to be stored for a long duration, they shall be coated with cement wash before stacking and/ or be kept under cover or stored as directed by the Employer's Representative.

Fabricated reinforcement shall be carefully stored lo prevent damage, distortion corrosion and deterioration.

4.44.3. QUALITY

All steel shall be of Grade I quality unless specifically permitted by the Employer's Representative. No re-rolled material will be accepted. If requested by the Employer's Representative, the Contractor shall submit the manufacturer's test certificate for the steel. Random tests on steel supplied by the Contractor may be performed by the Employer's Representativeas per relevant Indian Standards. All costs incidental to such test shall be at the Contractor's expense. Steel not conforming to specifications shall be rejected.

All reinforcements shall be clean, free from grease, oil, paint, dirt, loose rust, dust, bituminous material or any other substances that will destroy or reduce the bond. All rods shall be thoroughly cleaned before being fabricated. Pitted and defective rods shall not be used. No welding of rods to obtain continuity shall be allowed unless approved by the Employer's Representative. If welding is approved, the work shall be carried out as per IS: 2751 according to the best modem practices and as directed by the Employer's Representative, in all cases of important connections, test shall be made to prove that the joints are of full strength of bars welded. Special precautions, as specified by the Employer's Representative, shall be taken in the welding of cold worked reinforcing bars and bars other than mild steel.

4.44.4. LAPS

Laps and splices for reinforcement shall be 50 time the diameter of such reinforcement. Splices in adjacent bars shall be staggered and the locations of all splices, except those specified on the approved drawings, shall be approved by the Employer's Representative. The bars shall not be lapped unless the length required exceeds the maximum available lengths of bars at site.

4.44.5. BENDING

Reinforcing bars supplied bent or in coils, shall be straightened before they are cut to size. Straightening of bars shall be done cold and without damaging the bars.

All bars shall be accurately bent according to the sizes and shapes shown on the approved details working drawings/bar bending schedules. They shall be bent gradually by machine or other approved means. Reinforcing bars shall not be straightened and rebent in a manner that will injure the material, bars containing cracks or splits shall be rejected. They shall be bent cold, except bars of over 25mm in diameter which may be bent hot if specifically approved by the Employer's Representative. Bars which depend for their strength on cold working, shall not be bent hot. Bars bent hot shall not be treated beyond cherry red colour (nor exceeding 845°C) and after bending shall not be allowed to cool slowly without quenching. Bars incorrectly bent shall be used only if the means used for straightening and rebending be such as shall not, in the opinion of the Employer's Representative, injure the material. No reinforcement shall be bent when in position the work without approval, whether or not it is partially embedded in hardened concrete. Bars having kinks or bends other than those require by design shall not be used.

4.44.6. FIXING

Reinforcement shall be accurately fixed by any approved means and maintained in the correct position shown in the approved drawings by the use of blocks, spacers and chairs, as per IS: 2502, to prevent displacement during placing and compaction of concrete. Bars intended to be in contact at crossing points shall be securely bound together at all such points with number 16 gauge annealed soft iron wire. The vertical distances required between successive layers of bars in beams or similar members shall be maintained by the provision of mild steel spacer bars at such intervals that the main bars do not perceptibly sag between adjacent spacer bars.

4.44.7. COVER

Nominal cover shall be as per IS 456 – Table 16.

Increased cover thickness shall be provided for surfaces exposed to the action of harmful chemicals or exposed to earth contaminated by such chemicals, acid, alkalis, saline atmosphere, sulphurous smoke etc. and such increase of cover may be between 15 mm and 50 mm beyond the figures mentioned here as may be specified by the Employer's Representative.

The correct cover shall be maintained by cement mortar cubes or other approved means. Reinforcement for footings, grade beams and slabs on sub-grade shall be supported on precast concrete blocks as approved by the Employer's Representative. The use of pebbles or stones shall not be permitted.

The 28 days crushing strength of cement mortar cubes/ precast concrete cover blocks shall be at least equal to the specified strength of concrete in which these cubes/ blocks are embedded.

The minimum clear distance between reinforcing bars shall be 50 mm.

4.44.8. INSPECTION

Erection and secured reinforcement shall be inspected and approved by the Employer's Representative prior to placement of concrete.

4.44.9. WELDING OF REINFORCEMENT

Reinforcement which is specified to be welded shall be welded by an process which conforms with the Requirements of IS: 2751 and which the Contractor can demonstrate by bend and tensile tests will ensure that the strength of the parent metal is not reduced and that the weld possesses a strength not less than that of the parent metal. The welding procedure established by successful test welds shall be maintained and no departure from this procedure shall be permitted.

Weld in positions other than those shown on the approved drawings shall not be permitted. Tack welding lightly secure reinforcement in place will be permitted subject to approval of the Employer's Representative.

4.44.10. SUPPLY OF REINFORCING BARS

Steel reinforcement, such as M.S. bars high yield strength deformed bars etc. required for the works shall be procured by Contractor. The Contractor shall arrange for transport, loading, unloading and storage at the work sites. The Contractor should plan the procurement of steel in such a way that at least required quantity of steel of specified sizes is available at site for 3 months period.

Steel brought on site shall be stored in a proper manner as approved by the Employer's Representativeso as to avoid distortion, deterioration and corrosion. The Contractor shall maintain proper registers for the steel account, showing the steel received at site, steel used, and the balance stock on site, to the entire satisfaction of the Employer's Representative.

4.58 ROADWAYS

4.58.1. SCOPE

a) This specification covers the furnishing of all materials, plant, labour, equipment, tools and services for the complete and proper construction of approach roads and cross drainage works as specified herein and shown on the drawings including all surveying and setting out necessary for the same and clean up of working areas.

b) This specification covers the materials and construction of only water-bound macadam roads with bituminous surfacing treatments as shown on the drawings or as directed by the Employer's Representative, including all the necessary earthwork for the same.

4.58.2. MATERIALS

a) General

All materials shall be obtained from local sources and shall be subject to approval by the Employer's Representativeprior to use. Substitution of material shall be on and "Approved equal" basis as determined by the Employer's Representativeand shall result in finished roads as designated in this specification and at no additional cost to the Employer. Material aggregates shall consist of natural or crushed stone, gravel or sans, shall be of reasonably uniform quality throughout, and shall be clean and free from soft or decomposed particles, excess clay, foreign, organic, or other deleterious matter.

b) Materials for Embankment

Murrum to be used for making the road embankment shall be obtained from approved borrow areas of weathered disintegrated basalt. It shall contain silicious material. The murrum shall be dry friable, and free from clay and plastic materials, mud, sludges, vegetable matter or rotten material of any kind. The size of murrum lump shall not be more than 20 mm.

c) Coarse Aggregate for Sub-Base. Base and Semigrout

Coarse aggregate shall be crushed or broken stone and shall conform to the physical requirement given in Table 4.14.

TABLE 4.14

Physical requirements of Crushed Stone for Road Work

Sr. No.	Test	Limiting Value	
		For aggregates to be used for Road base and surfacing	For aggregate to be used for sub-grade
1.	Specific Gravity	Not less than 2.6	Not less than 2.0
2.	Water Absorption	Not more than 2%	Not less than 5%
3.	Flakiness Index	Maximum 25%	----
4.	Elongation Index	Maximum 40%	----
5.	Aggregate impact value or Aggregate Crushing Value	Not more than 30%	Not more than 40%
6.	Los Angeles Abrasion Value	Not more than 30%	Not more than 50%
7.	Stripping Test	Maximum 15%	----

The crushed or broken stone shall be hard, durable and free from excess of flat, elongated, soft and disintegrated particles, dirt and other objectionable matter. Crushed or broken stone shall conform to the grading given in Table 4.15

TABLE 4.15

Grading No.	Size Range	IS. Sieve Designations	Percent by Weight passing the sieve
3.	50 mm to 20 mm	63 mm	100
		50 mm	95 - 100
		40 mm	35 - 70
		20 mm	0 - 10
		10 mm	0 - 5

d) Screenings

Screenings shall consist of predominantly non-plastic materials such as sandy gravely murrum or gravel (other than rounded river borne material) with Liquid Limit and Plasticity Index below 20 and 6 respectively and fraction passing 75 micron sieve not exceeding 10%. The materials shall be sound and hard, of a quality not affected by weather and shall be screened at the quarry and shall be free from all impurities. Any large lumps of murrum shall be broken to pass gradation given in Table 4.16. Gravel shall be composed of large, coarse, silicious grains, sharp and gritty to the touch, thoroughly free from dirt and impurities.

Screenings shall conform to the grading indicated in Table 4.16.

TABLE 4.16

Grading Classification	Size of Screenings	IS. Sieve Designations	Percent by Weight passing the sieve
A.	12.5 mm	12.5 mm	100
		10.0 mm	90 – 100
		4.75 mm	10 – 30
		150 microns	0 – 8
B.	10.0 mm	10.0 mm	100
		4.75 mm	85 – 100
		150 microns	10 – 30
		75 microns	0 – 10

e) Blindage Material

To fill in the voids in the coarse aggregates, any non-plastic material such as gravel/ grit/ state dust/ sand/ brick powder may be used. The plasticity index of the material shall not exceed six.

f) Binder

The binder shall be straight run Bitumen of grade S35 or S65 and shall conform to the requirements specified in Table 4.17

TABLE 4.17

Sr.No.	Characteristic	Requirement of Grade		Method of Test Reference to
		S35	S65	
1.	Specific gravity at 27^0C Min.	0.99	0.99	IS : 1202
2.	Water prevent by weight. Max	0.2	0.2	IS : 1211
3.	Flash point. Pensky Martens closed type ^{0}C. Min.	175	175	IS : 1209 (Method A)
4.	Seftening point, ^{0}C	50 – 65	40 – 55	IS : 1205
5.	Penetration, at 25^0C , 100g, 5 sec in 1/100 m	30 – 40	60 – 70	IS : 1203
6.	Ductility at 20^0C in cm, Min	50	75	IS : 1208
7(a)	Loss on beating, percent by weight, Max.	1	1	IS : 1212
(b)	Penetration of residue (expressed as percentage of item 5), Min	60	60	IS : 1203
8.	Matter soluble in carbon disulphide, percent by weight, Min.	99	99	IS : 1216

4.58.3. SETTING OUT

The Contractor shall provide all labour and materials such as line, strings, pegs, nails, bamboos, stones, mortar, concrete etc., required for setting out, establishing benchmarks and giving profiles. The Contractor shall be responsible for maintaining the benchmarks, profiles, alignment and other stakes and marks as long as they are required for the work in the opinion of the Employer's Representative.

4.58.4. EARTHWORK

a) Earthwork in Excavation

Profiles of road excavation shall be laid at 50 m intervals to conform to the required alignment, sections, grades and side slopes and the lines of cuts shall be clearly marked. The Contractor shall on no account excavate beyond the slopes or below the specified grade unless so directed by the Employer's Representativein writing. If excavation is done below the specified level or outside the section it shall not be paid for and the Contractor shall be required to fill up such extra excavation with approved materials, in layers of 150 mm to 200 mm, watered and compacted as specified for the sub-grade. The excavation shall be finished neatly, smoothly and evenly to the correct lines, grades, sections, and side slopes as specified in the drawings or directed by the Employer's Representative.

b) Earthwork in Embankment Stripping

The entire area to be occupied by the embankment, shall be stripped to a sufficient depth, as determined by the Employer's Representative to remove all materials unsuitable and objectionable for incorporation in embankment. All excavations below the ground level arising out of the removal of trees, stumps, etc. shall be filled with suitable material and compacted thoroughly all as specified for the embankment fill material, so as to make the surface at these points conform to the surrounding area.

4.58.5. PREPARATION OF SUB-GRADE

Immediately prior to the laying of the sub-base metal, the sub-grade shall be cleaned of all foreign substances, vegetation etc. Any ruts or soft yielding patches that appear shall be corrected and the sub-grade dressed off parallel to the finished profile. The camber of sub-grade shall conform in shape to that of the finished road surface. Camber boards shall be used to get the required section. The prepared sub-grade shall be lightly sprinkled with water, if necessary and rolled with a power roller of 10-12 tonnes. The roller shall pass over the same area of the sub-grade a minimum of five runs. Any undulations in the surface that develop due to rolling shall be made good with approved earth and sub-grade re-rolled.

4.58.6. SUB-BASE

a) General

The sub-base shall not be constructed on a wet sub-grade. The width of the sub-base course shall be 150 mm more on either side than that of the water bound macadam wearing course. The finished thickness of the sub-base course shall be 160 mm. The sub-base metal course shall be laid in 2 layers, each of thickness 120 mm and finished to 80mm.

b) Spreading and Rolling

The metal shall be spread uniformly and evenly upon the prepared base to a thickness of 120 mm. The spreading shall be done from stock piles along the side of the roadway. In no case shall the aggregates be dumped in heaps directly on the surface prepared to receive the metal nor shall hauling over an un-compacted or partially compacted base be permitted. The surface of the aggregate shall be carefully checked, with templates and all high or low spots remedied by removing or adding aggregate as may be required. No segregation of large or fine particles shall be allowed and the coarse aggregates as spread shall be of uniform gradations with no pockets of fine material. Immediately

following the spreading of the metal, rolling shall be started with three wheeled power rollers of 10 to 12 tonnes capacity or tandem or vibratory rollers of approved type. Rolling shall begin from the edges gradually progressing towards the centre. First the edge/ edges shall be firmly compacted with roller running forward and backward. The roller shall then move inwards parallel to the center-line of the road, in successive passes uniformly lapping preceding tracks by at least one half width. Rolling shall be continued until the road metal has been thoroughly keyed and forward movement of stones ahead of the roller is no longer visible. Slight sprinkling of water may be done if necessary.

c) Application of Screening

After the metal has been thoroughly keyed and set by rolling, screening to completely fill the interstices shall be applied gradually over the surface. These shall not be damp or wet at the time of application. Dry rolling shall be done while the screening is being spread so that vibrations of the roller cause them to settle in the voids. The screenings shall not be dumped in piles but be spread uniformly by spreading motion of hand shovels. The dry rolling now shall be accompanied with brooming with hand brooms, wire brushes or both. In no case shall the screenings be applied so fast and thick as to form cakes or ridges on the surface in such a manner as would prevent tilling of voids or prevent the direct bearing of the roller on the metal. These operations shall continue until no more screenings can be forced into the voids in the metal.

d) Sprinkling and Grouting

The surface shall be copiously sprinkled with water, swept and rolled. Hand brooms shall be used to sweep the screenings into voids and to distribute them evenly. The sprinkling, sweeping and rolling operations shall be continued with additional screenings applied as necessary, until the coarse aggregate has become well bonded and firmly set in its full depth and a grout has been formed of the screenings. Care shall be taken to see that the underlying layers do not get damaged due to the addition of excessive quantities of water during construction. After the first layer of the sub-base has fully set, to the satisfaction of the Employer's Representative, the second layer shall be laid. The constructional operation for the second layer will be the same as that specified herein for the first.

4.59. Roadways, Pathways & Hardstandings

A comprehensive network of roadways shall be provided around the treatment plant to link in with the existing road network and permit access to the plant for necessary maintenance, delivery of consumables and personnel access. All roads shall be minimum 5 meters wide. Vehicular access shall be provided for all Plant structures and buildings. All roads shall be provided with drainage and shall be constructed to prevent standing water.

Paved pedestrian access ways shall be constructed to provide a network of logical routes interlinking plant areas. Damage to any existing roads on account of their use by the Contractor shall be made good to the satisfaction of the Employers Representative.

Hardstanding areas shall be provided to permit the parking of vehicles involved in the delivery of consumables from blocking site roadways during unloading or loading. The

road system shall be designed such that vehicles involved in the delivery of consumables can follow a continuous route through the works and out again without the need to reverse or carryout complicated maneuvers in order to exit the site.

Any structure or pipeline crossing below roads shall be designed for Class 'A' of IRC loading.

All roads shall be of asphalt macadam/ concrete and all strengthing of road required for plant entry is in scope of the Conatrctor.

4.59.1. EMABANKMENT CONSTRUCTION

General

These Specifications shall apply to the construction of embankments including sub-grades, earthen shoulders and miscellaneous backfills with approved material obtained from approved source, including material from roadway and drain excavation, borrow pits or other sources. All embankments sub-grades, earthen shoulders and miscellaneous backfills shall be constructed in accordance with the requirements of these Specifications and in conformity with the lines, grades, and cross-sections or as directed by the Employers representative.

Density Requirements of Embankment and Sub-grade Materials

Condition of Embankment	Type of Work Maximum laboratory dry unit weight when tested as per IS:2720 (Part 8)
Embankments up to 3 m height, not subjected to extensive flooding	Not less than 16 kN/cu.m
Embankments exceeding 3 m height or embankments of any height subject to long periods of inundation	Not less than 17 kN/ cu.m
Sub grade and earthen shoulders/verges/ backfill	Not less than 18 kN/cu.m

Compaction Requirements for Embankment and Sub-grade

Type of work/material	Relative compaction as percentage of max. laboratory dry density as per IS:2720 (Part 8)	Minimum CBR %
Sub grade and earthen shoulders	Not less than 98%	5
Embankment	Not less than 97%	5
Expansive Clays a) Sub grade and 500 mm portion just below the sub-grade	Not allowed Not less than 90%	- 4

b) Remaining portion of embankment		

Granular sub Base

Construction of Granular Sub-Base by providing close graded material, spreading in uniform layers with motor grader on prepared surface, mixing by Mix In Place Method with rotavator at OMC, and compacting with vibratory roller to achieve the desired density.

Scope

This work shall consist of laying and compacting well-graded material on prepared sub grade in accordance with the requirements of these Specifications. The material shall be laid in one or more layers as sub-base or lower sub-base and upper sub-base (termed as sub-base hereinafter) as necessary according to lines, grades and cross-sections shown on the drawings or as directed by the Employers representative.

Materials

The material to be used for the work shall be natural sand, crushed gravel, crushed stone, or combination thereof depending upon the grading required. The material shall be free from organic or other deleterious constituents and shall conform to the quality standards as prescribed in the specifications.

Table 400-1 of MORTH prescribes four gradings for Granular Sub-Base (GSB). Gradings I and II in Table 400-1 are well graded granular sub-base materials. These can be used at locations where drainage requirement are not predominant. Gradings III and IV are gap graded and addresses to the concern of the drainage requirements. These can be used at location experiencing heavy rainfall, flooding etc. Cases where GSB is to be provided in two layers, it is recommended to adopt either grading III or grading IV for lower layer and either grading I or grading II for upper layer. Minimum thickness of lower layer at locations where drainage requirements are predominant shall not be less than 200 mm.

Physical requirements: The material shall have a 10 percent fines value of 50kN or more (for sample in soaked condition) when tested in compliance with IS:2386 (Part IV) 1963. The water absorption value of the coarse aggregate shall be determined as per IS:2386 (Part 3). If this value is greater than 2 percent, the soundness test shall be carried out on the material delivered to site as per IS:383. For Gradings II and IV materials, the CBR shall be determined at the density and moisture content likely to be developed in the field.

Strength of Sub-Base

It shall be ensured prior to actual execution that the material to be used in the sub-base satisfies the requirements of CBR and other physical requirements when compacted and finished. When directed by the Employers representative, this shall be verified by performing CBR tests in the laboratory as required on specimens remoulded at field dry density and moisture content.

Table : Grading for Granular Sub-base Materials

IS Sieve Designation	Percent by weight passing the IS sieve			
	Grading I	Grading II	Grading III	Grading IV
75.0 mm	100	—	100	—
53.0 mm	80-100	100	100	
26.5 mm	55 –90	70-100	55-75	50-80
9.50 mm	35-65	50-80		
4.75 mm	25 – 55	40-65	10-30	15-35
2.36 mm	20- 40	30-50		
0.425 mm	10-15	10- 15		
0.075 mm	<5	< 5	< 5	< 5
CBR Value (Minimum)	30	25	30	25

Wet Mix Macadam -

Providing, laying, spreading and compacting crushed graded stone aggregate as per Table 400-10 & 400.11 to Wet Mix Macadam specifications of MORTH including premixing the material with water to OMC in mechanical mixer (Pug mill) as per design mix, carriage of mixed material by tipper to site laying in uniform layers, with motor grader/F.E. loader/Paver Finisher, in sub-base/base course on a well prepared under-base and compacting with Vibratory Roller to achieve the desired density including lighting, guarding, barricading and maintenance of diversion etc. (MoRTH specification : Clause 406).

WET MIX MACADAM SUB-BASE/BASE

Scope

This work shall consist of laying and compacting clean, crushed, graded aggregate and granular material, premixed with water, to a dense mass on a prepared sub-grade/sub-base/base or existing pavement as the case may be in accordance with the requirements of these Specifications. The material shall be laid in one or more layers as necessary to lines, grades and cross-sections shown on the approved drawings or as directed by the Employers representative.

The thickness of a single compacted Wet Mix Macadam layer shall not be less than 75mm. When vibrating or other approved types of compacting equipment are used, the compacted depth of a single layer of the sub-base course may be upto 200 mm with the approval of the Employers representative Refer below clause of MORTH

406.2 Materials

406.2.1 Aggregates

406.2.1.1 Physical requirements :

Coarse aggregates shall be crushed stone. If crushed gravel/shingle is used, not less than 90 percent by weight of the gravel/shingle pieces retained on 4.75 mm sieve shall have at least two fractured faces. The aggregates shall conform to the physical requirements set forth in Table 400-9 of MORTH. If the water absorption value of the coarse aggregate is greater than 2 percent, the soundness test shall be carried out on the material delivered to site as per IS:2386 (Part-5).

Grading requirements: The aggregates shall conform to the grading given in Table 400-10 of MORTH.

Table: Physical Requirements of Coarse Aggregates for Wet Mix Macadam for Sub-base/Base Courses

S. No.	Test	Test Method	Requirements
1.	Los Angeles Abrasion value	IS:2386 (Part-4)	40 percent (Max.)
	Aggregate Impact value	IS:2386 (Part-4) or IS:5640	30 percent (Max.)
2.	Combined Flakiness and Elongation indices (Total)	IS:2386 (Part-1)	40 percent (Max.)*

To determine this combined proportion, the flaky stone from a representative sample should first be separated out. Flakiness index is weight of flaky stone metal divided by weight of stone sample. Only the elongated particles are separated out from the remaining (non-flaky) stone metal. Elongation index is weight of elongated particles divided by total non-flaky particles. The values of flakiness index and elongation index so found are added up.

Table : Grading Requirements of Aggregates for Wet Mix Macadam

IS Sieve Designation	Per cent by weight passing the IS Sieve	
	Grade 1 layer thickness ≥ 100mm	Grade 2<100 mm
53.00 mm	100	
45.00 mm	95 – 100	
26.50 mm	–	100
22.40 mm	60 – 80	50-100
11.20 mm	40 – 60	-
4.75 mm	25 – 40	35-55
2.36 mm	15 – 30	-
600.00 micron	8 – 22	10-30
75.00 micron	0 – -5	2-5

Primer coat

Providing and applying Primer coat with bitumen emulsion on prepared surface of granular Base including clearing of road surface and spraying primer at the rate of 0.60 kg/sqm using mechanical means.

MoRTH Clause 502 - PRIME COAT OVER GRANULAR BASE

Scope

This work shall consist of the application of a single coat of low viscosity liquid bituminous material to a porous granular surface preparatory to the superimposition of bituminous treatment or mix.

Materials

The bituminous material to be used as primer shall be such that it can penetrate about 10 mm deep into base course. Bitumen emulsion SS1 grade conforming to IS:8887/ASTM D2397 or medium curing cutback bitumen conforming to IS:2177 can be used as primer. Quantity of SS1 grade bitumen emulsion for various types of granular surface shall be as per Table 500-1of MORTH as below:

Table : Quantity of Bitumen Emulsion for Various Types of Granular Surface

Type of Surface	Rate of Spray (kg/sq.m)
WMM/WBM	0.7–1.0
Mechanically lime/cement stabilized soil bases, lime cement bases	0.9–1.2
Gravel bases, Crusher run Macadam and crushed rock bases	1.2–1.5

Tack Coat

Providing and applying tack coat using bitumen emulsion conforming to IS: 8887, using emulsion pressure distributer including preparing the surface & cleaning with mechanical broom. On bituminous surface @ 0.25 kg/ sqm.

MoRTH Clause 503 TACK COAT

Scope

This work shall consist of the application of a single coat of low viscosity liquid bituminous material to existing bituminous, cement concrete or primed granular surface preparatory to the superimposition of a bituminous mix, when specified in the Contract or instructed by the Employers representative.

Materials

The binder used for tack coat shall be either Cationic bitumen emulsion (RS 1) complying with IS 8887/ASTM D 2397 or suitable low viscosity paving bitumen of VG 10 grade conforming to IS:73. The use of cutback bitumen RC:70 as per IS:217 shall be restricted only for sites at sub-zero temperatures or for emergency applications as directed by the Employers representative. The type and grade of tack coat shall be as specified in the Contract or as directed by the Employers representative.

Dense graded bituminous macadam

Providing and laying Dense graded bituminous macadam with 100-120 TPH batch type HMP producing an average output of 75 tonnes per hour using crushed aggregates of specified grading, premixed with VG-30 grade of bitumen @ 4-4.25% by weight of total mixture and filler, transporting the hot mix to work site, laying with a hydrostatic paver

finisher with sensor control to the required grade, level and alignment, rolling with smooth wheeled, vibratory and tandem rollers to achieve the desired compaction as per MoRTH specification clause No. 505 complete in all respects:Grade-1

MoRTH Clause 505 - DENSE GRADED BITUMINOUS MACADAM

Scope

This clause specified the construction of Dense Bituminous Macadam, (DBM), for use mainly, but not exclusively, in base/binder and profile corrective courses. The work shall consist of construction in a single or multiple layers of DBM on a previously prepared base or sub-base. The thickness of a single layer shall be 50 mm to 100 mm.

Materials

Bitumen : The bitumen for dense bituminous macadam shall comply with the Indian Standard Specification for viscosity graded bitumen, IS:73 modified bitumen complying with IS:15462 or as otherwise specified in the Contract. Guidelines for selection of viscosity graded bitumen and modified bitumen are given in Table 500-5 and Table 500-6 of MORTH respectively.

Table Selection Criteria for Viscosity-graded (VG) Paving Bitumens Based on Climatic Conditions

	Highest Daily Mean Air Temperature, °C		
Lowest Daily Mean Air Temperature, °C	Less than 20°C	20 to 30°C	More than 30°C
More than –10°C	VG-10	VG-20	VG-30
-10°C or lower	VG-10	VG-10	VG-20

Table Selection Criteria for Grade of Modified Bitumen

Lowest Daily Mean Air Temperature, °C	Highest Daily Mean Air Temperature, °C		
	Less than 20°C	20 to 30°C	More than 30°C
	Grade of Modified Bitumen		
More than -10°C	PMB/NRMB 120 CRMB 50	PMB/NRMB 70 CRMB 55	PMB/NRMB 40 CRMB 60
-10°C or lower	PMB/NRMB 40 CRMB 50	PMB/NRMB 120 CRMB 55	PMB/NRMB 70 CRMB 50

Bituminous concrete

Providing and laying Bituminous concrete with 100-120 TPH batch type hot mix plant producing an average output of 75 tonnes per hour using crushed aggregates of specified grading, premixed with VG-30 Grade of bitumen @ 5.4-5.6% by weight of total mixture and filler, transporting the hot mix to work site, laying with a hydrostatic paver finisher with sensor control to the required grade, level and alignment, rolling with smooth wheeled, vibratory and tandem rollers to achieve the desired compaction as per MORTH specification clause No. 508 complete in all respects:Grade-1

MoRTH Clause 508 - BITUMINOUS CONCRETE

Scope

This work shall consist of construction of Bituminous Concrete, for use in wearing and profile corrective courses. This work shall consist of construction in a single layer of bituminous concrete on a previously prepared bituminous bound surface. A single layer shall be 25mm/40 mm/50 mm thick.

The coarse aggregates shall be generally as specified in Clause 505.2.2, except that the aggregates shall satisfy the physical requirements of Table 500-18 and where crushed gravel is proposed for use as aggregate, not less than 95 percent by weight of the crushed material retained on the 4.75 mm sieve shall have at least two fractured faces.

Table : Physical Requirements for Coarse Aggregate for Bituminous Concrete

Property	Test		Specification
Cleanliness (dust)	Grain size analysis	Max 5% passing 0.075 mm sieve	IS:2386 Part I
Particle shape	Flakiness Index Elongetion index	Max 15% Max 20%	IS:2386 Part I
Strength	Los Angeles Abrasion Value Aggregate Impact Value	Max 30% Max 24%	IS:2386 Part IV
Durability	Soundness either : Sodium Sulphate or Magnesium Sulphate	 Max 12% Max 18%	IS:2386 Part V
Polishing	Polished stone value	Min 55	IS:2386 Part IV
Water Absorption	Water Absorption	Max 2%	IS:2386 Part III
Stripping	Coating and Stripping of Bitumen Aggregate Mix	Minimum retained coating 95%	IS:6241
Water Sensitivity	Retained Tensile Strength*	Min 80%	AASHTO 283

4.59.2. QUALITY CONTROL

a) General

All works performed shall conform to the lines, grades, cross sections and dimensions as specified or as directed by the Employer's Representative subject to the permitted tolerances described hereinafter.

b) Horizontal Alignments

These shall be reckoned with respect to the center-line of the carriageway as specified. The edges of the carriageway as constructed and all other parallel alignments shall be "corrected within a tolerance of ± 20 mm there from.

c) Longitudinal Profile

The level of any point on the various surfaces after compaction shall comply with the following:

TABLE 4.18

Surface	Tolerance from the specified Level
Sub-grade	±25 mm
Sub-base	±20 mm
Base-course	±15 mm
Wearing course	±10 mm

However, the negative tolerance for wearing course, shall not be permitted in conjunction with the positive tolerance for the base course, if the thickness of the wearing course is thereby reduced by more than 6 mm.

The longitudinal profile shall be checked with a 3.0 m long straight edge, along the center-line of the road. The transverse profile shall be checked with a camber board at intervals of 30m. Permitted tolerances are specified in Table 4.19 below:

Table 4.19

Permitted tolerances of surface regularity for pavement courses

No.	Type of construction	Longitudinal profile (Maximum permissible undulation when measured with a 3 m straight edge) (mm)	Cross profile (Maximum permissible variation from specified profile when measured with a camber template) (mm)
1.	Sub-grade	18	12
2.	Sub- base	18	12
3.	Base-course	12	10
4.	Asphalt	10	8

d) Rectification

Where the surface irregularity of sub-grade and the various pavement courses falls outside the specified tolerances, the Contractor shall be liable to rectify these in the manner described below and to the satisfaction of the Employer's Representative.

i) Sub-grade

Where the surface is high it shall be trimmed and suitably compacted. Where the same low, the deficiency shall be corrected by adding fresh material.

ii) Stabilized Sub-base

Where the surface is high, the same shall be suitably trimmed while taking care that the material below is not disturbed due to this operation. However, where the surface is low, the same shall be corrected as described herein below:

When the time elapsed between detection of irregularity and the time of mixing is less than 2 hours, the surface shall be scarified to a depth of 50 mm, supplemented with freshly mixed material as necessary and re-compacted to the relevant specification. When this time is more than 2 hours, the full depth of the layer shall be removed from the pavement and replaced with fresh material to specification. In either case the area treated shall not be less than 5m long 2m wide.

iii) Where the surface is high or low, the top 75 mm shall be scarified, reshaped with added material as necessary and recompacted to Clause 9.177 (c). The area treated at a place shall not be less than 5m long and 2m wide.

iv) Bituminous Construction

For bituminous construction other than wearing course where the surface is low, the deficiency shall be corrected by adding fresh material and compacting to specifications. Where the surface is high full depth of the layer shall be removed and replaced with fresh material and compacted to specifications.

For wearing coarse where surface is high or low, the full depth of the layer shall be removed and replaced with fresh material and compacted to specifications. In all cases where removal and replacement of bituminous layer is involved, the area treated shall not be less than 5m long and 2 m wide.

e) Quality Control Test during Construction

i) For ensuring the requisite quality of construction the materials and works shall be subjected to quality control test, as described hereinafter, by the Employer's Representative. The testing frequencies set-forth are the desirable minimum and the Employer's Representative shall have the authority to carry out tests as frequently as he may deem necessary to satisfy himself that the materials and works comply with the appropriate specifications.

The tests and their frequency to be used for different materials and works shall be as detailed in the following Tables:

Table 4.20

Tests on earthwork for embankment construction

Sr. No.	Test	Frequency
1.	Plasticity	As directed by the Engineer
2.	Density	Each soil type to be tested. 1-2 tests per 8000 cubic meters of soil
3.	Deleterious content	As directed by the Engineer
4.	Moisture content	1 test for every 250 cubic meters of soil
5.	CBR test	As required by the Engineer

ii) Where specific procedure is not indicated for quality control tests, in these specifications, the same shall be carried out as per prevalent accepted Employer's Representativeing practice to the directions of the Employer's Representative.

iii) Compaction Control

Control shall be exercised by taking at lease one measurement of density for each 1000 square metres of compacted area or as required to yield the minimum number of test results for evaluating a day's work on statistical basis. The determination of density shall be in accordance with IS: 2720 (Part 28). Test locations shall be chosen only through random sampling techniques. Control shall not be based on the result of anyone test but on the mean value of a set of 5 - 10 density determinations. The number of tests in one set of measurements shall be 5, as long as it is felt that sufficient control over borrow material and the method of compaction is being exercised. If considerable variations are observed individual density results, the minimum number of tests in one set of measurement shall be increased to 10. The acceptance of work shall be subject to the condition that the mean standard deviation for any set of results is below 0.08 g/cc. However, for earth work in shoulders and in the top 500 mm portion of the embankment below the subgrade, at lease one density measurement shall be taken for every 500 square meters of each set of measurements shall be at least 10. In other respects the control shall be similar as described earlier.

4.59.3. SLAB CULVERT

Where slab culverts are provided for cross drainage purposes, these shall conform to the following specifications. The concrete works specifications for construction of RCC slab and the rubble masonry specification for the supporting rubble walls are given in these specifications (Part 9) and they shall be followed:

a) Bitumen at Location of Contact

The Bitumen to be used on the top of the bed concrete at the location of contact of RCC slab above in two coats, shall be straight run Bitumen of grade S 35 conforming to the specifications given in Table 9.17 of Clause 9.172 (f)

b) Graded Gravel Free Draining Backfill

On each side of the un-coursed rubble walls supporting the slab culvert a free draining backfill of thickness 200 mm shall be provided. The material for Section –9 [Part-C & F]: - Page-121 this backfill shall be granular, consisting of sound, tough, durable particles of crushed or uncrushed gravel, crushed stone or brickbats which will not become dry powdery under loads and in contact with water. The material shall be free from soft, thin, elongated or laminated pieces and vegetable or other deleterious substances. It shall be graded and shall meet the grading requirements given in Table 9.22 of Clause 9.182 (g).

c) Weep Holes

Weep holes as required or as directed by the Employer's Representative shall be provided in the masonry to drain water from the backfilling. Weep holes shall be of uPVC pipes conforming to IS: 6908 in rubble walls with necessary M-10 concrete cushioning 75

mm thick. They shall extend through the full width of the masonry at a spacing of 1.5 mm c/c and with slope of about 1 vertical to 20 horizontal towards the draining face.

4.60. PIPE DRAINS

Where pipes are provided for cross drainage purposes, the sequence of construction shall be as follows:

i) laying of sand/ shingle bedding on the original ground,
ii) laying of PCC of M-15 grade
iii) laying of concrete pipes of Class NP2/NP3 as per IS: 458,
iv) constructing embankment above in compacted murrum, laying of the sub-base and water bound macadam as specified hereinabove.

Details of the above works as indicated in the specifications shall be followed:

a) Materials for Pipe Drains

All materials used in the construction of pipe drains shall be uPVC. Each consignment of pipes shall be inspected, tested if necessary, and approved by the Employer's Representative at the place of manufacture or at site before their incorporation in the works.

b) Excavation for Pipes

The foundation bed for pipe drain shall be executed true to the lines and grades as specified or as directed by the Employer's Representative. The pipes shall be placed in shallow excavation of the natural ground or in open trenches cut in the existing embankment, taken down to level as specified. Where trenching is involved, its width on either side of pipe shall not be less than 150 mm nor more than one third the diameter of pipe. The sides of the trench shall be as nearly vertical as possible. When during excavation the material encountered is soft, spongy or other unstable soil and unless other special construction methods are called for, such unsuitable material shall be removed upto a depth of 600 mm or as directed by the Employer's Representative. Before placing any backfill material exposed surface of the soft soil shall be lightly compacted with one Pass of a 0.5 T roller. On the lightly compacted surface, coarse sand and shingle shall be spread in two successive by rolling with a min. 0.5T roller and with a minimum of 10 passes each, both in longitudinal and transverse directions. Where bed rock or boulder strata are encountered, excavation shall be taken down at least 200 mm below bottom level or the pipe as directed by the Employer's Representativeand the space filled with approved sand and shingle and thoroughly compacted to provide adequate support for the pipes. Trenches shall be kept free from water until the pipes are installed and the joints have been hardened. For this purpose, the Contractor shall suggest a suitable method for diverting the water.

c) Bedding for Pipe

The bedding surface shall provide a firm foundation of uniform density throughout the length of the pipe drain and shall conform to the specified level and grade. The pipe shall be bedded in a cradle constructed of concrete having a mix not leaner than M-10 conforming to the specifications under the same section. The pipes shall be laid on the concrete bedding before the concrete has set.

d) Laying of Pipes

No pipe shall be placed in position until the foundations have been approved by the Employer's Representative. When pipes are to be laid adjacent to each other, they shall be separated by a distance equal to or greater than half the diameter of pipe subject to a minimum of 450 mm. The laying of pipes on the prepared concrete foundation shall start from the outlet and proceed towards the inlet and be completed to the specified lines and grades. The pipes shall be fitted and matched so that when laid they form a drain with a smooth uniform invert. Any pipe found defective or damaged during laying shall be removed and a new pipe substituted in its place at the cost of the Contractor.

e) Jointing

All joints shall be made with care so that their interior surface is smooth and consistent with the interior surface of the pipes. The ends of the pipes shall be so shaped as to form a self-centering joint with jointing space 13 mm wide. The jointing space shall be filled with cement mortar (1 cement to 2 sand) mixed sufficiently dry to remain in position when forced with a trowel or rammer. Care shall be taken to fill all voids and excess mortar shall be removed. After finishing, the joints shall be kept covered and damp for at least four days.

f) Back-Filling

Trenches shall be backfilled with murrum in accordance with the specification. Backfilling upto 1.0 metres above the top of the pipe shall be carefully done and murrum shall be thoroughly consolidated under the haunches of the pipe.

Before laying the filter medium, the sides of the banks shall be trimmed to the required slope. Depressions shall be filled and thoroughly compacted. The filter granular material shall be laid over the prepared base and suitably compacted to a thickness of 75 mm unless specified otherwise on the specification drawings.

4.61. BUILDING WORK

4.61.1. GENERAL

All the building works shall generally comply with the following specifications unless specified otherwise in further description in this part:

Unless otherwise specified, all the building and structure works shall generally comply with the following Employer's Requirements:

1. All building works shall be in reinforced concrete framework.
2. All external walls shall be In 200 mm thick brick masonry built in cement mortar in (1:6).

3. All internal partition walls shall be in 100 mm thick brick masonry built in cement mortar 1:6. Transoms and mullions shall be of size 100 mm x 200 mm and shall from panels not exceeding 3500 mm x 3500 mm in size.

4. All internal masonry surfaces shall be finished with 12 mm thick smooth faced cement plaster mortar (1:4). The walls shall be finished with painting and the type of painting shall be in accordance with the one specified in clause 12.5 of standard specifications (civil work).

5. All external masonry surfaces without rock facing shall be plastered in two coats with sand faced cement plaster in cement mortar (1:4) and shall have total thickness of 20 mm. Waterproofing compound of approved make and quality shall be added to the cement mortar in proportions as specified by the manufacturer.

6. All external surfaces above ground level shall be painted as specified in clause12.20 of standard specifications (civil work)

7. Bathroom/ W.C. floor slabs shall be sunk and filled with brickbat coba (broken bricks set in lime) and provided with waterproofing as per the specifications of an approved specialist waterproofing company. The finished floor level in Bathroom/ W.C. areas shall be 25 mm below the finished floor level on the outer side.

8. Wherever specified, staircases shall be finished with 25 mm thick KotaStone treads and 12 mm thick Kota Stone skirting. The rise of stairs shall not exceed 170 mm and minimum width of the tread shall not be less than 275mm.All steps shall have 20 mm nosing.R.C.C. stairways shall be provided to permit access between different levels within buildings. All roof tops and tops of overhead tanks shall be made accessible with ladder provision. Vertical ladders fitted with landing point extensions will be permitted where considered appropriate by the Employer's Representative to access areas not frequently visited.

9. Admin building hand rail should be of stainless steel SS 304.

10. All floor cutouts and cable ducts, etc. shall be covered with pre-cast concrete covers in outdoor areas and GRP chequered plates of adequate thickness in indoor areas. All uncovered openings shall be protected with SS-304 hand railing fixed with two rails.

11. Top railing and vertical of the SS-304 railing shall be 32 mm dia.. The lower railing shall be 25 mm dia. SS-304.

12. All staircases shall be provided with SS-304 hand railing.

13. The reinforced concrete roofs shall be made waterproof by application of approved cement/ lime based waterproofing treatment, guaranteed for 10years. The finished roof surface shall have adequate slope to drain quickly the rainwater to R.W. down-take points.

14. For roofing drainage, cast iron rainwater down-takes with uPVC mouth covered with D.I. grating at top shall be provided. For roof areas up to 40 sqm. minimum two nos. 100mm diameter down-take pipes shall be provided. For every additional area of 40 sq m or part thereof, at least one no. 110 mm OD. down take pipe shall be provide. The RW pipes shall preferably be concealed.

15. Top surface of chajjas and canopies shall be made waterproof by providinga screed layer of adequate slope or application of an approved roof membrane and sloped to drain the rainwater.

16. Building plinth shall be minimum 450 mm above average finished ground level around building.
17. All concrete channels and ducts used for conveying liquid shall have smooth finish from inside. The width of concrete channels shall not less than 500mm. All open channels shall be provided with SS-316 with catahodic protection hand railings.
18. Kerbs to be provided below the hand railing on the catwalks/pathways should be as per relevant sections of the Factory Act.
19. All rooms in the treatment plant building shall be provided with appropriate signboards indicating the function of the rooms involved.
20. Wherever equipment and machinery is required to be moved for inspection servicing, replacement etc, suitable movable gantry of required capacity shall be provided.
21. The design of building shall reflect the climatic conditions existing on site Process buildings shall as far as is possible permit the entry of natural light and the use of glazed paneling shall be kept to a minimum.
22. Emergency exit doorways shall be provided from all buildings in order to comply with local and international regulations. Stairways and paved areas shall be provided at the exit points.
23. Toilet blocks in process building shall be provided with a sink with two drinking water taps of 12 mm size with appropriate drainage.
24. Drinking water shall be supplied from an overhead tank to be constructed on Chemical & Coagulant Storage House. All plumbing work shall be carried out in GI pipes of Class-C/Polyproprelene.
26. Opening of the windows shall be minimum 25% of the wall area.
27. Minimum floor area of various units shall be as given table – B.30. Anti-termite treatment process as per IS: timber care ground treatment chemically emulsion 1:3 and creating a chemical barrier under and around the column pits, wall trenches, basement excavation, top surface of plinth filling, junction of wall and floor along the external perimeter of building, expansion joints, surrounding.
28. Roof sheeting should be of colour coated profile sheet of nom 1015 mm effective cover width and nominal 28 mm deep ribs with subtle square fluting in the pan at nominal 203mm centre-to-centre. The end rib shall be designed for anti-capillary action, to avoid any seepage of water through the lateral overlap. The feed material is manufactured out of nominal 0.60 mm Base Metal Thickness (BMT), Hi-Strength steel with min. 550 MPa yield strength, metallic hot dip coated with Aluminium-zinc alloy (55% Aluminium, 45% Zinc) as per AS 1397- Zincalume AZ150 (Min. 150 gms/sq.mt total on both sides) with Colorbond steel quality paint coat as per AS/NZS 2728 type 3 – 4 of BlueScope Steel make. The profile sheet, fastener size etc. needs to be approved by the concern authority. All the accessories like gutter/ flashing / capping shall be made from the same material (either soft steel or Hi strength steel) which is used for main cladding application.

    STEEL SHEET MATERIAL

    Base Steel: The steel base material of sheet shall manufactured from 0.45 mm (nominal) base metal thickness with minimum 550 MPa Yield Strength. The steel manufacturers test

certificate for the chemical and mechanical properties of steel must be concerned authority prior to installation.

Metallic Coating: The sheets shall have a hot dip metallic Aluminium-Zinc alloy coating of Aluminium (55%) & Zinc (45 %) with total mass coating of 150 gms/sq.mt on both sides as Zincalume AZ150 or equivalent coating as per AS 1397.

Colour Coating: The coated sheets shall be factory painted and oven-baked conforming to AS/NZS 2728 type 3- 4, the total coating thickness of 35 µm (nominal) of Colorbond steel quality paint system of BlueScope Steel make, comprising of nominal 20 µm exterior coat on top surface and nominal 5 µm reverse coat on back surface over nominal 5 µm primer coat on both surfaces of approved colour shade. The sheet shall have brand marking of the manufacturer giving product details on the back of the sheet at every 1 mtr c/c for confirming genuinity of the material.

29. Specification language for Skylight Translucent sheeting

The panel shall be nominal 1.5 mm thick, composed of a translucent, thermosetting polyester resin with a thoroughly impregnated glass fiber reinforcing mat (FRP) with or without an integrally bonded translucent film on the weathering face comply with AS/NZS 4256. The profile should match with cladding profile. The fixing shall be done with specially designed Lapseal and weather-tight washer for fixing the translucent sheeting. The profile and properties shall be approved by Engineer-in-charge before installation

4.61.2. CEMENT/ LIME MORTAR

Mortar for brickwork and stonework shall be prepared, in accordance with IS: 2250. Cement mortar shall consist of Portland cement and sand in proportions specified elsewhere. Lime mortar for laying of tiles shall consist of one part of cement, 2 parts of lime and 6 parts of sand.

Mortar shall be mixed on clean, hard dry platforms protected from sun and rain. The constituents shall be measured using properly made gauge boxes and shall be thoroughly mixed dry before water is added. Any mortar not used 30 minutes after the water is added shall be discarded.

For lime mortar, lime from burn stone shall be used. It shall be free from ash and impurities and be in the form of lumps and not powder when brought to site. Lime which is damaged due to rain, soaking, moisture or air slaking shall not be used.

Portland cement for mortar shall comply with IS: 269.

Sand for mortar shall comply with IS: 2116 and shall be of the following grading:

I.S. Sieve	**Percentage passing by Weight**
4.75 mm	98 - 100
2.36 mm	80 - 100
1.18 mm	60 - 80
600 microns	40 - 65

300 microns	10 - 40
150 microns	0 - 10

Sand for mortar shall be from an approved source and shall consist of hard, coarse siliceous grains free from deleterious matter. It shall be stored separately from other sand or fine aggregate and shall be kept covered. The Contractor shall submit samples of sand for mortar for the Employer's Representative's approval if ordered. Water for mortar shall comply with Clause 9.75

4.61.3. BRICKS

Bricks for common brickwork shall be whole, sound, well burnt clay bricks free from cracks and shall comply with the requirements of IS: 1077. Samples of bricks to be supplied shall be submitted to the Employer's Representative for his approval. Clay Project Managering bricks shall comply with the requirements of IS: 2180.

Bricks shall not be tipped on the site but shall be carefully stacked by hand in separate stacks. Broken or damaged bricks shall not be used in brickwork.

Crushing Strength = 50 kg/cm2
Water Absorption = not >25% for partition walls
Size = Tolerance Allowed = 3.3% positively

4.61.4. BRICKWORK

Brickwork shall be built in accordance with the requirements of IS: 2212. Every brick shall be wetted and laid on a full and close joint of mortar on its bed side and end in one operation, joints being fully flushed up as the work proceeds. Previous course shall be wetted if it has dried and the walls shall be brought up evenly with no portion racked up (and not toothed) more than one metre higher than another. All brickwork shall be properly bonded together. Joints shall not exceed 10mm in thickness and shall be raked out a depth of 7.5mm as a key for rendering or plastering. All courses shall be truly horizontal and all perpendiculars shall be strictly plumb and square.

In the cavity walls the two leaves of brickwork shall be bonded with galvanized wall ties 150 mm to 250 mm long as required. The ties shall be built into the horizontal joints as the work proceeds and the space between successive ties shall not exceed 750 mm horizontally nor 250 mm vertically. Ties shall be staggered and shall be laid sloping down towards the outer leaf of the cavity. Cavities shall be kepi free from mortar droppings by the use of suspended battens and temporary openings at the bottom of the wall. Every fourth vertical joint in the external face in the course immediately above the horizontal damp proof courses shall be raked out and left open to form a weep hole. Completed brickwork shall be kept wet for a minimum period of 14 days.

4.61.5. CONCRETE BLOCKS

Concrete blocks whether made on or off site shall be manufactured to the shapes, sizes and finishes as specified or directed by the Employer's Representative and shall comply with the requirements of IS: 2185. The Contractor shall submit full details of his proposed

manufacturing arrangements to the Employer's Representativefor his approval before making any blocks for use in the works and shall submit such samples as may be needed to demonstrate the quality of the finished product. Production of blocks shall be of equal standard to the approved sample blocks.

Concrete for blocks shall be made generally in accordance with section C of the specifications except that the combined aggregate shall have a fineness modulus lying between 3.6 and 4 and shall conform with the following grading:

I.S. Sieve	**Percentage passing by Weight**
12.5 mm	100
10 mm	>85
4.75 microns	>60
300 microns	>10

Concrete for blocks shall be minimum Class M-20. Hand mixing shall not be permitted. When ordered by the Employer's Representative, sample block from any batch shall be tested as specified in IS: 2185. Finished block shall be neatly stacked for storage on firm dry support and shall be covered to protect them from dirt, sun and rain. Damaged blocks shall not be used in the works.

4.61.6. BLOCK WORK

Concrete blockwork shall be laid generally as specified for brickwork above except where specified otherwise or as directed by the Employer's Representative. The construction of hollow block masonry shall be generally in accordance with IS: 2572. Block work for partition walls shall be laid in stretcher bond. Fair face block work which is not to be plastered shall be neatly pointed as specified.

4.61.7. UNCOURSED STONE MASONRY

Uncoursed stone masonry shall be built in layers not exceeding 450 mm in height. No stone shall be less in breadth than 14 times its height and less in length than twice in height. Every stone whether large or small shall be laid in its natural bed and set flush in mortar, and the small stones used for wedging or filling being carefully selected to fit the interstices between the large stones. Care shall be taken to see that no dry work or hollow space is left in the masonry. The stones shall be so arranged as to break joints at least every 80mm and long vertical joints of joints shall be avoided. The joints at the face shall be finished off neatly, being struck and smoothed with a trowel, while the mortar is fresh. The upper surface of the work shall be brought to a uniform level at the height of each course. The faces of masonry walls shall be kept in perfect plumb and where batter has to be given it shall be uniform. The stones at all comers and junctions of wall shall be of large sizes and hammer dressed to the concrete angle.

Each stone shall be thoroughly wetted before being used in the work. The masonry shall be kept thoroughly wet during the progress of the work, (care being taken to water it even on Sundays and Holidays, special labour being employed if so required for this purpose)

until it becomes hard. As far as practicable, the whole of the masonry shall be raised in one uniform level and no part of the masonry shall be allowed to rise more than 1 metre above the rest to avoid unequal settlement. If raising one part of wall before the other becomes unavoidable the end of the raised portion shall be racked back in steps to prevent cracks developing at the junction of the old and new work. Care shall be taken to see that the sides of the wall are not built separately from the hearting, the faces and internal filling being done simultaneously. The stones shall overlap and cross each other as much as possible. No course shall be laid unless the previous close is perfectly set.

At least one header or through stone per square metre of wall face shall be built into the work. The headers or through stones shall be at least 0.05 m2 in area at face and shall have at least 0.025m2 area at the back face. Where the thickness of the wall is more than 600 mm a series of through stones shall be laid through the work so as to form front to back, breaking joints or overlapping each other for at least 150 mm. No stone whose length is less than 600 mm shall be used in such work as a header.

All the through stones shall be marked inside and outside and the marks shall be retained until ordered by the Employer's Representative to be removed. Sufficient number of headers shall be collected on site before commencing any masonry work. Where adequate sized through stones are not available in required quantities, the use of pre-cast plain concrete headers in M-20 mix may be permitted at the discretion of the Employer's Representative. No extra payment will be made for the provision of substitute headers in concrete.

Quoins shall be 150 mm high and formed of header stones at least 300 mm long. They shall be laid lengthwise alternately along each face and square on their beds, which shall be dressed to a depth of at least 80 mm.

Weep holes 80 mm wide and 150 mm in height shall be provided in retaining walls at the rate of one square metre as specified or directed. They shall be pointed with 1 : 2 cement sand mortar after raking the joints to a minimum depth of 25 mm.
Completed masonry shall be kept wet for a minimum period of 14 days, hi wet weather newly laid masonry shall be protected from the effects of heavy rainfall by tarpaulins or other approved material.

4.61.8. POINTING OF UNCOURSED MASONRY

Joints in exposed masonry faces shall be formed while the mortar is still green and shall be finished as flush joints, weathered joints, round-recessed joints or square-recessed joints as directed by the Employer's Representative. Masonry which is to be rendered or plastered shall have the joints raked out to a depth of 1 5 mm to form a key.

4.61.9. STONE PITCHING

Stone pitching to slopes shall be carried out where specified or as directed by the Employer's Representative. Stone for pitching shall be obtained from an approved source and shall be hard, sound, durable, clean and generally as specified. The minimum dimension of any stone shall be at least equal to the specified thickness of the pitching.

After excavation and trimming, slopes to be pitched shall be spread with as 75 mm thick layer of crusher run rock or graded coarse aggregate ranging from 75 mm particle size to fines. The slope shall then be hand packed with hard broken rock to a total thickness of 150 mm, each stone being individually placed and rammed home, with smaller stones edged into the cracks. 50 mm dia weep-holes shall be provided where specified at intervals not exceeding two metres in both directions. Joints in stone pitching shall be flushed up with sand/cement mortar on completion.

4.61.10. RUBBLE STONE PACKING

Rubble used for packing under floors, foundations, etc., shall be hard and durable rock, free from veins, flaws and other defects. The quality and size of the rubble shall be subject to the approval of the Employer's Representative.

The rubble stone shall be of best variety of black trap / granite / basalt or other approved variety of stone available locally. The stone shall be hard, durable, free from defects and of required size and shall be approved by the consultant before incorporation in the work.

The bed on which rubble soling is to be laid shall be cleared of all loose materials, leveled, watered and compacted and got approved by Employer's Representative

Small interstices shall be filled with hard clean sand and well watered and rammed. Cable or pipe trenches if shown in the drawing and as required by the Consultant shall be got done before the soling is started. Over the prepared surface, the stone shall be set as closely as possible and well packed and firmly set. The stones shall be of full height and shall be laid so as to have their bases of the largest area resting on the sub-grade. Soling shall be laid in one layer of 230mm or 150mm or other specified thickness and no stones shall be less than 230mm or 150mm depth or specified thickness of soling with a tolerance of 25mm. After packing the stones properly in position, the interstices between them shall be carefully filled with quarry spoils of stone chips of larger size possible to obtain a hard, compact surface. Spreading of loose spoils or stone chips is prohibited.

All interstices shall be filled with approved murrum. Excess murrum if any over the surfaces shall be removed. Unless otherwise specified, the murrum shall be supplied by the Tenderer at his own cost from the selected areas. The surfaces shall then be watered and consolidated with mechanical or sufficiently heavy wooden tampers and log-rammers as approved by the Consultant to give the required slope or level and dense sub-base. After compaction, the surface shall present clean look. Adequate care shall be taken by the Tenderer while laying and compacting the rubble soling to see that concrete surfaces in contact with soling are not damaged.

RUBBLE SOLING

Rubble soling for road work including foot paths, culverts, side drains etc. shall be carried out as specified here-in as above for rubble stone soling, as far as they are applicable, with the following additions.

Subgrade for soling shall be prepared by cleaning of all foreign substances including rank vegetation, if any. Any ruts or soft yielding places that appear due to

improper drainage conditions, traffic, hauling or from any other cause shall be corrected by filling/cutting upto 150 mm and compacted and the Subgrade dressed off parallel to the finished profile and the same shall be approved by the Consultant, before laying of soling. Soling shall be laid in regular lines and staggered joints. The stones shall be laid as closely as possible and packed well. The stones shall be so laid as to have their bases and the target area resting on the Subgrade and in contact with each other.

Soling shall be laid to proper gradient and chamber, which shall be checked frequently to ensure accuracy. Rolling shall then be carried out by a 8 to 10 t power roller and soling consolidated properly shall be lightly sprinkled during rolling, if ordered by the Employers Representative. The surface thus prepared shall first be passed by the Consultant, after which 40mm to 50mm thick layer of selected hard murrum available from excavation shall be spread over the soling as directed by the Consultant, and rolled again such that the hard murrum gets into the interstices, It shall, however, be ensured that a thin layer of murrum/grit shall remain on the finished surface of soling. The area of soling actually done of specified consolidated thickness limiting to the dimensions as per drg. Shall be measured in square metre upto two decimal places.

4.61.11. FINISHES IN GENERAL

The Contractor shall demonstrate his ability to apply finishes to the standards required under the Contract. If in the opinion of the Employer's Representative, the demonstrations do not satisfy the standards required, the Employer's Representativemay order the Contractor to employ a specialist firm of subcontractors approved by the Employer's Representative to carry out all or part of this work.

4.61.12. FLOOR SCREEDS

Where required or specified, dense concrete floor screeds shall be placed over the structural concrete floor. Before the structural concrete is fully hardened, the surface shall be roughened by wire brushing or pickling in order to expose the aggregate. Immediately before laying the screed, the concrete shall be cleaned with stiff brushes and then thoroughly dampened. Before the screed is laid and after the excess water has been removed, a thin layer of stiff cement grout shall be well brushed into the roughened surface.

Where directed by the Employer's Representative approved water proofing admixture shall be added to screed concrete in accordance with the manufacturer's recommendations.

Heavy duty screeds shall be in M 20 concrete. The coarse aggregate shall be well graded to a maximum size of 12mm. Light duty screeds shall consist of 1 part Portland cement by weight to 4 parts sand. Water content shall be kept to the minimum consistent with providing adequate compaction. Unless otherwise specified, screeding shall be finished to a U2 quality.

Screeds shall be laid to the walls shown in the specification drawings subject to minimum fall of 1 in 120. The minimum thickness of screed shall be 60 mm for heavy duty and 40 mm for light duty. Curing of screeds and quality of materials shall conform to Section C of the specification.

4.61.13. INDIAN PATENT STONE FLOORING

The Indian Patent Stone Flooring shall be 50nmm in thickness and shall consist of cement concrete mixed in the proportion of 1: 2: 3 (with 12.5 mm chips only) with an admixture of approved water-proofing compound. The least amount of mixing water that will produce a workable mix and will allow finishing without excessive trowelling shall be used. Generally a water cement ratio of 0.5 should suffice.

It shall be laid, after applying to the surface neat cement slurry, in bays of suitable sizes but not exceeding 6 sq.m. each, and required slope in a chess board alternate panel fashion and neatly finished smooth in red colour where directed with lines drawn as directed. The concrete shall be cast against teakwood stop-off boards, which shall be removed only after the concrete is set.

No dry cement shall be allowed to be used for finishing the surface. Mechanical mixing may be resorted to.

The surface shall be kept well watered after it is dry, for period of 8 days.

Construction joints shall be formed in between the sequential panels cast, with straight edges, 20 mm deep and 12 mm wide in groove form. These joints on completion of work, shall be cleaned and washed free of dust with the help of brush and shall be treated with hot bitumen poured in the gap, over which fine sand shall be spread to arrest the flow of bitumen.

4.61.14. SHAHABAD/ TANDUR/ KOTA STONE FLOORING

Stones shall be of approved quality, hard, sound, durable and of uniform thickness. Edges shall be chisel dressed and the top surface shall be machine polished with joints running true and parallel from, side to side. Stones shall be laid on a bed of lime mortar of proportion 1: 2 or cement mortar or proportion 1: 4. Thickness of mortar bedding shall not be less than 12 mm and not more than 25 mm. Before laying, the stone slabs shall be thoroughly wetted with clean water. Thick cement slurry shall be spread over the mortar bed over as much area as could be covered with the stone slabs within half an hours. The slabs shall then be laid and gently tapped with mallet till they are firmly and properly bedded. There shall be no hollows left. The joints shall not be more than 2mm wide and shall be struck smooth. The floor shall be kept covered with damp sand or water for a week. Slabs shall be of standard sizes and shapes and shall meet all the required properties and test requirements as stipulated in IS: 1124.

Stones in skirting shall be laid against a bedding of cement mortar 1: 4 20mm thick to the full height of skirting, to a true plane, level and plumb,. The workmanship shall be similar to flooring. The skirting shall be laid projected beyond the finished plastered surfaces. The continuous horizontal grooves at the top of skirting shall be provided if required. The

skirting surfaces shall be repolished with hand to the satisfaction of the Employer's Representative. The skirting shall be cured for 7 days. Top of exposed skirting shall be machine cut and polished. The used at projecting corners shall be suitably leveled to present as neat corner.

4.61.15. TILE FLOORING AND DADO

Glazed tiles including angles, corners, borders and specials shall be of the approved make and quality, Johnson or equivalent with mat finish.

The tiles before laying shall be soaked in water for at least 2 hours and shall be set in lime concrete mortar of one part of cement, two parts of lime for dado to walls. Tiles which are fixed in the floor adjoining the wall shall be so arranged that the surface of the round edge tiles shall correspond to the skirting or dado. Neat cement grout of honey like consistency shall be spread over the bedding mortar just to cover so much area as can be toiled within half an hour. The edges of the tiles shall be smeared with neat white cement slurry and fixed in this grout one after the other, each tile being well pressed and gently tapped with a wooden mallet till it is properly bedded and in level with the adjoining tiles. There shall be no hollows in bed or joints. The joints shall be kept as close as possible and in straight lines. The joints between the tiles hall not exceed 1.5 mm in width.

4.62. ACID AND/ OR ALKALI RESISTANT TILE FLOORING AND DADO

a) Materials

The acid and/or alkali resistant tiles shall have true and straight edges, shall be non-absorbing, without stains, non-fading, shall conform to IS : 4457 and approved manufacturers.

b) Laying and Workmanship

The surface over which tiles are to be laid shall be plain and plumb and without uneven depressions. It shall be chemically etched with 15 % commercial hydrochloric acid and then washed with alkaline solution. Subsequently, the surface shall be washed with sufficient water until it is fully neutralized.

After the underbed is thoroughly dried, it shall be cleaned thoroughly with wire brushes to remove all loose particles and brushed properly to obtain a completely dust free surface. A heavy grade bituminous corrosion resisting protective coating shall be applied on this dust free surface either by brushing or other means in accordance with manufacturer's specifications so as to provide an isolating layer between the Portland cement concrete and the acid-alkali resistant treatment as well as to provide a proper bonding between the same.

This bituminous material; shall be resistant to the splashes and fumes of both inorganic acids and alkalis and should form an elastic film not subject to flaking. Prodorlac SPL as marketed by Coromandel Prodorite Pvt. Ltd. or equivalent may be used for this bituminous lining and the number of coats provided as per manufacturer's recommendation, if a multiple coat is used, sufficient drying period shall be allowed between completion of one coat and application of the next as recommended by the manufacturer, and depending on

the prevalent temperature. On top of minimum thickness or as recommended by the manufacturer shall applied to provide an impervious underlay membrane to the tiling. This special mastic shall consist of a primer and a mortar. Both these shall be thermoplastic compound of selected fillers and blended bitumens which are solid at ordinary temperatures.

The primer shall be broken up into small pieces and put into cauldron and heated. During heating care shall be taken that the primer does not burn, it is essential to keep it in motion as a preventative measure. When the primer is hot enough to flow like a liquid it is to be poured over the undercoat surface and promptly spread to uniform thickness.

Care shall be taken to avoid moisture entrapment on the surface and to eliminate bubbles. Two layers of primer are normally suitable, but manufacturer's recommendation in this regard shall prevail.

The mortar is to be heated as required to make a stiff paste similarly breaking up into fairly small pieces and melted in the cauldron. When it reaches a butter like consistency, it is to be applied on to the primer applied surface in single or multiple layers as to form a total thickness or the special mastic membrane of at least 12 mm or as required by the manufacturer's specification. The mortar shall be applied hot either by trowelling or by means of a standard wooden float and thoroughly worked in until it forms an even coating. The covering shall be done piece by piece and care taken to keep the correct temperature, so that a perfect weld is made. The special mastic material may be the product of Coromandel Prodorite Pvt. Ltd. or equivalent. Over this underlay the acid/ alkali resistant resin based cement mortar.

The bedding mortar shall have a bed thickness not less than 6 mm. The material shall be self-hardening, chemically setting silicate type and chemical resistant comprising an intimate mixture of solid filler, a setting agent usually contained in the filler and a liquid binder.

The material may be supplied in tow components, powder and solution. When the filler powder and the liquid binder are mixed at ordinary temperature, a trowelable mortar shall be formed which should subsequently harden by the chemical reaction between the setting agent and the silicate binder forming an insoluble silica gel. The liquid binder may be neutral solution of sodium silicate and/ or potassium silicate and the fillers may be silica, quartz or other material insoluble hi common mineral acids.

The jointing of the tiles shall be done with a self-hardening cement mortar specially designed to resist both acidic and alkaline as well as mixed acidic and alkaline conditions. For this purpose a resin-type chemical resistant mortar conforming to IS: 4832 Part II shall be used comprising an intimate mixture of liquid resinous material and a powder composed of properly selected filler material and a powder composed of properly selected filler material and usually containing the setting agent. The material may be supplied in two components which when mixed at ordinary temperature shall form a trowelable mortar that subsequently hardens. The liquid resin may be either one of or a combination of the types like phenolic resin, furane resin, epoxy resin and polyester resin. The filler materials, which

are usually of a carbonaceous or siliceous nature shall be selected to have resistance particularly to hydrochloric acid and caustic soda. The catalyst material may be incorporated in the fillers is such a manner that it becomes effective when mixed with resin. For phenolic and furane resin mortars the resin and the filler may be supplied in two packs. The resin shall have a viscosity that will permit it to be readily mixed with the powder by manual methods. The filler materials shall have properly graded particles that will permit the preparation of a minimum joint thickness of 1.5mm.

The mortar is to be prepared and applied strictly in accordance with the manufacturer's instructions, If the material is supplied in two separate parts, an inert powder and a resin based syrup, they must mixed in the proportions given by the manufacturer's data table.

The jointing shall be done for the full depth of the tile and the joint width shall be 3 mm. The joints shall be finished smooth and flush printed.

Mixing shall be carried out very thoroughly and carefully in a clean enamelled dish or bowl. Any lumps in the powder shall be broken down by careful mixing. Mixing shall be carried out by adding powder to the syrup. The mixing shall be arranged that the mixed mortar is used up quickly and does not remain in bulk longer than the time specified by the manufacturer. At a temperature of 200°C or above, the mixing pan and contents shall be kept cool by immersion in water. All necessary measures should be taken so that the bulk masses of this resin based mortar, which generates heat in setting, are not allowed to remain under fairly warm conditions which may lead to a flash set. To avoid this, it is essential that the mixed mortar is spread in a thin layer on a flat tray and not left in a mass. After jointing the tiles, the flooring should not be placed under service in normal conditions before eight days or as recommended by the manufacturer and depending on atmospheric temperature. During setting and hardening, no water, steam or acid should come in contact with flu's jointing mortar.

If the flooring has to be sloped the same shall be provided in the concrete slab or an additional graded under-bed shall be provided if required, with cement sand mortar(l:3) by volume as specified or as directed by the Employer’s Representative.

The Contractor shall furnish full details regarding the materials for the different treatments described above pertaining to this flooring works as per manufacturer IS specifications, shall lay under-layer, special mastic, setting mortar etc. and set the tiles properly in full conformation with the manufacturer's instructions. The entire work shall be done in workmanlike manner to the complete satisfaction of the Employer’s Representative.

4.63. HEAVY DUTY ABRASION FLOORING

The type, quality, size, thickness, colour, etc., of the tile for flooring and skirting work shall be of the best quality approved by the Employer’s Representative. For this purpose, the Contractor shall provide the Employer’s Representative with necessary samples for his selection. Tiles shall be hardwearing, resistant to impact, resistant to abrasion, free from slipperiness and also resistant to attack by water, oils and greases. The tiles shall be laid on lime concrete mortar bedding of about 30 mm thick to give an overall thickness of 50mm. The laying procedure shall be similar to Clause 9.214.

4.64. 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.

4.65. BRICK BAT COBA CHINA MOSAIC TYPE WATER PROOFING

In case of works where brick bat coba and china mosaic are specified, brick bat coba of average thickness shall be laid to the required slopes as shown on the drawing .Proportion of brick bat shall be 2 parts of brick bat to one part of lime mortar (one part of lime to 2 parts of sand). The brickbats shall be hard, well burnt and of size varying from 12 mm to 25 mm. Lime shall be of best quality of hydraulic lime double ground.

While preparing brick bat concrete, jaggery in portion indicated by the Employer's Representative shall be added.

The brick bat coba shall then be laid to slopes, providing necessary wattas, and beated at least for 48 hours after laying. Over the brick bat coba a bedding of 1: 2 lime mortar 20 mm to 25 mm thick, shall be provided. A layer of neat cement grout, about 10 mm thick shall then be laid. Immediately on application of cement grout, assorted pieces of coloured china, previously soaked in water shall be set closely on the fresh surface and properly tamped to the required grade. The cement grout freshly prepared shall be laid to the top surface. The surface after completion of work shall be finally cleaned with saw dust, and waste and if so directed by the Employer's Representativewith dilute acid. China mosaic shall be cured for at least 10 days. If so directed by the Employer's Representative, a border of colour or white mosaic shall be provided.

Brick bat coba and china mosaic shall be taken up the parapet walls to height of 125 mm to 150 mm. Necessary fillet shall be provided towards drain pipes as shown on drawings or as directed by the Employer's Representative.

On prior approval from the Employer's Representative, cement base proprietary type of waterproofing may be allowed to be done by a specialist Contractor.

The Contractor shall give a guarantee of waterproofing for a minimum period of 10 years against bad or faulty material and shall rectify the work at his own cost during the guarantee period.

4.66. Waterproofing Work

The Contractor shall give a guarantee for all waterproofing against bad or faulty material and construction and shall rectify the work at his own cost during the O&M period.

(a) All surfaces to be waterproofed shall be dry, clean, smooth and free from dust and loose particles. Water proofing treatment shall be as per specifications of approved specialist

waterproofing company and shall consist of brickbat coba covered with jointless waterproof plaster finished smooth with trowel in cement mortar with false marking of 300 mm squares.

Waterproofing treatment shall be taken up the parapet walls to a height of about 300 mm in shape of round fillet or as directed by the Employer's Representative.
Thickness of brickbat coba shall be as specified by the specialised agency. Additional thickness of brickbats shall be provided wherever there is an increased length of travel of rainwater and in such portions of baths, water closets, nahani, etc. as specified and as directed by the Employer's Representative.

(b) Where bitumen felt waterproofing is adopted, it shall be of a seven layer treatment over a properly sloped screed. The layers of bitumen felt shall conform to IS: 1322. The first layer of bitumen felt shall be bonded to the dry, clean and smooth concrete surface by bitumen bonding compound. The successive layers of bitumen felt shall be bonded together with hot bitumen bonding compound as described in IS: 1346 and IS: 3037. Bitumen felt shall be Shalimar or similar approved, laid with 50 mm side laps and 75 mm end laps staggered. The felt shall be laid continuously over the surface of the roof and shall not be terminated at expansion joints.

4.67. NEERU PLASTER

Cement and sand shall conform to IS: 269 and IS: 383 respectively.

Neat lime shall be made of the best description of lime, slaked with fresh water and sifted. The lime shall be reduced to fine powder by grinding it on a stone or in a hand mill as directed by the Employer's Representative. The neat lime thus prepared shall be kept moist until used and the quantity to be prepared at one time shall be such that it can be consumed within eight days.

All stone or brick masonry surface shall be thoroughly wetted for atleast 6 hours and the joints raked out to a depth of at least 12 mm and walls washed before any plastering is done. The surface shall then be rendered with 1:4 cement sand plaster with specified roughness. The surface shall then be floated or set with a thin coat, 3 mm thick, of cement and polished will with a trowel or flat board. The cement mortar shall be used within 30 minutes after it leaves the mixing board or mill. Before any plaster work is started patches of plaster 150 mm x 150 mm shall be put on at every 3 metres as gauges so as to ensure an even thickness throughout the work. Cement plaster shall be done in even squares or strips. Care shall be taken to keep the whole surface thoroughly wetted for at least a week. The finishing surface shall be as specified and directed. Neat lime finish shall be applied to the prepared and partially set but somewhat plastic surface with steel trowel to a thickness slightly exceeding 1.5mm, (1/16") and rubbed down to 1.5mm, (1/16") thickness and polished to a perfectly smooth and even finish working from top to bottom. The total thickness of the plaster shall be at least 12mm.

The junction between beams and brickwork shall be plastered after fixing the expanded metal wire mesh of 300 mm width 10mm deep and 15mm wide grooves shall be provided between concrete & brick surfaces.

4.68. SAND FACED CEMENT PLASTER

Cement and sand shall conform to IS : 209 and IS : 383 respectively. The sand faced cement plaster, where specified shall be applied in two coats. All stone or brick masonry surface to be plastered shall be thoroughly wetted for at least 6 hours and the joints raked to a depth of at least 12mm and walls washed before any plastering is done.

The first coat of cement plaster in 1:3 cement sand mortar shall be applied uniformly all over the surface to be plastered to a thickness of 14mm with a trowel and in exact plumb. This coat shall be allowed to set for not less than half an hour. Indentation shall then be made in the form of waves by raking a wire broom over the surface to form a key for the second coat. Water proofing compound such as CICO, Impermo etc. shall be added in the 1st coat of cement plaster at the rate of 1.50 kg per bag of cement oral the rate specified by the manufacturer for its effective results. The plastered surface shall be allowed to cure for at least four days.

The second coat shall be applied in 1:3 cement sand mortar using clean sand screened through a mesh of not less than 1.5mm and not more than 3.00 mm size to a uniform thickness of 6mm by trowel and flat board in exact plumb. The surface shall then be tapped with a cork, piece to give a desirable uniform granular appearance. Care shall be taken for keeping the whole surface thoroughly wetted for at least one week.

4.69. EPOXY LININGS

The Contractor shall employ specialist firms, approved by the Employer's Representtaive, for the supply and laying of epoxy linings on the surface of the concrete. The epoxy shall be food grade and shall comply with the requirements of IS:9833 - 1981.with min. three coats wherein each coat shall be 125 microns.

4.70. ACOUSTIC TILES

Acoustic tiles shall be of a design and manufacture approved by the Employer's Representative and shall be bonded to ceilings in accordance with the manufacturer's details. They shall have glass wool backing resin bonded to grade RB2 and be fixed on timber or aluminium scantlings.

4.71. INSERTS, BOLTS ETC.

Fabricated pipe, moulded cast or fabricated frame insets, bolts plates etc. shall be provided in masonry and concrete works as required and shall b embedded in concrete with min. 450 mm baove the finshed level. It is imperative that all inserts, bolts, fixtures and fittings shall be provided in their position very accurately. Such inserts and bolts shall be fixed by use of templates. If as a consequence of negligence on the part of the Contractor, the inserts, bolts, fixtures fittings etc. are out of alignment, the Contractor shall make arrangements to have the inserts and bolts removed and refixed in their proper position as directed by the Employer's Representative.

4.72. WOODWORK IN DOORS, WINDOWS, PARTITIONS. LOUVRES, RAILINGS. ETC.

Wood used for all work shall be of approved quality of teak wood and properly seasoned by at least 6 months air drying, suitable for joiner's work, should be of natural growth, uniform in texture straight grained, free from sapwood dead knots, open shakes, boreholes, rot, decay and all other defects and blemishes.

Propoer pest control for the soil shall be done to prevent damage by termites.

The thickness specified for joiner's wrought timbers are, unless otherwise specified, prior to planning and 3mm will be allowed from the thickness stated for each wrought faces.

The joints shall be pinned with hard wood pins and put together with white lead. Jointing shall be by means of mortice and tennon or dovetailed joints, as approved by the Employer’s Representative.

Any joiner's work which shall split, fracture, shrink or show flaws or other defects due to unsoundness, inadequate seasoning or bad workmanship, shall be removed and replaced with sound material at the Contractor's expense.

Doors, windows and ventilator frames shall be rebated. All dimensions shall be as approved. The top framing member of doors and top and bottom framing of windows and ventilators shall project about 150 mm in brickwork. The verticals of door frames shall project about 50mm below finished floor. Surface coming in contact with brick work shall be painted with bitumen as directed by me Employer’s Representative. Each of the door and window frames shall be provided with 3 Nos. M.S. 225 mm x 25 mm x 6mm flat split hold-fasts on each side. These hold-fasts shall be embedded in masonry or concrete work. The work shall conform to IS: 4021.

Panelled doors shall comprise a 250 mm wide bottom rail, 150 mm wide middle rail and all other rails, middle top and vertical 100 mm wide. All rails shall be 40 mm thick. Panels shall be 20 mm thick. The panelled doors shall have minimum of 3 panels.

The workmanship of all door shutters shall conform to the requirements of IS: 1003 (Parts 1 & 11) and IS: 2202 (Part I). If required, flush door panels shall be tested as per IS: 4020. Flush doors shall be of 35 mm thick solid core.

All doors shall have 15 mm thick, 40 mm wide teak wood architraves on both sides. Railing and architraves shall conform to the shape as approved and fixed by means of screws (counter-sunk or otherwise) or bolts.

Woodwork shall not be painted, oiled or otherwise treated before it has been approved by the Employer’s Representative.

The whole of the woodwork shall first be treated with two coats of anti-termite wood preservative chemicals of an approved make. All the wood shall thereafter be applied with primary coat of paint. The application of primer shall not be done within 24 hours of the application of the second coat of anti-termite treatment.

The doors shall have the following fixtures.

a) Single Leaf Doors

i) Heavy duty railway type butt hinges of oxidized brass, 150 mm long - 3 Nos.
ii) Godrej 6 lever mortise lock with lever handles on both sides - 1 No. (chromium plated brass)
iii) Tower bolt 300 mm long -1 No. (Chromium plated brass)
iv) Door stop - 1 No. (CP brass with rubber stopper)
v) Door Closer - 1 No. (heavy-duty hydraulic pipe)

b) Double Leaf Doors

All material shall be same as for single leaf doors

i) Heavy duty railway type hinges 150 mm long - 6 Nos.
ii) Aldrop - 1 No. (300 long)
iii) Tower bolls 300 mm long - 2 Nos.
iv) Pull handles - 4 Nos. (CP brass 150 long)
v) Door stops - 2 Nos.
vi) Door Closer -1 No.

Where the single leaf doors are 1200 mm wide the number of hinges used shall be four. Similarly, if the height of the door exceeds 2200 mm, the number of hinges shall be suitably increased. The doors shall be provided with parliamentary type hinges, wherever required.

Door closures shall be of heavy duty hydraulic type.

4.73. GLAZING FOR DOORS. WINDOWS AND VENTILATORS

a) Glass in general

Glass shall conform to the requirements of relevant IS codes and shall be free from bubble, smoke wanes, air holes, scratches and other defects and shall be cut to fit the rebates with due allowance for expansion. Glass which does not have uniform refractive index or which is wavy shall not be used.

b) Sheet Glass

Sheet glass shall be flat, transparent and clear as judged by the unaided eye. It shall be free from cracks. Sheet glass shall be of B quality or ordinary quality and the thickness shall be as specified. Sheet glass used for glazing in building shall conform to IS: 1761.

c) Wired Glass

All wired glass shall be 6 mm thick, polished Georgian or equivalent, with both faces ground and polished. The glass shall conform to IS: 5437.

d) Glazing

Putty for glazing to wood shall be prepared in accordance with IS: 1635. Glazing work in buildings shall conform to IS: 3548. Compound for glazing to metal is to be approved special compound manufactured for the purpose.

4.74. METAL DOORS AND WINDOWS

a) Aluminum Doors, Windows and Screens

All extruded sections used in work of aluminum doors, windows etc. shall be minimum 3 mm thick of Jindal or Hindal make or equivalent. All sections shall be aluminum anodized in matt or polished finish as directed. Aluminum doors, windows etc. of only approved manufacturers shall be used. The aluminum doors and windows shall conform to IS: 1948. Fixing of all aluminum doors and windows shall be carried out through the agency of manufacturers as per their specifications. Aluminum doors and windows shall be completely water tight.

The aluminum windows shall have either side projected or top projected shutters as specified to facilitate the cleaning of glasses. In case of side hung windows friction hinges shall be used, with stainless steel pins, Centre hung ventilators shall be hung on two pairs of cup-pivots of aluminium alloy or brass or bronze pivots chromium or cadmium plated.

Glass panes shall be free from flaws, speck or bubbles and shall be with properly squared corners and straight edges.

Following fixtures and fittings shall be provided :

For Doors

i) Two floor springs of suitable make such as Everite, Prabhat etc. or equivalent having double action spring,

ii) Each door leaf shall be fitted with two Nos. of suitable size of aluminium anodised handles from extruded tube of 100 mm x 50 mm minimum,

iii) One leaf out of two shall be fitted with tower bolt at top or bottom of 230mm size of chromium plated brass,

iv) 6 lever brass lock concealed in section tube and openable from both sides with two keys,

v) 1 door closer of heavy duty hydraulic type for each door leaf.

For Windows

One opener, one handle and 15 cm. long tower bolt of brass, chromium plated.

b) Steel Windows. Ventilators and Doors

Steel windows, ventilators and doors, including folding doors shall be supplied complete with frames and fitted with standard fixtures such as hinges, locks, bolts stoppers, handles as necessary.

Steel used in fabrication of windows and doors shall have a minimum thickness of 3 mm. There shall be no distortion in the frames. If steel doors are provided they shall be propoerly powered coated to prevent corrosion.

The whole frame with the exception of lugs and external faces of channels shall be painted after manufacture as per specifications.

c) Vehicular Doors

Vehicular doors shall be of mild steel construction not less than 1.25 mm thick and shall be of the roller shutter or concertina type as specified. The doors shall be supplied by a reputable manufacturer to the approval of the Employer's Representative and shall include a wicket door where specified. Doors shall be delivered to site painted with one coat of approved primer. After installation any damage to the paintwork shall be touched up and final painting will be carried out when approved by the Employer's Representative. Doors shall be smooth operating, capable of opening and closing by one man and shall be fully weatherproof when closed. They shall be supplied complete with secure locks including locks to the wicket doors where appropriate. Slats for the rolling shutters shall be in one piece and be made of heavy gauge steel sheets minimum 1.25 sq. in thickness. A cylindrical hood shall be provided on the top to enclosed the shutter when it is open.

5. GRAVEL IN UNDER DRAINS

The gravel/ metal shall be sound, durable tough clean chemically stable of 20 mm single sized which will not become powdery under loads and in contact with water. The gravel shall be free from soft thin, elongated or laminated pieces and vegetable or other delicious substances. The gravel shall be spread and thoroughly compacted in layers of 150 mm taking care that it does not get crushed.

4.78 WATER SUPPLY AND SANITARY WORKS - GENERAL

All plumbing works shall be carried out through a licensed plumber and the pipes and fittings shall be as per the requirements of the Municipal water bye-laws. The Contractor shall get the pipes and fittings work done to the entire satisfaction of the Employer's RepresentativeThe Contractor shall submit the name of the licensed plumber to whom the work is to be entrusted for approval of the Employer's Representative.

a) Sheet Lead for Flashing

The lead shall be new lead in accordance with IS: 405. Unless otherwise specified all lead shall weigh 200 N/m2. When laying lead care shall be taken to ensure that there is provision for expansion and contraction. No solder shall be used except where it is unavoidable.

b) Copper Tubing

Copper tubing shall be light gauge solid drawn seamless copper in accordance with IS: 5493. Brass of gunmetal fittings of the non manipulative compression joint type or capillary fittings shall be subject to the approval of the Employer's Representative. Copper tubing shall be fixed at not greater than 1.5 m centres with cast brass pipe brackets or other approved fasteners.

c) Galvanised Steel Tubing

Galvanised mild steel tubing and fittings shall be supplied by an approved manufacturer with screw and socket joints, tested hydraulically to a pressure of 48 bar. Pipes shall be

secured to structures at not more than 1.5 m centres with galvanized malleable cast iron brackets.

d) Fixtures and Valves

All fixtures and valves shall be of types approved by the Employer's Representative and in accordance with IS: 6157. Stop valves which arc generally concealed shall be made of brass or gunmetal. Stop cocks which are exposed and bid and pillar cocks attached to sanitary fittings shall be brass or gunmetal bodies chromium plated and market! "hot" or "cold" as required. Ball valves shall be brass in accordance with IS: 1703.

4.79 LAYING OF DRAINS

Before laying the drains the centre of each manhole shall be marked by a peg, or otherwise, as determined by the Employer's Representative. The Contractor shall then dig holes for setting up two posts (about 100 mm x 100 mm and 1,8m long) at each manhole at nearly equal distance from the peg and at sufficient distance therefrom to be well clear of all intended excavation. A sight rail shall then be fixed level against the posts and perpendicular to the line of excavation. The posts shall be erected in such a manner that they remain clear of all the other excavation trenches if any, converging on the manhole. The sight rails shall not be in any case more than 30 metres apart and intermediate rails may be erected if necessary.

Boning rods shall be prepared from timber section 75mm x 50mm in various lengths, each length being a multiple of half a meter and with a fixed tee head about 300 mm long. The boning rod shall be marked on both sides to indicate its length. According to the circumstances of each case, a suitable length of boning rod shall first be determined and thereafter markings shall be done on both posts or walls or fences to which the sight rails are fixed. These markings shall be at the level obtained by adding the invert level of the drain at the position of the sight rail and the selected level of the boning rod.

The sight rail (about 100mm x 25mm) shall then be screwed with top edge against the level marks. The centre line of the drain shall be marked on the rail, and this mark will denote also the meeting point of the centre lines of any converging drains. A line drawn from the tope edge of one rail to the top edge of the next rail will be vertically parallel with the invert of the drain, and the depth of the invert of any intermediate joint may be easily determined by letting down the selected boning rod until the tee head comes in the line of bight from rail to rail.

The posts and rails shall in no case be removed until the trench is excavated, the drains constructed and permission given to proceed with the filling-in. All drainage pipes /downtake pipes shall cPVC.

4.80 FORMATION FOR DRAIN PIPES

The bottom of every trench shall have a true grade throughout and shall be made in perfect straight lines. In case any loose, soft or bad ground is met with, it shall be excavated to a solid foundation and be filled up to the invert level of the drain sewer with concrete or otherwise as directed by the Employer's Representative.

The floor of every drain trench pit shall be formed for receiving the socket of the pipes and a mass of clay shall be placed all around every joint of the drain.

In excavating any trench, the materials forming the surface of any road, footpath, garden or field shall be kept separate and preserved for re-use at the surface when the trench is filled up. Before any road metalling is reused it shall be carefully shifted.

4.81 LAYING OF DRAIN PIPES

In laying the drains, care shall be taken that they are laid perfectly true to the grade and as far as possible straight from point to point of the manholes, vents or lamp holes and that all pipes are carefully and solidly packed underneath so as guard against subsidence or fracture of the pipes.

The drainage line shall be in uPVC pipes of approved make. The line shall be laid true to gradient in the underground portion. Where the pipeline is above ground, cast iron pipes shall be used. The pipes, bends and other specials in the superstructure work shall be laid vertical and fixed properly to the satisfaction of the Employer's Representative. The vent pipes shall be raised to about 200 cm above the terrace floor level. All pipes in trenches less than 1.5 m and over 4.5m deep and those in loose grounds and under-roads shall be protected and encased with concrete of grade M-15 all round.

4.82 JOINTING OF PIPES

The joints of cast iron shall be done in the manner described below:

Before treating the joint with cement sand mortar it shall be cleaned and moistened with water. The joint shall then be filled with a mixture of 1 part of cement and three parts of clean fine sand, with just sufficient water to have a consistency of semi dry condition. The mortar is forced into the joints and well rammed with caulking tool until the whole space round the spigot and the socket is filled and the joints shall then be finished off with a splayed fillet sloping at 45 degrees to the sides of the pipe. The shaft of the pipes entering or leaving the manhole shall have a splayed fillet or neat cement laid around the same extending outside the plastering of the manhole by 75mm.

Care shall be taken after the joints are made to see that the pipes are not moved or shaken before the cement has thoroughly set, and that they are watertight.

After the joints have thoroughly set, the Employer's Representative may inspect the joints, and if has any doubt as to their soundness, he may require, the Contractor to cut open and clear away the cement of any joint that he may select, and to make good the same at his expense. Normally he may not be required to open more than one joint in 20 metres of pipe laid. If however effects are found on such opening, the Employer's Representativemay direct him to open as many joints as he may deem necessary. The joints, made on any one day will not as a rule be inspected until the following day so that

the cement may have sufficient time to set, well before being covered up. For joining of PVC pipe refer Section-II of Volume-2, Employers Requirement.

4.83 REFILLING OF THE TRENCHES

After the foundations of any buildings or other work have been completed or the sewer or drain pipes have been laid and jointed or the inspection chamber manholes and vents completed and as soon as the joints have been inspected and passed by the Employer's Representative, the trenches shall be re-filled with the materials taken there from or as not to disturb, break or damage the jointed pipes. Immediately the finest selected material shall be put round the pipe or be thrown into the trenches until the same is completely protected by the finer material filling referred top above. The back filling shall be done in suitable layers and shall be rammed properly until it is thoroughly consolidated and watered in addition, if considered necessary by the Employer's Representative. Care shall be exercised so that the trenches are filled in solidly with selected material without voids under the pipes and that no damage is done to the pipe during the process of filling and consolidation.

4.84 MANHOLE

Manhole shall be constructed at places of every change of alignment of pipeline. The junction manholes shall be construction at places where two or more pipelines convergance at a point. Manholes shall be sufficiently spacious to accommodate a man to clean the same.

The manhole shall be circular and shall be construction in concrete only of required grade.

Where a pipe enters and leaves a manhole, on edge must be cut to proper form and laid around the upper half of pipe so as to form an arch. Where the depth of invert exceeds 1 meter below the surface of the ground, PVC encapsuled steps of approved pattern shall be built in at every four courses with additional hand irons.

The covers shall then be placed in position and the whole work shall be left neat and dry.

Covers and frames shall be of ductile iron and circular in pattern conforming to IS: 1726. They shall be coated with Dr. Angus Smith's composition. They shall be air tight, heavy pattern only, weighing about 150 kg to 180 kg.

4.85 SEPTIC TANKS AND SOAK AWAY PITS

The sewage from toilets shall be led to septic tanks prior to final disposal. The design and construction of septic tanks shall conform to IS:2470 (Part I). The floor shall be of cement concrete grade M20 and shall have a minimum slope of 1:10 towards the sludge outlet. The thickness of the floor at the lower most point shall be 150 mm. The walls shall be of such thickness as to provide adequate strength and water tightness. Walls built out of bricks shall be minimum 230mm thick and shall be plastered with 20mm thick 1:3 cement mortar of both inside and outside. Stone masonry walls shall be minimum 370mm thick. A

storage volume of sludge of 1 year shall be considered in the design. The effluent septic tank shall be taken to soak away pits which shall conform to IS: 2470 (Part 2).

4.86 C.I. NAHANI TRAP

The Contractor shall supply 8 cm (3") size C.I. Nahani traps, bends and pipes with 12.5 cm (5") C.I. grating of the best quality conforming to 1S:3989.

4.87 uPVC RAIN WATER PIPES

All downtake rain water pipes shall be of uPVC.

The size of the grating shall be slightly bigger than the external diameter of the pipe.

The cavity between brick masonry and the pipes etc. shall be made good in cement mortar, neatly after the fixing of the pipe.

In case of terraced roof, the cast iron grating shall be fixed at the inlet end of the pipes, properly secured in the wall to receive the rain water. The cast iron grating shall be recessed at a slightly lower level than the adjacent terrace floor level.

The pipes shall be fixed with nails driven through the holder battens fixed in the walls with the sockets facing up. Pipes and fittings shall be kept 12mm from the walls to facilitate cleaning, paintings etc. The joints shall be sealed with a few turns of spun yard soaked in bitumen or tar, which shall be pressed home with a caulking tool for 1/3" the depth of joints. More spun yam shall then be wound round the joint with cement mortar (1:3). At the ground level, they shall be supported on M-10 concrete blocks 300mmx300mm of sufficient height.

Pipes fittings and joints shall be tested for leaks as specified and defects, if any shall be rectified.

4.88. CAST IRON SOIL/ VENT/ WASTE PIPES WITH NECESSARY FIXTURES AND FITTINGS ETC.

The Contractor shall supply good quality pipes of approved make, including all fixtures viz. Tees, bends, etc. as required, free from cracks, flaws etc. Cast iron pipes shall be treated with Dr. Angus Smith's composition. The tolerance limits for various diameters for cast iron soil, waste and ventilating pipes shall be as set out in I.S.1729.

Care shall be taken to see that in case of soil or waste pipes the sockets shall be at the inlet end. In case of vent pipes, the sockets shall face up. The Cast iron pipes shall be fixed with nails driven through the holder battens fixed in the wall. Pipes and fittings shall be kept 12 mm from the walls to facilitate cleaning, painting etc. The joints shall be sealed with a few turns of spun yarn, soaked in bitumen or tar, which shall be pressed home with a caulking tool for 1/3 the depth of joints. More spun yarn shall then be wound round the joint with cement mortar (1:1).

The cast iron pipes shall be painted with one coat or red lead oil paint and two coats of anti-corrosive oil paint, of approved make and shade.

Pipe fittings and joints shall be tested for leaks as specified in 9.243 and defects if any, shall be rectified.

4.89. TESTING OF JOINTS OF DRAINAGE PIPES AND FITTINGS

The joints of drainage of pipes and fittings shall be tested by the Contractor as described below:

All soil pipes, waste pipes and vent pipes and all other pipes when above ground shall be tested for gas tightness by smoke test under a pressure of 25mm of water and maintained for 15 minutes after all trap seals have been filled with water. The smoke shall be produced by burning oily waste or tar paper in smoke machine. Chemical smokes are not satisfactory. If leaks are found during testing the joints shall be made good and the test repeated.

4.90. GULLY TRAPS

The Contractor shall supply and fix CI/DI gully trap outside the building and construct the brick masonry chamber including D.I. frame and cover around it as specified below.

The gully trap shall be set in M-10 cement concrete extending 30 cm beyond trap on three sides over which the brick masonry chamber shall be constructed in cement mortar (1:4). The building wall will be on the fourth side. Brick masonry shall have internal and external plaster 20mm thick in cement mortar (1:4). The C.I. cover including its frame shall be fixed in M-10 cement concrete 10 cm thick. The trap in the chamber shall be provided with a gratings.

4.91. INTERCEPTING SEWER TRAP

The Contractor shall provide the intercepting trap as approved by Employers representative.

The foundation concrete shall be in M-10 and shall be laid to a thickness of 250mm. The intercepting sewer trap shall be fixed into the extended portion of the foundation concrete on the main sewer side of the chamber. Brick masonry chamber of one brick thickness shall be constructed in cement mortar (1:4) with inside dimension of 90 cm x 90 cm and depth corresponding to the depth of the trap of the drain. During the construction, the rodding pipe of the trap shall be embedded in brick masonry. Channel in M-10 cement concrete shall be formed to lead away in the sewage. The floor of the chamber shall be sloping towards the channels. The brick masonry chamber shall be plastered on both sides in 20mm thick cement mortar (1:4). The C.I. cover and frame shall be fixed in M-10 cement concrete 10 cm thick.

4.92. BITUMEN LAYER TO WATER CLOSET SLAB

A bitumen layer shall be provided over the water closet slab for making it waterproof. Bitumen shall have a penetration limited to 40 when tested in accordance with IS: 1203.

The exposed slab surface shall be thoroughly cleaned of all dirt, dust and loose material. The surface of concrete shall be dry. Bitumen shall then be applied at the rate of 2 kg/sq. metre at a temperature of not less than 121°C (250°F) evenly throughout and allowed to dry before laying brick bat coba.

4.93. COLOURED GLAZED EARTHENWARE WATER CLOSET PAN

The Contractor shall provide English type white glazed earthenware water closet pan conforming to IS: 2556 of the specified dimensions with cast iron high level flushing cistern and other flushing accessories and necessary pipe connections up lo the soil and vend pipes fixed on the outside of wall. All the materials shall be of approved make. The Contractor shall obtain the prior approval of the Employer's Representative before fixing the pan and its accessories into place.

The pan shall be placed into position with the trap jointed in cement mortar (1:1) and the connecting pipes duly connected including the 32 mm diameter lead or galvanized iron pipe from the flushing cistern.

Brickbat cement concrete 1:2:4 shall be cast as specified by the specialist waterproofing agency in the fully water closet area and pressed all around the embedded surface of the pan and fittings and pipes to get solid embedding without any hollows. The pan be fixed at a slightly lower level than level of the general flooring which shall slope on all sides towards the pan. If the pan is damaged while handling or fixing, it shall be replaced by the Contractor at his own cost. The flushing cistern shall be fixed on two cast iron or mild steel cantilever brackets fixed in the wall at the height specified or as directed by the Employer's Representative.

The lead or galvanized iron flushing pipe shall be bent leaving a straight length of about 30 cm at the top and the lower portion after the bend shall be lowered into a recess left out in the wall and shall be concealed in the plaster. The whole installation shall be tested for leak-proof joints and satisfactory functioning.

The cistern brackets and all the exposed pipes shall be painted with a base coat of zinc rich primer and two coats of enamel paint of approved make and shade.

4.94. COLOURED GLAZED EARTHERNWARE URINAL

The Contractor shall provide white coloured earthenware flat back urinals or approved make conforming to IS:2556 including high level automatic flushing cistern of capacity as per 1S:2326, and a 'P' trap with vent extension. The urinal shall be securely fixed to the wall with the top of bowl 65 cm from the floor or such distance as may be directed by the Employer's Representative. All the pipe connections such as water connections from the cistern to the urinal with 20mm diameter main and 15mm diameter branch C.I. pipes and

32mm diameter lead waste pipe upto C.I. waste shaft on the outside wall shall be carried out as required. Holes made in wall shall be made good in cement mortar (1:4).

4.95. COLOURED GLAZED EARTHERNWARE WASH BASIN

Coloured glazed earthenware wash basin conforming to IS: 2556 including all necessary fixtures and pipe connections upto the outside the face of the wall, all of approved make and quality shall be provided and fixed at the location and level specified or as directed by the Employer's Representative. The wash basin shall be supported on a pair of rolled steel or cast iron cantilever brackets embedded in the wall or fixed to the wall with wooden cleats and screws. The height of the top of the basin from the floor shall be 75 cm unless otherwise directed by the Employer's Representative.

The waste pipe shall be of 32mm diameter galvanised iron and shall be provided as required upto a length of one meter with lead or nickel plate G.I. 'P' trap with rubber plug. The wash basin shall have G.I. supply pipe of 15mm diameter stop cock No. l and 15mm swan nickel plate tap. If holes are not left in the wall initially, they shall be cut and the cavity surrounding the drain or water pipes made good after fixing of the pipes.

4.96. WHITE WASH

Walls shall be thoroughly cleaned of all dirt and loose particles etc. before whitewash is applied. Inequalities and holes shall be filled up with gypsum which should be allowed to set hard. Whitewash shall be of ordinary fat lime and of a good quality. It shall be slaked with an excess of water to the consistency of a cream and allowed to remain under water for 2 days. It shall then be strained through a cloth and 2 kg of clean gum added for every cubic metre if lime ready for white washing.

Each coat is to be applied with a brush spray. It shall be laid with a stroke of the brush from the top downwards, another from bottom upwards over the first stroke and similarly, one stroke from the right and another from the left over the first brush before it dries. Three such coats shall be applied.

4.97. PAINTING

a) General

Employer's Representative's approval shall be obtained before commencing the painting work. All paints and preserves shall be of approved make and colour and their application shall conform to the manufacturer's instructions. Where more than one undercoat is specified it shall be applied in coats of distinctive tints. Workmanship shall conform to the requirements of IS: 2395.

Unless the manufacturer's instructions state otherwise 48 hours drying time shall elapse between successive applications of any primer and 24 hours between applications of all

subsequent coats. The surface of bituminous paints shall be left at least 3 days before further handling.

No paints in any coat shall be applied until the Employer's Representative is satisfied that the surface is clean and dry, and that any previous coat is satisfactory and has hardened adequately. When a surface has been approved, it must be painted immediately. Paintwork shall be rubbed down with a glass paper between coats. No paint shall be applied to a surface which is damp, dirty or otherwise inadequately prepared.

b) Concrete, Brickwork and Plaster

Where specified to be painted, concrete and plaster shall be rubbed smooth and any cracks, blister holes and other imperfections cut out, filled and made good. The surface shall be dried to the satisfaction of the Employer's Representative before painting is commenced and drying time of at least 28 days shall be allowed after laying brickwork and plaster or stripping formwork from concrete. The surface shall be brushed to remove any efflorescence and then painted with the following :

i) for interior brickwork and concrete, apply two coats of oil paint upto 1 meter height and for remaining part two coats of plastic emulsion paint over a coat of primer.

ii) for exterior brickwork and concrete, apply two coats of cement based paint over a coat of primer with a water repellent coat of siliconate solution of approved make.

Where painting with plastic emulsion is specified all uneven surfaces shall be made up by use of putty of appropriate quality after the surface has been thoroughly cleaned of all dust and dirt and sand papered.

c) Ironwork and Un-galvanised Steel Work

Structural steelwork shall be shot blasted to a "white metal" finish, and grease and oil removed prior to painting. Priming shall immediately follow blast cleaning and no cleaned surface shall be left unprimed for more than four hours. Only primers that chemically inhibit corrosion shall be used. Where the iron or steelwork is not in contact with raw or treated water, the primer shall be red lead complying with IS: 57. Where there is a possibility that the steel or ironwork may come in contact with water, the priming treatment shall be non toxic, zinc chromate or equivalent. Where it is anticipated that further welding will be required, an approved welding primer shall be applied to the areas to be welded and reprimed with the main primer when welding shall been completed. Primer coats shall not be less than 0.05 mm each. After erection, all damaged areas shall be made good, and reprimed where the original cost shall spread under the primer, the affected surface shall be cleaned down to bare metal to the satisfaction of the Employer's Representative and then reprimed.

Repainting shall be carried out as soon as possible after erection. If it is to be exposed to weather or condensation, it shall receive one further coat of primer.

Metalwork in intermittent or permanent contact with raw or treated water shall have two finishing coats of an approved coal tar pitch epoxy paint such as "Epilux 5" by Berger Paints, or equivalent. The total coating shall be minimum of 0.125 mm thick.

After the second coat of primer is hard dry, the entire surface shall be wet rubbed cutting down to a smooth uniform surface. When the surface becomes dry, the undercoat of synthetic enamel paint conforming to IS: 2932 of optimum thickness shall be applied by brushing with minimum of brush marks. The coat shall be allowed to hard dry. The under coat shall then be wet rubbed cutting down to a smooth finish, taking adequate care to ensure that at no place the undercoat is completely removed. The surface shall then be allowed to dry.

The first coat of paint shall be applied by brushing and allowed to hard dry. The gloss from the entire surface shall then be gently removed and the surface dusted off. The second finishing coat shall then be applied by brushing.

At least 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 Employer's Representative.

d) Galvanised Steelwork

Newly galvanised steelwork shall be primed with an etch primer such as calcium plumbate. Steelwork that has been galvanised for a long period so that the surface has oxidized adequately to allow adhesion of undercoats, need not have an initial coat of each primer.

After priming, galvanised steelwork in contact or intermittent contact with raw or treated water shall be given two coats of an approved coat of tar pitch epoxy paint such as "Epoxy 5" by Berger Paints, or equivalent. The total coating shall have a minimum thickness of 0.125 mm.

Protective coats for galvanised steelwork not in contact with water shall be:

i) one coat of micaceous iron oxide paint for interior galvanised steelwork.

ii) two coats of micaceous iron oxide paint for external galvanised steelwork.

Galvanised steelwork not in contact with water shall be finished with atleast one coat of gloss paint on top of approved undercoat.

e) Bituminous Surfaces

Metalwork items that have given a shop treatment of bituminous paint shall be painted with two coats of an approved anti-bleed paint before applying a coat of decorative finishing paint.

f) Aluminum Surfaces

Aluminum surface shall be worked clean, dried and thoroughly degreased before painting, by an appropriate solvent (such as one consisting of equal parts of white spirit and light solvent naptha). Flame cleaning shall not be permitted. The clean degreased surface shall be treated to ensure paint adhesion either by mechanical roughening, chemical adhesion, or etch primers or wash primers applied in strict conformity with the manufacturer's instructions or by other treatment approved by the Employer's Representative.

The pre-treated surface shall receive a priming coat with an inhibiting pigment containing not less than 20% by weight of fine chromate or other approved chromate in a suitable water-resisting vehicle.

The priming coat shall not contain any copper or mercury compounds and it shall also be free from graphite and carbonaceous materials and shall not contain any lead. Priming coat shall consist of a tung-oil phenolic-resin which is pigmented with equal parts of zinc tetroxy chromate and red iron oxide.

Aluminium surfaces in contact with concrete, or resting on pads on concrete, shall be painted with two coats bituminous paint, and the concrete surfaces shall also receive two coats bituminous paint.

g) Woodwork

Woodwork for painting shall be carefully rubbed down, treated with preservatives and knotted, stopped and primed in the shop. Care shall be taken to ensure that priming is thoroughly brushed into every part of the surface and in particular at end grains, joints and notches where two coats are to be applied. Primers for wood shall be of a standard equivalent to, or better than "Aluminium Wood Primer Sealer A 519-3697" by I.C.I Paints.

After the woodwork has been fitted and all defects in the surfaces have been made good and reprimed, one coat of approved undercoat shall be applied to internal surfaces and two coats to external; surfaces. An undercoat of quality equal to or better than "Delux Gloss Finish A365-line".

4.98. WATERPROOF CEMENT PAINT

a) Surface Preparation

The wall should be washed thoroughly with clean soft water and freed of all loose particles, dust, dirt, lichen, moss, efflorescence and lime wash by scrubbing with a wire brush. Inequality and holes shall be filled up with cement paste which should be allowed to set. To get even uniform mat finish it is necessary to keep the surface damp throughout the operation. In hot dry weather the wall should be frequently sprinkles with water to keep it moist.

b) Mixing the Paint

Loosen the contents by either rolling the drum or shaking the container before opening it. Take one measure of water by volume in a clean pot and add two volumes of approved quality waterproof cement paint conforming to IS: 5410. Stir well to make paste of high consistency then add one more measure of water constantly stirring the mixture. The final composition of water and paint is now 1: 1 by volume. Keep stirring the mixture all the time and use it up within an hour. Do not use the mix if it is left over for more than two hours.

c) Method of Application

Wet the surface by any convenient method. A small surface can be wetted by brush. When applying paint surface should be damp and not wet. While applying the first coat brush hared into the surface to cover pores and cavities to ensure better bond. Twelve hours after applying the first coat cure the surface by sprinkling the water. Before applying the second coat damp the surface and after the application of second coat cure it as directed above. In hot climate repeat curing at least twice at the interval of six hours for optimum best results.

d) Curing

After each application paint should be cured by sprinkling fine spray of water, normally after twelve hours when paint film is hardened satisfactorily. In summer when weather is hot, curing may be done little earlier. Water marks may be left over the surface if a stream of water is allowed to flow before the Paint film is hardened.

4.99. SILICON PAINT

a) Preparation

A solution for application shall be prepared from Syltrit 1722 or equivalent. The manufacturer's instructions shall be followed. This solution shall be prepared to a concentration of about 3% solids by mixing 1kg of water dilutable solution of sodium methyl siliconate with 9 kgs of water. Concentration higher than 3% solids are not recommended ad they may cause a white precipitate of sodium carbonate formation.

b) Application

A flooding technique should be used in applying to obtain the best penetration. When spraying, the solution should not be atomized or misted, but flowed on in a solid stream, with the spray gun held at distance just enough to eliminate foaming on the masonry surface. If foaming is allowed then certain visible marks might appear after application. The run down of 150 to 300 mm should be maintained with generous overlapping of passes. Dipping and brushing methods are also suitable. After application of the solution, the treated surface should be allowed to dry at least 24 hours to develop maximum water repellency. This interval may be shortened somewhat by force drying at temperatures to 30°C. Though this removes the water quickly, time must still be allowed for the curing. Reaction between the solution and the surface being treated. Until the reaction is complete

the applied film still remains water soluble and any rain falling during this time can wash it out. So application should be done in dry weather or at least in absence of rain and fog.

c) Spraying Equipment

Spraying equipment shall be hand operated stir up pump with stainless steel nozzle fitted with PVC or polyethylene delivery pipe. Components of the spraying, equipment that are in contact with the treating solution should be of black iron, mild steel, stainless steel, Teflon, PVC or polyethylene. They should not be of aluminium or galvanised steel.

d) Safety

The solution should always be applied in a liquid stream, not by misting or fogging. If misting occurs, avoid inhalation. Contact with eyes or skin should be treated immediately by flooding the area with large quantities of water for atleast 15 minutes.

4.100. BREAKING OF CONCRETE, BRICKWORK, BLOCKWORK AND STONE MASONRY

The Contractor shall demolish brickwork, blockwork, stone masonry or concrete either plain or reinforced, as indicated on the drawings. The waste material shall be at once removed from the location and dumped at a suitable location or transported and disposed off as directed by the Employer's Representative. The Contractor shall observe all precaution by way of necessary propping, strutting etc., to the satisfaction of the Employer's Representative, to ensure that the adjacent framework is not damaged. Any damage to any adjacent framework, brickwork or blockwork resulting from the negligence of the Contractor shall be made good at the Contractor's cost, to the satisfaction of the Employer's Representative.

4.101. LOCKS

All the doors and gates shall be provided with locks of approved quality available locally and in accordance with IS : 2209 or IS : 275 as appropriate. The locks shall be provided with keys in duplicate.

4.102. PROTECTIVE COATING TO PIPE LINES

In case of MS pipeline to be laid underground, before lowering into the trenches, the external surfaces of all pipes, specials and fittings shall be provided with 40 mm thick cement mortar coating by guniting, A length of 150 mm at each of the pipe strake shall be left ungunited to facilitate site welding. This portion shall be lined after laying, welding and field testing of the pipeline is completed satisfactorily. If the Contractor desires so, guniting the pipe externally after lowering them in the trenches will be allowed if the Contractor evolves a suitable method and the same is approved by the Employer's Representative. But, no extra payment will be made for widening or, deepening the trenches for this purpose. Where the pipes/specials are to be gunited externally or encased in concrete, the external surface of the pipe shall be given a coat of cement wash. The pipe surface shall be blast cleaned to the Employer's Representative's satisfaction. Immediately after the coating of the surface with cement wash.

Mix Proportion

The proportion of cement and sand shall be 1 to 3.5 by volume.

Thickness of Coating

The minimum thickness of the coating shall be 40 mm with a maximum plus tolerance of 3 mm.

Reinforcement

Welded fabric used as reinforcement shall conform to IS: 1566 or equivalent MS reinforcement, as directed by the Employer's Representative. The welded fabric used shall be bent to proper shape to conform to the surface of the fitting/special/pipe to be coated and shall be securely held 20 mms away from the surface of the pipe/special/fitting by means of spacer blocks made from cement mortar (1:1) and binding wire. Spacers shall be placed atleast 30 cm centre both ways. Adjacent sheets of fabric shall lap at least 80 mm and shall be securely fastened together by binding wire at intervals not exceeding 300 mm,

Preparation for Surfaces

The surfaces shall be thoroughly cleaned by sand or steel grit blasting before coating.

i) Hand Cleaning

Before blasting, all oil and greases on the surface of the metal shall be removed thoroughly by flushing and wiping using suitable solvents and clean rags. The use of dirty or oily rags will not be permitted. All other foreign materials shall be removed by buffing or by scrapping and wire brushing. After cleaning, the special shall be protected and maintained free of all oil, grease and dirt that might fall upon the plate from whatever source until the plate has received its cement mortar coating.

ii) Mechanical Cleaning

All metal surface shall be thoroughly blasted to bright metal. Blasted surfaces which acquire a coat of rust by buffing or wire-brushing or at the discretion of the Employer's Representative, shall be reblasted. Adequate air separators shall be used to remove all oil and free moisture effectively from the air supply 1o the blaster. Any plate showing pits or structural defects shall be kept aside pending examination.

iii) Rest preventing Coating

Immediately upon completion of blasting, surfaces at the end of fittings which are to be left bare shall be given a brush coat of a suitable rust preventive material. Rust preventing coating shall be applied and shielded and maintained during the subsequent application and curing of mortar lining and application of the exterior coating to protect from corrosion. Rust preventive material used shall be of such character that the quality of the weld and other functions of the steel plate will not be impaired by its presence.

Application of Mortar Lining by Guniting.

The pressure in the lower chamber of cement shall be sufficient to produce a nozzle velocity of 115tol 50 m/ second when a tip with 19 mm opening is used. The compressor used shall be of an adequate capacity to maintain a pressure of atleast 2.8 kg/sq cm at the gun end. The nozzle shall be held at such a distance (65 to 100cm) and position that the stream of flooding materials shall impinge as nearly as possible at right angles to the surface being gunited. All deposits of loose sand shall be removed prior to placing and layer of gunite. Gunite shall be shot in one coat to the specified, thickness. Every precaution shall be taken to prevent the formation of sand pockets and if any develop, they shall be cut our and replaced with satisfactory machine placed material. No hand patching will be allowed. The Contractor shall apply the coating in such manner that no sloughing shall occur at any time during or following its application.

Gunite shall be placed in the top and sides of the pipe, then screeded to a uniform thickness and the ground lines or blocks removed. All rebound and waste materials shall then be removed by air blowing and gunite placed in the bottom of the fittings and screeded. When completed, the lining shall be concentric with the barrel of an even thickness. The entire surface shall then receive a final flash coat of gunite and shall be steel trowelled to a true surface equal in smoothness to the spun lining in such manner not to impair the bond between mortar and steel plate. The guniting and surface finishing shall complete in set and shall be applied continuously without the fuse of construction joints. In case, for any reason whatsoever, the cement does not adhere to the walls of pipes and sloughs off, swabbing the pipe with cement slurry shall not be permitted.

If for any reason it is necessary to interrupt the placing of the gunite for a length of time that will result in the material tasking a permanent set, a square shoulder shall be formed at the ends of the sections and/or elsewhere by shooting against backing up strip or by cutting back with a trowel or other suitable tools the irregular edges of the material last placed to a clean unbroken surface perpendicular to the face that will provide a suitable connection or construction joint between such material and then all material to be placed subsequently. When performing this work care shall be taken not to shatter or disturb the embedded wire mesh. Before placing fresh material against the surface of such joints, it shall be carefully cleaned and wetted to ensure a good bond between the fresh material and that previously placed. When gunite has hardened sufficiently, it shall be thoroughly wetted by sprinkling and maintained in a moist condition for fourteen days.

4.103. SUPPLY, FABRICATION & ERECTION OF STRUCTURAL STEEL

4.103.1. MATERIAL

Steel materials shall comply with the specifications laid down under the relevant Indian Standards and as called for in the specifications.

All steel material (plates and structural) covered in this Contract shall be supplied by the Contractor, in this connection the Contractor shall furnish to the Employer’s Representative duplicate copies of all mill orders covering the material ordered by him for this project and also the test reports received from the mills for the Employer’s Representative's check and information.

It is not the intention of the Corporation that all the steel materials to be supplied by the Contractor for the work shall be specially purchased from the rolling mills. The Contractor's stock material may be used, provided the mill test reported identified with the materials, satisfactorily demonstrate, the specified grade and quality. The Employer's Representative shall have the right to test samples to prove authenticity of the test certificates produced by the Contract or at the Contractor's cost. All steel materials shall be in sound, condition, of recent manufacture, free from defects, loose mill scale, slag intrusions, laminations, pitting, flaky rust etc., and be of full weight or thickness specified. The length/ sizes of steel sections and plates shall be as supplied by the steel mills.

Unidentified stock material may be used, only with the prior permission from the Employer's Representative in writing, for short sections for minor importance or for small unimportant works and connections where, in the opinion of the Employer's Representative, the quality of such materials would not adversely affect the strength and/or durability of the structure. The Employer's Representativemay also permit use of such material for other works, if adequate random samples taken out and tested demonstrate conformity with the specification and requirement for the work in view.

4.104. SUB-STITUTIONS

Where the Contractor, in order to accommodate his materials in stock, desires to substitute structural steels or plates for the sizes shown on approved drawings, such substitutions shall be made only after authorization in writing by the Employer's Representative. The Employer's Representative may also direct that substitution be made, when considers such substitutions to be necessary.

4.105. FABRICATION

a) General

All workmanship and finish shall be of the best quality and shall conform to the best approved method of fabrication. All materials shall be finished straight and shall be machined true and square where so specified. All holes and edges shall be free of burns. Shearing and chipping shall be neatly and accurately done and all portions of work exposed to view shall be neatly finished. Unless otherwise directed/approved, reference may be made to the American Institute of Steel Construction Manuals for providing standard fabrication tolerance. Material at the shops shall be kept clean and protected from weather.

b) Connections

Shop connections shall be effected either by welding, riveting or bolting as specified or as indicated on approved drawings. Type and quality of bolts shall be in accordance with IS stipulations. However, standards MS bolts to IS: 1363 may be used for field connections for light members such as purloins, staircase stringers, hand railings, and landing beams.

Where necessary, tapered washers or flat washers or spring washers shall be used under with nuts or the heads depending upon whether the nuts or the heads are turned to tighten the bolts. The length of the bolt shall be such that atleast one thread of the bolt projects beyond the nut, except in case of high strength friction grip bolts where this projection shall be atleast three limes the thread pitch. In all cases where bearing is critical, the unthreaded bolt shall bear on the members assembled. A washer of adequate thickness shall be provided to exclude the threads from the bearing thickness, if a longer grip bolt has to be used for this purpose. All bolts, nuts, washers, rivets, electrodes, screw, etc., shall be supplied/brought to site 10 % in excess of the requirement in each category and size. All members likely to collect rainwater shall have drain holes provided. Not more than one shop splice shall be provided to make up the full length of a member.

c) Straightening

Rolled material, before being worked, shall be straightened, unless otherwise specified. If straightening or flattening is necessary, it shall be done by methods that will not injure the material. Long plates shall be straightened by passing through a mangle or leaving rolls and structural shapes by the use of mechanical or hydraulic bar/ section straightening machines. Heating or forging shall not be resorted to without the prior approval or directions of the Employer's Representative in writing.

d) Cutting

Cutting may be shearing, cropping, sawing or machine flame cutting if permitted by the Employer's Representative. All re-entrant comers shall be shaped notch-free to a radius of atleast 12mm. Sheared or cropped edges shall be dressed to a beat workmanlike finish and shall be free from distortion and burrs. The kerf on machine flame cut edges shall be removed. Where machine flame cutting is permitted for high tensile steel, special care shall be taken to leave sufficient margin and all flame hardened material shall be removed by machining/ edge planning. Hand flame cutting shall be undertaken only if so permitted by the Employer's Representative and shall only be carried out by and expert in such work. Hand flame cut edges shall be ground smooth and straight.

e) Rolling and Forming

Plates, channels, RSJ etc. for circular bins, bunkers, hoppers, gantry girders, etc., shall be accurately laid off and rolled or formed to required profile/shape. Adjacent sections shall be match-marked to facilitate accurate assembly, welding and erection on site.

f) Punching and Drilling

Holes in secondary members such as purlins, girts, lacing bars, etc may be punched nail size through materials not over 12 mm thick. Holes must be clean cut, without burr or ragged edges. Holes for all other connections shall be drilled accurately and the burrs removed effectively. Where several parts are to be connected to very close tolerances, such parts shall be first assembled, then tightly clamped together and drilled through. Sub-punching may be permitted before assembly, provided the holes are Punched 3 mm smaller in diameter than the required size and reamed after assembly to the full diameter. The thickness of material punched shall not, even in such case, exceed 16 mm. When batch-drilling is carried out in one operation through two or more separable parts, these parts shall be separated after drilling and the burrs removed. Holes for turned and fitted

bolts shall be drilled to a slightly smaller diameter and reamed to a diameter equal to the nominal diameter of the shank or barrel subject to H 8 tolerances specified in IS: 919. Where reamed members are taken apart for shipping or handling, the respective pieces reamed together shall be so marked that they may be reassembled in the same position in the final setting up. No inter-change of reamed parts will be permitted, Poor matching, over-drilling, and ovality in holes shall be a cause for rejection. Burning holes with gas is strictly prohibited.

(g) High Strength Friction Grip Bolting

High strength friction grip bolts and nuts shall conform to IS: 3757. Installation of high strength friction grip bolts in joints shall comply with IS: 4000. The diameter of the bolt hoes must not be more than 1.5mm larger than the nominal diameter of the bolt. All contact surfaces in a connection including those associated with the not heads, nut in a washers, shall be free of scale, burrs, dirt and other foreign matter tending to inhibit uniform sealing of the joint components/ nuts and washers need not be removed. All fasteners in a joint shall be tightened to a tension equal to or greater than the specified proof load show in the following table, either by the calibrated method or the turn-of-nut method.

Bolt Size	Proof Load (Kg)	
	Bolts to I.S. 37S7-BG	Bolts to I.S. 3757-10K
M16	9120	10790
M20	14700	17150
M22	18180	21210
M25	21180	23710
M27	27450	32130
M33	41640	48580

Tightening may be achieved by use of pneumatic powered impact wrenches, long-handled manual torque wrenches with or without torque multipliers or electric wrenches. A hardened washer shall be placed under the element being turned. Bolts shall be tightened at the most rigid portion of the joint, proceeding towards the free edges.

When using the calibrated wrench method, adjustable power impact wrenches and manual torque wrenches shall be calibrated to induce bolt tensions of 5 percent in excess of the proof load values for each size of bolt to be used in installation. Every wrench shall be calibrated by having it tighten a minimum of three bolts of the same diameter, in a hydraulic tension measuring device. Calibration shall be repeated whenever a wrench is required to tighten a different size bolt, or atleast once each working day if there is no change in the bolt size. Impact wrenches shall be set so as to shall or cut at the torque effort corresponding to the prescribed fastener tension. When manual torque wrenches are used, the torque indication corresponding to the calibrating tension shall be determined and taken as the job standard. Torque measurements shall be read while the turned element is in tightening motion. As subsequent tightening of bolts in any particular assembly is liable to loosen bolts already tightened, all bolts must be "Touched up".

When using the turn of nut method a sufficient number of bolts must initially be 'snugged up' to bring the connection components into full contact, by either a standard power impact wrench or an ordinary spud wrench. Snug tight condition shall indicate the point at which the turned element ceases to rotate freely and the impact wrench begins to impact or if a common spud wrench is employed, snug tightness shall mean the position resulting from the full effort of a man. Subsequently, the remaining bolts in the joints shall also be brought to snug tightness. All nuts and projecting bolt points shall be matchmarked in this starting position and all bolts in the joints relevant specifications for the bolt length and type of connection proceeding in an orderly fashion from the most rigid portion of the joint, towards the free edges.

If the finger-tight condition is used as a starting point extra full turns shall be taken to correspond to one-half turn from the snug tight position.

Load indicating bolts or load indicating washers may be used if so approved by the Employer's Representative in writing.

Inspection after tightening of bolts shall be carried out as stipulated in the appropriate standards depending upon the method of tightening and the type of bolt used.

(h) Welding

Electrodes for shielded-arc manual welds shall comply with the requirement of IS: 814, and shall be approved make.

The electrodes for manual arc welding shall be suitable for use in the position and type of work, as laid down in the above specifications and as recommended by the manufacturers. Electrodes classification group 1 or 2 as given in IS: 814 shall be used for welding steel conforming to IS: 2062 and electrodes shall conform to IS: 1442 for steel conforming to IS: 8500. Joints in materials above 20 mm thick and all-important connections shall be made with low hydrogen electrodes.

The wire and flux combination for submerged arc welding shall conform to the requirements for the desired application as laid down in IS: 3613. The weld metal deposited by the submerged arc process shall have mechanical properties not less than that specified by the relevant standard.

Electrodes flux covering shall be sound and unbroken. Broken or damaged coating shall cause the electrodes to be discarded. Covered electrodes for manual-arc welding shall be properly stored in an oven prior to use in a manner recommended by the manufacturer and only an hour's quota shall be issued to each welder from the oven.

Electrodes larger than 5 mm diameter shall not be used for root-runs in butt welds.

Welding plant and accessories shall have capacity adequate for the welding procedure laid down and shall satisfy appropriate standards and be of approved make and quality. The Contractor shall maintain all welding plant in good working order. All the electrical plant in connection with the welding operation shall be properly and adequately earthed and adequately earthed and adequate means of measuring the current shall be provided.

All welds shall be made only by welders and welding operators who have been properly trained and previously qualified by tests to perform the type of work required as prescribed in the relevant applicable standards.

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

Fusion faces and surfaces adjacent to the joint or a distance of atleast 50 mm on either side shall be absolutely free from grease, paint, loose scales, moisture or any other substance which might interfere with welding or adversely affect the quality of the weld. Joint surfaces shall be smooth, uniform and free from fins, tears, laminations, etc. Preparation of fusion faces shall be done in accordance with the approved fabrication drawings by shearing, chipping, machining or machine flame cutting except that shearing shall not be used for thickness over 8 mm.

In the fabrication of cover-plated beams and built up members all shop splices in each component part shall be made before such component part is welded to other parts of the member. Wherever weld reinforcement interferes with proper fit-up between components to be assembled for welding, these welds shall be ground flush prior to assembly.

Members to be joined by fillet welding shall be brought and held as close together as possible and in no event shall be separated by more than 3 mm. If the separation is 1.5 mm or greater the fillet weld size shall be increased by the amount of separation. This shall only apply in the case of continuous welds. The fit-up of joints at contact surfaces which are not completely sealed by welds shall be close enough to exclude water after painting.

The separation between the two surfaces of lap joints and butt joints with backing plate shall not exceed 1.5 mm. Abutting parts to be butt welded shall be carefully aligned and the correct root gap maintained throughout the welding operation. Misalignments greater than 25 % of the thickness of the thinner plate or 3mm,whichever is smaller, shall be corrected and in making the correction the parts shall not be drawn into a slope sharper than 2° (1 in 27.5).

Pre-qualified welding procedures recommended by appropriate welding standards and know to provide satisfactory welds shall be followed .A welding procedure shall be prepared by the Contractor and submitted to the Employer's Representative for approval before start of welding. This shall include all details of welding procedures with reference to provisions of IS: 9595 and IS: 4353.

Approval of the welding procedure by the Employer's Representative shall not relieve the Contractor of his responsibility for correct and sound welding without undue distortion in the finished structure.

Submerged arc, automatic or semi-automatic welding shall generally be employed. Only where it is not practicable to use submerged arc welding, manual arc welding may be resorted to.

Voltage and current (polarity of direct current is used) shall be set accordingly to the recommendations of the manufacturer of the electrode being used and suitability of thickness of material, joint form etc.

The work shall be positioned for flat welding wherever practicable and overhead weld shall be avoided.

No welding shall be done when the surface of the member is wet, not during periods of high wind unless the welding operator and the work are properly protected.

In joints connected by fillet welds, the minimum sizes of single fillet welds or first runs and minimum full sizes of fillet welds shall conform to the requirements of IS: 816 and IS: 9595.

All complete penetration butt welds made by manual arc welding, except when produced with the aid of backing material or welded in flat position, from both sides in square-edge material not over 8mm thick with root opening not less than one-half the thickness of the thinner part joined, shall have the root of the initial layer gouged out on the back side before welding is a started from that side, and shall be so welded as to secure sound metal and complete fusion throughout the entire cross section.

Butt welds shall be terminated at the ends of a joint in a manner that will ensure their soundness. Where abutting parts are 20 mm or more than in thickness, run-on and run-off plates with similar edge preparation and having a width not less than the thickness of the thicker part jointed shall be used. These extension pieces shall be removed upon completion of the weld end, the ends of the weld made smooth and flush with the abutting parts. Where the abutting parts are thinner than 20 mm, the extension pieces may be omitted but the ends of the butt welds shall then be chipped or gouged out to sound, metal and side welded to fill up the ends to the required reinforcement.

Each layer of a multiple layer weld except root and surface runs may be moderately peened with light blows from a blunt tool. Care shall be exercised to prevent scaling or flaking of weld and base metal from over peening.

No welding shall be done on base metal at a temperature below 5°C. Base metal shall be preheated to the temperature given in the table below prior to tack welding or welding. When base metal not otherwise required to be preheated, is at a temperature below 0°C, it shall be preheated to at least 20°C prior to tack welding or welding. Preheating shall bring the surface of the base metal within 75 mm of the point of welding to the specified preheat temperature, and this temperature shall be maintained as minimum inter pass temperature while welding is in progress.

Table 4.21

Thickness of the thickest part at point of welding	Minimum preheat & inter pass temperature			
	Other than low-hydrogen welding electrodes		Low hydrogen welding electrodes	
	IS: 2062 Steel	IS: 8500 Steel	IS: 2062 Steel	IS: 8500 Steel
Upto 20 mm incl.	None	Welding	None	10°C
Over 20 mm to 40 mm incl.	65°C	With this process not allowed	10°C	65°C
Over 40 mm to 63mm incl.	110°C		95°C	110°c
Over 63 mm	150°C		110°C	150°C

Electrodes other than low-hydrogen electrodes shall not be permitted for thickness of 75 mm and above.

Before commencing fabrication of a member or structure in which welding is likely to result in distortion and/or locked up stresses, a complete programmed of fabrication, assembly and welding shall be made and submitted to the Employer's Representative for approval. Such a programme shall include, besides other appropriate details, full particulars in regard to the following:

i) proposed pre-bending in components such as flanges and presetting of joints to offset expected distortion.

ii) Make up of sub-assemblies proposed to be welded before incorporation in final assembly.

iii) Proposed joint forms, classification of wore and flux or covered electrodes, welding process including fitting and welding sequence with directions in which freedom of movement is to be allowed.

iv) Proposed number, spacing and type of strong backs, details of jigs and fixtures for maintaining proper fit up and alignment during welding.

v) Any other special features like assembling similar members back to back or stress relief.

So desired by the Employer's Representative, mock up welding shall be carried out at the Contractor's cost to establish the efficiency of the proposed programme, with any modification suggested by the Employer's Representative, in limiting distortion and/ or residual stress to acceptable levels. Such modification will not relieve the Contractor of any of his responsibilities,

i) Inspection of Welds

All welds shall be inspected for flaws as described elsewhere under "Inspection".

In case the tests uncover defective work, the Contractor shall correct such defects at his own cost, and prove the soundness of rectified work.

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

j) Tolerance

The dimensional and weight tolerance for rolled shapes shall be in accordance with IS: 1852 for indigenous steel and equivalent applicable codes for imported steel. The acceptable limits for straightness (sweep and camber) for rolled or fabricated members are:

Struts and columns	-	L/1000 or 10 mm whichever is smaller
For all other members not Primarily in compression such Such as purlins, girts, bracing and the web members of trusses latticed girders	-	L/500 or 15 mm whichever is smaller

Where L is the length of finished member or such less length as the Engineer may specify.

A limit for twist prior to erection		
In box girders & heavy columns	-	L/1500
Other members	-	L/1000

The twist of the member between any two sections shall be measured with the web vertical at one of the sections.

Tolerance in specified camber of structural members shall be ±3 mm.

Tolerance is specified length shall be as follows :

Type of member	Tolerance
A column finished for contact bearing	±1 mm
Other members (e.g. beams) under 10m	+ 0 & -3 nun
Other members (e.g. beams) under 10 m long and over	+ 0 & -5 mm

End of members

Beams to beam and beam to column connections - Where the abutting parts are to be joined by butt welds, permissible deviation from the squareness of the end is :

Beams upto 600 mm in depth -	1.5 mm
Beams over 600 mm in depth -	1.5mm every 600mm depth, to a max. of 3 mm

Where abutting parts are to be joined by bolting through cleats or end plates, the connections require closer tolerance, permissible deviation from the squareness of the end is :

Beams upto 600 mm in depth -	1.0 mm
Beams over 600 mm in depth -	1.0mm every 600 mm depth, to a max. of 2.0 mm

Butt Joints

For full bearing, two abutting ends of columns shall first be aligned to within 1 in 1000 of their combined length and then the following conditions shall be met:

i) Over at least 80 % of the bearing surface the clearance between the surfaces does no exceed 0.l mm

ii) Over the remainder of the surfaces the clearance between the surfaces does not exceed 0.3 mm

Where web stiffeners are designed for full bearing on either the top flange or bottom flange or both, at least half the stiffener shall be in positive contact with the flange. The remainder of the contact face could have a maximum gap of 0.25 mm.

Depth of Members

Acceptable deviation from the specified overall depth :

For depth of 900 mm and under	±3 mm
For depth of over 900 mm and Under 1800 mm	±5 mm
For depth of over 1800 mm and over-	+8 mm -5mm

Web Plates

An acceptable deviation from flatness in girder webs in the length between the stiffeners or in a length equal to the girder depth shall be 1 /150th of the total web depth.

Flange Plates

A reasonable limit for combined warpage and tilt on the flange of a built up member is l/200lh of the total width of flange or 3 mm whichever is smaller measured with respect to centerline of flange.

Lateral deviation between centerline of web plate and centerline of flange plate at contact surface, in the case of built up sections shall not exceed 3 mm.

End Milling

Column bearing on each other of resting on base plates and compression joints designed for bearing shall be milled true and square to ensure proper bearing and alignment. Base plates shall also have their surfaces milled true and square.

4.106. INSPECTION

The Contractor shall give due notice to the Employer's Representative in advance on the materials or workmanship getting ready for inspection. All rejected material shall be promptly removed from the shop and replaced with new material for the Employer's Representative's approval/inspection. The fact that certain material has been accepted at the Contractor's shop shall not invalidate final rejection at site by the Employer's Representative if it fails to be in proper condition or has fabrication inaccuracies which prevents proper assembly. No material shall be painted or dispatched to site without inspection and approval by the Employer's Representativeunless such inspection is waived in writing by the Employer's Representative.

Shop inspection by the Employer's Representativeor his authorized representative or submission of test certificate and acceptance thereof by the Employer's Representative shall not relieve the Contractor from the responsibility of furnishing material conforming to the requirements of these specifications, nor shall it invalidate any claim which the

Employer may make because of defective or unsatisfactory material and / or workmanship.

The Contractor shall provide all the testing and inspection services and facilities for shop work except where otherwise specified. The Contractor's inspection work shall be under the control of a competent Chief Inspector whose primary responsibility is inspection, reporting to management and not to production departments.

For fabrication work carried out on site, the same standard of supervision and quality control shall be maintained as in shop fabricated work. Inspection and testing shall be conducted in a manner satisfactory to the Employer's Representative.

Inspection and tests on structural steel members shall be as set forth below:

a) Material Testing

If mill testing reports are not available for any steel materials the same shall be got tested by the Contractor to the Employer's Representative's satisfaction to demonstrate conformity with the relevant specification.

b) Test on Welds

Magnetic Particle Test

Where the root and intermediate passes of a weld are examined by magnetic particle testing, such testing shall be carried out throughout its entire length in accordance with IS: 5334 or ASTM specification E-I09. In the case of completed welds, such tests shall be carried out in accordance with IS: 5334 or ASTM specification E-109 or E-138 as decided by the Employer's Representative. If heat treatment is performed, the completed weld shall be examined after the heat treatment. All defects shall be repaired and retested. Magnetic particle tests shall be carried out using alternating current. Direct current may be used with permission of the Employer's Representative.

Liquid Penetrant Inspection

In the case of welds examined by Liquid Penetrant Inspection, such tests shall be carried out in accordance with ASTM E-165 or I.S. 3658. AI defects shown shall be repaired and rechecked.

c) Radiograph Inspection

All full strength butt welds shall be radiographed in accordance with the recommended practice for radiographic testing as per IS:2595.

d) Dimensions, Workmanship & Cleanliness

Members shall be inspected at all stage of fabrication and assembly to verify that dimensions, tolerances, alignment, surface finish and painting are in accordance with the requirements indicated in the specification and approved drawings.

e) Inspection or Test Failure

In the event of any failure of members to meet an inspection or test requirement, the Contractor shall notify the Employer's Representative or his authorized representative.

The Contractor must obtained permission from the Employer's Representative before repair is undertaken. The quality control procedures to be followed to ensure satisfactory repair shall be subject to approval by the Employer's Representative.

The Employer's Representativehas the right to specify additional inspection or testing as he deems necessary, and the additional cost of such testing will be borne by the Contractor.

The Contractor shall maintain record of all inspection and testing which shall be made available to the Employer's Representative or his authorized representative.

4.107. STAIRWAYS & INTERMEDIATE LANDINGS & GRATINGS

All stairways and intermediate landings shown and/ or listed on the drawings or specifications shall be fabricated as per specifications drawings as a complete unit and shall include grating treads, landings, hangers, brackets, struts, clips, bracings, etc. as necessary for erection. The gratings shall be capable of sustaining a minimum safe live load of 750 kg/sq metre of plan are unless otherwise specified or required and shall have a minimum thickness of 25 mm. Treads and landings shall be suitable for the prescribed ;loadings and be furnished complete with one piece standard non-slip abrasive nosing of approved type. The maximum width of openings in gratings shall not exceed 100 mm and the maximum spacing of bearing bars shall not exceed 40 mm. The minimum thickness of main bare shall be 5mm. Gratings shall be hot dip galvanised and painted. The grating pattern shall be approved by the Employer's Representative.

4.108. CHEQUERED PLATE

GRP Chequered plates used shall be minimum 6 mm thick and shall be capable of carrying a minimum live load of 750 kg/sq metre unless otherwise required. Chequered plate shall be fixed by 8 mm diameter non crossive steel screws with counter sunk heads at a maximum spacing of 400 mm. Members supporting the chequered plate shall have matching holes tapped in them. The chequered plate pattern shall be approved by the Employer's Representtaive.

4.109. DISSIMILAR METALS

The Contractor shall not use fixtures and fittings for metal work including pipe work, in which dissimilar metals are liable to lead to galvanic action when placed in permanent contact with each other. Mild steel surfaces in contact with aluminum alloy shall be galvanised or otherwise protected. Where faces of aluminum join, only aluminum bolts, nuts washers and screws shall be used. Aluminum shall be fixed to structures using galvanised mild steel bolts, nuts and screws, tufnol sleeves and washers.

4.110. GALVANISED STEELWORK

Galvanising shall be carried out in accordance with IS: 6159 and IS: 2629. All rough edges and burrs shall be neatly filed off, all holes required are to be drilled, and all fabrication shall be completed before the work is galvanised. No galvanised metal shall be painted until the Employer's Representative has inspected the coating.

4.111. ACCESS LADDERS

Access ladders shall be made of mild steel and galvanised as specified. Rungs shall be 20mm diameter.

Ladders shall be fixed at the top and the bottom and at intervals not exceeding 2.5m and the rungs shall not be less than 200 mm from the wall, secured by galvanised ragbolts of an approved type.

Ladders may also be fixed at the bottom by bending the stringers and bolting to the floor.

4.112. PROVIDING. HOISTING AND FIXING IN POSITION WATER STORAGE TANK

This item pertains to the provision and installation of the HOPE UV stabilised water storage tank including all necessary fittings.

The HDPE tank shall conform to IS: 12701. Galvanised iron pipes, ball cocks, stop taps, provided by the Contractor shall be approved by the Employer's Representative.

Unless other sizes are shown in the drawing galvanised iron pipes shall be (i) 25mm size for overflow, (ii) 38 mm size for scour, (iii) 50mm size for inter connection. These pipes shall conform to IS: 1239. Overflow pipe shall be provided with a brass mosquito proof coupling and galvanised iron plug for scour pipe.

4.113. MAKING OF MEMBERS

After checking and inspection, all members shall be marked for identification during erection. This mark shall correspond to distinguishing marks on approved erection drawings and shall be legibly painted and stamped on it. The erection mark shall be stamped with a metal dye with figures at least 20mm high and such optimum depth as to be clearly visible, even after a member is galvanised.

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

Erection marks on like pieces shall be on identical location. Members having length of 7m or more shall have the erection mark at both ends. In addition, colour code marking shall be clearly painted on the member in the manner specified.

4.114. ERRORS

Any error in shop work which prevents proper assembling and fitting up of parts in the field by moderate use of drift pins or moderate amount of reaming will be classified by the Employer's Representative as defective workmanship. All charges incurred by the Corporation either directly or indirectly because of the poor workmanship will be deducted from the amount due to the Contractor before payment is made. In case the Employer's Representative choose to reject the material because of poor workmanship, the cost of all handling and returning the material of the Contractor, if he so desires shall entirely be borne by the Contractor. All the replacement materials shall be supplied free and in all such cases, the cost of handling, transporting and delivery to site also be borne by the Contractor.

4.115. PAINTING

Fabricated Steel material, where specified, shall be receive protective paint coating. All paint shall be of approved make and shade. The painting work shall be carried out as specified in Section 'G' - Building works to the complete satisfaction of the Employer's Representative.

4.116. HANDLING AND STORAGE

No dragging of steel shall be permitted. All steel shall be stored 300mm above ground on suitable packing to avoid damage. It shall be stored in the order required for erection, with erection marks visible. All storage areas shall be prepared and maintained by the Contractor. Steel shall not be stored in the vicinity of areas where excavation or grading will be done and, if so stored temporarily, this shall be removed by the Contractor well before such excavation and/ or grading commence to a safe distance 1o avoid burial under debris.

Scratched or abraded steel shall be given a cost of primer for protection after unloading and handling prior to erection. All milled and machined surfaces shall be properly protected from rust/ corrosion and also from getting damaged by suitable coating.

4.117. ANCHOR BOLTS AND FOUNDATIONS

The Contractor shall carefully check the location and layout of anchor bolts embedded in foundations constructed to ensure that the structures can be properly erected as specified.

Any discrepancy in the anchor bolts/ foundations shall be reported to the Employer's Representative.

Anchor bolts shall be provided with three nuts on upper threaded portion, one of which shall be used for leveling the column base to the required elevation and one will be a lock nut. All shim stock, required for keeping the specified thickness of grout and in connection with erection of structures on foundations, crane brackets or at any other locations shall be of good mild steel plates and shall be supplied by the Contractor at his cost.

All cleaning and preparing the foundation area shall be carried out by the Contractor at no extra cost.

Where beams bear in pockets or on walls, bearing plates shall be set and leveled as part of the work. All grouting under column base plates or beam bearing plates shall also be carried out by the Contractor.

4.118. ASSEMBLY & CONNECTIONS

Field connections may be effected either by riveting, bolting, welding or by use of high strength friction grip bolts as specified or required.

All welding shall be in accordance with IS: 816 and IS: 9595. All assembling shall be carried on a level platform.

Drifts shall be used only for drawing the work to proper position and must not be used top such an extent as to damage the holes. Size of drifts, larger than the nominal diameter of hole shall not be used. Any damaged holes or burrs must be rectified to the satisfaction of the Employer's Representative.

Corrections of minor misfits and reasonable amount of reaming and cutting or excess stock from rivet shall be considered as a part of erection. Any error in shop which prevents proper fit on a moderate amount of reaming and slight chipping or cutting shall be immediately reported to the Employer's Representative.

4.119. ERECTION

All structural steel shall be erected as shown on the specification drawings and as per an erection scheme approved by the Employer's Representative. Proper size steel cable slings etc., shall be used for hoisting. Guys shall not be anchored to existing structures, foundations etc., unless so permitted by the Employer's Representative in writing. The Contractor shall furnish the necessary non-inflammable staging and hoisting materials or equipments required for the erection work sand shall remove and take them away after completion of the job.

Structural steel frames shall be erected plumb and true. All steel column and beams shall be checked for plumb and level individually before and after connections are made. Temporary bracings shall be introduced wherever necessary to tame care of all loads to

which the structure may be subjected. Such bracings shall be left in place as long as may be required for safety and stability.

As erection progresses, the work shall be securely bolt to take care of all dead load, wind, seismic and erection stresses.

No riveting or welding or final bolting shall be done until the structure has been properly aligned and approved by the Employer's Representative. No cutting, hating or enlarging of the holes shall be carried out without the prior approval of the Employer's Representative.

After steel has been erected, all bare and abraded spots, rivet heads, field welds, bolt heads and nuts shall be spot painted with primer specified. Before paint is applied the surface shall be dry and free from dust, dirt, scale and grease. All surfaces in accessible after erection shall receive two coats of the approved paint before erection.

The Employer's Representative shall have free access to all parts of the job during erection and all erection shall be subject to his approval. In case of faulty erection all such dismantling and re-erection required will be at the Contractor's cost. No paint shall be applied to rivet heads of field welds or bolts until these have been approved by the Employer's Representative.

4.120. TOLERANCES

Tolerances mentioned below shall be achieved after the entire structure or part thereof is in line, level and plumb.

Beams

Deviation in difference of bearing levels of beams from the true difference	Depth <1800 mm i 6 mm Depth > 1800 mm i 10 mm
Deviation in sweep of beams in the horizontal plane	1/1000 of span in mm subject to a maximum of 10 mm

Crain girders and rails

Shift in the centre line of crane rail with respect to centre line of web of crane girder	± 5 mm
Shift in plan of alignment of crane rail with respect to true axis of crane rail at any point	± 5 mm
Differences in alignment of crane rail in plan measured between any two points 2 meters apart along rail	± 1 mm

Deviation in crane track with respect to true gauge

a)	For track gauges upto and including 15 metres	± 5 mm
b)	For track gauges more than 15 metres Where S in meters is true gauge	±5[5+0.25(5– 15)]
	Deviation in the crane rail level at any point from true level	1/1200 of the gauge distance or+10 mm whichever is less
	Difference in the crane rail actual levels between any two points 2 metres apart along the rail length	± 2 mm

Columns

Deviation of column axes at foundation top level with respect to true axes

a)	In longitudinal direction	± 5 mm
b)	In lateral direction	± 5 mm

Deviation in the level of bearing surface of columns at foundation top with respect to true level ± 5 mm

Out of plumbness (verticality) of column from true vertical axis, as measured at column top

a)	For columns upto and including 15 m in height	± 1/1000 of column height in mm or ± 15 mm whichever is less
b)	For columns exceeding 15 m in height	± 1/1000 of column height in mm or ± 20 mm whichever is less

Deviation in straightness in longitudinal and transverse planes of column at any point along the height	+ 1/1000 of column height in mm or- 10mm whichever is less
Difference in erected position of adjacent pairs of columns along length or across width of building, prior to connecting trusses /beams with respect to true /distance	± 10 mm
Deviation in any bearing or seating level with respect to true level	± 5 mm
Deviation in differences bearing levels of a member on adjacent pair of columns both across and along the building	± 10 mm

Difference in levels between crane track rails at		
a)	Supports of crane girders	+ 15 mm
b)	Mid span of crane girders	+ 20 mm
Relative shift of crane fail surfaces at a joint in plan and elevation		2mm subject to grinding of surfaces for smooth transition
Relative shift in the location of crane stops (end buffers) along the crane tracks with track gauge S in mm		1/100 of track gauge S in mm subject to maximum of 20mm

TECHNICAL SPECIFICATIONS FOR CIVIL, MS PIPELINE, HYDRO-MECHANICAL AND ELECTRO-MECHANICAL WORKS

I N D E X

PART – A

CIVIL WORKS

1.0 INTRODUCTION AND SCOPE OF WORK

1.1 INTENT OF TECHNICAL SPECIFICATIONS

1.1.1 The General Technical Specification (hereinafter called GTS) broadly cover the information about site conditions, transport requirements, excavation, execution of works like masonry, concrete, steel, etc., construction materials and general requirements. The GTS also covers the broad specifications and regulations for all major civil works included in the contract documents as well as the conditions for measurements and payments.

1.1.2 The items of works are based on Employer's preliminary designs as indicated in Bid Document. These specifications shall be part of the requirements for various items related to the work, which are to be provided according to the stipulations of the contract. The items of works may be modified /altered to meet the requirements of Bidder's Design and Engineering of the permanent civil works. Accordingly, the technical specifications may require additions/alterations to conform to Bidder's Design and Engineering mutually agreed to with the Employer. However, the technical specifications shall be in general as per Bureau of Indian Standards or corresponding International Standards as mutually agreed by the Employer and the Contractor during preparation of detail design and drawings and approval thereof.

1.1.3 These specifications shall be read in conjunction with the Conditions of Contract, the drawings and the preliminary Schedule of Works. While quoting the price the Contractor shall comply with all provisions contained within the bidding documents and instructions of the Engineer-in-Charge.

1.1.4 All works shall be executed according to the drawings approved by the Engineer-in-Charge for construction, in a professional and diligent manner and all supplies and works shall comply with the quality requirements defined in the relevant sections of these specifications and other bidding documents. The Contractor shall endeavour to provide all such necessary efforts in order to comply with the intent of these specifications to the satisfaction of the Engineer-in-Charge.

1.1.5 Addenda to these specifications may be issued, as required, during bidding that will form part of these specifications.

1.2 SCOPE OF WORK

The scope of work includes Design, Engineering, Construction, Erection, Supply, Installation, Testing and Commissioning of Storm Water Drainage Pumping Stations at Patna, Bihar.

The scope of work includes Construction Civil Works, Electro-Mechanical Works, Hydro-Mechanical works pertaining to the Pumping Stations and Final Disposal Pipeline.

1.2.1 **Pumping Station:**

It is proposed to excavate the Pumping Station with a required bottom size to a required suitable bottom level as per design. The proposal consists of Inlet Chanel, Trashracks, Gates and Sump cum Pumping Station. EOT crane along with necessary support system of suitable capacity is to be erected.

1.2.2 **Pressure Mains:**

It is proposed to take up suitable diameter of MS pressure mains for lifting the suitable discharge from the sump cum pumping station to outfall for a suitable length as per design.

1.2.3 The successful bidder has to submit the detailed designs to the employer for approval before executing the works.

1.3 **EXECUTION OF WORKS:**

The successful bidder, after approval of the design and drawings by the employer has to execute the works as per the specifications given in the subsequent sections of this volume.

1.4. **MEASUREMENT & PAYMENT:**

The quantum of work of different items will be measured periodically by the concerned Engineer-in – Charge or the contractor has to bill the quantities of work done periodically and produce to the Engineer-in – Charge to Asses the quantum of the work done. The payment will be made proportionate to the value of work done as per the conditions stipulated in this document.

2.0 TRANSPORTATION

2.1 The Contractor should make his own assessment about the accessibility to work site, quarry areas or otherwise and also the mode and means of transportation as would be required for execution of requisite works.

2.2 The Contractor shall be responsible to select proper routes to meet his needs and shall bear all costs of transportation including loading and unloading as deemed fit by the Contractor.

2.3 The costs, if any, for adjusting, modifying roads and bridges shall be borne by the Contractor. The Contractor shall submit for approval of the Engineer the method of transportation and routes he proposes to use.

2.4 In case any approval from the concerned authorities are required for transportation of materials through road/railway, the Contractor shall make necessary arrangements for obtaining the same, well in advance to avoid any interruption in works for want of materials, etc.

3.0 WORKING FACILITIES

3.1 GENERAL

3.1.1 Scope

The Contractor shall design, provide, erect, operate and maintain the working facilities required for the execution of the Permanent Works, within the specified time schedule, such as but not necessarily limited to:

- Camp and Facilities
- Plant and Equipment
- Electric Power Supply System
- Telephone and Communication Network
- Water Supply System
- Sewage and Waste Water System
- Fire Fighting Equipment
- Temporary Access and Construction Roads
- Testing Laboratory

Working facilities shall be subject to the Engineer-in-Charge's approval. The Contractor shall comply with all applicable laws, regulations, and ordinances relating to the construction and operation of the working facilities.

Materials for the working facilities shall be of first-class quality and if not new, in best condition. The capacity and number of equipment shall conform to the specific minimum requirements for the works they are intended for and the climatic conditions prevailing at the site. The capacity and number of equipment shall be determined taking into account of the requirement of equipment throughout the entire work.

The Contractor shall attach to his bid documents drawings, pictures and operating descriptions for his proposed working facilities and shall indicate weight, standards, capacity, manufacturing date and country of origin.

The Contractor shall, prior to dispatching any items of the Working Facilities, give written notice to the Engineer-in-Charge with clear indications about the purpose of the items, the kind, date and place of consignment (factory or the Contractor's premises). Said notice must be given in due time to allow for a possible cancellation in case the items do not comply with the requirements as stipulated. The Engineer-in-Charge will agree or disagree with the inquiry in writing within the next 15 days on arrival of the notice.

The Contractor shall provide all his equipment with sufficient spare parts, special tools for repair work and complete standby units of vital parts to guarantee a continuous operation without untimely delays. The Contractor is fully responsible for any delays due to disregard of said necessity.

Should the Engineer-in-Charge determine that the equipment furnished does not meet all requirements, the deficiencies shall be corrected by the Contractor before further use, or the deficient equipment shall be replaced with satisfactory equipment any cost incurred in the correction or replacement shall be borne by the Contractor.

All Working Facilities shall be built in the areas indicated by the Engineer-in-Charge. The Contractor shall submit prior to the start of the Works to the Engineer-in-Charge for approval, a drawing showing the exact positions of the main Working Facilities.

3.2 SUBMISSIONS

The Contractor shall submit basic plans of Working Facilities together with his bid.

3.3 CAMP AND WORKING FACILITIES

3.3.1 General

The Camp and Facilities include but are not limited to

- ❖ Staff residential quarters for the Contractor's staff
- ❖ Accommodation and canteen for the Contractor's workmen
- ❖ Miscellaneous social facilities
- ❖ Offices for the Contractor
- ❖ Miscellaneous Working Facilities
    - • Warehouses and sheds for the Contractor
    - • Work and repair shops

All working facilities shall be equipped with lighting arrangement, telephone, water supply with drinking water, sewage system and if necessary with air conditioning. Contractor shall make his own arrangement for electricity supply as would be necessary for all sorts of works.

3.3.2 Offices for the Contractor

Offices for the Officers and staff of the Contractor shall be of sufficient size and fully furnished and equipped with sanitary facilities, telephone, etc.

3.3.3 Miscellaneous Working Facilities

The Contractor shall construct and maintain warehouses, storage yard, a motor tool, repair shops, workshops, vehicle sheds, garages, fuel storages and field laboratory etc. for efficient execution of the work.

a. Warehouse(s) and Sheds

Warehouse(s) for the storage of materials, mechanical and electrical units, spare parts etc. shall be well secured, ventilated (if necessary) and waterproof and shall be installed with the necessary appliances.

b. Work and Repair Shops

All work and repair shops shall be well secured, ventilated (if necessary) and waterproof. They shall be equipped with adequate equipment and tools necessary to carry out all works and repairs which are usually to be done at the Site.

3.4 PLANT AND EQUIPMENT

3.4.1 General

The Contractor shall provide all construction plants and equipment necessary for the efficient execution of the work described in the bid documents and the Specifications and details furnished by the Contractor in the construction plant and equipment schedule.

The Contractor shall also deploy additional equipment, if needed, at his own cost for timely completion of the Works.

The Contractor may collect and use sand and gravel within the construction area provided by the Employer if approved by the Engineer-in-Charge. The Contractor shall obtain aggregate through crushing of the excavated rock and/or from outside of the area at his own expenses and responsibility if he intends to do so.

Plants and equipment for the execution of all civil works include but are not limited to:

- Plant for aggregate and concrete production
- Processing plant for filter and selected surfacing material
- Open excavations
- Steel fabrications, bending and other equipment.

3.4.2 Plant for Aggregate and Concrete Production

3.4.2.1 Aggregate Crushing Plant

The number and capacity of crushing plants for aggregate shall be sufficient enough such that daily production shall at least meets the 2-3 days elements. The processing plant for aggregate for concrete shall be capable of producing the separate aggregate size groups with the proper grading stipulated in the Specifications.

Care shall be taken so that water which has been used to wash the aggregates does not cause turbidity of the river/stream water.

The Contractor shall submit the following data for approval before ordering equipment or initiating work on the Plant:

- flow diagrams
- size and capacity of each separate piece of equipment

3.4.2.2 Cement Transportation Equipment and Storage Facilities

Transportation of bulk cement shall be accomplished in adequately designed weather-tight trucks or other means which will protect the cement completely from exposure to moisture.

Storage of bulk cement at the Site or in the railway yard shall be done in weather-tight and properly ventilated structures with adequate provisions for the prevention of absorption of

moisture. Said structures shall be complete with all equipment for loading, unloading and weighing of cement. A weather - tight equipment shall be provided for conveying cement.

The cement storage structure on the Site shall be at least for 30-day capacity.

3.4.2.3 Concrete Batching and Mixing Plant

The concrete batching and mixing plant shall be a modern and dependable, automatically controlled interlocked batch-type mixing plant. Manual operation shall also be possible in the event of fault in the automatic system. The equipment shall be capable of combining the aggregate, cement, admixtures, and water into a uniform mixture within the time limit specified and of discharging this mixture without segregation. The equipment shall provide adequate facilities for the accurate measurement and control of each of the materials entering plant. The complete plant assembly, including provisions to facilitate the inspection of all operations at all times and the adequacy and dependability of each of its parts, shall be adequate to meet the requirements of the work.

The batching and mixing plant shall have means for readily wasting any material or concrete that is improperly batched, mixed or held in the mixers too long.

Auto-balance scale for weighing concrete materials and digital instruments shall be inspected, tested and calibrated in the presence of the Engineer-in-Charge after repair and maintenance of the equipment and at least once in every two (2) months or as directed by the Engineer-in-Charge.

3.4.2.4 Batching Equipment

Batching shall be done by individual weight batching equipment. Aggregate weight batching may be cumulative but by individual size. Weighing hoppers shall be arranged to permit the convenient addition or removal of material.

Delivery of materials from the batching equipment shall be within the following limits of accuracy:

Material	Percent by Weight
Cement	2
Water	1
Aggregate smaller than 5 mm size	2
Aggregate larger than 5 mm size	3
Admixture	1

Suitable facilities shall be provided for readily obtaining representative samples of aggregate from each of the batchers for test purposes.

3.4.2.5 Mixing equipment

The mixing plant shall consist of batch type tilting mixers or pan type forced paddle mixer and a discharge hopper arranged with suitable devices for obtaining representative samples and delivering to ground level of concrete for slump, unit weight, and uniformity tests. The operator platform shall be conveniently located so that the operator can visually observe the mixing action in at least one mixer and the discharge from all mixers. A platform for

access from the control room shall be provided to permit visual inspection of the concrete in the mixers while mixing. All necessary platforms, tools, equipment shall be furnished by the Contractor.

On each mixer a consistency indicator and an acceptable device to lock the discharge mechanism until the required mixing time has elapsed shall be provided.

3.4.2.6. Digital Recorder

An accurate recorder of digital type shall be provided to make continuous visible combined record on a single chart of the separate measurement of each concrete ingredient, including all mixing water, air-entraining admixture, water-reducing and set-retarding admixture, and also mixing time of each batch after all materials are in the mixer, date and time of each batch, and the type of mix proportion.

The visible portion of the chart shall cover a period of not less than 30 minutes. All digital recorder charts shall be locked and the charts shall be submitted to the Engineer-in-Charge.

3.4.2.7 Communications

An effective telephone or two-way communication system for the exclusive use of the batch plant inspector, placement inspector and the laboratory shall be maintained. Telephones shall be provided with a suitable bell, buzzer, or light to attract attention under working conditions.

3.5 ELECTRICAL POWER SUPPLY SYSTEM

The contractor shall make his own arrangement at his own cost for power supply for construction and other uses. The Contractor shall furnish, install and maintain the electrical distribution system of required capacities to the required areas for his work.

For camp area, the Contractor shall arrange himself for a connection with the closer existing power-line.

As an alternative measure, the Contractor shall install generators of required capacity and related facilities at his own expenses in case of an excessive energy demand and/or for supply of power at the instance of power failure at the power network.

3.6 TELEPHONES & COMMUNICATION NETWORK

The temporary tele-communication system shall be established at site and the Contractor shall make necessary arrangement for the same.

The Contractor will be responsible for furnishing, installing and maintaining, the telephone and communication network to individual sites/offices and other areas like quarries etc., as needed.

The contractor shall be equipped with at least one mobile connection at site office. All the charges for telephone and communication network shall be borne by the contractor.

3.7 WATER SUPPLY SYSTEM

The Contractor shall make all necessary arrangements for the adequate supply of raw water for construction use and potable water for human consumption at the various work areas as well as at the camps. Regulating, transporting, treating and distributing the water shall be included in it.

For construction and other uses, sufficient storage of water shall be secured especially during dry seasons. The Contractor shall be fully responsible for the arrangement of necessary facilities for water supply.

Only adequately treated water which complies with the current sanitary standards will be accepted for human consumption. Installation of non potable water supply systems in the camp areas will not be permitted. Storage tanks with a reserve capacity equivalent to two (2) days of normal usage will be required for the drinking water system.

The Contractor shall take drinking water samples from time to time if so requested by the Engineer-in-Charge. The samples shall be sent for chemical and bacteriological analyses to approved laboratories at his expense and the results of the analysis shall be obtained within 7 days of the sampling.

If the sampling and testing are not properly performed, the Employer may perform the same directly and charge the Contractor for the corresponding expenses.

3.8 SEWAGE AND WASTE WATER SYSTEM

The Contractor shall design, construct, equip, operate and maintain all the installation necessary to properly collect, treat and dispose of sewage from his camps and other construction facilities.

The Contractor shall not, under any circumstances, discharge sewage or contaminated water into natural streams or any open areas. The pondage system for treatment and disposal of sewage shall not be used.

Treatment and disposal of sewage shall be performed in accordance with the current related standards and laws in force in India and always subject to the Engineer-in-Charge 's approval.

The drainage systems shall be designed taking into account the rainfall rate in the area and the disposal of rainwater shall be accomplished in such a way that no stagnation of water or any erosion problem is caused which may alter the stability of the soil.

3.9 FIRE FIGHTING EQUIPMENT

The Contractor shall provide complete fire fighting equipment necessary to ensure the safety of the Work.

The Contractor shall supply and maintain an abundant length of fire hoses, fire buckets, sand buckets, approved fire extinguishers and alarm systems installed over the complete work and camp sites.

The Contractor shall have on the Site at all times a trained fire fighting and first-aid crew with the necessary mobilization means.

3.10 TEMPORARY ACCESS AND CONSTRUCTION ROADS

3.10.1 General

The Contractor shall design, construct and maintain the construction roads and related works that may be necessary, from the existing roads and tracks to the various work areas, and other areas such as camps, stores, explosive magazines, plants, disposal areas and any other areas related to the work at his own cost.

Additionally, the Contractor shall improve where necessary and maintain all the existing roads and tracks in and adjacent to the project area to the satisfaction of the Engineer-in-Charge for guaranteeing normal traffic for any kind of vehicle.

The Contractor shall be responsible for the safety of the traffic during the construction. The training for safe driving together with providing number of traffic signs are the responsibility of the Contractor. Additionally, he will be responsible for protecting against damage any part of the work and the property of others in relation to the performance of this works.

The construction roads as well as existing roads will be utilized by the Employer, and the Contractor will not be entitled for any payment for such use.

3.11 FIELD LABORATORY

The Contractor shall establish a well equipped field laboratory for testing of materials of construction and other as required at his own cost and responsibility. This laboratory shall be of the size with equipments and the with all testing facilities as per Indian or other equivalent Standards. Prior to setting up of the laboratory, Contractor should submit detail plan with exhaustive equipment-list, and list of professionals and other personnel identified for laboratory work, to the Engineer-in-Charge for approval.

The laboratory shall be established as early as possible. The Contractor shall collect the samples as specified or as directed by the Engineer-in-Charge, carryout the relevant test under the guidance of Engineer or Engineer-in-Charge’s representative, prepare the complete report and submit them to the Engineer-in-Charge.

All tests shall be made according to approved standards and therefore, the equipment shall comply with the same standard. All relevant standards shall be made available in the laboratory. For any material/work in particular where the Contractor’s laboratory has no facility, tests shall be got done in an outside standard laboratory with the approval of Engineer-in-Charge at Contractor’s cost.

The laboratory shall be provided with light, ventilation, water, telephone, air-conditioner, cold and hot water supply, tank for curing, heating, toilet, etc., and be spacious enough in order to store the test samples. The details and location of the laboratory are subject to the Engineer-in-Charge 's approval.

4 GEOTECHNICAL AND CONSTRUCTION MATERIAL INVESTIGATION

4.1 GENERAL

The Contractor shall conduct all necessary geotechnical and construction material investigation as specified in the various sections of the Technical Specifications of different works with the prior intimation to the Engineer.

4.2 MEASUREMENT AND PAYMENT

No work related to any geotechnical and construction material investigations will be measured for the purpose of payment. There will be no separate payment for the investigations and related auxiliary services, as the cost thereof is deemed to be included in quoted price

5.0 MATERIALS FOR CONSTRUCTION

5.1 SCOPE OF WORK

(i) The specifications described herein under relate to the work which includes all labour, materials, equipment, transportation and services required to arrange materials for construction of various works under this Contract.

(ii) Samples for testing of materials for the concrete shall be supplied by the Contractor to the Engineer-in-Charge at the Trial Mix Stage as set out in Section on "**Concrete Works**".

(iii) The specifications of some of the major construction materials are given here under. The specifications and other details for masonry stone is not included here, but given in details in the Section on "**Masonry**".

5.2 SUBMITTALS

(i) The Contractor shall specify in his bid and subsequently also, if asked by the Engineer-in- Charge, the source(s) from which the cement, steel etc. will be obtained. In case the specified source(s) is not acceptable to the Engineer-in-Charge, the Contractor shall be required to substitute the source by an acceptable source. Additional suppliers and change of suppliers shall be subject to the approval of the Engineer-in-Charge.

(ii) At least 30 days prior to procuring or dispatch of the materials to site, the Contractor shall submit the following to the Engineer-in-Charge:

(a) **Certified quality test reports** from manufacturers in respect of cement, steel and other materials. This will also be necessary whenever the source is changed or when the sub-standard materials are received on the site.

(b) If the materials are to be arranged from several sources, the estimated quantity to be procured from each source and the proposed schedule of supply.

(iii) The layout of the stockpiles and the method of drawing aggregates from them shall be submitted to the Engineer-in-Charge at least 30 days prior to the commencement of stockpiling of aggregates.

(iv) The details relating to the source, method of delivery and storage of water to be used during construction shall be submitted by the Contractor to the Engineer-in-Charge for approval atleast 30 days prior to the commencement of the works.

(v) The Engineer-in-Charge reserves the right to ask for any additional information deemed necessary to be included in the submitted documents.

5.3 STANDARDS

(i) The specifications, production, sampling, testing and storage of constructional materials shall conform to the following latest Indian Standards or where not covered by these Standards, to the equivalent International Standards :

(a) Aggregates and Water

IS:456-2000 (Code of Practice for Plain & Reinforced Concrete)
IS:383-2000 (Specification for Coarse and Fine Aggregates for Natural Surface for Concrete)
IS:2116-1992 (Sand for masonry mortar)
IS:2386 (Part-IV)-1963 (Reaffirmed 1990) (Method of Tests for Aggregate for Concrete)
IS:516-1959 (Reaffirmed 1991) (Method of Tests for Strength of Concrete)

(b) Cement

IS:269-1989 (Specification for 33 Grade Ordinary Portland Cement)
IS:1489-1991 (Specification for Portland Pozzolona Cement)
IS:8112-1989 (Specification for 43 Grade Ordinary Portland Cement)
IS:12269-1987 (Specification for 53 Grade Ordinary Portland Cement)
IS:12330-1988 (Specification for Sulphate Resisting Portland Cement)
IS:455-1989 (Specification for Portland Slag Cement)

(c) Steel for Reinforcement

IS:432 (Part-I)-1982 (Reaffirmed 1995) (Mild Steel and Medium Tensile Steel Bar)
IS:1786-1985 (Reaffirmed 1990) (Specification for High Strength Deformed Steel Bars and Wires for Concrete Reinforcement)

(d) Structural Steel

IS:2062-1992 (steel for General structural purposes)
IS:808-1989 (Dimensions for Hot Rolled Steel Beam, Column, Channel and Angle Sections)
IS:8500-1991 (Structural Steel Medium and High Strength Qualities)
IS:800-1984 (Reaffirmed 1991) (Code of Practice for General Construction in Steel)

(e) Steel for fabrication of Pipes

IS:6286-1971 (Reaffirmed 1988) (Seamless and Welded Steel Pipes for Sub-zero Temperature Service)
IS:3589-1991 (Electrically Welded Steel Pipes for Water, Gas and Sewage)
IS:1536-1989 (Reaffirmed 1993) (Centrifugally Cast (Spun) Iron Pressure Pipes for Water, Gas and Sewage)
IS:6631-1972 (Reaffirmed 1988) (Steel Pipes for Hydraulic Purposes)

(f) Welding Electrodes

IS:814-1991 (Covered Electrodes for Metal Arc Welding of Structural Steels)
IS:816-1969 (Reaffirmed 1992) (Code of Practice for Use of Metal Arc Welding for General Construction in Mild Steel)

(ii) In case of conflict between the above Standards and the Specifications given herein, the Specifications shall take precedence.

5.4 BRICKS

5.4.1 General

Bricks shall be hand moulded or machine moulded. They shall be free from nodules of free time, visible cracks, flaws warpage and organic matter, have a frog 100mm in length 400mm in width and 10mm to 20mm deep on one side of its flat sides. Each brick shall be marked in the frog with the manufacturer's identification mark. The bricks shall have smooth rectangular faces with sharp corner and shall be uniform in colour and emit clear ringing sound when struck. Bricks shall have nominal size of: 200mm x 100mm x 100mm; and shall be of class designation 10 with average compressive strength of $10N/mm^2$.

5.4.2 Sampling and Tests

Sample bricks shall be subject to the following tests:

(i) Dimension tolerance
(ii) Water absorption.
(iii) Efflorescence.
(iv) Compressive strength

5.4.2.1 Sampling

For carrying out compressive strength, water absorption, efflorescence and dimensional tests, the samples of bricks shall be taken at random. The sample thus taken shall be stored in a dry place until tests are made. Sampling shall be done as per CPWD norms.

5.5 STONES FOR MASONRY/AGGREGATES

5.5.1 General

(i) All stones used for masonry works and concrete aggregates shall be of sound, hard, durable and of tough quality approved by the Engineer-in-Charge.

(ii) The stones shall be fine or medium grained, hard, bright in colour, breaking with a clean fracture and as such make a ringing sound when struck with a hammer.

(iii) It shall be free from decay, vesicles, holes, flaws, cracks and other defects and must have, as far as possible, uniform colour and texture. Porous stone absorbing water more than 1 (one) percent of its dry weight after 24 hours immersion shall be rejected. No stones shattered or cracked by blasting operations or having any skin or earthy cover shall be used.

(iv) In case the stone is not considered to be free from dust or dirt etc. by the Engineer-in-Charge, the Contractor shall get the stone screened, washed and/or treated as directed by the Engineer-in- Charge.

(vi) Stone for masonry shall be roughly cubical, but not be conical in shape and stones weighing between 40 Kg to 75 Kg shall not be less than 15 cm and shall not be less than 25 cm if weighed between 75 Kg to 150 Kg in any direction. Spalls between 10 cm to 20 cm size shall also be used to wedge into the thick mortar spaces. No individual stone for use in masonry shall weigh less than 40 Kg and more than 150 Kg. Generally, the stones shall have more bedding area in the natural bedding plan. The percentage of water absorption, according to tests conforming to IS-1124-1990 shall not exceed 1% to 3% of its own dry weight, after 24 hours submersion in water. Stones for masonry shall not contain crytocrystalline silica or chertmica or any other deleterious material like iron-oxide, oganic impurities, etc. If considered necessary, the stone shall be examined petrographically in accordance with IS-1123-190.

(vii) Samples of stones that the Contractor intends to use shall be submitted for the approval of the Engineer-in-Charge not later than 45 days prior to the date of use.

5.5.2 Tests for Stones

The crushing strength in unconfined compression test shall not be less then 150 kg/cm^2 when tested on any plane. Samples of stone from quarries shall be tested for compressive strength in accordance with **IS:1121 (Part-I)- 1993**. The compressive strength testing shall be conducted with the load parallel to the bedding plane and also perpendicular to the bedding plane. The stone samples shall also be tested for water absorption **(IS : 1124-1990)** and also for soundness to ensure suitability of stones for masonry.

5.6 AGGREGATES

5.6.1 General

(i) Use of aggregates (coarse and fine) containing excessive amount of zeolites, secondary minerals and such other components which cause alkali reactivity of the aggregates and consequent reduction in durability of the concrete is prohibited. The Engineer-in-Charge may, however, allow the use of such material either in part or in full keeping in view the extent of reactivity, the location, the nature of exposure and the structure. If the Engineer-in-Charge considers necessary, he may carry out mineralogical tests to ascertain the lack of harmful minerals in the stones.

(ii) The Contractor shall make his own arrangements for aggregate crushing plants etc. for crushing of aggregates from stones extracted from approved quarries or other works.

(iii) The quality of all aggregates used in the works, as also processing such as washing, classifying, screening, re-screening, crushing and blending necessary to meet the required specifications shall be subject to the approval of the Engineer-in-Charge.

(iv) The aggregates shall be supplied only from the sources/quarries approved by the Engineer-in- Charge. The Contractor shall supply necessary quantities of aggregates to carry out the desired tests by the Engineer-in-Charge.

(v) The aggregates shall be sampled and tested by the Engineer-in-Charge in accordance with the Indian Standards referred above.

(vi) The tests shall be made on samples that are representative of the grading that will be used in concrete and the aggregates shall be processed by the equipment proposed for the works.

(vii) The Contractor shall at all times have access to and associate with sampling and testing of aggregates and shall be entitled to discuss with the Engineer-in-Charge, the results and proposals for grading of aggregates.

(viii) Stored Fine sand shall be stacked and maintained in such a manner as to avoid the inclusion of any foreign materials in the concrete, and such that no equipment will be operated on the storage piles. The storage piles shall be constructed so as to prevent contamination. The Contractor shall remove the excess moisture in the fine sand by adequate means.

(ix) Coarse aggregate storage piles shall be built and maintained in such a manner as to avoid the inclusion of any foreign material in the concrete and to prevent segregation and excessive breakage. No equipment shall be operated on storage piles. Rock ladders of satisfactory design shall be used with conveyor systems for stockpiling aggregate larger than 40 mm in size.

(x) Sand and aggregate storage piles shall be located close to the mixing plant and shall always contain at least a **reserve for one month**

5.6.2 Coarse Aggregates

(i) The term coarse aggregates applies to pieces of natural or crushed rock ranging in size from 4.75 mm to 150 mm.

(ii) The aggregates shall be composed of clean, hard, strong, durable pieces of stone, angular or rounded in shape obtained naturally or by crushing from suitable stones approved by the Engineer- in-Charge. Coarse aggregates shall not contain more than 15% elongated or flat particles. An elongated particle is defined as a particle having a maximum length of more than 5 times its maximum width. A flat particle is defined as a particle in which its maximum width or length is more than 5 times its maximum thickness.

(iii) Coarse aggregates delivered to the batching plant shall have a uniform and stable moisture content.

(iv) The coarse aggregates shall be free from objectionable materials such as wood or other deleterious substances, the percentage of which in any size of coarse aggregate shall conform to the relevant standards except that the coarse aggregate shall contain not more than 0.30 percent by weight of deleterious (reactive) iron sulphides. The sum of the percentage of all deleterious substances in any size shall not exceed 3 percentage by weight. Coarse aggregates having a specific gravity (saturated surface-dry basis) less than 2.60 shall be rejected.

(v) The aggregates shall be resistant to deleterious, chemical or physical changes such as cracking, swelling, softening, leaching or chemical alterations after its incorporation in concrete.

(vi) For concrete exposed to the flowing water at high velocities, the coarse aggregates having high abrasion resistance shall be used.

(vii) When subject to soundness test with a solution of Sodium Sulphate coarse aggregates shall not suffer more than 12 percent loss of weight after five cycles.

(viii) The aggregates shall be crushed in approved type of stone crushers and different sizes of the coarse aggregate shall be separated into nominal sizes by screening over vibrating screens as under :

Designation of Size	**Nominal size range**
20 mm aggregate	4.75 mm to 20 mm
40 mm aggregate	20 mm to 40 mm
80 mm aggregate	40 mm to 80 mm
150 mm aggregate	80 mm to 150 mm

(ix) The grain-size distribution of the coarse aggregate for the various maximum sizes of aggregates shall be as set out in the relevant standards.

(x) These may be altered by the Engineer-in-Charge from time to time, if necessary, on the basis of actual tests carried out regularly in the laboratory so as to get the best possible coarse aggregate grading.

(xi) The percentage of weight of all the significant under-sizes shall be less than 5 percent when tested on the designated test screens having opening 5/6 times the normal minimum size of the material. No over size (i.e. material that would be retained on the designated test screens having opening 6/7 times the normal sizes of the material) shall be permitted.

5.5.3 Fine Aggregates (Sand)

(i) General

(a) Sand or fine aggregates shall be used for mortar in stone masonry and as fine aggregates in concrete work. It shall be either natural river sand or manufactured sand crushed from rock/stones or mixture of both in specified proportions. The sand shall be composed of hard, clean and gritty pieces of stone and of a quality approved by the Engineer-in-Charge. It shall be free from injurious amount of clay, soft and flaky

particles, vegetable or organic matter, loam, mica and other deleterious substances and shall not contain any salts.

(b) The fine aggregates shall conform to the requirements of IS:383-1970 (Reaffirmed 1990). Varying amount of moisture in fine aggregates contributes to lack of uniformity in concrete consistency. The fine aggregates shall therefore have uniform and stable moisture contents. Dry sand shall be preferred. Hence sand stockpiles shall be protected from rainfall.

(c) The percentage of deleterious substances in the fine aggregates shall conform to relevant standards except that the fine aggregates shall contain not more than 0.10 percent by weight of deleterious (reactive) ferrous sulphides. The total percentage of deleterious substances must not exceed 5 percent of the weight.

(d) Fine aggregate having a specific gravity of less than 2.60 are liable to be rejected. Fine aggregates when subjected to a soundness test with a solution of sodium sulphate, after 5 cycles of tests, shall not suffer a loss of weight in excess of 10 percent.

(e) The sand shall be well graded and, when tested by standard sieves, shall conform to the prescribed limits of gradation. The best gradation shall be determined after experiments and tests and the Contractor shall follow the same on approval of the Engineer-in-charge.

(f) The sand, as delivered to the batching plant shall have a fineness modulus of 2.6 to 3. The grading of fine aggregates shall be so controlled that the fineness moduli of at least 9 out of 10 samples of fine aggregates delivered to the batching plant shall not vary more than 0.20 from the average of 10 samples tested. All classifying, batching or other operations on the fine aggregates shall be done by the Contractor.

(ii) Natural Sand

(a) Natural sand shall be obtained from an approved source. No sand affected by salty water shall be used. The sand shall be screened and thoroughly washed, preferably in flowing water so as to remove all earthy impurities and very small fines unless otherwise permitted by the Engineer- in-Charge.

(b) Natural sand shall be free from softer grains and all sources of sand showing appreciable percentage of these impurities shall be rejected.

(c) The presence of mica in the fine aggregate has been found to reduce considerably the compressive strength of concrete. It is advisable, therefore, to investigate the mica content of the fine aggregates and make suitable allowances for possible reduction in strength of concrete or mortar. The decision of the Engineer-in-Charge whether to use such sand and if so, what allowances to be made, shall be final and binding on the Contractor.

(d) The contents of the organic matter shall conform to relevant standards.

(a)

5.6.4. Storage of Aggregates

(i) The Contractor shall, at all times, maintain storage of all grades of aggregates for atleast one month requirement.

(ii) Adequate drainage of stockpiles shall be provided.

(iii) The stockpiling of the processed aggregate and drawl therefrom shall be such as to ensure that the variation in the free moisture in the aggregate, during any one shift of working, does not exceed 1 percent.

(iv) The coarse aggregate shall, as far as possible, be stored in shade or covered storage and arrangement made for sprinkling of water to ensure wetting of the aggregates.

(v) Care shall be taken in screening and stocking of the coarse aggregates so as to avoid intermixture of different gouge materials and inclusion of any foreign materials.

(vi) The stockpile shall be built up in horizontal or gently sloping layers.

(vii) Trucks and bulldozers shall be kept off the piles to prevent breakage and impairing the cleanliness of aggregate.

(viii) A hard base shall be provided to prevent contamination from underlying materials in storage areas in continuous use.

(ix) Overlap of different sizes of materials shall be prevented with suitable walls or by ample distance between storage piles.

(x) Arrangements shall be made to store natural and manufactured sand in a way that shall protect it from being contaminated with dust, organic matter or other deleterious substances.

5.7 WATER

(i) A reliable water supply for construction purposes shall be installed and maintained by the Contractor.

(ii) Adequate water storage facilities shall be provided by the Contractor at the batching and mixing plant and other work sites so that various operations of works do not suffer due to temporary breakdown in the main supply system.

(iii) The Contractor shall supply water samples from the intended sources to the Engineer-in-Charge for testing and approval.

(iv) The Engineer-in-Charge shall establish the suitability of water to be used for construction purposes.

(v) Water for washing of aggregates, mixing mortar, concrete or grout and/or other construction activities shall be clean and free from earth, vegetable or organic matter, injurious amount of oils, acids, sugar, salt and alkaline substances in solution or in suspension and shall conform to relevant standards. The maximum allowable contents of sulphates (SO_4) shall be 250 parts per million (ppm) and those of chlorides (Cl) shall be 2000 mg per liter for plain concrete / mortar works and 1000 mg per liter for reinforced

concrete works. Turbidity shall be within 2000 ppm (or 0.2 percent by weight) and preferably as low as possible.

(vi) Water used for curing shall be clean and free from contamination and from excess amounts of acids or alkalis or other matter combining chemically with and thus disfiguring the concrete / masonry surface. Water shall not contain organic matter causing stink.

(vii) Average 28 days compressive strength of at least three 15 cm concrete cubes prepared with water proposed to be used shall not be less than 90 percent of the average of strength of three similar concrete cubes prepared with distilled water. The cubes shall be prepared, cured and tested in accordance with the requirements set out in Section on Concrete Works.

(viii) The Contractor shall bring to the notice of the Engineer-in-charge, of the occurrence of hot water found in existence during excavation. He shall supply samples of such water to the Engineer-in-Charge for testing. Suitable measures shall be taken in case such testing reveals deleterious effect on concrete.

5.8 CEMENT

5.8.1 General

(i) The Contractor shall procure the cement of the specified quality from the cement sources/plants approved by Employer/Employer. For this purpose Employer/Employer will approve atleast two sources/plants out of those intimated by the Contractor so that one is a standby for taking care of any eventualities.

(ii) Cement to be used for various works shall be of different types such as Ordinary Portland Cement or Portland Pozzolana Cement or Portland Slag Cement as approved by the Engineer-in-Charge and shall conform to the relevant Standards at the time of its use.

(iii) The Contractor shall deliver with each supply of 1000 tonnes of cement a certificate from the manufactures/suppliers by which the cement is guaranteed to comply with the requirement of the specifications. **The Employer/Employer shall have the right to check or test the cement at any stage of its manufacture or delivery and the Employer/Employer's test reports shall supersede the test report given in the manufacturer's certificate.**

(iv) Aggregate which has alkaline reactive tendency shall be avoided for use in concrete. In case, such aggregate has to be used, prior approval of the Engineer-in-Charge shall be obtained. In that case, the cement with alkali contents (i.e. Na_2O and K_2O expressed in equivalent weight of Na_2O) not exceeding 0.6 percent by weight of cement shall be used.

(v) The cement will be sampled and tested by the Engineer-in-Charge for strength and physical properties and chemical analysis will be carried out as set out in relevant standards.

(vi) The cement samples for testing at the source/plant shall be obtained by the Contractor as the bins are being filled. Tests for false set shall be made on samples taken at the latest time prior to shipment.

(vii) Ordinary port land cement conforming to latest revision of IS shall be procured from the reputed manufacturers only and will be accompanied by test certificate of manufacturers. Quality shall be checked regularly and Employer reserve the right to reject/approve cement quality after getting the same tested in approved Government Laboratories.

5.8.2 Transportation

(i) Cement shall be delivered on site in bulk/bags in bulk containers/trucks approved by the Engineer-in-Charge.

(ii) All bulk containers/carriers shall be clean and dry prior to filling/loading with cement and equipped with weather proof closures on all openings

5.8.3 Storage

(i) Sufficient storage facilities shall be provided at the batching plant to enable each new shipment of cement to be stored separately from the cement stored from earlier shipments.

(ii) Cement shall be stored above ground, adequately protected against rain, sun and moisture. Bulk storage bins and silos shall be emptied completely and cleaned of all cement accumulation **after every 3 months**.

(iii) Arrangements shall be made such that stock of approved cement are adequate to meet the programme of work at all times. The programme shall allow time for testing and approval of each shipment before such cement is incorporated in the works.

(iv) Cement shall be used in the order in which it is received on site. Cement of different brands, if received on site, shall not be combined in the same mix and structure. Such cement shall be used in different structures as approved by the Engineer-in-Charge.

(v) Handling and storage facilities shall be such that no cement is stored before use for **more than 120 days.** Should any cement be unavoidably kept in storage longer than 120 days, it shall be tested and if found defective, shall condemned for use on the project.

5.9 STEEL FOR REINFORCEMENT

5.9.1 General

(i) The Contractor shall procure the steel reinforcement of the specified quality from **the sources/plants approved by the Employer/Employer**. Sources of steel shall preferably be SAIL and TISCO.

(ii) Steel reinforcement shall conform to relevant Indian Standards or equivalent.

(iii) Steel shall be free from loose mill scale, rust, oil, grease, dirt, paint or other deleterious matter, when examined immediately before concrete is being placed.

(iv) Wire for tying reinforcement steel shall be black annealed iron wire or acceptable equivalent with a suitable diameter and shall have an ultimate strength of 5.68 tonne/sq.cm. and yield strength of not less than 8.8 tonne/sq.cm.

5.9.2 Transportation and Storage

(i) Transportation shall be undertaken in such a manner that no damage is done to the steel.

(ii) Reinforcement steel shall be stored off the ground in separate groups according to size and length. Reinforcement steel, which has been cut and bent according to the schedules approved by the Engineer-in-Charge, shall be marked with bar number, as shown in the schedule, by using same form of weather proof tag or by placing marked bins, and shall be stored in such a manner as to be readily accessible when required and to facilitate inspection.

5.10 STRUCTURAL STEEL

5.10.1 General

(i) The Contractor shall procure structural steel of the specified quality from **the sources/plants approved by the Employer/Employer**. Sources of steel shall be limited to SAIL and TISCO.

(ii) All structural steel shall be of new/unused stock, clean and straight, free from rust or scale and without any sharp kinks, bends or other objectionable defects.

(iii) All structural steel including steel plates, shall conform to relevant standards.

(iv) The material used in splices shall conform to the specifications of the material being spliced.

5.10.2 Transportation and Storage

Structural steel shall be transported, handled and stored in such a manner that no damage is done to the material or the structure.

6.0 EXCAVATION WORKS

6.1 SCOPE OF WORK

(i) The specifications described hereunder, relate to the work of excavation and shall include all labour, tools, construction plant and services, necessary to carry out the excavation of different materials, transportation and stockpiling / disposal of all excavated materials into stockpiles / dumping areas as approved by the Engineer-in-Charge.

(ii) Excavation shall be made to the lines, grades and dimensions shown on the drawings approved for construction or as otherwise agreed with the Engineer-in-Charge.

(iii) The Contractor shall maintain the excavated slopes, drainage and trenches and prepare foundations as shown on the drawings or as agreed with the Engineer-in-Charge.

(iv) The area of open excavation shall, where, in the opinion of the Engineer-in-Charge clearing is necessary, be cleared of all trees, bushes, rubbish and other objectionable matter and the materials, so removed, shall be disposed off suitably or as directed by the Engineer-in-Charge.

(v) When additional excavation outside the lines and grades shown on the drawings is required by the Contractor for his own convenience, such additional excavation shall be required to be backfilled with acceptable material and compacted by the Contractor in a manner satisfactory to the Engineer-in-Charge. The Contractor shall submit his plans for such proposed work in writing for Engineer-in-Charge's acceptance prior to the commencement of the work.

(vi) The removal of mud and slush resulting from heavy rains or flooding of the sites, when necessary to ensure the safe and effective performance of the work, shall be performed by the Contractor.

(vii) At all times during construction, the Contractor shall adopt excavation procedures such that at no time shall the stability of any slope be impaired.

(viii) The approval given by the Engineer-in-Charge to the Contractor's methods and equipment shall not relieve the Contractor of his full responsibility for a proper and safe execution of excavations, or of liability for injuries to, or death of person(s), or any obligations under this Contract.

(ix) The Contractor shall comply with all safety procedures and requirements as stipulated in this document.

6.2 SUBMITTALS

(i) At least **30 days prior** to the commencement of excavation, the Contractor shall submit his programme of excavation with details of his excavating methods and sequences for all open excavation works including the equipment.

(ii) At least **30 days prior** to dumping or stockpiling of any material, the Contractor shall submit the layout of the spoil and stockpile areas, which shall be within the identified areas. All pertinent data of working methods and provisions for the security, stability and temporary and permanent drainage of the areas shall be included along with details of volumes, material types, heights and grades provided.

(iii) To enable the Engineer-in-Charge to verify all necessary setting out and elevations carried out by the Contractor, the later shall notify the Engineer-in-Charge in writing, giving **at least 7 days notice** of his intentions to start excavation.

(iv) The Engineer-in-Charge reserves the right to ask for any additional information deemed necessary to be included in the submitted documents.

6.3 SETTING OUT

(i) The Contractor shall establish, at suitable points, to the satisfaction of the Engineer-in-Charge, permanent reference marks on the centerlines, as may be necessary and directed. The permanent marks shall be inscribed on bronze pegs, set in concrete blocks where they will be free from any likelihood of the disturbance. Suitable number of benchmarks with corresponding co-ordinates shall be established with reference to SOI benchmark and grid within the project area. The reference drawing indicating all benchmarks vis-à-vis project components shall be prepared and submitted to the Engineer-in-Charge for approval.

(ii) As the work progresses, centre line marks shall be made on pegs, inserted at the convenient intervals to the satisfaction of the Engineer-in-Charge, for checking alignment, grades, levels etc. The Contractor shall at all times, remain responsible for the sufficiency and accuracy of all such benchmarks and reference points.

6.4 ACCURACY OF ALIGNMENT, GRADES AND LEVELS ETC.

(i) Bench marks and fixed reference points with the value of the levels and the coordinates, will be fixed by the Engineer-in-Charge in the work areas. The plans showing the position, co-ordinates and the levels of the salient points as available will be supplied to the Contractor. The Contractor shall fix his permanent points and benchmarks in relation to these.

(ii) The Contractor shall take all precautions to ensure that the points fixed by the Engineer-in-Charge are not disturbed by his work and shall make good the damage, if any.

(iii) The Contractor shall provide all facilities like labour, instruments, etc. and all co-operation to the Engineer-in-Charge to check the alignments, grades, levels etc. whenever and every time they are asked for.

(iv) Any discrepancy or error detected during the course of excavations and / or at the end of work shall be set right by the Contractor, in the manner satisfactory to the Engineer-in-Charge.

6.5 Earth Work Excavation

All excavation operations manually or by mechanical means shall include excavation and ‘getting out’ the excavated materials. In case of excavation for trenches, basements, water tanks etc. ‘getting out’ shall include throwing the excavated materials at a distance of at least one meter or half the depth of excavation, whichever is more, clear off the edge of excavation. In all other cases ‘getting out’ shall include depositing the excavated materials as specified. The subsequent disposal of the excavated material shall be either stated as a separate item or included with the items of excavation stating lead. During the excavation the natural drainage of the area shall be maintained. Excavation shall be done from top to bottom. Undermining or undercutting shall not be done.

In firm soils, the sides of the trenches shall be kept vertical up to a depth of 2 meters from the bottom. For greater depths, the excavation profiles shall be widened by allowing steps of 50 cms on either side after every 2.0 m from the bottom. Alternatively, the excavation can be done so as to give slope of 1:4 (1 horizontal: 4 vertical). Where the soil is soft,

loose or slushy, the width of steps shall be suitably increased or sides sloped or the soil shored up as directed by the Engineer-in- Charge. It shall be the responsibility of the contractor to take complete instructions in writing from the Engineer-in-Charge regarding the stepping, sloping or shoring to be done for excavation deeper than 2 meter.

The excavation shall be done true to levels, slope, shape and pattern indicated by the Engineer-in-Charge. Only the excavation shown on the drawings with additional allowances for centering and shuttering or as required by the Engineer-in-Charge.

In case of excavation for foundation in trenches or over areas, the bed of excavation shall be to the correct level or slope and consolidated by watering and ramming. If the excavation for foundation is done to a depth greater than that shown in the drawings or as required by the Engineer-in-Charge, the excess depth shall be made good by the contractor at his own cost with the concrete of the mix used for leveling/ bed concrete for foundations. Soft/defective spots at the bed of the foundations shall be dug out and filled with concrete (to be paid separately) as directed by the Engineer-in-Charge.

In all other cases where the excavation is taken deeper by the contractor, it shall be brought to the required level by the contractor at his own cost by filling in with earth duly watered, consolidated and rammed.

In case the excavation is done wider than that shown on the drawings or as required by the Engineer-in-Charge, additional filling wherever required on the account shall be done by the contractor at his own cost.

The excavation shall be done manually or by mechanical means as directed by Engineer-in-charge considering feasibility, urgency of work, availability of labour /mechanical equipments and other factors involved. Contractor shall ensure every safety measures for the workers. Neither any deduction will be made nor will any extra payment be made on this account.

6.6 Planking and Strutting:

When the depth of trench in soft/loose soil exceeds 2 meters, stepping, sloping and/ or planking and strutting of sides shall be done. In case of loose and slushy soils, the depths at which these precautions are to be taken shall be determined by the Engineer-in-Charge according to the nature of soil.

Planking and strutting shall be ‘close’ or ‘open’ depending on the nature of soil and the depth of trench. The type of planking and strutting shall be determined by the Engineer-in-Charge. It shall be the responsibility of the contractor to take all necessary steps to prevent the sides of trenches from collapse. Engineer-in-Charge should take guidance from IS: 3764 for designing the shoring and strutting arrangements and specifying the profile of excavation Close planking and strutting shall be done by completely covering the sides of the trench generally with short upright, members called ‘poling boards’. These shall be 250x38 mm in section or as directed by the Engineer-in-Charge.

The boards shall generally be placed in position vertically in pairs. One boards on either side of cutting. These shall be kept apart by horizontal walling of strong wood at a maximum spacing of 1.2 metres cross strutted with ballies, or as directed by Engineer-in-Charge. The length and diameter of the ballies strut shall depend upon the width of the trench. Where the soil is very soft and loose, the boards shall be placed horizontally

against the sides of the excavation and supported by vertical 'wallings' which shall be strutted to similar timber pieces on the opposite face of the trench. The lowest boards supporting the si
des shall be taken in the ground for a minimum depth of 75 mm. No portion of the vertical side of the trench shall remain exposed. The withdrawal of the timber members shall be done very carefully to prevent collapse of the trench. It shall be started at one end and proceeded systematically to the other end. Concrete or masonry shall not be damaged while removing the planks. No claim shall be entertained for any timber which cannot be withdrawn and is lost or buried, unless required by the Engineer-in-Charge to be left permanently in position.

Open Planking and Strutting: In case of open planking and strutting, the entire surface of the side of the trench is not required to be covered. The vertical boards 250 mm wide & 38 mm thick shall be spaced sufficiency apart to leave unsupported strips of 50 cm average width. The detailed arrangement, sizes of the timber and the distance apart shall be subject to the approval of the Engineer-in-Charge. In all other respect, specifications for close planking and strutting shall apply to open planking and strutting.

During excavation and trenching work etc. the contractors shall ensure compliance to the guidelines in such matter laid down by the authority to ensure that there is minimum hazard to the operating personnel and user, minimum inconvenience to users, minimized damage to the underground plant / services of other utilities in a coordinated way in the interest of public inconvenience and overall safety of the adjoining structures etc.

6.7 Filling

6.7.1 Earth: Normally excavated earth from same area shall be used for filling. Earth used for filling shall be free from shrubs, rank, vegetation, grass, brushwood, stone shingle and boulders (larger than 75mm in any direction), organic or any other foreign matter. Earth containing deleterious materials, salt peter earth etc. shall not be used for filling. All clods and lumps of earth exceeding 8 cm in any direction shall be broken or removed before the earth is used for filling.

6.7.2 Earth Filling: The space around the foundations and drains in trenches shall be cleared of all debris, brick bats etc. The filling shall be done in layers not exceeding 20 cm in depth. Each layer shall be atered, rammed and consolidated. Ramming shall be done with iron rammers where possible and with blunt end of crow bars where rammers cannot be used. Special care shall be taken to ensure that no damage is caused to the pipes, drains, masonry or concrete in the trenches. In case of filling under floor, the finished level of filling shall be kept to the slope intended to be given to the floor.

6.7.3 Filling Side of Foundations: The cubical contents of bed concrete leveling course and masonry/ concrete in foundations up to the ground level shall be worked out and the same deducted from the cubical contents of earthwork in excavation for foundations already measured under the respective item of earth work to arrive at the quantity for filling sides of foundation. The quantity shall be calculated correct to two places of decimal.

6.7.4 Filling in Plinth and under Floors*:* Depth of filling shall be the consolidated depth. The dimensions of filling shall be on the basis of pre-measurement correct to the nearest cm and cubical content worked out in cubic meters correct to two places of **decimal.**

6.7.5 Compaction Quality: Compaction of earth and sand filling in areas where foundation & floors are located, the degree of compaction achieved shall be minimum 95% of maximum dry density. As obtained by proctor compaction as per IS: 2720 (Part-IIV). In road and other areas the degree of compaction shall be 90%.

6.7.6 Testing of Filling Layer: After the compaction of each layer, samples shall be taken from compacted layer and tested for dry density as per IS practice. The next layer of filling shall not be permitted until the engineer in charge is satisfied that pervious layer has achieved required compaction. If any particular layer fails to meet the required compaction, it shall be recompacted as directed by the engineer in charge and fresh samples shall be taken to ascertain the compaction density. Such re-compaction shall be continued till the desired compaction is achieved. The thickness of each compacted layer shall not exceed 200mm.

6.8 FORM WORK (CENTERING & SHUTTERING)

6.8.1 Form Work: Form work shall include all temporary or permanent forms or moulds required for forming the concrete which is cast-in-situ, together with all temporary construction required for their support.

6.8.2 General Requirement: It shall be strong enough to withstand the dead and live loads and forces caused by ramming and vibrations of concrete and other incidental loads, imposed upon it during and after casting of concrete. It shall be made sufficiently rigid by using adequate number of ties and braces, screw jacks or hard board wedges where required shall be provided to make up any settlement in the form work either before or during the placing of concrete.

Form shall be so constructed as to be removable in sections in the desired sequence, without damaging the surface of concrete or disturbing other sections, care shall be taken to see that no piece is keyed into the concrete.

6.8.3 Material for Form Work:

6.8.3.1 Centering/Staging:

(a) Propping and Centering: All propping and centering should be either of steel tubes with extension pieces or built up sections of rolled steel. Staging should be as designed with required extension pieces as approved by Engineer-in-Charge to ensure proper slopes, as per design for slabs/ beams etc. and as per levels as shown in drawing. All the staging to be either of Tubular steel structure with adequate bracings as approved or made of built up structural sections made from rolled structural steel sections.

(b) In case of structures with two or more floors, the weight of concrete, centering and shuttering of any upper floor being cast shall be suitably supported on one floor below the top most floor already cast.

(c) Form work and concreting of upper floor shall not be done until concrete of lower floor has set at least for 14 days.

Shuttering: Shuttering used shall be of sufficient stiffness to avoid excessive deflection and joints shall be tightly butted to avoid leakage of slurry. If required, rubberized lining of material as approved by the Engineer-in-Charge shall be provided in the joints. Steel shuttering used or concreting should be sufficiently stiffened.

Camber: Suitable camber shall be provided in horizontal members of structure, especially in cantilever spans to counteract the effect of deflection. The form work shall be so assembled as to provide for camber. The camber for beams and slabs shall be 4 mm per meter (1 to 250) or as directed by the Engineer-in-Charge, so as to offset the subsequent deflection, for cantilevers the camber at free end shall be 1/50th of the projected length or as directed by the Engineer-in-Charge.

Removal of Form work (Stripping Time): In normal circumstance and where various types of cements are used, forms may generally be removed after the expiry of the following periods:

Type of Form work	Minimum period Before Striking Form work for OPC 43 grade
(a) Vertical form work to wWalls, columns, or as directed by EIC Walls, beams	16-24 hr
(b) Soffit form work to slabs (Props to be fixed immediately after removal of formwork)	3 days
(c) Soffit form work to beams (Props to be re-fixed immediately after Removal of formwork	7 days
d) Props to slabs: (1) Spanning up to 4.5m (2) Spanning over 4.5m	7 days 14 days
(e) Props to beams and arches: (1) Spanning up to 6m (2) Spanning over 6m	14 days 21 days

(b)

Note 1: For other types of cement, the stripping time recommended for ordinary Portland cement may be suitably modified. Generally, If Portland pozzolana or low heat cement or OPC with direct addition of fly ash has been used for concrete; the stripping time will be 10/7 of the period stated for OPC with 43 grade cement above.

Note 2: The number of props left under, their sizes and disposition shall be such as to be able to safely carry the full dead load of the slabs, beam or arch as the case may be together with any live load likely to occur during curing or further construction.

Surface Treatment

Oiling the Surface: Shuttering **surfaces** of form work are coated with suitable mould oil which acts both as a parting agent and also gives surface protections.

Inspection of Form Work: The completed form work shall be inspected and approved by the **Engineer** in-charge before the reinforcement bars are placed in position.

6.90 DISPOSAL OF EXCAVATED MATERIALS

(i) The excavated materials suitable for construction shall be stockpiled in areas where permanent works are not located.

(ii) Excavated materials which are not suitable for construction and those in excess of the requirement for construction shall be disposed off in the waste disposal areas as proposed by the Contractor and subsequently approved by the Engineer-in-Charge. Surfaces of material so disposed off shall be trimmed to regular lines and grades satisfactory to the Engineer-in-Charge. Disposal of all materials shall be such that it will not interfere with natural drainage and is as per the regulations for environmental protection; drains will be constructed to prevent the undesirable accumulation of water in or around the disposal area. If additional areas are required, the Contractor shall propose such areas for approval of the Engineer-in-Charge.

(iii) The Contractor shall ensure that no excavated materials are disposed off in the streams or at locations, where in the opinion of the Engineer-in-Charge, these are liable to be washed away by the floods.

(iv) All other specifications/stipulations in this regard laid in this document shall also apply.

6.11 DRAINAGE/DEWATERING

Seepage water from springs or rain water shall be suitably collected and drained away by gravity, wherever it is possible to do so. Where, however, drainage by gravity is not feasible, pumping could be resorted.

The Contractor shall make all arrangements deemed necessary for keeping the excavation and work areas dry for execution of works as per specification.

6.12 BACKFILL

(i) Backfill shall consist of materials as approved by the Engineer-in-Charge and shall be placed in locations as shown on the approved drawings or as directed by the Engineer-in-Charge.

(ii) Earthfill, which on account of its nature or a location requiring no compaction, shall be classified as backfill.

(iii) Backfill which shall be compacted by means of roller, mechanical or manual tampers is classified as compacted backfill.

(iv) At locations, where areas to be backfilled are too small or confined, compaction may be done manually with tampers etc.

(v) Only suitable materials obtained from excavation, if practicable, shall be used for backfill and construction of such features as approach road, causeway etc.

(vi) Material to be used in backfill shall be free draining type.

6.13 ILLUMINATION

The Contractor shall install an adequate illumination system at the work site.

6.14 MISCELLANEOUS WORKS

Besides the above, the Contractor shall also carry out, but not limited to, the following activities:

(i) Excavation for drainage trenches

(ii) Clearing of all trees, bushes, rubbish and any other objectionable materials and their removal and disposal.

(iii) Replacement of survey points fixed by the Engineer-in-Charge which are damaged by Contractor's negligence.

(iv) Formation of berms or ramps, sump pits for installation of dewatering pumps at places which fall beyond the specified excavation lines.

(v) All dewatering and drainage works

(vi) Methods adopted for specially controlled excavation at foundation level or near the faces where plain surfaces are required.

(vii) Replacement or repair of concrete or other works damaged by blasting.

(viii) Draining, shaping and trimming of the dumped material in waste disposal areas to the lines and grades as directed or approved by the Engineer-in-Charge.

(ix) All shoring, strutting and other protective as required during excavation.

6.15 Measurements and Payments

(i) Immediately after the final excavation of foundation or otherwise, inspection and approval of Engineer-in-Charge, levels at salient locations of the foundation pit/trench, etc., shall be measured jointly by the Contractor and the Engineer-in-Charge.

(ii) Interim/progressive payments will be made, in accordance with Clause 14 of the General Conditions of Contract, Volume – II (Part – A), at the appropriate unit rate entered in the Schedule of works which shall include the entire cost of all operations required for execution of the respective item.

7 CONCRETE WORKS

7.1 SCOPE OF WORK

(i) The specifications described hereunder cover all labour, materials, equipment, plant and services related to the concrete work to be carried out by the Contractor under the Contract.

(ii) The concrete work shall be performed to the dimensions as shown on the approved drawings.

(iii) The approval given by the Engineer-in-Charge to the Contractor's plants and equipment or their operation, or of any construction methods shall not relieve the Contractor of his full responsibility for the proper and safe execution of concrete work or any obligations under the Contract.

7.2 SUBMITTALS

(i) Submittals listed herein are related to the items which require the consent of the Engineer-in-Charge and are to be made by the Contractor before the appropriate work may proceed.

(ii) Within 30 days from the date of issue of the Letter of Acceptance, but before procuring or mobilizing to the site, the equipment, the Contractor shall submit to the Engineer-in-Charge, updated and detailed plans and descriptions, consistent with those submitted with his bid and any subsequent amendments and additions agreed to by the Engineer-in-Charge and the Contractor, of the following:

(a) Aggregate Processing Plant

Description, flow diagrams and drawings in sufficient details to indicate layout, type and capacity of crushing, screening, washing, covering and other aggregate processing and handling equipment.

(b) Batching and Mixing Plants

Description, flow diagrams and drawings of the plants and details of the equipment, the Contractor intends to use to determine and control the amount of each separate concrete ingredient and mixing thereof into uniform mixture.

(c) Concrete Cooling Plant

Details of refrigeration and ice plants and other method which the contractor proposes to use to comply with concrete temperature requirements.

(d) Transport and Placing of Concrete

Full details of the equipment and method for transporting the concrete from the concrete plant to the final point of placing, including numbers, type and capacity of transport vehicles, concrete pumps, and details of standby plants to be installed.

(iii) **At least 30 days** in advance of any concrete work being carried out in the site, the Contractor shall submit to the Engineer-in-Charge, following information:

(a) Details of surface finishes, treatment of construction joints and construction techniques which the Contractor proposes to use in order to achieve the required concrete surfaces and allowable tolerances.

(iv) **At least 30 days prior** to procuring or dispatch to the site of the particular item of work to which the submittal relates, the Contractor shall submit to the Engineer-in-Charge.

(a) Details covering the properties and performance, including the certified copies of reports of all tests made by the manufactures of waterstops, expansion joint fillers and joint sealing compounds along with samples of the products.

(b) Details of curing compounds

(c) Details of epoxy mortar for concrete repair

(d) Details of the cooling system for post-cooling of mass concrete.

(v) Drawings showing the location of construction joints proposed by the Contractor which differ from those on the drawings approved by the Engineer-in-Charge, including formwork and reinforcement details, shall be submitted to the Engineer-in-Charge **at least 30 days prior** to the commencement of work on the particular structure.

(vi) During the performance of the concrete work, the Contractor shall keep a diary where he shall record the construction procedures related to concreting. This diary shall be made available to the Engineer-in-Charge upon request. The records shall contain at least the following:

(a) Commencement and termination of concreting of various parts of the structures
(b) Quantities and quality of aggregates and cement provided and the storage from which they were drawn
(c) Temperature of air, water, cement aggregates and concrete
(d) Meteorological conditions and humidity of air
(e) Personnel employed during various stages of the concreting operation and name of the responsible inspector or foreman
(f) Equipment used
(g) Directives received from the Engineer-in-Charge
(h) Any special material or procedures employed
vii) The Engineer-in-Charge reserves the right to ask for any additional information deemed necessary to be included in the submitted documents.

7.3 STANDARDS

(i) The concrete material, production methods, testing and admixtures shall conform to the following Indian Standards or, where not covered by these standards, to the equivalent International Standards:

IS : 456 – 2000	-	
IS : 1199-1959	-	(Reaffirmed 1991)
IS : 457-1957	-	(Reaffirmed 1991)
IS : 1972-1989		-
IS : 7861 (Part-I) – 1975	-	(Reaffirmed 1990)
IS : 7861 (Part-I) - 1981	-	(Reaffirmed 1992)
IS : 2505 - 1980	-	(Reaffirmed 1993)

(ii) In cases of conflict between the above standards and the specification given herein, the specifications shall take precedence.

7.4 QUALITY CONTROL AND TESTING

7.4.1 General

Field tests for quality assurance and testing of concrete and admixtures shall be performed by the Contractor at regular intervals or as directed by the Engineer-in-Charge. Employer may also carry out the required tests and for this purpose the Contractor shall supply labour, material, equipment necessary to sample and transport materials to the field laboratory from any part of the project area.

7.4.2 Test Prior to the Start of Concrete Works (Trial Mix Design)

7.4.2.1 General

(i) Immediately after the Aggregate Processing Plant and Batching and Mixing Plants are established by the Contractor but at least two months prior to the Contractor's programme to commence any concreting of permanent works, the Contractor shall start the testing of materials, conduct various trial mix design of concrete ingredients for the desired strength of different grades of concrete and propose the composition of concrete mixes and prepare trial mix of each of the proposed concrete class. The Engineer-in-Charge may also prepare the trial mixes using the cement, water, aggregates and admixtures intended for the work. Such materials shall be arranged by the Contractor which shall conform to the requirements specified in **"Materials for Construction".**

(ii) The trial tests shall be carried out until the concrete mixes show appropriate strength, workability density, and water tightness without the use of excessive cement. The trial tests shall include determination of the following parameters:
(a) Cement properties
(b) Characteristics of aggregates
(c) Water properties
(d) Admixture properties
(e) Proportion of aggregate ranges in the mix
(f) Proportion of uncrushed to crushed aggregates
(g) Cement dosage
(h) Water-Cement ratio (W/C)
(i) Workability of concrete mixes
(j) Compressive and tensile strength
(k) Entrained air
(l) Density
(m) Water tightness

7.4.2.2 Cement, Aggregates and Water

Cement, aggregates and water will be sampled and tested by the Contractor as set out in **"Materials for Construction".**

7.4.2.3 Concrete

(i) Concrete test cubes shall be prepared and cured in accordance with IS : 456 – 2000. Six test cubes shall be made from the each mix proposed for the different classes of concrete. Compressive strength of concrete will be tested at 7,28 and 90 days.

(ii) The consistency of the proposed mixes shall be tested by means of slump test. Specimen for slump test will be taken from each batch of concrete used to make the test cubes.

(iii) Air content will be determined in accordance with IS : 9103 – 1979.

(iv) Prior to the execution of large scale concreting work at the site, test will be performed to determine the temperature development due to hydration within the concrete with various types of cement. The temperature rise will be recorded and corresponding diagrams established.

7.4.3 Tests During Execution of Works by the Contractor

(i) Samples from the concrete being used for the permanent works, taken either at the batching and mixing plant or the placing point, shall be cured and tested hereafter as set out in Para 9.4.2.3.

(ii) In addition to the seven, twenty-eight days strength tests, ninety days strength tests and also at other ages shall be carried out as required by the Engineer-in-Charge.

(iii) Concrete for test specimens for compressive strengths shall be collected at random as it comes out of the mixer or at placing point once every shift or more often as the Engineer-in-Charge may require, and in quantity sufficient to prepare necessary number of test pieces from each sample. The concrete so collected shall be representative sample.

(iv) In addition to the strength tests carried out as above, it is contemplated that tests on actual cores from the concrete laid in position will be made by the Contractor, and results thereof shall be in conformity with those obtained in cube cast at the batching and mixing plant or at the placing point. For this purpose, it may be necessary to establish relationship between concrete strength versus age, as it may be possible to test control cubes and cores of the same age taken from the hardened concrete in the structure. Location and number of cores shall be decided by the Engineer-in-Charge. If the cores taken out show unreasonably low results, the work is liable to be rejected and may be required to be dismantled and re-done with all consequences to the Contractor.

(v) The contractor shall fill the test holes left by the removal of the cores with concrete of the required strength to the satisfaction of the Engineer-in-Charge.

(vi) The Engineer-in-Charge shall at all times, have access to and association with sampling, design and test of trial mixes, tests of strength corresponding to the laboratory tests.

7.5 PROPORTIONING OF CONCRETE

(i) All grades of concrete shall be air entrained concrete by using an approved air entraining agent. The air to be entrained shall vary in contents from 2% to 7% as per the laboratory tests.

(ii) Based on the analysis and tests made from time to time during the progress of work on the samples of various ingredients of concrete e.g. cement, aggregates and admixtures, and the resulting concrete, the Contractor will determine and submit to Employer for approval about the quantity of each ingredient to be used in the concrete mix.

7.5.1 MINIMUM LEVEL OF THE CEMENT CONTENT FOR DESIGN MIXES

S.NO	GRADE OF CONCRETE	Cement content / Cum in Kgs for 40mm MSA	Cement content / Cum in Kgs for 20mm MSA
1	M10	220	220
2	M15	280	280
3	M20	340	350
4	M25	370	380
5	M30		420
6	M35		450

7.6 HANDLING OF AGGREGATES

(i) The coarse aggregates shall be stacked in three separate stock plies, designated 80 mm to 40 mm, 40 mm to 20 mm and 20mm to 4.75 mm nominal size aggregates. A separate stockpile shall however be made for 150 mm nominal size aggregate.

(ii) If tests reveal the separation of the 10 mm and lower sizes is required, a separate stockpile, shall made for this aggregate.

(iii) The fine aggregate, having the required grading, shall ordinarily be stacked in two piles, one of which is washed and drained and other freshly washed, to minimise the variation in the moisture content.

(iv) Where crushed fine aggregate replaces a part of natural fine aggregate, the two shall be stacked in independent stockpiles.

(v) It may be necessary to have two or three piles, by sizes, in case of natural fine aggregate to get the required grading.

7.7 BATCHING AND MIXING

7.7.1 Batching and Mixing Equipment

(i) The Batching and Mixing Plant shall be of the requisite capacity to maintain the required progress on different items of work.

(ii) The Plant shall be capable of determining accurately, by direct weighing, the prescribed amount of the various ingredients including water, cement, admixtures and puzzolana etc. and each individual size of aggregate entering the concrete and combining them to give a uniform mix within the prescribed time and discharging the mix without segregation.

7.7.2 Calibration of Measuring Devices

(i) The Contractor shall provide standard test weights and other auxiliary equipment required for checking the operating performance of each scale and other measuring device and shall make periodic tests over the ranges of measurements involved in the batching operation.

(ii) The tests shall be made in the presence of a representative of the Engineer-in-Charge and shall be adequate to prove the accuracy of the measuring devices.

(iii) The frequency of such tests will be determined by the Engineer-in-Charge. Unless otherwise directed, tests shall be made once in two weeks at random without any notice in the case of cement and water scales and once a month in the case of all other scales.

(iv) The Contractor shall make such adjustments, repairs or replacements as may be necessary to meet the specified requirements for accuracy of measurement. The devices shall be capable of being operated to control the delivery of materials so that the combined in-accuracies in feeding and measuring do not exceed the following limits:

S. No.	Material	Percent (by weight)
1	Cement	1
2	Water	1
3	Aggregate	3
4	Admixtures	1

7.7.3 Mixing

(i) All concrete shall be thoroughly mixed in the Batching and Mixing Plants/Tilting batch mixer of an approved type, size and design as to positively ensure uniform distribution of the components throughout the mass during the mixing operations.

Mixing shall be continued until there is a uniform distribution of the materials and the mass is uniform in colour and consistency. If there is segregation after unloading from the mixer, the concrete shall be remixed. Unless otherwise authorised by the Engineer-in-Charge for mixers of one cubic metre capacity or less, the mixing of each batch shall continue for 1.5 to 2 minutes after all materials, except the full amount of water, are in the mixer. For mixer of larger capacity, the minimum mixing time shall be increased by fifteen seconds for each additional 0.5 cubic metre.

(ii) The mixing time shall be increased when, in the opinion of the Engineer-in-Charge, the charging and mixing operations fail to result in the uniformity of composition and consistency within the batch to batch.

(iii) Separation of coarse aggregate from mortar shall be avoided by proper arrangement of the discharge so that the concrete falls vertically and not diagonally into whatever container is to receive it.

(iv) Should the last fraction of the batch contain an excessive amount of coarse aggregate, this portion shall be retained and mixed with the succeeding batch.

(v) Discharge pipes of all water batches shall be of such a size and so arranged that the flow into the mixer is completed within the first 25% of the mixing time and delivered well inside the mixer where it is mixed quickly with the entire batch.

(vi) Over mixing requiring additions of water to preserve the required consistency shall not be permitted.

(c)

(vii) On no account shall any addition be made to any component of a concrete batch once that batch has been mixed and discharged from the mixer, whether for the purpose of retempering or any other reason, without the prior approval of the Engineer-in-Charge.

7.8 TEMPERATURE OF CONCRETE

Placing temperature of concrete for open works shall be maintained as stipulated in the BIS Codes or as directed by the Engineer-in-Charge. The measures to maintain these temperatures shall, but not, be limited to the following:

(a) Pre-cooling coarse aggregate with refrigerated water or with cold air blasts.

(b) Using cold mixing water by adding ice. Ice, if used, shall preferably be batched by weight, separately from the water. In short time mixing when aggregates are pre-cooled substantially, the ice may not completely melt in the mixer. In such a case, additional mixing time may be required or the amount of ice limited to about 30% of the mixing water.

(c) Using cement having low heat of hydration.

(d) Insulating water supply lines and tanks or at least painting exposed portions white.

(e) Insulating mixer drums or cooling them with sprays.

(f) Shading the batching, mixing and conveying equipment.

(g) Working only at night.

(h) Keeping mixing time and the time required to convey to the point of placement to a minimum.

(i) Spraying foams and reinforcement with water when they are exposed to direct sun light.

(j) Placing concrete in accordance with the procedure set out in IS : 7861 (Part-I) – 1975 (Reaffirmed 1990).

(k) Protecting all freshly placed concrete from exposure to direct sun light.

(l) Employing continuous moist curing.

7.9 CONVEYING

(i) Concrete shall be conveyed from mixer to forms as rapidly as practicable by methods, which shall prevent segregation and / or loss of ingredients. In case such separation occurs, concrete shall be remixed before being laid in place.

(ii) The distance between the mixer and the place of concreting and also the mode of transport of concrete shall be subject to the prior approval of the Engineer-in-Charge.

(iii) Concrete shall be deposited in the final position as early as practicable but always **within a period of 30 minutes after mixing**. This limit may be modified by the Engineer-in-Charge to suit working or weather conditions.

(iv) Plants, such as buckets, plant conveyors and/or pumping equipment, which may be used for conveying concrete from mixing plant shall be of such size, design and condition so as to ensure an even and adequate supply of concrete at the placement area.

(v) Particular attention shall be paid to prevent segregation at the ends of chutes /hopper gates and at all other points of discharge.

(vi) Methods of conveying concrete in a thin continuously exposed flow to the forms to any part of the structure shall not be permitted except for very limited or isolated sections of the work, and only when approved in writing by the Engineer-in-Charge.

(d)

(vii) Where chutes are used, they shall be so constructed and arranged as to permit continuous flow of the concrete without separation of the ingredients. Chutes shall not have a slope steeper than 1 V : 2 H.

(viii) There shall be no vertical drop greater than 1.5 m unless warranted, but subject to the approval of Engineer-in-Charge is used to confine and control the falling concrete.

(ix) Concrete may be dropped through flexible elephant-trunk chutes, provided some method is used at the lower end to retard the speed of the falling concrete and prevent it from segregating.

(x) Buckets for transporting concrete shall be manufactured as low-slump concrete buckets.

(xi) The conveying plant shall be kept free from hardened concrete and foreign materials and shall be cleaned at frequent intervals.

(xii) During hot or cold weather, concrete shall be transported in deep containers, on account of their lower ratio of areas to mass, reduce the rate of loss of water by evaporation during hot weather and loss of heat in cold weather.

(xiii) All conveying plants shall be supported independently of the forms, except as specifically permitted by the Engineer-in-Charge.

7.10 PLACING OF CONCRETE

7.10.1 General

(i) No mortar or concrete shall be placed except in the presence of the Engineer-in-Charge.

(ii) The Contractor shall provide Engineer-in-Charge with a weekly placing schedule giving the detailed location of the pours, the approximate extent of pours and the date on which the concrete shall be placed.

(iii) Concrete shall be placed only in locations where authorised and no concrete or mortar shall be placed until formwork, installation of reinforcing steel, steel ribs, piping and other embedded parts, preparation of surface and necessary clean up have been done and checked and certified by the Engineer-in-Charge as being in conformity with specifications and drawings.

(iv) Concrete placed without prior knowledge and approval of the Engineer-in-Charge shall be required to be removed and replaced.

(v) Earth foundations on which concrete is to be laid shall be firm drained soil, free from any soft mud or other objectionable material.

(vi) Whenever concrete is to be placed on earth, a layer of lean concrete of approved proportion shall first be placed before placing concrete of the specified grade. The thickness of such layer of lean concrete shall be as shown on the drawings or as directed by the Engineer-in-Charge.

(vii) No concrete shall be placed in running water. Water shall, generally, not be allowed to flow over freshly poured concrete until final set has been achieved.

(viii) Immediately, before placing concrete, all the surfaces upon which concrete is to be placed 0shall be thoroughly cleaned by the use of high velocity air and water jets or sand blasting, steel brooms, picks or other effective means, satisfactory to the Engineer-in-Charge.

(ix) All pools of water from the surface on which concrete is to be placed shall be cleaned to ensure proper bonding of fresh concrete with the rock surface. The method of disposal of water in working site shall be subject to the approval of the Engineer-in-Charge.

(x) Sufficient mixing and placing capacity shall be provided so that the work may be kept alive and free from cold joints. Formed concrete shall be placed in horizontal layers, avoiding inclined layers and construction joints.

(xi) To get a monolithic placement, it is important that each layer be shallow enough so that the previous layer is still soft and the two layers are vibrated together.

(xii) Concrete shall not be allowed or caused to flow horizontally or on slopes in the forms.

(xiii) Concrete placing on slope shall begin at the lower end of the slope and progress upward, thereby increasing compaction of concrete.

(xiv) In pneumatic placement of concrete, usual high velocity discharges shall be reduced to a point where no separation and scattering of the concrete occurs.

(xv) In order to reduce bleeding, slump shall not be more than necessary to achieve proper placement and consolidation.

(xvi) All care shall be taken to avoid separation of coarse aggregate from the concrete. Obvious groups and clusters of separated coarse aggregates shall not be permitted. They shall be removed before the concrete is placed over them, otherwise they may cause serious imperfections in the finished work. Hence particular attention shall be paid to the tendency for objectionable separation to occur at the points of discharge so that uniformity and homogeneity of concrete in placement and good workmanship is assured.

(xvii) The concrete shall drop vertically into the centre of whatever container receives it. To protect the roads, spacers, and embedded features from damage and to prevent displacement of reinforcement, concrete falling in forms shall be confined in a suitable drop chute.

7.10.2 Preparation for Placing of Concrete

(i) All surfaces on which or against which concrete is to be placed, including surface of construction joints between successive concrete placement, reinforcing steel and embedded parts, shall be thoroughly cleaned of dirt, mud, debris, grease, oil dried mortar or grout, laitance, loose particles or other deleterious matter.

(ii) Surface seepage and other water shall be so controlled, to the satisfaction of the Engineer-in-Charge, that no time during the placement or hardening of the concrete will it wash, mix with, or seep into the concrete.

7.10.3 Concrete Placement

(i) The method and equipment used for placing concrete shall be such as shall permit the delivery of concrete of the required consistency into the work without objectionable delay, segregation, porosity of loss of workability.

(ii) All surfaces of forms and metal work including reinforcement bars that have become encrusted with dried mortar or grout from concrete previously placed, shall be cleaned of all such matter or grout before the surrounding or adjacent concrete is placed.

(iii) Concrete shall be placed in lifts as shown on the drawings or as directed by the Engineer-in-Charge.

(iv) In reinforced concrete work, which have congested parts, care shall be taken to see that all the bars are properly embedded and that no voids are left. On flat, horizontal surfaces, where the congestion of steel near the forms makes placing difficult, a mortar of the same cement sand ratio as is used in the concrete shall be first deposited to cover the forms.

(v) After the surface have been prepared, all approximately horizontal surfaces or rock and construction joints shall be coated with cement slurry of water cement ratio approximately of 0.60 by weight or as directed by the Engineer-in-Charge. It shall then be covered with layers of mortar approximately 50 mm to 75 mm thick for rock surface and approximately 15 mm thick for construction joints. The mortar shall have the same proportion as that of concrete mix unless otherwise prescribed by the Engineer-in-Charge. The consistency shall be suitable for placing and working in the manner hereinafter specified. The mortar shall

be spread uniformly and thoroughly with stiff brooms into all irregularities of the surfaces. Concrete shall then be immediately laid upon the fresh mortar.

(vi) No concrete shall be placed in running water or during rain, high winds, dust storms, excessive heat or cold and similar conditions without prior approval of the Engineer-in-Charge.

(vii) In all cases, concrete shall be deposited as nearly as practicable directly in its final position and shall not be caused to flow by vibrators or otherwise in a manner which shall permit or cause segregation.

(viii) The maximum time internal between placing successive layers within a lift shall not exceed 30 minutes. However, depending upon job requirements and climatic conditions, the Engineer-in-Charge can allow to increase this time interval using appropriate methods of vibration/agitation.

(ix) Concrete shall not be piled up in the forms in a manner that causes movement of the unconsolidated concrete, or permit mortar to escape from the coarse aggregate.

7.10.4 Rate of Placing of Concrete

(i) Concreting shall be done as a continuous operation until the structure or section is completed or until a satisfactory construction joint can be made. The Contractor shall make all arrangement necessary to maintain continuity of concrete placing in any particular pour during meal periods, shift changes, or any other such interruptions.

(ii) Concrete shall not be placed faster than the placing crew can compact it properly.

(iii) In placing thin members and columns, precaution shall be taken against too rapid placement which may result in movement or failure of the form due to excessive lateral pressure. An interval of at least 24 hours, unless otherwise approved or directed by the Engineer-in-Charge, shall elapse between the completion of columns and walls and the placing of slabs, beams or girders supported by them.

(iv) The rate of placing shall be such as to have no objectionable effect on placement of concrete, particularly near forms and in and around embedded equipment where the rate shall not exceed the limit placed by the Engineer-in-Charge.

7.10.5 Consolidation of Concrete

(i) Consolidation of newly placed concrete shall ordinarily be done with internal vibrators of approved design. The equipment of vibration shall have adequate power and shall be of high frequency, rugged and reliable.
(ii) Operators of vibrators shall be experienced, competent in handling these devices.
(iii) Ample stand-by-units and parts as well as systematic servicing shall be provided.

(iv) Vibrators shall not be used to cause concrete to move more than a short distance laterally, otherwise fine wet material may run ahead and separate from the coarse aggregate.

(v) Inadvertent or unintended revibration of concrete is beneficial provided the concrete becomes momentarily plastic again during revibration. Revibration shall be resorted to only after specific instructions are given by the Engineer-in-Charge.

(vi) Where Vibrator is used to full advantage for consolidation of newly placed concrete, no supplementary rodding or other working of the concrete is necessary.

(e)

(vii) Concrete shall be compacted and worked into all corners and angles of forms, obstructions, blockouts, locations with congested reinforcement and around embedded items. Special care shall be taken to attend to these places with ample, properly applied additional vibration or rodding as the case may be, without permitting the concrete materials to segregate.

(viii) Internal vibrators of approved weight and frequency 7000 to 9000 r.p.m. to secure maximum consolidation shall be used.

(ix)External from vibrators of an approved type shall be used only in inaccessible locations and where it is impracticable to use immersion type vibrators after their use has been specifically authorised by the Engineer-in-Charge. The form shall be designed to receive vibrations without losing shape and causing leakage of mortar.

(f)

(x) The immersion type mechanical vibrators, complying with **IS : 2505-1980**, electric, air driven of diesel, shall generally be inserted vertically and the vibrating head shall be allowed to penetrate under the action of its own weight. In very shallow concrete, some consolidation can be obtained by using vibrators in horizontal position.

(g)

(xi)Internal vibrators, when used, shall be inserted at regular intervals and vibration, with the vibrator fully into the layer being compacted, shall be continued till acceptable degree of compaction has been achieved taking care to avoid excessive paste and laitance.

(xii) The entire depth of new layer of concrete shall be vibrated and ordinarily the vibrators should penetrate the layer below (which has not yet become rigid) for several millimeters to ensure thorough bond between the layers.

(xiii) Under ordinary job conditions, there is little likelihood of damage from direct revibration of lower layer or by vibration transmitted by embedded steel provided the disturbed concrete still is or again becomes plastic. Vibrators shall not, however, be inserted into lower courses that have commenced final set nor shall they be directly applied to or allowed to disturb reinforcement extending into hardened or partially hardened concrete.

(xiv) Systematic spacing of points of vibrators shall be established to ensure that no portions of the concrete are missed. It shall be ensured that zones of influence overlap and the concrete is properly consolidated.

(xv) In compacting the surface of a concrete lift, the coarser particles of the aggregate in the surface shall be embedded while the concrete is being vibrated, but the surface left with the desired degree of roughness.

(xvi) Disturbance of the surface concrete at construction joints during early stage of hardening shall be on timber walkways constructed so as not to cause injury to the concrete.

(xvii) When smooth surfaces are required, for all surfaces which shall be permanently exposed to the weather and for all surfaces next to embedded metal work around which it is desired to prevent leakage, the adjacent concrete shall be properly vibrated, spaded or tamped.

(xviii) To ensure even and dense surfaces which are free from aggregate pockets, honey combing or air holes, it may be necessary to supplement internal vibration with hand spading or tamping all along the boundaries of the concrete and around embedded parts, while the concrete is plastic under vibrating action.

7.11 Concrete in R.C.C. Frames/Walls/Slabs

(i) Concrete shall be placed in lifts of heights as shown on the approved construction drawings or as directed by the Engineer-in-Charge. Within each lift, concrete shall be deposited in approximately horizontal layers about 40 cm in thickness unless otherwise directed by the Engineer-in-Charge.

(ii) At locations where lift heights are not shown on the drawings, the Contractor shall submit to the Engineer-in-Charge for approval, details of the placing procedure which he proposes. No concrete shall be placed at such locations without the prior approval of the Engineer-in-Charge.

(iii) Slabs shall be placed in one lift unless otherwise indicated or directed by the Engineer-in-Charge.

(iv) In walls, lifts shall terminate at such levels as will conform to the structural requirements.

(v) The placement of concrete shall be carried out at such rate and in such a manner that the formation of cold joints is prevented.

(vi) Where slabs and beams are placed continuously with walls and columns, the concrete in walls and columns shall have been in place for at least 2 hours or for a longer period when so directed by the Engineer-in-Charge before placing concrete in the slabs and beams.

7.11.1 Concrete for Blockouts

(i) Blockouts for gate guides, seals or tack assemblies of the like shall be provided as indicated on the drawings.

(ii) After the assemblies have been installed and adjusted, the blockout recesses shall be filled with concrete as specified on the approved construction drawings or as directed by the Engineer-in-Charge.

(iii) Before installing the components to be embedded in blockout concrete and before depositing mortar or concrete, the surfaces of the blockout shall be cleaned in the manner specified for cleaning construction joints.

(iv) Exceptional care shall be taken in placing mortar or concrete in the blockouts to ensure satisfactory bond with the concrete previously placed and to secure complete contact with all components embedded in the blockouts.

(h)

7.11.2 Concrete Deposited Under Water

(i) Concrete shall be deposited in water only with the prior approval of the Engineer-in-Charge.

(ii) Concrete placed underwater shall be deposited by a tremie or by a valved tremie.

(iii) The methods and equipment used shall be subject to the prior approval of the Engineer-in-Charge.

(iv) Concrete buckets shall not be permitted for underwater placement of concrete.

(v) The tremie seal shall be affected in a manner which will not produce undue turbulence in water around the pipe. The discharge end shall be kept submerged continuously in the concrete and the concrete pumped in without interruption until the concrete has been brought to the required height.

(vi) The tremie shall not be moved horizontally during a placing operation and a sufficient number of tremies shall be provided so that concrete does not have to flow horizontally, a distance of more than 3 metres.

7.12 CHIPPING AND ROUGHENING OF CONCRETE SURFACES

(i) Surface upon or against which additional concrete is to be placed shall be chipped and roughened to a depth of not greater than 25 mm.

(ii) The roughening shall be performed by chipping, sand blasting or other satisfactory methods and in such manner as not to loosen, crack or shatter any part of the concrete beyond the roughened surface.

(iii) After being roughened, the surface of the concrete shall be cleaned thoroughly of the loose fragments, dirt and other objectionable substances and shall be sound and hard and in such condition as to assure good mechanical bond between old and new concrete.

(iv) All concrete which is not hard, dense and durable shall be removed to the depth required to secure a satisfactory surface.

(v) Prior to placement of new concrete against the old concrete surfaces and the concrete surfaces over which flood has passed shall be chipped and roughened to a depth of not greater than 25 mm or sand blasted to make them clean and free from loose materials/laitance, oil, grease, etc. so as to develop good bond between the old concrete and new concrete.

(vi) Just before placement of concrete, the rock/concrete surface shall be cleaned by high velocity water jet (about 5 kg/cm^2 at the nozzle) followed by careful blowing of high

pressure air jet so as to make the surface free from dirt, mud, debris, grease, oil, laitance, grout, loose particles and other deleterious matter. Contractor shall also use picks, wire brushes, if necessary for cleaning. All pools of water shall be removed from depressions.

7.13 DEFECTIVE AND DAMAGED CONCRETE

Concrete which is damaged from any cause and which is not manufactured, placed and compacted in accordance with these specifications and is found to have lower strength, density etc. than specified, as determined from test samples or core samples, shall be removed and replaced by the Contractor.

7.14 FINISHING OF CONCRETE

7.14.1 Finishing of Formed Surfaces

Except as otherwise specified or directed, all permanently exposed concrete surfaces and other waterway surfaces requiring durability under water shall be finished in the following manner:

(i) Any damage to finished concrete resulting from the action of removing formwork or from any other cause shall be repaired to the satisfaction of the Engineer-in-Charge. Immediately on removal of the form, the surface shall be examined and all porous honeycombed or defective concrete removed and repaired as specified herein.

(ii) All imperfections or ridges due to joints in the formwork, shall be removed by light chipping or grinding down if necessary, to produce a smoother surface.

(iii) When the treatment of a surface has been completed, the surface shall be cured.

(iv) All patches and mortar filled pits on exposed surfaces shall be neat and of the same colour and texture as the adjoining concrete.

(v) The finished surfaces concrete shall be true, sound, smooth and free from fins, offsets, pits, depressions, voids, blemishes and other defective concrete and surface irregularities and shall be in accordance with the requirements for the particular class of finish specified herein or as shown on the drawings.

(vi) Finishing work shall be done only by skilled workman in the presence of the Engineer-in-Charge and shall be performed within 4 weeks of placing.

(vii) Before final acceptance of the work, Contractor shall clean all exposed concrete surfaces of all encrustations of cement, mortar or grout, to the satisfaction of the Engineer-in-Charge. Concrete shall not be considered finished until all required repair work and finishing have been completed.

7.14.2 Finishing of Unformed Surfaces

Unformed surfaces shall be finished by one or more methods of screeding, floating and trowelling and working of the surfaces shall be done at the proper time, employing experienced men and shall be just sufficient to produce the desired finish.

(i) Screeding

(a) It gives the surface its approximate shape by striking off surplus concrete immediately after completion and shall be accomplished by moving a straight edge or template with a swing motion across wood or metal strips which have been established as guides.

(b) Where the surface is curved, a special screed shall be used.

(ii) Floating

Shortly after the concrete is screeded, the surfaces shall be brought true to from and grade by working it sparingly with a wooden float. If a coarse textured finish is specified or if the surface is to be steel trowelled, a second or final floating shall be performed after some stiffening has occurred and the surface moisture film or shine has disappeared.

(iii) Trowelling

(a) If a smooth dense finish is desired, floating shall be followed by steel trowelling some time after moisture film or shine has disappeared from the floated surfaces and when the concrete has hardened sufficiently to prevent fine material and water from being brought upto the surface. Excessive trowelling at an early stage as would tend to produce creaking or result in a surface that is too hard to finish properly shall be avoided.

(b) Trowelling shall, therefore, be done at the appropriate time and shall have the surface smooth, even and free of trowel marks and ripples. A fine textured surface that is not slick shall be obtained by trowelling lightly over the surface with a circular motion keeping the trowel flat on the surface of the concrete. Where a hard steel trowelled finish is required, trowelling shall be continued until it no longer produces noticeable compaction and the surface has a glossy appearance, trowelling pressure being increased gradually as the operation progresses.

(c) The use of any finishing tool in areas where water has accumulated shall be prohibited. Operation on such areas shall be delayed until the water has been absorbed or has evaporated or has been removed by draining, mopping or other means.

(d) All joints and edges on unformed surfaces, that shall be exposed to view, shall be finished with suitable moulding tools with rounded, bevelled or filleted edge, as directed by the Engineer-in-Charge. Unless the use of other slopes or level surface is indicated on the drawings as directed, narrow surfaces such as top of walls or tunnel portals shall be sloped approximately 9 mm per 300 mm of width. Broader surfaces as walls, roadways, platforms and decks shall be sloped approximately 6 mm per 300 mm.

(e) Where separate floor finish is specified or directed, the concrete shall be struck of sufficiently below grade to allow for the subsequent placing of a finished floor. The surface of such concrete shall be left rough.

(f) As soon as the condition of the base permits and before it has hardened fully, all dirt, laitance and loose aggregate shall be removed from the surface, by means of water jets and

wire brooms leaving the coarse aggregate slightly exposed and the surface made suitable for taking further concrete.

7.14.3 Tolerance for Concrete Construction

(i) General

(a) The contractor shall construct all concrete structure to the exact lines, grades and dimensions established. However, inadvertent variations for the established lines, grades and dimensions shall be permitted to the extent set forth herein, provided, that the Engineer-in-Charge reserves the right to diminish the tolerances set forth herein if such tolerances impair the structural action or operational function of the structure.

(b) Where tolerances are not stated in the specifications or on the drawings for any individual structure or features thereof, permissible deviations shall be interpreted in conformity with the provisions of this paragraph.

(ii) Tolerance for Surface Finishes

(a) Surface finishes shall generally conform to the types and tolerances indicated in the table given below, unless otherwise specified on the drawings or as required by the Engineer-in-Charge.

(b) Positive tolerance shall be measured outside and negative inside the lines and grades defining the structure on the drawings.

Type of Finish	General Area of Application and method of Forming	Tolerance (mm)
1	**2**	**3**
F1	Formed surfaces of construction joints and other surfaces which shall not be permanently exposed. The surface shall required no treatment after form removal, other than repair of defective concrete and specified curing, or treatment as specified for construction joints.	+ 10 - 10
F2	All permanently exposed formed surfaces for which type F3 finish is not specified. Form sheathing or lining shall be placed so that joint marks on the concrete surface shall be in general alignment, both horizontally and vertically and conform to a standard pattern. Immediately on the removal of forms, all unsightly ridges of fines shall be removed; all holes left by removal of ends of form roads shall be neatly filled with mortar and surfaces treated to meet the required tolerances by tooling and rubbing.	+5 -5
F3	Formed surfaces which shall be exposed to flowing water shall be hard, smooth and dense, free from offsets, pits, voids, air holes and irregularities, and shall be chipped, ground and thoroughly cleaned as necessary to conform to the required tolerances.	+5 - 5
U1	Unformed, screeded surfaces which shall be covered by fill materials, static water or concrete. Type U1 finish shall be used as the first stage of type U2 and U3 finishes. Finishing shall consist of sufficient levelling and screeded to produce an even, uniform surface meeting the required	+ 10 - 10

Type of Finish	General Area of Application and method of Forming	Tolerance (mm)
1	2	3
	tolerance.	
U2	Unformed surfaces not permanently concealed by fill or concrete or not required to receive Type U3 finish. (Type U2 finish shall be used as the second stage of Type U3 finish). Floating by means of hand or power driven equipment shall be started as soon as the screeded surface has stiffened sufficiently and shall be the minimum necessary to produce a surface that is free from screed marks and uniform in texture if type U3 finish is to be applied, floating shall be continued until a small amount of mortar without excess water is brought to the surface so as to permit effective trowelling.	+5 - 5
U3	Unformed, screed surfaces which shall be exposed to flowing water. This finish shall be applied by steel trowelling after the concrete has hardened enough to prevent excess of fine materials and water from being brought to the surface free from blemishes, ripples and trowels marks. After the surface has nearly hardened, it shall be trowelled once more until the surface is hard and glossy in appearance.	+3 - 3

7.15 EMBEDMENTS IN CONCRETE

7.15.1 Embedded Parts

(i) Before placing concrete, care shall be taken to ensure that all embedded parts are firmly and accurately fastened in place as indicated on the drawings or as directed.

(ii) All embedded parts shall be thoroughly cleaned, free from all foreign matter such as scale, rust, oil, etc.

(iii) Concrete shall not be placed on embedded parts unless these are checked and approved by the Engineer-in-Charge.

(iv) Parts of gates, gate hoists, valves, operating machines and other control equipment as also the anchor bolts, structural steel plates and bearings shall be installed/embedded in concrete/rock as shown on the drawings or as directed.

(v) Embedded parts for pump and other equipments as needed will be supplied to the Contractor and the same shall be embedded in concrete as shown on the drawings or as directed by the Engineer-in-Charge.

(vi) If concrete is placed by the without correctly placing in position, the necessary embedded parts, concrete shall have to be removed and replaced to enable such embedded parts to be installed in position.

(vii) Care shall be taken not to disturb or displace embedded parts during concrete placement.

7.15.2 Water Stops

(i) Polyvinyl Chloride (PVC)/rubber water stops of width and section as shown on the drawings approved for construction shall be furnished and installed for water tight construction at various locations of concrete structures/components covered under these specifications. In order to ensure proper alignment and fixing of water-stops in correct position/place, the same shall be rigidly secured to the formwork or reinforcement steel as directed/approved by the Engineer-in-Charge. Number of joints in PVC/ water stops, when installed in place shall be the barest minimum and joints, thus made, shall be suitably vulcanised/welded by the use of best method/engineering practice satisfactory to the Engineer-in-Charge. The PVC water stop shall be properly protected from sunrays and weather.

(ii) All types of water stops shall be tested as per IS : 8543 in a recognised laboratory prior to transport to the site. Test specimens shall be furnished by the manufacturer and the tests shall be carried out at the manufacturer's place.

(iii) Water stops shall be tested as to their tensile strength, elongation, tear resistance, stiffness, water absorption, gravity, effect of alkali and impact resistance etc.

(iv) The Contractor shall submit to the engineer for approval the test result from recognised institution showing that the material supplied meets the requirements specified. The Engineer may carry out the additional tests, for which the Contractor shall supply specimens from the same material to be used in the work. Test specimens, if required, shall be of the shape and dimensions as required in the individual tests methods.

7.16 EXPANSION AND CONTRACTION JOINTS

i. Expansion and contraction joints shall be constructed at such points and of such dimensions as indicated on the drawings or as required by the Engineer-in-Charge. The method and material used shall be subject to the approval of the Engineer-in-Charge.

ii. Standard bitumen sheets, impregnated with saw dust or any other filler material and sealing compounds, required to be placed in the expansion joints, shall be fixed in position as shown on the drawings or as directed by the Engineer-in-Charge.

7.17 CURING AND PROTECTION OF CONCRETE

(i) Plant and materials required for curing and protection of concrete shall be available at the location of each concrete placement before concrete placement is started and the water used for curing shall meet the requirement set out in these documents.

(ii) All concrete shall be protected against injury until final acceptance.

(iii) Exposed finished surfaces of concrete shall be protected from the direct rays of the sun for at least 72 hours after placement.

(iv) Fresh exposed concrete shall also be protected from the action of the rains, flowing water and mechanical injury.

(v) No fire shall be permitted in direct contact with concrete at any time.

(vi) Concrete in which standard Portland cement is used shall be kept continuously moist for not less than 14 days for normal concrete and 21 days for concrete containing puzzolana, by covering with water saturated materials or a system of perforated pipes, mechanical sprinklers or porous hose or by any other approved method. Curing period where special cement may be used shall be as approved by the Engineer-in-Charge.

(vii) Construction joints shall be cured in the same manner as the other concrete and shall also, if practicable, be kept moist for at least 72 hours prior to the placing of additional concrete upon the joint.

(viii) Horizontal surfaces shall be cured by sprinkling water or by covering with damp sand or may be cured by the use of wet quilts or mats which will satisfactorily supply the required curing water. If damp sand or quilt is used for curing, it shall later be completely removed. The time of applying damp sand shall be specified by the Engineer-in-Charge before which curing shall be carried out by other approved methods.

(ix) The method of keeping formed concrete surface moist shall be continuous sprinkling or spraying of water as may be necessary to prevent any portion of the surface from drying during the specified period.

(x) The water and other methods of curing shall be so handled as not to stain concrete surfaces, which shall be exposed.

(xi) The actual method of curing adopted shall be subject to the approval of the Engineer-in-Charge.

(xii) The contractor shall have on hand and ready to install before actual concrete placement is started, all equipment needed for adequate curing and protection at all locations of concrete placement.

(xiii) In limited areas and for special purposes, the use of an approved and properly applied compound may be permitted at the discretion of the Engineer-in-Charge to restrict the evaporation of the mixing water. Such curing compound shall be of the surface membrane type which will thoroughly seal the surface. Curing compound shall not be used on joints where bonding is required.

(xiv) Curing compounds shall be applied according to the manufacture's recommendations to provide a continuous uniform membrane over all areas. Curing compounds shall be applied only after moist curing has been carried out for at least 24 hours.

(xv) A curing compound shall not be used on any unformed surface where, in the opinion of Engineer-in-Charge, the irregularities in that surface would prevent the membrane forming an effective seal, on any surface which has a temperature lower than manufacturer's recommended application temperature, or any surface where a bond is required for additional concrete, or where a curing compound is placed on a

surface where a bond is required, it shall be removed by sand blasting or by other means satisfactory to the Engineer-in-Charge.

(xvi) Curing membranes shall be protected from damage at all times.

(xvii) Care shall be taken not to disturb the steel reinforcement projecting from any placement for at least 24 hours after the completion of such placement.

(xviii) Finished concrete surface shall be protected from stains or abrasion and surface of edges likely to be injured during the construction period shall be kept properly protected by leaving forms in place or erecting protective covering satisfactory to the Engineer-in-Charge.

(xix) In case, the curing operations are inadequate or unsatisfactory, the Engineer-in-Charge shall be entitled to take such steps as he may deem necessary to make good the deficiencies and defects.

7.18 REPAIR OF CONCRETE

(i) Repair of concrete shall be performed by skilled workmen and in the presence of the Engineer-in-Charge.

(ii) No repair work shall be carried out until the Engineer-in-Charge, has inspected the location of the proposed repair and accepted the method of repair.

(iii) The Contractor shall correct all imperfections on the concrete surfaces as necessary to produce surfaces that shall conform to the required standards.

(iv) All materials, procedures and operations used in the repair of concrete shall be subject to approval by the Engineer-in-Charge.

(v) Surfaces of concrete finished against forms shall be smooth and free from projections. Immediately upon the removal of forms and within 24 hours thereof, wherever practicable, all unsightly ridges or fines shall be removed and any local bulging on exposed surfaces shall be remedied by tooling and rubbing. All holes left by the removal of fasteners from the tie rods shall, after being reamed with a toothed reamer, be neatly filled with dry pack mortar.

(vi) All honeycombed, porous, fractured or otherwise defective concrete and surface concrete in which, in the opinion of the Engineer-in-Charge, additions are required to bring it to the prescribed lines, shall be removed by chipping concrete.

(vii) The chipped openings shall be sharp edged and keyed, and shall be filled to required lines with fresh concrete or as found suitable. Where concrete is used for filling, the chipped openings shall be not less than 100 mm in depth and the fresh concrete shall be reinforced and dowelled to the surface of the openings as directed by the Engineer-in-Charge.

(viii) Dry pack mortar shall consist of one part of cement to two parts of sand by volume and just enough water so that the mortar as used sticks together on being moulded into a ball by slight pressure of the hands and does not free water when so pressed but leaves the hands

damp. The mortar shall be fresh when placed and any mortar that is not used within 30 minutes, after preparation shall be wasted with all consequences to the Contractor.

(ix) The mortar shall be placed in layers not more than 25 mm thickness after being compacted and each layer shall be thoroughly tamped to the satisfaction of the Engineer-in-Charge. Each layer except the last shall be roughened thoroughly to provide effective bond with the succeeding layers. The last or finishing layer shall be smoothened to form a surface continuous with the surrounding concrete. Dry pack mortar shall be used for filling behind reinforcement or for filling holes that extend completely through a concrete section. Shotcrete shall be used for holes too wide for dry pack mortar filling and too shallow for concrete filling and no deeper than the far side of the reinforcement that is nearest to the surfaces.

(x) All patches shall be bonded thoroughly to the surface of the chipped openings and shall be sound and free from shrinkage cracks and trummy areas.

(xi) Concrete surfaces where high velocity flows may occur and as required by the Engineer-in-Charge, repair to the surfaces having F3 and U3 finishes shall be bonded with an epoxy adhesive acceptable to the Engineer-in-Charge.

(xii) All repairs to the surface of concrete for flowing water shall be ground smooth to meet the tolerances set out in the specifications

7.19 CONSTRUCTION JOINTS

(i) Concrete surfaces, which become so rigid, by reason of limitations in the rate of placing of concrete imposed by these specifications or by reason of delays in construction progress, that in the opinion of the Engineer-in-Charge, the new concrete cannot be integrally incorporated with that previously placed, shall be defined as construction joints.

(ii) Construction joints shall be located in the positions shown on the approved drawings or as directed by the Engineer-in-Charge and the Contractor shall not be permitted to make any additional joints or deviate from the joints indicated on the approved drawings without the written authorisation of the Engineer-in-Charge.

(iii) Joints at exposed surfaces of concrete shall be straight and continuous, as shown on the drawings or otherwise directed.

(iv) The concrete of the earlier pour shall be hacked to produce a rough surface or green cut with air-water jet or by sand blasting after the concrete has hardened sufficiently as directed by the Engineer-in-Charge. Before placing new concrete, the surface shall be restored to the condition existing immediately after hacking or green cutting by means of another washing with air-water jet, vigorous brushing, sand blasting etc.

(v) All the joints shall be cleaned by the Contractor, to the satisfaction of the Engineer-in-Charge. All intersections of construction joints with concrete faces, which will be exposed to view, shall be made straight, level and in plumb.

(vi) All exposed construction joints shall conform to the requirements of aesthetic and their pattern shall be subject to the approval of the Engineer-in-Charge. Surfaces of the construction joints, which have been permitted to dry by reasons of the succeeding layer

not placed within the specified moist curing period, shall be kept moist for at least 72 hours prior to placing the succeeding layers.

(vii) Horizontal construction joints shall be arranged wherever possible to coincide with joints in the formwork.

(viii) To prevent feather edges, the construction joints at the tops of horizontal lifts near sloping exposed concrete surface shall be inclined near the exposed surface so that the angle between such inclined surface and the exposed concrete surface shall not be less than 50 degrees.

(ix) When the work has to be resumed on a surface which has hardened, such surfaces shall be roughened and new concrete placed after taking all measures mentioned in Para 9.10.3 hereof.

(x) The use of a retarder shall not relieve the Contractor of the responsibility of producing surfaces at construction joints as specified and to the satisfaction of the Engineer-in-Charge.

(xi) Disturbance of surface concrete at the joints shall be avoided during the early hardening period. Before placing the succeeding layer, the surface of the construction joint shall be thoroughly cleaned and loose, defective or fractured concrete shall be removed satisfactorily.

7.20 OTHER RELATED EXPRESS

Besides the above, following items including others shall be carried out by the Contractor:

(i) Collection of seepage water or water inflow from the surrounding work site and diverting it into the drainage systems to maintain working area dry during execution.

(j) Developing alternative sources of aggregates by the Contractor and the resulting additional material testing.

(k) Pumping of the Concrete and plasticizers.

(l) Replacement or repair of concrete damaged during blasting carried out by the Contractor.

(m) Making stockpiles for coarse and fine aggregate.

(n) Forming expansion and contraction joints including making drainage and other holes where such joints occur.

(o) Filling of holes left by the removal of concrete cores with the concrete of the same grade.

7.21 MEASUREMENT AND PAYMENT

Measurement of concrete work shall be made for making progressive payments against the total contract price using the agreed item rates entered in the contract document.

8 STEEL FOR REINFORCEMENT

8.1 COPE OF WORK

The specifications described hereunder relate to the work which includes all labour, materials, equipment and services required for the supply, handling, storing, cutting, bending, cleaning, placing and fastening into position all reinforcing steel as shown on the drawings, to be carried out by the Contractor under this contract.

8.2 SUBMITTALS

(i) **Within 30 days** from the date of issue of the Letter of Acceptance, but before procuring the equipment or mobilisation to the site, the Contractor shall submit to the Engineer-in-Charge, the description and drawings showing the sufficient details of the layout and capacity of the equipment proposed for the fabrication of reinforcing steel.

(ii) **At least 30 days** in advance of the reinforced concrete works being carried out on the site, the Contractor shall submit to the Engineer-in-Charge for approval, detailed bar list and bending diagrams showing the number, size, length and bending of all bars required for various parts of the work on the basis of the reinforcement drawings approved by the Engineer-in-Charge from time to time during the progress of works.

(iii) The Engineer-in-Charge reserves the right to ask for any additional information deemed necessary to be included in the submitted documents.

8.3 STANDARDS

(i) The cutting, welding, placement and binding of reinforcing steel shall conform to following Indian Standards or, where not covered by these standards, to their equivalent International Standards.

IS : 456-2000	
IS : 1786-1985	(Reaffirmed 1990)
IS : 2502-1963	(Reaffirmed 1990)
IS : 2751-1979	(Reaffirmed 1992)
IS : 9417-1989	

(ii) In case of conflict between the above standards and the specifications given herein, the specifications shall take precedence.

8.4 GENERAL

(i) Steel for reinforcement shall conform to the standards and requirements outlined in the **Section on "Materials for Construction".**

(ii) Cutting, bending, cleaning, placing and fastening in position of the reinforcement steel shall conform to the requirements of relevant Indian Standards and as shown on the drawings.

(iii) Transportation and storage of reinforcing steel shall conform to the requirements outlined.

8.5 FABRICATION

(i) All bars shall be cut and bent in accordance with the bar bending schedules approved by the Engineer-in-Charge.

(ii) Reinforcing steel bars shall be cut and bent on the site of the works.

(iii) Reinforcing steel shall not be straightened or rebent in a manner that will damage the materials. Bars with kinks or bends other than those indicated on the drawings and schedules shall not be used.

(iv) Shorter lengths of steel shall not be used in places where continuous lengths are required as per the drawings without the approval of the Engineer-in-Charge. Shorter bars, if approved for use, shall be lapped or spliced to achieve continuity in accordance with the requirements of relevant Indian Standards or as approved by the Engineer-in-Charge.

(v) Bars shall be bent cold to the shape and dimensions shown on the drawings using a bar bender operated by hand or power to attain the proper radii of bends.

(vi) A hook at the end of the M.S. bar, if used, shall have an inner diameter not less than four times the diameter of the bar and shall have length of straight part beyond the curve of at least four times the diameter of the bar. Hooks shall be used only where shown on drawings or as required by the Engineer-in-Charge. The radii of bends for stirrups and ties shall not be less than twice the diameter of the bar.

(vii) Heating of reinforcement bars to facilitate bending shall not be permitted.

(viii) The reinforcement available from rejected concrete shall not be used without prior approval of the Engineer-in-Charge.

8.6 PLACING

(i) Before being placed in position, the reinforcing steel shall be thoroughly cleaned of loose mill scale and rust, grease, paint, or other coatings that would reduce bond. All splashed concrete which has dried on reinforcing steel shall be removed.

(ii) Reinforcing steel to be incorporated in the works shall be placed accurately in position as shown on the drawings and shall be held firmly in place during the placing and setting of the concrete.

(iii) Reinforcing steel shall be placed such that there will be a clear distance of at least 50 mm between the reinforcing steel and anchor bolts or embedded metal work.

(iv) Reinforcing steel shall be maintained in position by the use of small concrete blocks, steel chairs, steel spacers, steel hangers and other steel supports and ties, acceptable to the

Engineer-in-Charge at sufficiently close intervals so that they do not either sag between supports or be displaced during placing of concrete or by any operation on the work. Wood supports or spreaders shall not be used. All intersections shall be securely tied except that where the bar spacing is less than 300 mm in each direction, when only alternate intersection need to be tied.

(v) Binding wire and steel chairs shall not be carried to permanently exposed surfaces and shall be subject to the same requirements with regard to concrete cover as for the reinforcing steel.

(vi) Special care shall be exercised to prevent any disturbances of the reinforcement in concrete that has already been placed. The reinforcement after being placed in position shall be maintained in a clean condition until it is completely embedded in concrete.

(vii) The longitudinal bars shall be straight and fixed parallel to each other and to the sides of the form. The ties, links and stirrups connected to the bars shall be tightly fixed so that the bars are properly braced. The inside of their curved part shall be in actual contact with the bars around which they are fixed and their position shall be exact as shown on the drawings.

Wire for tying reinforcement shall be black annealed iron wire. The diameter of wire shall be adequate and shall have ultimate strength of 5.63 tonnes per sq.cm and yield point of not less than 3.87 tonnes per sqm.

(viii) Reinforcement for lining in special locations, as required, may be fixed in position by means of anchor rods or supporting and hanger rods as approved by the Engineer-in-Charge. In difficult locations, tack welding of bars at isolated spots may be permitted to keep these bars in position provided that diameter of the bars is not reduced adjacent to the weld.

(ix) The steel bars shall be joined by providing lap joints in accordance with the requirements of the relevant Indian Standards or as approved by the Engineer-in-Charge. "Bar-Grip" type joints may also be adopted by the Contractor for deformed bars of 25mm diameter and above, subject to the approval of the Engineer-in-Charge. Splices at points of maximum stress shall however, be avoided. Splices in adjacent bars shall be staggered as directed by the Engineer-in-Charge. Lap length of bars shall be as shown on the drawings. This length may be changed by the Engineer-in-Charge in special locations.

(x) Sufficient concrete coverage as indicated on the drawing shall be provided to protect reinforcement from corrosion. All protruding bars from which other bars are to be attached and which shall be exposed to action of the weather for long period shall be protected from rusting by thin coat of neat cement grout. Accurate record shall be kept at all the times of the number, sizes, lengths and weights of bars placed in position for different parts of the work.

(xi) Where reinforcement bars are bent aside at construction joints and afterwards bent back into their original positions, care shall be taken to ensure that at no time is the radius of the bend less than 4 times of bar diameter for plain mild steel or 6 times of bar diameter for deformed bars. Care shall also be taken when bending back bars to ensure that the concrete around the bar is not damaged.

8.7 WELDING FOR REINFORCEMENT BARS

(i) Lap splices shall not be used for bars larger than 36 mm diameter, which may be welded with the approval of the Engineer-in-Charge. In case where welding is not practicable, lapping of bars larger than 36 mm may be permitted, in which case, additional spirals shall be provided around the lapped bars. Where welding is approved, the Contractor shall prepare at least three samples of butt welds as directed by the Engineer-in-Charge in recognised laboratory. If the results are satisfactory, the Engineer-in-Charge may allow welding in place of lap joints. The decision of the Engineer-in-Charge in this regard shall be final. The joint shall be butt welded by the electric-arc-method. The ends of the bars shall be cleaned of all loose scale, rust, grease, or other foreign materials and all welding shall conform to the relevant standard specifications for welding or reinforcement bars used in reinforced concrete construction or as directed by the Engineer-in-Charge.

(ii) A weld shall be considered unsatisfactory if it fails to sustain a tensile stress of at least 90% of the tensile strength of the bar in which the weld has been made.

8.8 TOLERANCE FOR PLACING REINFORCING STEEL

Unless otherwise required by the Engineer-in-Charge, reinforcement shall be placed within the following tolerances.

(a) For effective depth of 200mm or less $\pm$ 10mm
(b) For effective depth more than 200mm $\pm$15mm

The cover shall, in no case, be reduced by more than one-third of specified cover or 5 mm whichever is less.

8.9 Tests

The Contractor shall carry out tests

(a) for checking butt welds to replace lapping/ splicing of reinforcing bars.
(b) for to quality of steel reinforcement to be used as per Indian Standards or as directed by the Engineer-in-Charge.

8.10 Measurements

Measurement of steel reinforcement placed will be made for making progressive payments against total contract price as per the item rate entered in the Contract document.

9 FORMWORK

9.1 SCOPE OF WORK

(i) The specifications described hereunder relate to the Formwork. This work shall include all labour, plant and materials and services related to the design, fabrication, supply, erection,

maintenance and removal of formwork and false work to be carried out by the contractor under this contract.

(ii) The formwork shall be fabricated and erected to the dimensions of finished surfaces of concrete / masonry as shown on the approved construction drawings or as otherwise directed by the Engineer-in-Charge.

9.2 SUBMITTALS

(i) **At least 30 days prior** to the construction of formwork for concrete and other works, the contractor shall submit, to the Engineer-in-Charge, the following:

a) Shop drawings, details and structural computations of the formwork construction.
b) Details of materials, which the contractor intends to use for the fabrication of formwork.

(ii) The Engineer-in-Charge reserves the right to ask for any additional information deemed necessary to be included in the submitted documents.

9.3 GENERAL

(i) Forms or formwork shall mean the mould into which concrete / masonry is placed.

(ii) False work or shoring shall mean the structural supports and bracing for forms used in any part of the works.

(iii) All exposed concrete surfaces having slopes of 1.5 : 1 or steeper shall be formed unless otherwise directed.

(iv) Where the character of the natural material cut in, to receive concrete is such that it can be trimmed to the prescribed lines, the use of forms shall not be required.

(v) In this specifications form work / false work has been indicated for concrete work, the same shall apply for other works also like masonry etc.

9.4 MATERIALS

(i) Forms shall be of timber, steel or other approved material except that the sheeting for all exposed surfaces, where form lining is not specified, shall be of tongue and groove timber of uniform width unless otherwise directed by the Engineer-in-Charge.

(ii) All materials used in formwork construction shall be of adequate strength and quality for their intended purpose and shall be satisfactory to the Engineer-in-Charge.

(iii) Timber shall be sound, straight, free from warp, decay and loose knots and shall be dressed smooth.

(iv) Where plywood is used, it shall be non-warping, non-wrinkling and manufactured with special water-proof glues. Plywood sheets shall be of uniform width and length.

(v) The surface of steel or steel lined forms shall be smooth. Forms with dents, buckled areas or other surface irregularities shall not be used.

(vi) Reuse of forms and form lumber shall be allowed only if they are cleaned and repaired and capable of producing the finish required for the concrete. Timber or plywood forms repaired with metal patches shall not be used unless permitted by the Engineer-in-Charge.

(vii) Damaged forms or forms which have been deteriorated through usage shall not be used.

(viii) Form oil used on surfaces of timber or plywood forms shall be a straight, paraffin base refined, pale, mineral oil. The oil used on the surface of steel forms shall be specially compounded petroleum oil and other oils of animal or vegetable origin and gums or resins which are heavier in body and frequently darker than straight petroleum oils shall be used in case of steel lining forms. The contractor may use any other material also for coating of the formwork with the approval of the Engineer-in-Charge.

(ix) Forms of like character shall be used for similar exposed surface in order to produce a uniform appearance.

(x) The type, size, shape, quality and strength of all materials from which forms are made shall be the sole responsibility of the contractor but subject to the approval of the Engineer-in-Charge.

(xi) In general, forms for permanently exposed surfaces shall consists of or shall be lined with matched or dressed edge grain timber of appropriate thickness, free from loose or cracked knots.

(xii) Metal forms or metal-lined forms shall be permitted for permanently exposed surfaces only when an entire surface is to be built completely with such forms.

9.5 DESIGN, FABRICATION, ERECTION AND MAINTENANCE OF FORMWORK

(i) Forms and false work shall be designed, fabricated, erected and removed in accordance with the applicable provisions of the Recommended Practice for Concrete formwork of IS:456-1978 and as specified herein.

(ii) All false work shall be designed to withstand safely all live and dead loads, necessary pressures, ramming and vibrations without significant deflection from the prescribed lines, which might be applied to the false work during all stages of construction, service and removal.

(iii) The Contractor shall be solely responsible for the design, construction and maintenance of all formwork and false work required in the work.

(iv) Detailed drawings of shoring and false work shall be prepared by the Contractor. The calculations and drawings shall show the size and specification of the false work, including the type and grade of all materials used in the construction, design loads on false work supports, horizontal forces imposed on the false work and used for design purpose and details of splices and connections including nails, spikes and other fasteners. If mechanical equipment such as concrete buggies, screening machines etc. are to be used, this information shall be shown on the drawings.

(v) False work shall be constructed only after the false work drawings have been approved by the Engineer-in-Charge.

(vi) The approval of Contractor's drawings by the Engineer-in-Charge shall not relieve the Contractor of his responsibility for the adequacy of form and false work or for the successful completion of the work.

(vii) The Contractor shall construct the false work strictly in accordance with the approved false work drawings, one set of which shall be kept on the site at all times and no changes shall be allowed without prior written acceptance of such changes by the Engineer-in-Charge.

(viii) Forms shall be designed to permit the concrete to be deposited, as nearly as is practicable, directly in its final position and to allow inspection, checking and clean up of the formwork and reinforcement to be completed without delay.

(ix) Formwork and false work shall be designed, constructed, erected and maintained such as to confine the concrete without loss of mortar and produce finished surface which are within the tolerances specified.

(x) Forms for concrete against which backfill is to be placed or which shall not be exposed to view may be constructed of smooth tight boards not less than 25 mm nominal thickness.

(xi) Forms for concrete exposed to flow of water or exposed to view shall be constructed of steel or plywood which is smooth and free from defects with matched and sanded joints to give a symmetrical pattern over the entire area. Chamfer strips (40 mm x 40 mm) shall be used on all exposed concerns, unless otherwise specified or required by the Engineer-in-Charge.

(xii) Forms ties, supports, anchors, braces, spreaders and other similar devices which shall be embedded in the concrete for holding the forms shall incorporate threaded metal bars to facilitate removal of forms. Wood spreaders shall not be left in the forms. Any metal remaining embedded in the concrete shall be at least 50 mm from the surface of concrete. Holes left in the concrete by removal of parts of form ties or similar devices shall be well filled with cement mortar and neatly finished to match the adjacent concrete.

(xiii) Form inserts or similar permanently embedded items shall be accurately located and securely fastened in place. The number and location of form ties and bolts shall be such as to ensure that forms fit tightly against the concrete previously placed and remain in tight contact during operations.

(xiv) Forms shall be set and maintained within the specified tolerance limits such that the complete concrete surfaces are within these limits.

(xv) All form surfaces shall be thoroughly cleaned before erection and shall be lubricated with a non-staining mineral oil. All excess oil shall be wiped off the forms prior to placement of concrete. Oil shall not be allowed to come into contract with reinforcing steel or other embedded items. For use of timber forms, the oil shall be capable of penetrating the timber and keeping it sufficiently oily to eliminate sticking and preventing absorption of water and consequent warping.

(xvi) The oils shall be applied by brush, spray or swab and the forms shall be covered fully and evenly without excess or drip. Care shall be taken to prevent oil from getting in the surface of construction joints. Special care shall be taken to oil thoroughly the form strips for narrow groove seats, windows, doors and elsewhere so as to prevent swelling of the forms and consequent damage to concrete prior to the removal of forms.

(xvii) Immediately before concrete is placed, all forms shall be inspected to ensure that they are properly placed, sufficiently rigid, clean, tight and properly surface treated and free from encrustations of mortar, grout or other foreign materials. No concrete shall be placed until formwork has been inspected and accepted by the Engineer-in-Charge. Where forms of continuous surfaces are placed in successive units, the forms shall fit tightly over the surface so as to prevent leakage of mortar from the concrete and to maintain accurate alignment of the surface.

(xviii) The formwork for the gate groove areas shall be accurately drilled to be held with first stage anchor couplings/plates to be embedded in primary concrete. Both shall be fixed through formwork into the first anchor couplings/plates to ensure that the coupling/plates remain flush with primary concrete face and the coupling do not get plugged.

(xix) Where timber forms are used, the laying shall be in the direction which will blend architecturally into the lines of the structures as decided by Engineer-in-Charge.

(xx) Curved and special forms shall be such that these will result in smooth concrete surfaces. They shall be designed and constructed so that they will not warp or spring up during erection or placing concrete.

(xxi) When metal sheets are used for lining forms, the sheets shall be placed and maintained on the form with the minimum amount of wrinkles, humps or other imperfections. The use of sheet metal to cover imperfections in the lining of timber faced forms for surfaces that shall be permanently exposed to view shall not be permitted.

(xxii) Where plywood or hardboard is used for form lining, the joints between the sheets shall be smooth and as perfect as practicable and no patching of the plywood or hardboard shall be permitted for permanently exposed surfaces. Minor imperfections in the plywood may be corrected by the use of plastic wood secured firmly in place and sand papered smooth.

(xxiii) Wire ties shall be permitted for the forms when specially approved by the Engineer-in-Charge and shall be cut off flush with the surface of concrete, after the forms are removed. Wire ties shall not be used when permanently exposed finished surfaces are required.

(xxiv) Forms shall be so constructed that the finished concrete surfaces shall be of uniform texture in accordance with the type of finish specified for concrete surfaces in these specifications.

(xxv) The erection of formwork in position shall be rapid enough, rigid and strong to withstand concreting operations and maintain the alignment. Panels of similar shape shall be identical and inter-changeable.

(xxvi) For special section/shapes, timber/steel form shall be used as approved by the Engineer-in-Charge.

(xxvii) The contractor shall strengthen or modify the formwork whenever required by the Engineer-in-Charge.

(xxviii) Unless authorised, suitable mouldings shall be placed to level all exposed edges at construction joints and any other edges shown on the drawings or as required by the Engineer-in-Charge. The final detailed drawings shall show any formed recesses, slots, block outs and similar construction details which have to be taken into account in fixing the formwork.

(xxix) Forms shall be maintained, at all times, in good condition particularly as to size, shape, strength, rigidity, tightness and smoothness of surface.

(xxx) The Engineer-in-Charge will, at any time, have the right to reject formwork which he considers to be no longer fit for use.

9.6 REMOVAL OF FORMWORK

(i) Forms shall not be removed until the concrete has hardened and has attained a crushing strength of at least twice the stress which the concrete may be subjected to at the time of removal of forms.

(ii) Duration for which the forms shall remain in place shall be decided by the Engineer-in-Charge, with reference to weather condition, shape, position of the structure or structural members and the nature and magnitude of dead and live loads. The forms shall not be removed without the permission of the Engineer-in-Charge.

(iii) The following minimum intervals of time shall generally be allowed between completion of placing of concrete and removal of forms but the period shall be increased in case of wet or cold weather and also at the option of the Engineer-in-Charge.

Structure	**Period in days with normal Portland Cement**
(a) Beam sides, walls, columns (unloaded)	3
(b) Slabs and arches (Props left under)	4
(c) Props to slabs and arches	10
(d) Beam soffits (Props left under)	8
(e) Props to beams	21
(f) Mass concrete	2

The above minimum periods are only recommendatory. The Contractor may where he so desires, extend the above to longer intervals. This shall not, however, constitute any reason for any claim for extension of time or damage to concrete etc.

(iv) If the Contractor desires to remove the forms earlier than the period stated above by addition of cement and/or suitable admixtures in the concrete, so as to gain early strength

without affecting long term strengths, the matter shall be examined by the Engineer-in-Charge in each case and his decision in the matter shall be final and binding.

(v) Heavy live loads shall not be permitted until after the concrete has reached its design strength.

(vi) The forms shall be removed with great caution and without jarring the structure or throwing heavy forms upon the floor. In order to achieve this end, wedges and clamps shall be used whenever practicable instead of nails.

(vii) In order to avoid excessive stresses in concrete that might result from swelling of the forms, wood forms for wall opening shall be loosened as soon as this can be accomplished without damage to the concrete. Forms for the opening shall be constructed so as to facilitate such loosening.

(viii) The Contractor shall be solely responsible for any damage that may be caused by negligence, lack of proper precautions of hastiness etc. in the matter of removal of forms and shall make the same good to the satisfaction of the Engineer-in-Charge.

9.7 Measurement

No separate measurement or payment will be made for any formwork used, as required, at any location of any works and the costs for this is deemed to be included in the contract price.

10 MASONRY

10.1 General

10.1.1 Scope

The scope of work covered in this section shall comprise all work, the supply of all labour, construction plant and materials of required in connection with the construction of miscellaneous masonry works for civil structures as shown in the Drawings approved by the Engineer-in-Charge.

It shall also include all appertaining materials and structural parts, scaffolding, transportation, loading, unloading, survey, inspection, test, quality control preparation of foundation surfaces, adjustment of surfaces adjacent to the walls, linings, pavement, etc., and all other operations required to complete the masonry work in all respects.

10.1.2 General Requirements

All materials and structural parts incorporated in the permanent work shall be new and unused. Regarding quality and dimensions they shall comply with these Specifications and approved standards.
All masonry shall be carried out in a workmanlike manner at the highest standard.

All materials to be used for masonry works shall be protected from rain and other deleterious conditions to the satisfaction of the Engineer-in-Charge.

10.1.3 Standards and Codes

All materials and testing shall comply with the standards and codes hereinafter:-

IS1129	Dressing of Stones
IS2250	Sand for Masonry Mortars
IS2116	Specification for Sand
IS3466	Specification for Portland Cement
IS3025	Specification for Water for Concrete Construction

10.1.4 Mortar for Masonry

10.1.4.1 General

The mortar for all masonry works shall consist of cement, admixture for preventing cracks, sand and water. The mortar for masonry work shall be proportioned as given in Table 12.1 . The quantity of water shall be as necessary to obtain a satisfactory workability regarding the use of the mortar.

Proportion of Cement Mortar is given in table below

Particulars	**Cement/Sand Mix Ratio Part by Volume**
Brick masonry work	1 : 4
Stone work	1 : 3

10.1.4.2 **Cement**

The cement shall be ordinary Portland cement complying with the standards specified and all handling shall be in accordance with the provisions set forth.

10.1.4.3 **Sand**

The sand for mortar shall comply with the requirements described in **Section "concrete works"**. The grading of sand shall be as per table 12.2.

Table12.2

Grading of sand

US Standard Sieve Square Mesh No.	Percentage by Weight Passing %
4	100
8	95 – 100
16	70 – 90
30	40 – 75
50	20 - 40
100	5 - 20
200	0 - 10

10.1.4.5 **Water**

Water shall comply with the requirements set forth under **Section "Concrete Works**".

10.1.4.6 **Mixing, Transporting and Placing**

The mortar shall be mixed for a minimum of 2 minutes in a mechanically operated drum-type mixer or equivalent mixer approved by the Engineer-in-Charge and the mixer shall be rotated at the speed recommended by the manufacturer. The total quantity of material mixed in each batch shall not exceed the rated capacity of the mixer.

The water shall be added gradually to the mixer, partly before the loading of the dry material and partly immediately after loading. The drum shall be totally emptied before a new batching cycle is started. The drum shall be kept free from hardened mortar and shall be thoroughly cleaned prior to change of mix or on cessation of mixing.

Hand-mixing for small batches may be approved by the Engineer-in-Charge. However, the mortar shall be mixed up to the degree obtained with a mechanically operated mixer. Prior to adding water to the mix, the fine aggregate, cement and admixture shall be mixed dry in a tight box until the mixture has a uniform colour.

The equipment and tools used for transporting and for placing of mortar shall ensure that contamination or loss of ingredients do not take place.Mortar shall be stirred or worked at frequent intervals to prevent separation. All mortar shall be placed within thirty (30) minutes after the water has been added to the batch. Except for necessary tempering on the mortar board, re-tempering of mortar is not permitted.

10.2 Brick work

10.2.1 General

10.2.1.1

All brick works shall be carried out in a workmanlike manner of the highest quality. The masonry shall be performed in horizontal courses true to line and plumb. The arrangement of headers and stretchers within the walls shall be such as to surely bond the masonry and, unless otherwise specified, the masonry shall consist of alternate headers and stretchers with staggered vertical joints in consecutive joints.

Wall ends shall have finished return ends. For masonry permanently exposed to view all bricks shall have sharp, undamaged edges and cutting of bricks to required lengths shall

be done carefully. Bed joints shall measure between 8 mm and 15 mm, however, the thickness shall be uniform throughout. Vertical joints shall be 10 mm. All joints of walls to be plastered shall be raked out to a depth of approximately 15 mm. Joints of walls permanently exposed to view shall be raked out to 20 mm while the mortar is still fresh and subsequently neatly pointed at a form instructed by the Engineer-in-Charge.

At corners and intersections of walls the masonry shall be bonded by overlapping blocks at alternate courses. In exceptional cases, the Engineer-in-Charge may permit the use of wire ties thoroughly embedded within the bed joints and anchored in mortar-filled cells. The connection between concrete columns and masonry shall be performed by ties or anchors protruding the concrete. Immediately after completion of a wall or part thereof the wall or part shall be thoroughly cleaned and watered. The wall or part shall be kept wet for at least 3 days.

10.2.1.2 Setting-out

All walls shall be accurately set-out to the dimensions shown in the approved Drawings by suitable equipment and the deviation between the actually set out walls and their theoretical location shall not exceed the below mentioned tolerances, unless otherwise approved by the Engineer-in-Charge. For vertical dimensions of the masonry a site datum shall be fixed at a convenient position to represent the finished ground floor level of the building. The Contractor shall take care when setting-out the first course of a wall and the combination of stretchers, closers and headers shall be laid "dry" for the approval by the Engineer-in-Charge. Repeated dimension controls shall be made at short intervals on all lines, levels and plumb throughout all masonry work.

10.2.1.3 Permissible Tolerances

The dimensional tolerances of masonry in respect of alignments, length, height, thickness, unevenness, etc. shall comply with the following limits:

a. Masonry exposed to view

- all bed joints shall be horizontal and they shall not deviate from a straight, horizontal line by more than 5 mm on a length of 2.50 m;

- the wall surface shall be vertical and it shall at no location deviate by more than 4 mm from the plumb at a length of 2.50 m;

- horizontally the wall surface shall not deviate by more than 4 mm from a straight line on a distance of 2.50 m;

- the deviation of any dimension from the design dimension of walls, openings, recesses, piers, etc., shall not exceed the following values:

Respective Dimension	Maximum Deviation
<1.00 m	4 mm
1.00 m - <2.50 m	5 mm
2.50 m - <10.00 m	8 mm
10.00 m	10 mm

- no abrupt irregularities will be permitted.

b. Masonry to be plastered

- the wall surface shall be vertical and it shall nowhere deviate by more than 6 mm from the plumb at a length of 2.50 m;

- horizontally the wall surface shall not deviate by more than 6 mm from a straight line on a distance of 2.50 m.

- the deviation of any dimension from the design dimension of walls, openings, recesses, piers, etc., shall not exceed the following values:

Respective Dimension	Maximum Deviation
<1.00 m	6 mm
1.00 m - <2.50 m	7 mm
2.50 m - <10.00 m	10 mm
10.00 m	12 mm

- abrupt irregularities shall not exceed 3 mm.

All masonry exceeding the above stated tolerances shall be corrected or replaced by the Contractor.

10.3 Stone Masonry

For the purpose of stone masonry, the Contractor shall stockpile sufficient amount of suitable stones from the rock excavation or from approved quarries.

Stockpiled stone shall be left in air for seasoning preferably for a period of one month prior to placement or as instructed by the Engineer-in-Charge. The moisture of stones shall be kept uniform.

Stone masonry wall shall be of Random Rubble type. Dressing of stone shall conform to IS 1229.

Stonewall shall be sufficiently wetted before laying, to prevent absorption of water from mortar. The bed which is to be received the stone shall be cleaned, wetted and fully covered with mortar. All stones shall be laid in full in wetted surface both in bed and vertical faces and carefully settled in place immediately on placement. Clean Chips and Spalls may be wedged into mortar to avoid thick beds or joints. No dry or hollow space shall be left anywhere in the masonry and stones shall have all its embedded faces completely covered with mortar.

Masonry shall be laid in courses, generally of the same height, where there is a variation in the heights of the courses, longer courses shall be placed at lower levels, with course heights decreasing towards top. Pressure relief sleeves or orifices shall be left in masonry walls as shown on the Drawings or as instructed by the Engineer-in-Charge.

All exposed faces of masonry wall shall be cleared of mortars dropping.

10.3.1 Tests and Properties

All materials applied in masonry work shall comply with the relevant standards regarding quality, dimensions, strength, etc. The Engineer-in-Charge may instruct the Contractor to carry out suitability tests on the material proposed to be applied in the Works as well as to perform quality control tests during the progress of the work as described in the relevant standards.

10.4 Measurement and Payment

Measurement and payment for brick/stone masonry shall be made on the basis of the respective volume in cubic meters of masonry including bonding mortar constructed in accordance with the approved Drawings and Specification for the purpose of making progressive payments on the basis of unit rates entered in the contract against total price of the relevant items.

11 DEWATERING AND DRAINAGE

11.1 SCOPE OF WORKS

i. The specifications described hereunder relate to the works of dewatering and drainage to be carried out by the Contractor, which shall include supply of all labour, construction plant and material and performance of all services required to remove sludge/ muddy water, service water and natural surface flow or ground water seepage from the Work areas for the construction of various structures covered under the contract.

ii. The works shall be executed in accordance with the Contractor's designs, specifications and sequences as approved by the Engineer-in-Charge.

11.2 SUBMITTALS

(i) **Within 30 days** after the date of issue of the Letter of Acceptance, the Contractor shall submit, to the Engineer-in-Charge, the detailed design of dewatering system.

(ii) This design shall be consistent with the outline description submitted by the Contractor with his bid and shall include the following :

a) Design assumptions and calculations
b) Layouts of drainage / dewatering facilities

(iii) The Engineer-in-Charge reserves the right to require any additional information deemed necessary to be included in the submitted documents.

11.3 GENERAL

The pumped water carried in pipes or channels shall be discharged at point sufficiently away from the edge of foundation excavation as directed by the Engineer-in-Charge. Care shall be taken to ensure that there is no seepage and flow of water back to the pit of the working areas.

11.4 DEWATERING OF SURFACE WATER AT CONSTRUCTION SITES

11.4.1 General

(i) The Contractor shall perform all works necessary to drain out the surface water which happen to be accumulated at work site due to rain, ground water and / or service water. The works shall include, but not be limited to the following :

a) Design and construction of drainage, ditches, pits and pump sumps
b) Design, furnishing, operation and maintenance of dewatering equipment
c) Relocation of dewatering facilities required for the performance of other works, if any.
d) All auxiliary works required for safe and continuous dewatering of the construction sites.

(ii) river/stream Dewatering of construction sites located near a river/stream shall be done upto the existing water level in the river/stream by gravity or otherwise as directed by the Engineer-in-Charge. Suitable drainage shall be made joining the course downstream of the construction site to provide required gradient to facilitate proper and efficient dewatering. Below the water level of the stream, dewatering shall be done by pumping water collected in the sumps and discharging the same into course of the downstream of the construction site.

11.4.2 Requirements and Design

(i) The Contractor shall design and install complete facilities at the surface construction sites.

(ii) The surface water dewatering systems shall be designed to accommodate, without undue disruption to the works, any rainfall event and taking into account the extent of the sites to be dewatered and the dewatering arrangements proposed.

(iii) Claims for extension of time due to delays caused by unfavourable weather conditions will not be considered.

(iv) The Contractor shall provide adequate pumps of suitable capacity, including standby units, to handle all water entering into any of surface construction sites. In addition, he shall provide sumps and pumps and or well points in the immediate vicinity of the structure foundations using such water conductors as are necessary to conduct the water away from the work site as per the requirement of works to be executed in an manner so that such operation shall be kept free from standing or running water.

(v) Power for operating the dewatering system shall be arranged by the Contractor. The Contractor shall make his own arrangements for sufficient standby power at his cost to carry on the works during any interruption of power. The standby power supply shall undergo weekly trial runs lasting at least 30 minutes.

(vi) The Contractor shall ensure that all dewatered / drainage water is disposed off without causing interference on the site and that no drainage water runs into adjacent works.

(vii) The dewatering systems shall be designed and installed in such a way that modifications and extensions to the systems are possible while they are in full operation.

(viii) All the components of the dewatering systems shall be installed and operated in accordance with the approved method and the construction time schedule or approved modification thereof.

(ix) The approval by the Engineer-in-Charge of the dewatering system shall not relieve the Contractor from being fully responsible for the design, construction, operation, maintenance, safety and removal of the facilities provided for the dewatering system and he shall be liable for any damage or delays caused by its failure.

11.4.3 Materials and Execution

(i) Drainage ditches shall be excavated along the top of excavated slopes. Such ditches shall be kept well back from excavation edges in order to prevent saturating the upper part of the slopes. The ditches shall be regularly cleaned out of all accumulated silt and other matter so that water may flow freely at all times.

(ii) Where excavation is to be made below the ground water table, the Contractor shall lower the water table sufficiently below any working surface by means of properly screened wells and/or ditches to ensure that the foundation surface remain free of standing water and undamaged by the passage of construction traffic. All ditches shall be outside the foundation areas. The water shall be collected and removed by pumping, if no outflow by gravity is possible.

(iii) Where concrete / masonry is to be placed, the water table shall be maintained below the lowest part of the finished excavation for minimum of one day following the raising of structure above the natural ground water table and for such additional time as may be necessary to preclude damages to structure foundation.

(iv) In trenches and foundations, the dewatering shall at all times enable to carry out the excavation works in dry.

(v) Upon completion of dewatering, temporary pipes and pump sumps beneath permanent structures shall be closed off and completely filled with grout, mortar or concrete as directed by the Engineer-in-Charge.

11.5 MEASUREMENT AND PAYMENT

No measurement for payment against dewatering and drainage would be recorded as the cost for the same are deemed to be included in the contract price.

12 METAL WORK

12.1 GENERAL

12.1.1 Scope

The work to be performed under this section consists of furnishing and installing the various metal works as necessary in the execution of structures including all the auxiliary works in all structures of the Work as shown on the approved drawings or as directed by the Engineer-in-Charge.

12.1.2 Submissions

At least thirty (30) days prior to commencing the work, the Contractor shall submit to the Engineer-in-Charge the following documents for his approval.

- Detailed shop and construction drawings which shall include complete details, sections and plans of all parts, assemblies, components, connections and supports, and connections to the work of other items.

- Detailed structural analysis of the proposed metal structures, if required.

- Test certificates proving the physical properties stipulated in the Specifications.

Before purchase, samples of all materials proposed for incorporation in the works shall be submitted for approval to the Engineer-in-Charge, as and when required.

12.1.3 Standards and Codes

Unless otherwise specified the materials to be used for the works shall conform to the Indian standards or equivalent International standards with regard to quality, properties and workmanship.

The Contractor shall inform the Engineer-in-Charge of the standards he follows if no particular ones are specified hereinafter. In case the Contractor wishes to follow any other standards and codes, he shall submit sufficient copies of the same to be applied in English to the Engineer-in-Charge for his approval.

12.2 MATERIALS

All materials and structural components to be supplied, erected or installed and, therefore, ultimately incorporated in the structure shall be new and unused. They shall be suitable for their intended purpose and appropriately match each other.

Unless otherwise specified, all materials of metal work shall conform to applicable BIS Codes or the following requirements or equivalent:

- Structural steel : ASTM A6/A6M, A36
- Steel tube and pipe : ASTM A53, A500, A501
- Welding : AWS A5.1, A5.17

In the drawings and the specifications, the size of steel pipes and shaped steel are indicated in the metric system as a rule. The Contractor will be permitted to use those of inch size which are approximately same or more in size as those indicated on the drawings or the specifications.

12.3 Execution

12.3.1 General

(1) Fabrication and Installation

All works shall be executed by skilled workers in a workmanlike manner.

All members shall be cut in such a manner as not to cause deformation or distortion. Irregularity of cut surface shall be properly finished by planer.

The work shall be shop fitted and shop assembled where possible, and shall conform to the details on approved shop drawings to be provided by the Contractor.

Welding shall be made by arc welding unless otherwise directed by the Engineer-in-Charge.

Where necessary, metals shall be insulated to prevent electrolysis due to contact between dissimilar metals and to prevent corrosion due to contact between metals and masonry or concrete. Insulation shall be by means of bituminous paint or other approved means.

All fastenings, anchors and accessories required for fabrication and erection of the work under this section shall be provided by the Contractor. Exposed fastenings shall be kept to an absolute minimum, evenly spaced and neatly set out. Wood plugs shall not be permitted.

Metal work to be embedded in concrete shall be set and fixed in position as shown on the drawings or as directed by the Engineer-in-Charge before placing concrete. If blockouts will be arranged at the locations where embedded parts are set in concrete as shown on the drawings or directed by the Engineer-in-Charge, the metal work shall be fixed in place by the second stage concrete.

The bond surfaces between the first and the second stage concrete shall be roughened. The cross-section dimensions of the second stage concrete and the locations of embedded anchor bolts shall be as shown on the drawings or as directed by the Engineer-in-Charge.

Where it is impracticable to place anchors or anchor bolts when the concrete is placed, holes will be drilled in the hardened concrete 28 days after placing concrete. And expansion bolts, adhesive anchor bolts or other approved anchors will be installed and fixed in place, and then grouted or backfilled with mortar.

(2) Painting and Galvanizing

All components of the metal works shall either be painted or galvanized against corrosion prior to assembly and/or erection. Any preliminary treatment against corrosion shall

ensure a basic protection remain effective for at least six months.

All steel surface except galvanized surface and embedded parts in concrete shall be painted. Rust-resistant paint shall be applied in two coats and finishing paint shall be applied in two coats. The quality of paint and the painting works shall be performed in accordance with the provisions in the Specification. The color of paint shall be approved by the Engineer-in-Charge.

Components to be installed to the exterior shall in any case be hot dip galvanized. Galvanizing of steel shall be in accordance with ASTM A123 A153 and A386 or equivalent and the zinc coating shall be not less than 610 g/m.

(3) Auxiliary Works

The following auxiliary works and services shall be deemed to be included in the metal works.

- transport, storing and protection of all structural components on site;

- protection of the executed works from detrimental influences, theft and damages until the time of handover;

- supply of consumable stores;

- removal and making good of all contaminations (building rubbish, refuse and the like) arising from and in connection with the Contractor's works;

12.3.2 Steel Cover

Steel covers shall be installed at openings designated on the approved Drawings or as directed by the Engineer-in-Charge.

Steel covers shall be of steel plate or chequered steel plate, with lifting devices as shown on the drawings or as approved by the Engineer-in-Charge.

Frames shall be composed of shaped steel sections, angles, etc. and shall be anchored to concrete as approved by the Engineer-in-Charge. The frame shall be adjusted during installation to provide an accurate fit with the cover.

In order to ease removal and setting, all covers shall be tapered along the perimeter towards the bottom. The maximum clearance between hatch cover and outer frame shall be 5 mm around at finished floor level.

The corrosion protection shall be generally achieved by painting.

12.3.3 Steel Grating

The steel gratings will serve as covers for gutters, sump and trench, and as tread for step ladder etc.

The steel gratings are normally of a rectangular shape. Some are to be provided with openings for the passage of pipes or ducts as directed by the Engineer-in-Charge or shown on the drawings.

Sizes of steel gratings shall be such as to afford easy handling.

Minimum support width shall be the height of the grating and not less than 30 mm.

The bearing frames of steel angles or channels shall be anchored to the concrete with steel bolts or straps as shown on the drawings or as directed by the Engineer-in-Charge.

Before installation the frame shall be adjusted to allow the steel grating to have a continuous support by the frame.

Before ordering the gratings, the Contractor shall check all relevant locations, dimensions and shapes of the openings.

Steel gratings and frames shall be galvanized. Damaged finishing shall be repaired on site as specified by the manufacturer and to the approval of the Engineer-in-Charge.

12.3.4 Ladder

The Contractor shall supply and install step ladders and steel ladders to the numbers and dimensions as required. Ladders shall be installed where shown in the drawings or where directed by the Engineer-in-Charge. The details of the ladders are referred to the approved drawings or as directed by the Engineer-in-Charge.

Step ladders shall be securely fastened at top and bottom to the wall and shall have intermediate clips and plates be riveted or welded to the side.

All steel members shall be galvanized. All bolts for fastening the ladder to the concrete wall shall be of stainless steel. Where splices are required, bolted connections have to be used.

12.3.5 Steel Stair and Cat Walk

The Contractor shall prepare his own design of steel stairs and cat walks in accordance with the layout and details shown in the approved drawings or as directed by the Engineer-in-Charge.

All landings, stairs and cat walks shall be made of standard steel sections of angle, channel and I-beam shape.

Components or portions thereof shall be pre-assembled with field points designed such as to allow fast and easy erection on site.

Treads of stairs and landings shall be of galvanized steel grating, which have slipless nosing.

The catwalk shall be covered by steel checkered plate.

All outdoor metal parts shall be hot-dip galvanized after manufacture but prior to assembly and no tooling on these parts will be permitted after galvanization.

Of indoor sections only the steel gratings and the chains of railings shall be galvanized; the entire supporting steel structure and railings shall be painted.

12.3.6 Entrance Gate

The Contractor shall design, manufacture, supply and install the entrance gates at the structures to prevent unauthorized persons from entering to the relevant structures as shown in the approved construction drawings or as directed by the Engineer-in-Charge. The gate shall be of a rigid construction. The materials shall be of hot dip galvanized steel sections unless otherwise specified.

12.3.7 Steel Handrail

The Contractor shall position the steel handrails in places as shown on the approved construction drawings or as directed by the Engineer-in-Charge. The Contractor shall be responsible for furnishing of materials, fabrication and installation of the handrails.

Steel handrails shall be fabricated and installed in the places as shown on the drawings. Steel handrails shall be properly anchored to the structures. In general blockouts shall be provided whenever possible and the blockout shall be filled with the concrete after installation.

All parts shall be rust proof painted after manufacturing but prior to installation.

12.3.8 Frame for Opening and Cover

a. Frame for opening

Steel angle, z-and/or channel profiles shall be provided for all openings in the size and shape indicated in the approved drawings. These frames shall be embedded in the concrete and attached to the concrete by anchors securely welded to each side of the frame. Anchors may be replaced by anchor plates and stud bolts whenever possible and where shown in the drawings and/or instructed by the Engineer-in-Charge.

All corners of the frames shall be mitered. The surfaces of the frames shall be flush with the concrete surface and the supporting parts, if any, shall be aligned in a way to prevent riding of the covers.

b. Frame for Cover

Concrete covers such as concrete hatch cover and concrete trench cover shall be provided with steel frames as shown in the approved Drawings and/or directed by the Engineer-in-Charge. In general these frames shall be formed by channel profiles, however, the lateral vertical surface shall be slightly inclined to ease lifting of the covers.

All corners of the frame shall be mitered and continuously flush- welded. All welding seams shall be ground smooth. For the connection between the frame and the cover concrete anchors or steel bars shall be welded to the frames.

The frames shall be provided with lifting rings or other arrangements to allow lifting of the covers.

12.3.9 Other Metal Works

Any other metal shall be furnished and installed as shown on the approved drawings or as directed or approved by the Engineer-in-Charge.

12.4 Measurement and Payment

Measurement and payment for metal works shall be made on the basis of the respective items in accordance with the approved Drawings and Specification for the purpose of making progressive payments on the basis of unit rates entered in the contract against total price of the relevant items.

13 STRUCTURAL STEEL

13.1 GENERAL

13.1.1 Scope of Works

This chapter shall include all work in connection with anchor bolts, structural steel works for approach bridge and other miscellaneous works the steel frame of Pumphouse etc., as shown in the approved drawings and as specified hereafter.

The work shall consist of preparation of shop drawings, supply of all materials, fabrication, transportation, storage, erection, painting, inspection, quality control including survey, loading and unloading, protection from damages and other auxiliary works as required.

13.1.2 Submission

The following documents shall be submitted to the Engineer-in-Charge for approval.

(1) Schedule

The Contractor shall **submit a work schedule indicating time schedule** of all works including shop fabrication, transportation, field fabrication, erection at the site and other necessary items related to the work.

(2) Detail Design, Calculation and Shop Drawing

The Contractor shall submit complete shop drawings supported by structural computations, of all structural steel work showing sizes, type and grade of metal, method of assembly, hardware and anchorage or connection with the main structures at least one month before beginning the manufacture of the various items.

Full account shall be made in the design for all temporary loads and stresses which may occur during fabrication, assembly, transportation or erection.

(3) Erection Procedure

The Contractor **shall submit drawings or documents explaining** erection procedure including the temporary bracing method and installation equipment or machinery, at least one month before beginning the erection.

(4) List of Materials

Prior to the procurement of materials, the Contractor shall submit list of materials to be used. The name, official address and brochures showing manufacturing facilities of the manufacturer of materials shall be attached with the list.

(5) Mill Sheet and Certificates of Materials

Mill sheets or certificates of materials which are based on the tests performed in the steel maker or an approved independent laboratory shall be submitted to the Engineer-in-Charge.

13.1.3 Standards and Codes

All design, material, execution of work shall comply with the applicable Indian standards and codes or where not covered by these standards to the equivalent International Standards.

13.2 MATERIAL

Except as otherwise specified, all material furnished by the Contractor under this section shall be new, free from defects and imperfections and conform to the BIS or equivalent International Standards.

13.3 EXECUTION

13.3.1 Shop Fabrication

(1) Measuring Tape

Measuring tapes for shop fabrication and for erection at site shall be of steel, and deviation of each other shall be measured and informed to the Engineer-in-Charge for approval.

(2) Marking-Off on Material

The positions of bolt hole and shape, dimensions of plate shall be accurately marked on base metal using full size templets.

(3) Cutting and Forming

In cutting base metal, automatic flame-cut method shall be employed. Base metal shall be accurately cut at right angle to the axis and true to marked line and well-formed to size and shape as marked on. Roughness, burrs or any other irregularity of all edges shall be

removed using a grinder or a planer.

(4) Bending

Except where inevitable, bending of structural steel shall be done cold. In case that it is necessary to employ a heating process, bending of steel shall be done while the steel is red hot with the approval of the Engineer-in-Charge.

(5) Bolt Hole

Holes shall be drilled with a bit at right angles to the surfaces, and shall not be made or enlarged by burning holes. All bolt holes shall be clean-cut without any burrs or ragged-edges resulting from drilling.

Diameters of holes provided for insertion of bolts shall be as follows:

D	Diameter of bolt hole
More than 20 mm	D + 1.5 mm
Not more than 20 mm	D + 1.0 mm

D: Nominal diameter of bolt

When loose bolt holes are employed, the shape of loose bolt holes shall be shown on the approved drawings.

(6) Welding

a. Welder

Welding shall be executed only by professional welders who are skillful with welding with all position and experienced in welding of structural steel more than 6 months and approved by the Engineer-in-Charge.

b. Edge preparation and assembling

Edge to be welded shall be made into shape in accordance with the approved edge preparation plan, and shall be free from loose scale, slag, grease, paint or other objectionable materials.

Materials to be welded shall be held firmly by an adequate method so as not to move during the welding works. Tack welding shall be performed in such a manner as to minimize residual internal stress. The Contractor shall take other proper means to prevent strain or residual internal stress from welding.

c. Handling of welding rod

The welding rod shall be stored in their original packing in a dry place, with appropriate protection against the weather. If the welding rod which seem to have suffered the effects of moisture but do not have any other damage can only be used when they have been dried in satisfactory manner.

Welding rod which have areas where the flux covering is broken or damaged shall be rejected.

(7) Permissible Variation

Permissible variation in dimensions of the steel members fabricated at the manufacturer shall be in accordance with the relevant standards stipulated before.

(8) Shop Painting

a. Base preparation and treatment

After the completion of fabrication at shop all of the surface to be painted shall be cleaned of all rust, dirt, oil, slag, scale and any other foreign substance. Cleaning of the surface shall be executed with sandblasting or shotblasting and immediately thereafter wash-primer shall be applied to the surface.

b. Rust-resistant painting

Rust-resistant paint shall be applied in two coats prior to the shipment.

c. Contacting faces for friction grip joint

Contacting faces for friction grip joint of high strength bolt shall be cleaned with sand blasting or shot blasting. Wash-primer, or rust-resistant paint shall not be applied on those faces.

13.3.2 Transportation

The Contractor shall be responsible for all necessary notifications to the concerned office or Authority concerning to the transportation of the member and parts of structural steel. They shall be transported carefully to the site in such a manner as to prevent deformation, corrosion, or other damages.

If necessary, adequate reinforcements, bracing, stiffeners or other means shall be provided.

13.3.3 Storage

The member and parts of structural steel shall be stored under proper covers and placed on supports, so that they are not in contact with the ground or with substances which may cause oxidation and deterioration.

13.3.4 Erection

(1) General

The erection work shall be executed in such a manner that the steel structure do not suffer permanent deformation, and are not subject to stress greater than those considered in the design.

During the erection work the Contractor shall adopt all measures which are necessary to prevent injuries to persons and damage to the neighboring works.

(2) Installation of Anchor Bolts

Anchor bolts shall be installed accurately to meet the positions shown on the approved drawings and the positions of anchor bolts shall be inspected before placing of concrete. When placing concrete, care shall be taken so as not to move the position of anchor bolts.

(3) Friction Grip Joint

a. Length of high strength bolt

Standard length of stem shall be obtained by adding respective length tabulated below to the grip thickness.

D (mm)	L (mm)
16	30
20	35
22	40
24	45

Where,
D : Nominal diameter of bolt
L : Length to be added to grip thickness

The bolt set shall be stored in their original packing, and care shall be taken so that materials would be free from dirt, damage and corrosion.

b. Treatment of contacting surfaces

The surfaces to become in contact with surface of another steel plate in friction grip joint shall be free from paint, oil and other defects that would decrease friction force.

c. Tightening

Temporary tightening shall be performed using bolts not less than one third (1/3) of the total number of bolts in each completed joint but never less than two. Bolts for temporary tightening shall be distributed uniformly about the joint.

Tightening shall be done using either the impact wrench method or the "turn-off-nut" method in accordance with the instruction of the bolt manufacturer. The work shall be done by competent and experienced bolting crews.

70 percent of design bolt tension shall be given to the bolts at preliminary tightening and then 100 percent of design bolt tension shall be given to the bolt finally. Excessive tightening of the bolts shall not be permitted.

d. Calibration of impact wrench

If the bolts are tightened by impact wrench method, each impact wrench shall be calibrated

prior to the commencement of the work each in the morning and the afternoon.

The impact wrenches shall be equipped with torque indicating scale or calibrating means so that the torque can be measured clearly.

(4) Erection

All steel members shall be installed accurately to meet the positions and level shown on the approved drawings and the positions and level shall be inspected before permanent fixing.

During the erection works, the steel structure shall be ensured sufficiently to withstand all loads such as its own weight, live loads, wind loads and erection loads. All temporary bracing, guys and bolts necessary to ensure safety of the structure shall be provided.

(5) Permissible Variation

Permissible variation shall be in accordance with the relevant Indian standards.

13.3.5 Field Retouch Painting

After installation, all damaged shop coated areas and all bolting, welded and other surfaces left un-painted with rust-resistant paint shall be cleaned of all rust, dirt and any other foreign substances and shall be painted with rust-resistant paint.

13.3.6 Inspection

(1) General

All materials supplied and all work performed shall be subject to inspection by the Engineer-in-Charge at the place of manufacture, fabrication and/or erection. Unless inspection is waived by the Engineer-in-Charge, no material shall be shipped until after such inspection and acceptance of the material has been performed.

Where directed by the Engineer-in-Charge, certified mill or shop-test reports shall be furnished in lieu of inspection at the mill. Acceptance of material or waiving of inspection thereof shall in no way relieve the Contractor of the responsibility of furnishing the materials and workmanship conforming with the Specifications in all respects.

The Contractor shall submit the records of tests stating the name of test, time and place, results and name of inspector.

The judgement of results of test and inspections shall be made according to the applicable provisions of the standards stipulated before.

Tests or inspections may be waived with the approval of the Engineer-in-Charge in case mill sheets or certificates or other appropriate evidences are submitted by the Contractor.

(2) Material Test

Quality of the principal materials to be used, such as rolled steels, bolt and nuts, electrodes shall be tested.

(3) Qualification Test for Welding Operators, Welders and Welding Procedures:

Shall be performed in accordance with the applicable standards.

(4) Inspection of Edge Preparation

Shall be performed in accordance with the approved plan of edge preparation.

(5) Appearance and Measurement Inspection

The appearance inspection shall be made on welded joints, bolts holes to be bolted in the field, coated surfaces and on other items for defects.

(6) Inspection of Welded Joint

Welded joint shall be inspected by means of radiographic (X-ray) method and/or ultrasonic method.

The rate of spot inspection shall be not less than 10% of the total welded length.

13.3.7 Quality Control

The Engineer-in-Charge reserves the right to ask for independent analysis and tests on the materials by an analyst or testing laboratory selected by him, in order to check the works, analysis and tests. For this purpose the Engineer-in-Charge may take samples for analysis and have pieces cut out side by side with pieces subjected to test in the workshops. Should the comparison of the result of any independent analysis or test be unsatisfactory, the materials represented will be rejected. All incidental cost for the above shall be borne by the Contractor.

13.3.8 Auxiliary Work

Mortar grouting at the base plate, installation of embedded steel parts in concrete structure shall be included in the work. Shuttering needed for these works shall also be included in the work.

13.4 MEASUREMENT

Measurement of structural steel shall be based on weight by metric ton. All materials including bolts, deck plates and other steel parts shall be measured. Measurements will be made for making the progressive payments against the total contract price for the work, on the basis of rates entered in the schedule of works

14 FINISHING AND MISCLLENEOUS ITEMS

14.1 SCOPE OF WORK

This section covers specifications for miscellaneous item like providing and fixing aluminum windows/doors with glazing, rolling shutters, terrazzo tiles, vinyl asbestos

tiles, improved flooring, CC flooring, M.S. grating, steel work in single section in cable duct, RCC jali, W.C. Pan, wash basin, urinal unit and aluminum pipe railings, joints and water proofing treatment in intake and pump house building, pipes, installation of embedded parts, shotcreting, brickwork, coursed rubble masonry, sausage wall, approach road, and drainage arrangement etc. The work shall include all labours, materials, equipment tools and tackles etc. required for completion of the works.

14.1.1 Application Publications

All methods and procedures shall conform to Indian Standard Specification some of which are listed below :

IS:816	**Welding**
IS:1038	Specification for steel doors and windows
IS:1081	Glazing
IS :1239	Mild steel tubes
IS:1761	Glazing
IS:3548	Glazing
IS:4351	Door Frames
IS:269	Portland Cement
IS:800	Structural Steel
IS:814	Welding Electrodes
IS:2556 (Part. II)	Water Closet
IS:2556 (Part. IV)	Wash Basin
IS:2556 (Part. VI)	Urinals
IS:774	Flushing System for W.C.
IS:781	Copper alloy bib taps
IS:775	Cast iron brackets
IS:1948	Specification for aluminum doors windows and ventilation
IS:1949	Aluminum Windows for industries building

14.2 ALUMINIUM DOORS, WINDOWS AND VENTILATORS

14.2.1 General

The contractor shall submit shop drawings details of various parts, methods of anchoring and any other pertinent details for the approval of the Engineer-in-charge. Before placing orders the contractor shall submit sample of hardware to the Engineer-in-charge for approval.

14.2.2 Materials

a) Aluminum alloy used in the manufacture of extruded window sections shall correspond to IS designations HEO 9-WP of latest edition of IS : 733. Hollow aluminum alloy sections used shall conform to IS Designation HV9-WP of latest edition of IS : 1285. Dimensions and weight per metre run of the extruded sections shall conform to latest edition of IS : 1948 and IS : 1949.

b) Coupling sections – Aluminum alloy coupling sections used shall conform to IS Designation HV9-WP of latest edition of IS : 1285.

c) Glass panes – Glass panes shall weigh atleast 7.5 kg/cm^2 and shall be free from flaws, specks or buggles. All panes shall have properly squared corners and straight edges. The sizes of glass shall conform latest edition of IS : 1948.

d) Screw threads of machine screws used in the manufacture of aluminium doors and windows and ventilators shall conform to the requirements of latest edition of IS : 1362.

e) The metal thickness shall not be less than 1.6 mm for frame and 2.3mm for threshold.

14.2.3 Fabrication

Frames shall be square and flat, the corner of the frame being fabricated to a true right angle. Both the fixed and opening frames shall be constructed of sections which have been cut to length, metred and welded at the corners. Where hollow sections are used with welded joints, argon arc welding or flash butt welding shall be employed (gas welding or brazing not to be done). Subdividing bars of units shall be tenoned are riveted into the frame.All fabrication shall conform to latest edition of IS 1948, 1949 and other relevant IS wherever available. Generally side hung shutters shall be used for door and windows.

Top-hung shutters shall be used for ventilators. And Central hung shutters shall be used for doors also. For fixing aluminum alloy hinges, slot shall be cut in the fixed frame and the hinges inserted inside and may be riveted to the frame. Cast or extruded aluminum alloy hinges for doors shall conform to latest edition of IS :1949, IS :617 and IS :733. The hinge shall be of projecting type. Non projecting type of hinges may also be used. The handle for doors and windows shall conform to latest edition of IS 617 and other relevant Indian Standards wherever applicable. Suitable lock for door operable either from inside or outside shall be provided. Any steel lugs coming in contact with aluminum should be either galvanized or given one coat of bituminous paint.

14.2.4 Finish

Aluminum doors, windows and ventilators shall be supplied & be anodized. Colour anodizing to be done using approved light fast shades.
A thick layer of clear transparent lacquer based on methacrylates shall be applied to protect the surface from wet cement during installation and after installation the lacquer coating shall be removed.

14.2.5 Glazing

Glazing shall be provided on the outside of the frames.

14.2.6 Hardware

Hardware for the Aluminum doors, windows and ventilators shall comply with the requirements specified on the drawings. The contractor shall submit catalogues and samples to the Engineer-in-charge for approval prior to supplying hardware. The hardware shall comply with the following requirement :

Hinges	Conforming to latest edition of IS :1948, IS :617, IS :753, IS :1949.
Knobs	Aluminum approved quality.
Lock sets	Aluminum cylinder lock of approved make.
Flush bolts	Wall or floor mounted type with rubber bumper and holder.
Door stops	Wall or floor mounted type with rubber bumper and holder
Door closers	As per relevant IS code
Hand plates	Aluminum approved make as per IS code
Hand Balls	Aluminum approved make as per IS code

The contractor shall supply three keys for each lock fitted.

14.2.7 Glazing

14.2.7.1 Materials

Glass for glazing of windows and doors shall be sound free from specks, waves and flows and shall be conforming to latest edition of IS : 1761, IS : 1081 and IS : 3548.

14.2.7.2 Execution

Glass shall be accurately cut to size to suit the dimension of openings. Glazing to Aluminum doors, windows and ventilators shall be carried out by means as described in IS code wherever available. Glass shall be cleaned and polished on completion of building works.

14.3 STEEL ROLLING SHUTTER DOOR

Steel Rolling Shutter doors capable of both electric and manual operation shall be installed at the location shown in the approved drawings and in accordance to the relevant IS Specifications. All steel plate and angles, welding and bolting shall conform to the specifications provided in section-7. The doors shall be composed of a shutter, guide rails, rolling drum and cover case, with a motor control gear, safety switch, wiring and all other accessories.

The various components shall be as follows :

Guide rails: 2.3 mm thick roll-formed steel plates, depth 75 mm, with safety stop at a height 2.2 mm above the floor.

Cover Case: 1.6 mm thick steel plate with adequate reinforcement and inspection hole.

Motor : Electric Source A.C. 230 Volt, 3 Phase 50 Hz. Operation speed 3 to 5 m/min. Motor to be installed in the cover case, operation box to be installed in the side wall at adequate height and provided with both electric and manual operation devices with all

necessary accessories including hand plate and hand bar of stainless steel. The manual operation device shall be suitably geared to allow operation by one man.

14.3.2 Measurement

Measurement for providing, fabricating and fixing for Aluminum windows, doors with glazing and steel rolling shutters shall be measured on the basic of square metre.

14.4 FINISHES FOR WALLS, CEILING AND FLOORS

14.4.1 Cement Plaster

The walls and the ceilings of the intake structure and the pumphouse shall be finished smooth with cement plaster as specified below:

	Particulars	Thickness of plaster	Proportion
1.	Wall	15 mm	1 cement : 4 sand
2.	Ceiling	6 mm	1 cement : 3 sand

14.4.2 Materials

i. Cement mortar shall consist of cement and sand and shall conform to the following.

1. Cement shall be ordinary Portland cement type in accordance with latest editions of IS : 269. The supply, use, storage and testing of cement shall be in accordance with IS specification.
2. Sand shall be clean, hard and durable, of proper grading and free from dirt, organic or deleterious materials.

The grading of the sand shall be within the following limits:

Classification	Screen Designation	Percentage by weight Passing screen
Rendering Coat	5 mm	100%
	0.15 mm	10% or under
Finishing Coat	2.5 mm	100%
	0.15 mm	10% or under

ii. The quality of the mortar. If required by the Engineer-in-charge water shall be tested Water used in the mixing of mortar shall be fresh, clean water suitable for drinking. Water shall not contain salt, oil, alkali, organic matter or other deleterious substances which would impair.

iii. Waterproofing and colored admixture shall be used in the cement mortar in strict accordance with the manufacturers printed instructions.

iv. The mix proportions of the cement mortar shall be as specified in the bill of quantity of this work. Water proofing compound @ 5% by weight of cement (maximum) shall be used in strict direction of the Engineer-in-charge.

Rate of respective items of work shall include cost of admixture etc.

v. The pigment of the coloured cement mortar shall be of good quality and approved by the Engineer-in-charge. It shall be used in accordance with the manufacturer's instructions.

14.4.2.1 Preparation of Surface

The joints shall be raked out properly. Dust and loose mortar shall be brushed out. Efflorescence if any shall be removed by brushing and scrapping. The surface shall then be thoroughly washed with water, cleaned and kept wet before plastering is commenced.

In case of concrete surface if a chemical retarder has been applied to the form work, the surface shall be roughened by wire brushing and all the resulting dust and loose particles cleaned of and care shall be taken that none of the retarders is left on the surface.

14.4.3 Mortar

The mortar of the specified mix using the type of sand described in the item shall be used. For external work and under coat work, the fine aggregate shall conform to grading IV. For finishing coat work the fine aggregate conforming to grading zone V shall be used.

14.4.4 Application of Plaster

Ceiling plaster shall be completed before commencement of wall plaster. Plastering shall be started from the top and worked down towards the floor. All putlog holes shall be properly filled in advance of the plastering as the scaffolding is being taken down. To ensure even thickness and a true surface, plaster about 15 x 15 cm shall be first applied horizontally and vertically at not more than 2 metre intervals over the entire surface to serve as gauges. The surfaces of these gauged areas shall be truly in the plane of the finished plaster surface. The mortar shall be applied in a uniform surface slightly more than the specified thickness. This shall be beaten with thin strips of bamboo about one metre long to ensure thorough filling of the joints, and then brought to a true surface, by working a wooden straight edge reaching across the gauges, with small upward and sideways movements at a time. Finally the surface shall be finished off with trowel or wooden float accordingly, as a smooth or a sandy granular texture, as required. Excessive trowelling or of working the float shall be avoided. During this process, a solution of lime putty shall be applied on the surface to make the later workable.

All corners, arises, angles and junctions shall be truly vertical or horizontal as the case may be and shall be carefully finished. Rounding or chamfering corners, rises, junctions etc. where required shall be done without any extra payment. Such rounding or chamfering shall be carried out with proper templates to the sizes required.

In suspending work at the end of the day, the plaster shall be left, cut clean to line both horizontally and vertically, when recommencing the plastering the edge of the old work shall be scraped and wetted with lime putty before plaster is applied to the adjacent areas, to enable the two to properly join together. Plastering work shall be closed at the end of the day on the body of wall and not nearer than 15 cm to any corners or arises. It shall not be closed on the body of the feature such as plasters, bands cornices, nor at the corners or rises. Horizontal joints in plaster work shall not also occur on parapet tops and copings, as these invariably lead to leakage. No portion of the surface shall be left out initially to be patched up later on.

a) Beating with thin bamboo strips shall not be done on the cement plaster and

b) No lime putty solution shall be applied on the face when finishing. Further the plastering and finishing shall be completed within half an hour of adding water to the dry mortar.

14.4.5 Curing

Curing shall be started as soon as the plaster has hardened sufficiently not to be damaged when watered.

The plaster shall be kept wet for a period of not less than 7 days. During this period, it shall be suitably protected from all damages at the contractor's expense by such means as the Engineer-in-charge may approve. The dates on which the plastering is done shall be legibly marked on the various section plastered so that curing for the specified period there after can be watched.

14.4.6 Finish

The plaster shall be finished to a true and plumb surface and to the proper degree of smoothness as required. The work shall be tested frequently as the work proceeds with a true straight edge not less than 2.5 m long and with plumb bobs. All horizontal lines and surfaces shall be tested with a level and all jambs and corners with a plumb bob as the work proceeds.

14.4.7 Measurements for Payment

Length and breadth shall be measured for payment correct to a cm and its area shall be calculated in square metres correct to two places of decimals.

Thickness of the plaster shall be exclusive of the thickness of the key i.e. grooves, or open joints in brick works.

The measurements of wall plaster shall be taken between the walls or partitions (the dimensions before plastering shall be taken) for the length, and from the top of the floor or skirting to the ceiling for the height. Depth of coves or cornices if any be deducted.

Deductions in measurement, for openings, etc. will be regulated as follows :-

a) No deduction will be made for openings or ends of joints, beams, posts, girders, steps etc. upto 0.5 sq m in area, no additions shall be made either, for the jambs, soffits and sills of such openings. The above procedure will apply to both faces of wall.

b) Deduction for openings exceeding 0.50 sq. m but not exceeding 3 sq. m each shall be made for reveals, jambs, soffits, sills etc. of these openings.

i. When both face of walls are plastered with different types of plaster or if one face is plastered and other is pointed, or one face is plastered and other is unplastered, deductions shall be made from the plaster or pointing on the side of the frame for the doors, windows, etc. on which width of reveal is less than on the other side but no deductions shall be made on the other side.

ii. Where width of reveals on both faces faces of are equal, deduction of 50% of area of opening on each face shall be made from area of plaster and/or pointing as the case may be

iii. For opening having door frame equal to or projecti.ng beyond thickness of wall, full deduction for opening shall be made form each plastered face of wall.

14.5 NEAT CEMENT PUNNING

Specifications for this item of work shall be same as described in clause 17.4 except for the additional floating coat of neat cement to be carried out as below :

When the plaster has been brought to a true surface with the wooden straight edge it shall be uniformly treated over its entire area with a paste of neat cement and rubbed smooth, so that the whole surface is covered with neat cement coating. The quantity of cement applied for a floating coat shall be 1 kg sq. m smooth finishing and shall be completed with trowel immediately and in no case later than half an hour of adding water to the plaster mix. The rest of the specifications described in 17.4.4 shall apply.

14.6 NISHES OF FLOOR

14.6.1 Resilient Tiles

Resilient tile and skirting shall be approximately 250 mm x 250 mm x 3 mm and 100 mm x 100 mm x 3 mm, respectively. Colour and patterns shall be selected by the Engineer-in-charge from the standard range.

The tiles shall be set on a thoroughly dried rendered base.

The layout shall be subject to the approval of the Engineer-in-charge.

Tile and skirting shall be adequately protected during the time of setting for a subsequent period. No traffic shall be allowed on the tiles for 48 hours after setting

14.6.2 Pre-cast Terrazzo Tiles

Pre-cast terrazzo floor tiles shall be made from portland cement and coloured stone chipping and shall be pressure moulded and ground to size. The tiles shall be hard, durable and sharp, true edges. Colours and patterns and patterns shall be selected by the Engineer-in-charge from a standard range.

The size of tile shall be as follows :

Floor tiles : 300 mm x 300 mm x 20 mm thick

Floor skirting 100 mm and 200 mm high.

Tiles and skirting shall be bedded and pointed in 1:3 cement mortar. Bedding for tiles shall be of required thickness to suit finished floor levels.

14.6.3 Ceramic Glazed Wall Tiles (Internal)

The ceramic will tiles for interior use shall be made of porcelain or earthenware. Tiles shall be 100mm square x 6 mm thick. Tiles shall be hard, durable and non-absorbent of exact shape and even thickness and shall have cushioned edges. Coloured and patterns shall be selected by the Engineer-in-charge from a standard range. Tiles shall be bedded in adhesive supplied by the tile manufacturers and pointed with white cement.

14.7 FALSE CEILING

14.7.1 The entire area to be air conditioned shall be provided with false ceiling of hard board three layer flat pressed teak timber tile each of size 60 cm x 60 cm x 12 mm thick or other approved suitable material for the false ceiling and the supporting frame material which shall be supplied & installed by the contractor. The complete material for the false ceiling and the supporting frame work shall be supplied by the contractor & shall conform to the relevant Indian Standards. After installation, the false ceiling (face towards the floor of the air condition rooms), shall be given suitable coating for protection as well as better finish. The colour of the coating shall be as approved by the Engineer-in-charge. Detailed

embedment drawing showing details of necessary embedments (Aluminum) to be provided in the ceiling for supporting the false ceiling frame work and ducts etc. shall be furnished by the bidder alongwith their offer. A suitable arrangement properly utilising these plates shall be furnished for approval of the Employer. All supporting material shall be supplied by the contractor.

14.7.2 Specification

Suitable provision such as semi-transparent panels or louvered openings etc., for illumination of the room shall be made in the design of the false ceiling. Full information regarding the proposed fittings for illumination purposes shall be furnished by the Contractor to the Employer. Supply and installation of lighting equipment shall be the responsibility of Contractor.

14.7.3 False ceiling supporting frame work including the Aluminum plates shall be given suitable rust resistant coating after proper cleaning of the surfaces.

14.7.4 The supporting arrangement shall be so designed as to permit easy dismantling etc. for maintenance of air conditioning equipment's or light fittings, etc.

14.8 PAINTING

14.8.1 Materials

Paints, oils, varnishes, etc., of approved brand and manufacture shall be used. Paints shall be synthetic enamel ready mixed paints and shall be used as received from the manufacturer. If for any reason, thinning is necessary in case of ready mixed paint, the brand of thinner recommended by the manufacturer or as instructed by the Engineer-in-charge shall be used.

Approved paints, oils, or varnishes shall be brought to the site of work by the contractor in their original containers in sealed condition.

14.8.2 Execution

Painting shall not be started until the Engineer-in-charge has inspected the items of work to be painted, satisfied himself about their proper quality and given his approval to commence the painting work. Painting of external surface should not be done in adverse weather condition like hail storm and dust storm.

Painting, except the priming coat, shall generally be taken in hand after practically finishing all other builder's work.

The rooms should be thoroughly swept out and the entire building cleaned up, at least on day in advance of the paint work being started.

14.8.2.1 Preparation of Surface

The surface shall be thoroughly cleaned and free from dust. All rust, dirt, scales, smoke and grease shall be thoroughly removed before painting is started. The prepared surface shall have received the approval of the Engineer-in-charge after inspection, before painting is commenced.

14.8.2.1.1 Application

Painting/Varnishes of approved colour and quality shall be done two coats over a priming coat over steel/wood works

Before pouring into smaller containers for use, paint shall be stirred thoroughly in its containers, when applying also, the paint shall be continuously stirred in the smaller containers so that its consistency is kept uniform.

The painting shall be laid on evenly and smoothly by means of crossing and laying off, the latter in the direction of the grain of wood. The crossing and laying off consists of covering the area over with paint, brushing the surface hard for the first time over and then brushing alternately in opposite direction two or three times and then finally brushing lightly in a direction at right angles to the same. In this process, no brush marks shall be left after the laying-off is finished. The full process of crossing and laying off will constitute one coat.

Where so stipulated, the painting shall be done by spraying. Spray machine used may be (a) high pressure (small air aperture) type, or (b) a low pressure (large air gap) type, depending on the nature and location of work to be carried out. Skilled and experienced workmen shall be employed for this class of work. Paints used shall be brought to the requisite consistency by adding a suitable thinner.

Spraying should be done only when dry condition prevails. Each coat shall be allowed to dry out thoroughly and rubbed smooth before the next coat is applied. This should be facilitated by thorough ventilation. Each coat except the last coat, shall be lightly rubbed down with sand paper or fine pumice stone and cleaned off dust before the next coat is laid.

No hair marks from the brush or clogging of paint puddles in the corners of panels, angles of mouldings, etc shall be left on the work.

In painting doors and windows, the putty round the glass panes must also be painted; but care must be taken to see that no paint stains etc., left on the glass. Tops of shutters and surfaces in similar hidden locations shall not be left out in painting.

In painting steel work, special care shall be taken while painting over bolts, nuts, rivets, overlaps etc.

14.8.2.2 Brushes and containers

After work, the brushes shall be completely cleaned of paint and linseed oil by rinsing with turpentine. A brush in which paint has dried up is ruined and shall on no account be used for painting work. The containers when not in use, shall be kept closed and free from air so that paint does not thicken and also shall be kept safe from dust. When the paint has been used, the containers shall be washed with turpentine and wiped dry with soft clean cloth, so that they are clean, and can be used again.

14.8.2.2.1 Measurements

The length and breadth shall be measured for payment to a cm. The area shall be calculated in sq. metres (correct to two places of decimal), except otherwise stated.

Small articles not exceeding 10 sq. decimetre (0.1 sq. m) of painted surfaces where not in conjunction with similar painted work shall be enumerated.

Painting up to 15 cm in width or in girth and not in conjunction with similar painted work shall be given in running metres.

Components of trusses, compound girders, stanchions, lattices and similar work shall, however, be given in sq. metres irrespective of the size or girth of members.

In measuring painting, varnishing, oiling etc., of joinery and steel work etc. the coefficients as in following tables shall be used to obtain the area payable.

The following coefficients shall be applied to the areas measured flat and not girthed.

Table 1 Equivalent Plain Areas of Uneven Surfaces

Sl. No.	Description of work	How measured	Multi plying co-efficient
1	2	3	4
a)	Panelled or framed and braced doors, windows etc. .	Measured flat (not girthed) including Chowkhat or frame Edges, chocks, Cleats,etc. shall be deemed to be included in the item.	1.30 (for each side)
b)	Ledged and battened or ledged, battened and braced, doors, windows etc.		
c)	Flush doors etc.	DO	1.20 (for each side)
d)	Rolling shutters of interlocked laths	Measured flat (size of opening) all over jamp guides, bottom rails and locking arrangement etc. shall be included in the item (top cover shall be measured separately)	1.10 (for each side)
e)	Fully glazed or gauged steel doors windows	Measured flat (not girthed) including frame edges etc.	0.50 for each side)
f)	Expanded metal, hard drawn steel wire fabric of approved quality, grill works and gratings in guard Bars, balustrades, Railings, partitions And M. S. Bars in Windows frames	Measured flat overall ; no deduction shall be made for open spaces; supporting members shall not be measured separately	1 (for paint all over)
g)	Open palisade fencing and gates including standards, braces; rails stays etc,. in	------Do---------	1 (for paint all over)

timber or steel

Explanatory notes for table 1

1. Measurement for doors windows etc. shall be taken flat (and not girthed) over all including chowkhats or frames, where provided. Where Chowkhats or frames are not provided, the shutter measurements shall be taken.

2. Where doors, windows, etc., are of composite types other than those included in Table 1 the different portion shall be measured separately with their appropriate coefficients, the center line of the common rail being taken as the dividing line between the two portions.

3. The coefficients for doors and windows shall apply irrespective of the size of frames and shutter members.

4. In case steel frames are used the area of doors, windows shutters shall be measured flat excluding frames.

5. When the two faces of a door, windows etc., are to be treated with different specified finished, measurable under separate items, the edges of frames and shutters shall be treated with the one or the other type of finish as ordered by the Engineer-in-charge and measurement of this will be deemed to be included in the measurement of the face treated with that finish.

6. In the case where shutters are fixed on both faces of the frames. The measurement for the door frame and shutter on one face shall be taken in the manner already described, while the additional shutter on the other face will be measured for the shutter area only excluding the frame.

7. Where shutters are provided with clearance at top or/ and bottom each exceeding 15 cm height, such openings shall be deducted from the overall measurements and relevant coefficients shall be applied to obtain the area payable.

8. Measurements of painting as above shall be deemed to include painting all iron fittings in the same or different shade for which no extra will be paid.

9. The measurements of guard bars expanded metal, hard drawn steel wire fabric of approved quality grill work and gratings, when fixed in frame work, painting of which is once measured else where shall be taken exclusive of the frames. In other cases the measurements shall be taken inclusive of the frames.

14.8.2.2.2 For painting open palisade fencing and gates etc., the height shall be measured from the bottom of the lowest rail,. if the palisades do not go below it, (or from the lower end of the palisades, if they project below the lowest rail), upto the top of rails or palisades whichever are higher, but not up to the top of standards when the latter are higher than the top rails or the palisades. Measurements of wall surfaces and wood and other work not referred to already shall be recorded as per actual.

14.8.2.2.3 Precautions

All furniture's, fixtures, glazing, floors, etc., shall be protected by covering and stains, smears, splashings, if any shall be removed and any damage done shall be made good by the contractor at his cost.

14.8.4 Painting priming coat on wood, iron or plastered surfaces.

14.8.4.1 Primer

The primer for wood work, iron work or plastered surface shall be as specified in the description of the item.

Primers for plaster/ wood work/iron & steel/ aluminum surfaces shall be as specified below :

TABLE - 2

	Surfaces	Primer to be used
1.	Wood work (hard & soft wood)	Pink conforming to latest edition of IS 3536)
2.	Resinous wood and plywood	Aluminum Primer
	Aluminum steel and galvanised Steel work	Zinc chromate primer conforming to latest edition of IS : 104
4.	Cement brick work, plaster surface, asbestos surface for oil bound distemper and paint	Cement Primer

The primer shall be ready mixed of approved brand and manufacture.

14.8.4.2 Preparation of Surface

14.8.4.2.1 Wooden Surface

The wood work to be painted shall be dry and free from moisture.
The surface shall be thoroughly cleaned. All unevenness shall be rubbed down smooth with sand paper and shall be well dusted. Knots, if any shall be covered with preparation of red lead made by grinding red lead in water and mixing with strong glue sized and used for. Appropriate filler material with same shade as paint shall be used where specified.

14.8.4.2.2 Iron & Steel Surface

All rust and scales shall be removed by scraping or by brushing with steel wire brushes. Hard skin of oxide formed on the surface of wrought iron during rolling which becomes loose by rusting, shall be removed.
All dust and dirt shall be thoroughly wiped away from the surface.
If the surface is wet, it shall be dried before priming coat is undertaken.

14.8.4.2.3 Plaster Surface

The surface shall ordinarily not be painted until it has dried completely. Trial patches of primer shall be laid at intervals and where drying is satisfactory, painting shall then be taken in hand. Before primer is applied, holes and undulations, shall be filled up with plaster of Paris and rubbed smooth.

14.9 DRY DISTEMPER

14.9.1 Materials

Dry distemper of required colour and (IS-427) of approved brand and manufacture shall be used. The shade shall be got approved from the Engineer-in-charge before application of distemper. The dry distemper colour as required shall be stirred slowly in clean water using 6 decilitres (0.6 litre) of water per kg of distemper or as specified by the manufacturer. Warm water shall preferably be used. It shall be allowed to stand for at least 30 minutes (or if practicable over night) before use.

14.9.2 Application

i. Before application of distemper is taken up, the surface shall be thoroughly brushed free from mortar dropping, other foreign matter and sand and prepared smooth. New plaster surface shall be allowed to dry for at least two months before applying distemper.

ii. After preparation of the surface A priming coat of whiting shall be applied over the prepared surface. No white washing coat shall be used as a priming coat for distemper. The treated surface shall be allowed to dry before distemper coat is given.

iii. Whiting (ground white chalk) shall be dissolved in sufficient quantity of warm water and stirred to form a thin slurry and two kg of gum and 0.4 kg of copper sulphate dissolved separately in hot water shall be added for every cum of slurry. The mixed slurry shall then be diluted with water to the consistency of milk so as to make a wash ready for use.

iv. Distemper shall be applied two or more coats over the dried surface of the primary coat till the surface shows an even colour. The entire surface shall be coated with mixture uniformly, with proper distemper brushes in horizontal strokes followed immediately by vertical ones which together shall constitute one coat. The subsequent coat shall be applied only after the previous coat has dried. The finished surface shall be even and uniform and shall show no brush mark.

14.10 PROVIDING AND FIXING ANODIZED ALUMINIUM PIPE RAILING 40 MM DIAMETER

14.10.1 General

Anodized aluminum pipe railing shall be provided as shown on the drawing or as directed by the Engineer-in-charge. The railing shall be made of 3 rows of 40 mm diameter anodized aluminum pipes conforming to IS fixed in position one above the other as shown on the drawings in 1.2 metre height with vertical supports of 100 x 50 x 5 mm J section, 1.5 meter center to center. In the construction drawing suitable adjustment in the pattern as indicated above and as required as per actual site condition and as directed by the Engineer-in-charge shall have to be carried out by the contractor. All railing shall be so constructed as to enable removal of the parts for repair and replacement.

14.11 PIPES

14.11.1 General

The work to be done under these specifications include providing and installing mild steel black perforated pipes, G.I. pipes required for water supply system connecting drainage

holes to the gallery, and internal drainage of intake and pump house building, vertical drainage pipe, rigid un-plasticized PVC pipes for potable water supplies.

14.11.2 Application Publications

All methods and procedures for installing and testing of pipes shall conform to latest edition of Indian Standard Specification listed below, unless otherwise specified.

Indian Standards:

1. IS:2026 Specification for Structural Steel (Standard Quality)

2. IS:554 Dimension for Pipe Thread where Pressure Tight Joints are Required in Threads.

3. i) IS:1239 (Part – I) Specification for Mild Steel Tubes, Tubulars and other Wrought Steel Fittings.

ii) IS :1239 (Part – II) Mild steel Tubulars and other wrought steel pipe fittings.

4. IS:3589 Specification for Electrically Welded Steel Pipes of Water and Sewage.

5. IS:4711 Methods of Sampling of Steel Pipes, Tubes and Fittings.

6. IS:4984 Specification for high Density polythylene pipes for potable water supply.

14.11.3 Rigid (Unplasticized) PVC Pipes

14.11.3.1 The pipes shall be reasonably round and shall be supplied in straight lengths with socketed end. The internal and external surface of pipes shall be smooth and clean, free from grooving and other defects. The pipe shall be designated by external diameter and shall conform to latest edition of IS 4985.

14.11.3.2 Fittings :- Fittings used shall be of the same make as that of PVC pipes, injection moulded or made in cast iron and shall conform to relevant Indian Standard.

14.11.3 JOINTING

17.11.3.1 G. I. Pipes

The pipes shall be cleaned and cleared of all foreign matter before being laid. In jointing the pipes, the inside of the socket and the screwed end of the pipes shall be oiled and rubbed over with white lead and a few turns of spun yarn wrapped round the screwed end of the pipe. The end shall then be screwed in the socket, tee etc., with the pipe wrench also as not to damage the pipe care shall also be taken that all pipes and fittings are properly jointed so as to made the joints completely water tight and pipes are kept at all times free from dust and dirt during fixing.

14.11.3.2 PVC Pipes

Solvent cement joints/ flanged joint/rubber ring joints shall be provided and shall conform to relevant Indian Standards.

14.11.3.3 Cast Iron Detachable Joints

The joints shall consist of a central collar, two rubber rings two flanges of cast iron and the required number of bolts and nuts. One flange and rubber ring shall be placed one end of the pipe already laid and the other flange, rings and central collar shall be slipped on the pipe to be assembled. The rubber ring shall be kept positioned at half the collar width less 2.5 mm from the end of the pipe already laid. A site gauge may be used for convenience. The other pipe shall be brought nearer leaving a gap of 5 mm between the two pipe ends. This gap will facilitate maneuvering of deflection at joints after assembly and will take care of an expansion in the pipe line. The collar shall be slided to sit square around the rubber ring on pipe to sit around collar. The flange shall be moved on both ends to enclose rubber rings. The fastenings bolts shall be inserted through the holes of the flanges and the bolts shall be tightened alternately and evenly for proper sitting of the joint.

14.11.3.3 Cast iron fittings and accessories

Cast iron fittings are jointed by cast iron detachable joints only. Cast iron specials having flanges jointed in the pipe with the cast iron flange adapters having one end flanged and the other plain ended. When there will be tendency for the pipe ends or specials ends to slipout of the joints anchorage shall be provided against the direction of thrust.

14.12 WATER SUPPLY, SANITARY AND DRAINAGE FITTINGS

14.12.1 PROVIDING AND FIXING WATER CLOSET

White vitreous china water closet squatting pan (Indian type) shall be provided and shall conform to latest edition of IS : 2556 Pt.II. The pan shall have following accessories :

a) ‘P’ or ‘S’ trap
b) Foot rest pair in white vitreous china (size 25 x 13 x 3 cm.)
c) Low level flushing cistern of 12.5 litre capacity of white vitreous china including 15 mm dia inlet, float valve, C.P. brass heavy stop cock and handle etc.

The squatting pan shall be fitted flush with floor level. Brick lime coba shall be filled under the pan after fixing it to the correct position.

In fixing the pan if holes are made in the floors or wall the same should be repaired with 1:3 cement mortar, complete.

Flushing cistern to the wall shall be with CI bracket and repair of wall with 1:3 cement mortar.

14.12.3 Providing and Fixing in Position White Vitreous Flat Back Lipped Urinal

White vitreous flat back lipped urinals shall conform to IS : 2556 (Pt. IV). The urinal unit shall have following fittings and accessories.

a) Flushing cistern of 5 litre capacity – conforming to IS : 774 with flush pipe for back and front flush with spreader pipes with fittings.
b) Standard urinal C.I. trap 65 mm dia with vent arm and outer gratings and coupling in C.P. brass trap and unions.
c) White vitreous china tiling upto 1200 mm height on front and side walls.

The urinal shall be fitted on C.I. bracket embedded in wall. In fixing the urinal if wall is damaged the same shall be made good by repair. All fittings and C.I. bracket shall be painted with ready mixed paint of approved quality.

Payment for the item shall be made on the basis of numbers of urinal units fixed in position.

14.12.4 Providing and Fixing Wash Basin

White vitreous china wash basin shall conform to IS : 256 (Pt. IV). The wash basin of size 55 x 40 cm size shall have following accessories.

a) Rolled Steel or Cast Iron conforming to IS :775 duly painted
b) 15 mm dia C.P. brass pillar taps and C.P. brass chain rubber plug.
c) 32 mm dia brass waste coupling
d) 15 mm dia lead inlet connection of minimum 40 cm in length
e) 15 mm dia brass heavy duty stop cock
f) 32 mm C.I. trap and brass cleaning thimble upto and outside wall till gully trap
g) C.I. clips, 40 mm dia G.I. pipe sleeve.

The wash basin shall be fixed on C.I. bracket embedded in wall. In fixing the wash basin if holes are made in floor or walls the same should be repaired with 1:3 cement mortar to the original condition. All fittings and C.I. bracket shall be painted with ready mixed paint of approved quality.

14.13 MS GRATING AND STEEL WORK IN SINGLE SECTION (CABLE DUCT)

14.13.1Description

400 mm wide M. S. grating over drain is consisting of 25 x 3 mm MS flats 50 mm c/c both ways welded to IS Angles of size 30 x 30 x 5 mm. All structural steel used for grating shall conform to latest edition of IS : 226. The welding shall conform to latest edition of IS : 816.

14.13.1.1 Steel work in single section for cable duct consists of 9 rows of angles 50 x 50 x 5 mm on both sides fixed in R.C.C. wall.

14.14 R.C.C. PRECAST COVER

The specification for providing and fixing RCC pre-cast cover of size 750 x 750 x 300 mm over drain shall conform to Section-5 concrete and reinforcement of this specifications.

14.15 JOINTS AND SEALS

14.15.1 Scope of Work

14.15.1.1

The section covers specifications for providing Polyvinyl Chloride (PVC) waterstops, asphalt seals with or without stainless steel strip. 12 gauge steel plate formed holes, joints filler and water proofing treatment over slab and corner joints at the location of joints as shown on the drawings or as directed by the Engineer-in-charge.

14.15.2Classification

The items covered under the specifications are as under :

Providing and fixing in position PVC water stop 305 mm/ 225 mm wide embedded in concrete with heat sealed joint, etc. complete as per drawings and specifications.

Providing and fixing in position PVC joints strip with 12 gauge stainless steel strip and stainless steel bolts and washer expansion anchors, etc. complete as per drawings and specifications.

Providing and laying asphalt seal in formed hole, at joints, including 12 mm diameter standard steam pipe duly fitted in 20 gauge sheet metal all along pipes including clamps, nuts, bolts, couplings, plugs and steam supply filled with an approved 'H' grade asphalt etc. Complete as per drawings and specifications.

Providing and laying joint filler of approved quality in joints as per drawings and specifications.

Providing and fixing 20 gauge stainless steel strip (175 mm x 27 mm) with 12 mm dia, 80 long hexagonal head, stainless steel bolts embedded in concrete and nuts and washer, etc complete as per drawings and specifications.

Providing formed holes of different sizes and shape varying form 50 mm to 175 mm for joints including centering, shuttering, etc. complete as per drawings and specifications.

Providing and laying 6 layer water proofing treatment including 12 gauge 200 mm wide galvanised steel plate embedded in bituminous plastic cement, including fixing the plate at both corner joints to the standard galvanised shape anchor 20 mm wide 200 mm, providing flushing reglet and fixing the plate at corner joints with the help of 35 mm long 28 gauge galvanised barbed roofing nails in nailing concrete a the corner joints including providing 100 mm thick, 600 mm wide A. 20 S-200 RCC with 8 mm dia bars both ways over the steel plate including water proofing treatment etc. complete as per drawings and specification.

14.15.3 Application Publications

14.15.3.1 All methods of tests and welding procedure shall conform to latest Indian Standard Specification and other publication listed below unless otherwise specified.

14.15.3.2 Indian Standards

IS:702	Asphalt
IS:1322	**Bitumen felt**
IS:1346	Water proofing treatment 6 course.

IS:3384	Asphalt primer
IS:8004	Recommended procedure for welding of Flexible PVC (Flexible Polyvinyl Chloride)

14.15.3.3 Other Publications

American Society for Testing and Materials Designation D-638.

American Society for Testing and Materials Designation D-2240.

14.15.4 Polyvinyl Chloride (PVC) Water Stops

14.15.4.1 General

The dimension of Polyvinyl Chloride (PVC) waterstops, shall normally be as shown in approved drawings. The Contractor, however, will be permitted to use waterstops of any alternative manufacturer, such as waterstops with diamond shape and bulb, provided they conform with the specifications and the functional and construction requirement. For this purpose, the Contractor shall submit to the Engineer-in-charge for approval four sets of drawings, showing details of the waterstops, including shapes and details of intersections and splices between water stops of the same sizes and of different sizes. Fabrication and procurement of materials shall be made only after approval of the drawings by the Engineer-in-charge. Any fabrication or procurement of materials done prior to approval of the drawings shall be at the Contractor's expense. The Engineer-in-charge shall have the right to require the Contractor to make any changes in the drawings which may be necessary to make the finished installations conform to the requirements and intent of these specifications, without additional cost to the Employer. Approval by the Engineer-in-charge to the Contractor's drawings shall not be held to relieve the Contractor of any part of this obligations to meet all of the requirement of these specifications or of the responsibility for the correctness of his drawings.

One set of the above drawings will be returned to the Contractor, either approved, disapproved, or conditionally approved. All drawings that are disapproved shall be revised and resubmitted for approval, as directed.

The waterstops shall be dense, homogeneous and free from holes and other imperfections. The waterstops shall meet the material and test requirements given in concrete specifications. The cross-section of the waterstops shall be uniform along its length and thickness shall be symmetrical transversely. Tolerance from the dimensions given above shall be plus 5 mm in width, plus 2 mm in thickness and plus 1 mm for the rest.

Certified copies of laboratory test reports on the physical properties of the PVC waterstops and a certificate stating the PVC waterstops as furnished meet all other requirements of these specifications, shall be obtained by the Contractor from the manufacturer of the PVC waterstops and submitted to the Engineer-in-charge for approval. Three 1.5 m long samples of the PVC water stops shall be obtained by the contractors from the suppliers and submitted to the Engineer-in-charge. These samples shall be furnished atleast 60 days prior to embedding of any waterstops in the structures.

The contractor shall arrange to obtain the waterstops from the suppliers in rolls securely packed, containing a single length of not less than 12 linear metres and having inside diameter of not less 0.3 meter.

14.15.4.2 Installation

The location and embedding of the PVC waterstops shall be as shown on the drawings, with approximately one half of the width of the waterstops embedded in the concrete on each side of the joint. In order to eliminate faulty installation that may result in leakage, particular care shall be taken that the waterstops are correctly positioned and secured during installation. Where the bottom end of PVC waterstops contact rock at the base shall be embedded at a minimum depth of 30 cm into sound rock, All waterstops shall be so installed as to form a continuous water tight diaphragm in the joint unless otherwise shown. Adequate provision shall be made to completely protect the waterstops during the progress of the work.

Additional vibration, over and above that used of adjacent concrete placement, shall be employed near the waterstops to assure complete embedding of the waterstops in the concrete. Larger pieces of aggregates near the waterstops shall be removed by hand during embedding to assure complete contact between the waterstops and the surrounding concrete.

Splices of waterstops shall be fabricated only by workmen who have demonstrated to the satisfaction of the Engineer-in-charge that they are sufficiently skilled to fabricate the required splices. Splices in the continuity of or at the intersection of runs of PVC waterstops shall be performed by heat sealing the adjacent surfaces in accordance with the manufacturer's recommendations. A thermostatically controlled electric heat source shall be used to make all splices. The correct temperature at which splices should be sufficient to melt but not char the PVC material. All splices shall be neat with the ends of the joined waterstops in the true alignment. A meter box guide and portable saw shall be provide and used to cut the ends to be joined to ensure good alignment and contact between the surface joint. After splicing, a remoulding iron with ribs and corrugations to match the pattern of the waterstop, shall be used to reform the ribs at the splice. The continuity of the characteristic members of the waterstop design (ribs, tubular central axis, protrusions and the like) shall be maintained across the splice.

Where splices are required between waterstops of different sizes the splices shall be made as recommended by the manufacturer of the waterstops and drawings showing the details of the splices shall be submitted to the Engineer-in-charge.

Prior to embedding, the edges of the waterstop shall be secured to looped wire in the end bulbs to improve the concrete bond as shown on the drawings. The bars shall conform to the provision of Section-9 "Concrete works". The manner in which the waterstop is secured to the reinforcing bars shall be subject to approval of the Engineer-in-charge.

14.15.4.3 Asphalt Seal

14.15.4.3.1General

The contractor shall construct asphalt seals in contraction joints of dam intake and pump house and intake structure as shown on the drawings or as directed by the Engineer-in-charge.

14.15.4.4 Material

Asphalt fill hole shall be filled with 'H' grade asphalt or blow bitumen asphalt R 85/25. 11mm diameter heating pipes and fittings shall be provided in the formed hole for asphalt fill as shown in the drawing.

14.15.4.5 PVC Joints Strip

14.15.4.6 PVC joint strips : PVC joint strips with or without stainless steel metal strips shall be installed in the places shown on the drawings and elsewhere as directed. The Contractor shall furnish the PVC joint strips, metal strip, expansion anchors, bolts and washers. The joint strips shall be furnished in not less than 3.5 m length. All PVC joint strips shall be stored in as cool place as practicable, preferable at 70^0 F or less, and in no case shall the rubber be stored in the open or exposed to the direct rays of the sun. PVC material for the joint shall have the physical characteristics as per para 17.15.4.1 of this section.

All PVC joint strips shall be extruded and cured in such a manner that any cross section will be dense, homogeneous, and free from porosity and other imperfection. Surface defects such as surface peel, flow lines, blisters, nonfills and air traps shall be minimum. Any defects which is not acceptable shall be repaired to the satisfaction of Engineer-in-charge or shall be removed from the finished product by cutting out a length of joint strip containing such defect.

The Contractor shall also furnish to the Engineer-in-charge with three 300mm samples of the PVC joints strips for testing for tensile strength and elongation by the Employer. The samples shall be cut from the finished product in the presence of the Engineer-in-charge. The contractor shall furnish samples at no extra cost to the Employer.

PVC joint strips shall not be installed until at curing of the adjacent concrete has been complete. The joint strips shall be installed as shown by close fitting butt joints and the location of all such joints shall be submitted to the approval of the Engineer-in-charge. The metal strips for the PVC joint strips shall be fastened to the concrete with, bolts as shown on the drawings. Where required, the metal strips shall be bent to conform to the angles formed by abutting surface.

14.15.4.6 Joint filler

The joint filler shall normally be as shown on drawing. The Contractor however, will be permitted to use, joint filler of the approved quality as per relevant Indian Standard, or any alternative manufacturer of joint filler, provided they conform to the specification and the functional and construction requirement The Contractor shall submit to the Engineer-in-charge for approval the proposal 30 days before for using such joint filler along with relevant certificate from manufacturer of joint filler.

The joints in the joint filler shall be scarfed, made tight and filled with suitable material so that mortar from the concrete will not seep through the opposite surface. The joint filler shall be racked out after the concrete has set.

14.15.5 **Water Proofing arrangement at the corners and joints in slab**.

The water proofing arrangements shall be provided on the roof at the junction of roof and the wall. The arrangement including providing fixing and laying 12 gauge G.I. plate embedded in 100 mm thick 600 mm wide RCC, including 28 gauge roofing nails of 30 mm long fixed in nailing concrete in the corner and providing and fixing flashing reglet and standard galvanized anchor strap of 200 mm long 20 mm wide, 6 layer of water proofing membrane, caulking compound etc. complete as per drawing and specification.

14.16 MISCELLANEOUS WORKS FOR CIVIL STRUCTURES

14.16.1 ROADWAY

The approaches to pump houses of Gouravelly reservoir shall be black-topped metallic road and shall consist of stone metal mechanically interlocked by rolling and bonded together screening and binding material, where necessary and water laid on a prepared subgrade. The road will be finished in accordance with the requirements of these specifications, description of item of work and in conformity with the lines, grades and cross-sections shown on the drawings or otherwise directed by the Engineer-in-charge.

14.16.1.1 MATERIALS

a) Coarse aggregates

Coarse aggregates shall be stone aggregate with impact value conforming to IS : 2386 and IS : 5640. The grading of aggregates shall be as under :

Size range	Sieve designation	Percent by weight passing the sieve
63 mm to 40 mm (For Stone metal)	80 mm	100
	63 mm	90-100
	50 mm	35-70
	40 mm	0-15
	20 mm	0-5

b) Crushed or Broken Stone

Crushed or broken stone shall be free of flat, elongated, soft and disintegrated particles and should not contain any excess of dirt or other objectionable materials.

i) Screening

Screening to fill voids in the coarse aggregate shall generally consist of the same material as the coarse aggregate. However, where permitted, predominantly non-plastic material such as moorum or gravel (other than rounded river-borne material) may be used for this purpose provided liquid

limit and plasticity index of such material is below 20 and 6 respectively and fraction passing 75 micron sieve does not exceed 10 percent.

As far as possible, screening shall conform to the following gradings :

Size of Screening	Sieve designation	Percent by weight passing the sieve
10 mm	10 mm	100
	4.75 mm	85-100
	150 micron	10-30

ii) Binding Material

Binding material to be used for water-bound macadam construction shall comprise a suitable material approved by the Engineer-in-charge having plasticity index value of less than 6 as determined in accordance with IS : 2720 (Part V).

Application of binding material may not be necessary, when the screenings used are of crushable type such as moorum or gravel.

14.16.1.2 CONSTRUCTION OPERATIONS

a) Preparation of Subgrade

The subgrade to receive the water-bound macadam course shall be prepared to the specified grade and camber and made free of dust and other extraneous material. Any ruts or soft yielding places shall be corrected in an approved manner and rolled until firm.

b) Spreading Coarse Aggregate

The coarse aggregates (stone metal) shall be spread uniformly upon the prepared subgrade in two layers in such quantities so that the compacted thickness of each layer is 100 mm. Each layer is to be rolled separately but no binding material will be used in the first layer.

The spreading shall be done from stockpiles along the side of the roadway or directly from vehicles. In no case shall the aggregate be dumped in heaps directly on the surface prepared to receive the aggregate nor shall hauling over uncompacted or partially compacted base be permitted.

The surface of the aggregates spread shall be carefully checked with templates and all high or low spots remedied by removing or adding aggregate as required. No segregation of large or fine particles shall be allowed and the coarse aggregate as spread shall be of uniform gradation with no pockets of fine material.

The coarse aggregate shall not normally be spread more than 3 days in advance of the subsequent construction operations.

c) Rolling

Immediately following the spreading of the coarse aggregate, rolling shall be started with three-wheeled power rollers of 8 to 10 tonne capacity or tandem or vibratory rollers of approved type. The weight of the roller shall depend upon the type of the aggregate and be indicated by the Engineer-in-charge. Except on super-elevated portions where the rolling shall proceed from inner edge to the outer, rolling shall begin from the edges gradually progressing towards the centre. First the edge/edges shall be compacted with roller running forward and backward. The roller shall then move inwards parallel to the centre line of road, in successive passes uniformly lapping preceding tracks by at least one half width.

Rolling shall be discontinued when the aggregates are partially compacted with sufficient void space in them to permit application of screenings. However, in the case of first layer, where screenings are not to be applied, compaction shall be continued until the aggregates are thoroughly keyed. During rolling slight sprinkling of water may be done, if necessary. Rolling shall not be done when the ubgrade is soft or yielding or when it causes a wave-like motion in the sub-grade or sub-base course.

The rolled surface shall be checked transversely and longitudinally with templates and irregularities corrected by loosening the surface, adding or removing necessary amounts of aggregate and re-rolling until the entire surface conforms to desired camber and grade. In no case shall the use of screening be permitted to make up depressions.

d) Application of Screenings

After the coarse aggregate has been rolled, screenings to completely fill the inter-stices shall be applied gradually over the surface. These shall not be damp or wet at the time of application. Dry rolling shall be done while the screening are being spread so that vibrations of the roller cause them to settle into the voids of the coarse aggregate. The screenings shall not be dumped in piles but be spread uniformly in successive thin layers either by the spreading motion of hand shovels or by mechanical spreaders, or directly from trucks. Trucks operating for spreading the screenings shall be so driven as not to disturb the coarse aggregate.

The screening shall be applied at a slow and uniform rate (in three or more applications) so as to ensure filling of all voids. This shall be accompanied by dry rolling and brooming with mechanical brooms, hand-brooms or both. In no case shall the screenings be applied so fast and thick as to form cakes or ridges on the surface in such a manner as would prevent filling of voids or prevent the direct bearing of the roller on the coarse aggregate. These operations shall continue until no more screenings can be forced into the voids of the coarse aggregate.

The spreading, rolling and brooming of screenings shall be carried out in only such lengths of the road which could be completed within one day's operation.

e) Sprinkling and Grouting

After the screenings have been applied, the surface shall be copiously sprinkled with water, swept and rolled. Hand brooms shall be used to sweep the wet screenings into voids and to distribute them evenly. The sprinkling, sweeping and rolling operations shall be continued, with additional screenings applied as necessary, well-bonded and firmly set in its full depth

and a grout has been formed of screenings. Care shall be taken to see that the base or subgrade does not get damaged due to the addition of excessive quantities of water during construction.

f) Application of Binding Material

After the application of screenings, binding material where it is required to be used shall be applied successively in two or more thin layers at a slow and uniform rate. After each application, the surface shall be copiously sprinkled with water, the resulting slurry swept in with hand brooms, or mechanical brooms to fill the voids properly, and rolled, during which water shall be applied to the wheels of the rollers if necessary to wash down the binding material sticking to them. These operations shall continue until the resulting slurry after filling voids, forms a wave ahead of the wheels of moving roller.

g) Setting and Drying

After the final compaction of water-bound macadam course, the road shall be allowed to dry overnight. Next morning deficient spots shall be filled with screenings of binding material as directed, lightly sprinkled with water if necessary and rolled. No traffic shall be allowed on the road until the macadam has set. The Engineer-in-charge shall have the discretion to stop hauling traffic from using the completed water-bound macadam course if in his opinion it would cause excessive damage to the surface.

14.16.2 Specifications for the work of preparation of road base, laying and compaction of road base, providing water-bound macadam base course and asphalt wearing course/carpet shall be done as per IRC/IS specifications applicable from time to time.

14.17 RAILING

14.17.1 R.C.C. Railing

Railing shall not be cast until the centering or form-work for the span has been removed, and the span is self-supporting. The type of railing to be constructed shall be as shown on the drawings. The railing shall be carefully erected, true to line and grade. Posts shall be vertical within a tolerance not to exceed 6 mm in 3 metres.

Forms shall either be of single width boards or shall be lined with suitable material duly approved by the Engineer-in-charge. Form joints in plane surface will not be permitted.

All mouldings, panel work and level strips shall be constructed according to the details shown on the drawings. All corners in the finished work shall be sheared and clean-cut and shall be free from cracks, spalls or other defects. Payment for railing will be made at the rate per running metres. The rate shall include cost of labour, material, tools, and plant required for doing the work complete in all respects as per specifications.

14.17.2 G.I. Railings

All pipes and all steel elements used for railing, terminal sections, posts, bolts, nuts, hardware and other steel fittings shall be galvanized.

All elements of the railing shall be free from abrasions, rough or sharp edges, and shall not be kinked, twisted or bent. If straightening is necessary, it shall be done by methods approved by the Engineer-in-charge.

The railing shall be carefully adjusted prior to fixing in place to ensure proper matching at abutting joints and correct alignment and camber throughout their length. Holes for field connections shall be drilled with the railing in place in the structure at proper grade and alignment. Welding may be substituted for riveting in field connections only with the approval of the Engineer-in-charge. The payment for G.I. Railing will be made at the rate per running metre. The rate shall include cost of all labour, material, tools and plant required for doing the work complete in all respect as per specifications.

14.18 Guard Rail

the Contractor shall furnish and install guard rails at the location as shown on the drawings or as directed by the Engineer.

Prior to the work the Contractor shall submit to the Engineer for his approval shop drawings and installation method of guard rails.

The rails and posts shall be structured conforming to international standard and formed to the dimensions as shown on the Drawings or as directed by the Engineer.

Required bolts, nuts and washers shall be galvanized. The post shall be set to the required depth and be held firmly in place by concrete foundation.

After the guard rails are installed in place, painting shall be executed in accordance with the relevant provisions of the Specifications.

Reflector strip shall be attached to the guard rail wherever instructed by the Engineer and at maximum distance of 30 m along straight stretch.

Measurement for payment of guard rail shall be made at actual length in meter installed in service roads and accepted by the Engineer.

The unit prices for guard rail in service roads shall include all the cost for furnishing, installing and painting of guard rails and any other incidental works.

Guard rials installed in other construction roads including existing roads shall not be paid for separately, and the cost for which shall be included in the lump sum price of construction road in the Bill of Quantities.

14.19 Laying of Concrete Block

(1) General

The concrete block work shall be provided as indicated on the Drawings

Concrete block may be pre-cast / cast-in-situ and the volume of which should not be less than 0.3 m^3. Concrete mix should be of 1:2:4 with 20 mm nominal size of aggregate. In

case pre-cast blocks proper arrangement for placement of the same without damage and according to the line and levels shall be made.

In case of cast-in-situ blocks casting is to be done over the bed itself. Alternate blocks are to be taken up for casting at one time. Placement of pre-cast block/cast-in-situ block should be done in such a manner as there should not be any continuous joints.

Measurement for concrete block shall be made as per gross volume of each block in cubic metres.

Rate for concrete block shall include:

i) Cost of find and coarse aggregate / cement etc.
ii) Mixing, placing, compaction
iii) Shuttering and curing
iv) Placement of block over prepared bed.

15 FOREBAY BED LINING

15.1 GENERAL: These specifications apply to:

(a) Clearing site, preparation of sub grade in soils and rock, providing under drainage, pressure relief arrangements, anti salt treatment, placing model sections, laying plain cement concrete with machine crushed hard broken graded quartzite/ granite/ other than granite metal of 40 mm/ 20 mm. maximum nominal size and using cement level of not less than 310 Kgs. per cubic meter of concrete to yield a 28 days characteristic compressive strength specified based on laboratory tests for bed and sides respectively using conventional placement of concrete lining.

(b) If during construction, it is found necessary to alter the canal sections and side slopes without alterning the thickness of lining, the contractors shall be informed in writing of such changes.

(c) The scope of work also includes the following :

(i) Dewatering the canal section for preparing the base for lining and for laying concrete lining.

(ii) Providing necessary, under drainage arrangements consisting of longitudinal and transverse drains, pressure relief valves as per drawings.

(iii) Providing filter materials of approved quality as per designs.

(iv) Bed and side lining of the cement concrete with machine crushed hard broken graded Quartzite/granite/ other than granite metal of 40 mm./ 20 mm. nominal size and using cement of not less than 310 Kgs/cum. of concrete to yield a characteristic compressive strength specified based on laboratory tests respectively.

(v) Providing grooves for joints by cutting the concrete to the required depth and width as per drawings.

(vi) Curing.

(vii) Filling joints:

(viii)

15.2 APPLICABLE PUBLICATIONS:

All concrete, its constituents, methods and procedures of manufacture shall conform to Indian Standard Specifications and other publications listed below unless otherwise specified.

Indian Standards

1. IS : 456 -1978 Code of practice for plain and reinforced concrete (Second Revision) (Amendment No. 1).
2. IS : 3873-1978 Code of practice for laying in-situ cement concrete lining first Revision of canals (First Revision)
3. IS : 2505-1980 General requirements for concrete vibrators immersion type.
4. IS: 2506- 1985 General requirements for screed board concrete vibrators.
5. IS :3366-1965 Specification for pan vibrators.
6. IS : 3558-1983 Code of practice for use of immersion vibrators for consolidating concrete.
7. IS : 4558-1983 Code of practice for under drainage of lined canals.(First Revision)
8. IS : 5256-1968 Code of practice for sealing joints in concrete lining on canals
9. IS : 3085-1965 Methods of test for permeability of cement mortar and concrete. .
10. IS : 1199-1959 Method if sampling and analysis of concrete.
11. IS : 516 -1959 Method of tests for strength of concrete (Amendment No.1)
12. IS : 5529-1985 (part I&II) Code of practice for insitu-permeability test.
13. IS: 9103-1979 Specifications for admixtures for concrete.
14. IS : 2720-1980 (Part– 7) Methods of test for soils Determination of water content –dry density relation using light compaction (second revision)
15. IS : 9451-1985 Guidelines for placing lining for Canals in expansive soils. In addition to the above I.S. codes, the specifications of A.P.S.S. and manual for quality control and inspection shall also be complied with.

15.3 PREPARATION OF SUBGRADE:

15.3.1 Scope :

Preparation of sub grade (Back filling) to canal side and bed lining with CNS soils of approved quality, obtained from available canal spoil including cost and conveyance of soils, Clearing the site, dewatering if necessary, treatment of the soil laying moistening compacting to 98% proctor's density with suitable compacting equipment, trimming, all water leads,

material leads, lifts, delifts, and all the operations necessary to complete the finished item of work to specifications, as per drawings or as directed by the Engineer-in-charge.

15.3.2 CLEARING SITE:

The area proposed for lining the canal as a whole shall be cleared of all objectionable material. Any waste material contained from such site clearance shall be disposed off in a manner directed by the Engineer-in-charge. The cost of this operation shall be deemed to have been covered under the rates quoted for canal lining.

15.3.3 GENERAL :

The provisions of this para shall apply to the preparation of all sub-grade up on which concrete lining is to be laid. The work of trimming canal section upto the under side of concrete lining and preparing sub-grade for concrete placement includes removal of proud section. Proud equivalent to thickness of lining on sides and in bed on the underside of lining should be left un-excavated and the removal of this proud should be done prior to laying of lining but in no case, should the time interval exceed 3 days in normal weather and two days in adverse weather conditions. It shall be ensured that the subgrade is made thoroughly moist with fine water spray, through deployment of proper nozzles, to a depth of about 15 cms to prevent it from absorbing water from the freshly laid concrete.
Soil in all reaches should be tested for salt content before lining is started. Where the salt content is over one percent or sodium sulphate is over 0.36 percent, the sub grade should first be covered with about 2 mm. thick layer of bitumen, if ordered by the Engineer-in-charge It shall be treated in accordance with para 4.3 I.S. of 3873-1978.

Preparation of sub grade for concrete lining shall conform to clause 4.1 to 4.5 of IS:3873-1978.

Wherever rock is over excavated it shall be filled as specified under subsequent paras.
At the end panels of existing lining against which lining is to be placed under these specifications, all these materials shall be removed and all voids beneath the existing lining shall be refilled and thoroughly compacted.

15.3.4 SUB -GRADE :

i) Preparation of sub grade consisting of earth.

a) The sub grade shall be prepared, dressed and rolled true to level and according to the required cross- section of the canal to form a firm compacted bed for the lining.

b) The contractor shall place selected bedding material, test profile true to the cross section of the canal at times and places designated by the Engineer to show the adequacy of his construction procedures for laying bedding materials. The test sections shall conform to clause 4.5.2.of I.S. 3873. - 1978. The cost of this operation shall be deemed to have covered in the rates quoted for side and bed lining.

c) In other than predominantly sandy reaches where the dry density of the natural soil is not less than 1.8 gm. per cubic centimeter, initial excavation shall be done up to about 300mm**.** above the final section and the cutting to final shape shall be done immediately before lining. The compaction shall conform to Clause 4.5.6. of IS 3873-1978.

d) If at any point material of prepared sub grade has been excavated beyond the neat lines required to receive lining, the excess excavation shall be filled in horizontal layers with suitable semi pervious soil material compatible with the sub grade material moistened and thoroughly compacted in accordance with Clause 4.5.5. and 4.5.6of I.S. 3873-1978. Where placing and compacting bedding materials is on slopping foundation, the layers may be placed parallel to the surface of the foundation. If at any point, the foundation. material is disturbed or loosened during the excavation process or other wise, it shall be moistened if required, and thoroughly compacted by tamping, rolling or other approved methods to form firm foundation for placing the concrete lining**.** Slope compactors may also be used for effective compaction of subgrade.

e) In bed, where the dry density of the natural soil is less than 1.8 gm**.** per cubic centimeter and sub soil water is near the sub grade, the consolidation shall be done by under cutting the bed by 7.5cm and then ploughing upto 15.0cm**.** below the subgrade level. Theloosened soil shall then be recompacted with suitable devices. All along the canal alignment the raincuts on the banks shall be filled up with approved soil and shall be compacted adequately to required lines, dimensions and levels.

f) In bed where the sub soil water is low, requiring no dewatering and the dry density of the natural soil is less than 1.8 gm**.** per cubic centimeter, the consolidation shall be done by digging the canal up to sub grade level and after loosening the earth below subqrade up to 15.0cm**.** by disc harrows, or ploughing and compacting the same to a layer of 11.0cm. After that, the second layer of 15.cm**.** of earth shall be laid over the compacted layer by taking earth from lip cutting and compacting this to a depth of 11.00cm. The compacted layer of 7.0 cm above the subgrade level**.** shall be removed and the subgrade brought to design profile before laying the lining.

g) Consolidation on sides shall be done by suitable slope compactors to obtain a minimum dry density of not less than 90-98% of the density at optimum moisture content obtained in accordance with IS : 2720(part vii) 1965**.** Compaction by manual labour shall not be permitted.

ii) Preparation of sub grade consisting or rock.

a) The sub grade in rock shall be excavated to the required cross section. Final cutting for 450-600 mm**.** in hard rock shall be carried out by**,** wedging**,** barring controlled blasting or trimming with the help of suitable equipment. No extra payment will be made to this.

b) The bed and side slopes of the canal excavation profile over which the bedding material,. under drainage and pressure relief arrangements are to be placed and over laid with lining shall be finished accurately to true and even surfaces and to the dimensions shown on the drawings.

c) All excavation including over breakages below the lines of the underside of lining shall be back filled as follows:

In slopes : In slopes, the selected bedding material shall be semi pervious material forming, the bulk of back fill with smaller aggregate filling the voids**,** and a layer of gravel as binding material duly compacted with rammers to form a firm backing for the lining (IS: 3873-1978).

In bed : In case of bed, the selected bedding material shall be rock spells and chips available from canal cutting duly compacted with Diesel Road Roller to form a firm backing to lining (IS: 3873-1978).

Tolerance in Excavation :- Excavated profile provides the final base for lining and tolerances should be comparable to the following :

Departure from established alignment :
(+) or (-) 2 mm**.** on straight section:
(+) or (-) 50 mm**.** of tangents, and
(+) or (-) 100 mm**.** on curves.
(+) or (-)20 mm**.** Departure from established alignment.

The above tolerances shall be negotiated gradually, through smooth transition in a length of 50 m**.** No over- run in excavation. Filling with the materials as directed by the Engineers, shall be paid to the contractor.

The selected bedding material in the cases of bed and sides of canal profile in normal soils shall be graded filter material comparable with sub grade material and thoroughly compacted.

iii) Preparation of sub grade consisting of expansive soils. (IS : 9451-1995)**.**

(a) Field and laboratory experiments shall be carried out to determine the physical**,** texture, engineering and chemical properties of the black cotton soils/expansive soils and evaluate the swelling pressures of soils in various reaches to establish the thickness of CNS**.** layer required so that the determination is within the permissible limit.

In respect of the provision of CNS layer is worked out from the consideration of swelling pressure. However, the thickness of CNS layer to be provided on slopes shall, in addition, be governed by the construction considerations viz., from rollable width consideration for achieving effective compaction. However making due allowance for field controls, variations in the properties of CNS materials in the field an optimum thickness of 600 mm**.** normal to the slope shall be used in the channels of discharge more than one cumec. The thickness shall be appropriately decreased to 300 mm**.** (150mm**.** in small section of less discharges) channels. Filling and compaction of CNS material in such channels shall be done by pad/file and cut method as specified in the drawings.

15.3.5 C.N.S. BACK-FILL:

Formation of CNS soils backing to lining for bed of the forebay including breaking clods, sectioning, watering, and consolidation with 8-10 ton power roller to 98% proctor, density at optimum moisture content including spreading of horizontal layers of not more than 100 to 150mm thick upto the top level of P.C,C . lining/ cast-in-situ lining.

The surface to receive the filling shall be first cleared free from all roots, vegetation or spoils and then wetted and rolled thoroughly. The C.N.S. soils to be used for filling shall be free from salts or organic or other deleterious mater. All clods of the soils selected shall be

broken to small pieces less than 100 mm**.** size. No stones cobbles having maximum dimensions more than 100mm. size shall be placed in the fill. Filling shall be done in layers not exceeding the compacted thickness of 100 to 150mm. each layer being watered and compacted before succeeding layer is laid. If the moisture is below the optimum moisture content for the given compaction. Then the required water shall be added by sprinkling if the moisture content in the soils is more than the optimum moisture content then it shall be allowed to dry down to the optimum moisture content. The moisture content shall be uniform throughout the layer of material. Compaction shall be achieved by using appropriate power roller. The number of passes shall be determined by testing the density of the compacted soil at site after taking trial compaction for specified passes of the, roller. The roller shall be taken close to the sides of the trench. In cases where the compaction by roller. is not possible compaction shall be done as specified by the Engineer-in-charge. Care shall be taken to ensure that over compaction does not take place. The CNS material shall be filled in layers not exceeding the 225 mm compacted thickness of 100 to 150mm. up to T.B.L. and shall be consolidated with 8 to10ton power roller to the proctor's density of 98%at optimum moisture content. Serrations should be provided in expansive soil to present contact slides between CNS. materials and expansive soil .The work shall be tackled in continuous horizontal layers. On resuming work each day or after an interval of few day or when work is not done in continuity the previous layer shall be well raked and water sprinkled over it before the fresh layer is laid and compacted. Special precautions shall also be taken while rolling the spread soil near structures, conduits, sluices, etc., Quality control tests shall regularly be carried out to determine the suitability of the soil used for filling and to control moisture content to ensure that the specified density is obtained. All. tests shall be done in accordance with the relevant Indian standards. The frequency of the test shall be as determined by the Engineer-in-charge. The work shall be done to the construction profile.

The canal section including the thickness of the lining shall be excavated in CNS soils and canal sides and bed are trimmed to receive P.C.C slab lining and cast -in-situ lining respectively

The soils excavated shall be rehandled and used for forward reach as directed by the Engineer. No extra payment will be made for the excavation of CNS soil in canal section and rehandling the soils as above separately.

i) Gradation of C.N.S Soil :

1. Clay (less than 2 microns) -15 to 20%
2. Silt (0.06mm-0.002mm.) -30to 40%
3. Sand (2mm -0.06mm.) -30to 40%
4. Gravel (Greater than 2mm.)-0to10%

i. The CNS**.** material shall be non-swelling, with maximum swelling pressure of 10KN/m2 when tested in accordance with IS: 2720(Part-41)-1977at field moisture content oven dry condition

ii. The minimum shear parameters may range from 10.3422 Kn/m2 and 25^{o} to 27.5790 KN/m2 and 12^{o} to 14^{o}

iii. Index properties:

1. Liquid Limit. Less than 50% but greater than 30%

2. Plasticity Index Less than 30% but greater than 15%

a) If the expansive clay is in thin layers or in small pockets in an otherwise suitable sub grade shall be over excavated as determined by the Engineer-in-charge. and replaced with suitable non-expansive soil and compacted suitably.

b) After the canal prism has been shaped to a reasonably true and even surface, selected bedding materials shall be placed on thoroughly wetted surfaces in layers of 15CM.maximum thickness to bring the bedding material to a height where it can be trimmed to form a true and even surface upon which to place the concrete lining. Each layer shall be moistened and thoroughly compacted as per specification 3.2. Where the bedding material is placed and compacted on a slopping ground layers may be placed parallel to the surface of the foundation. The moisture content of the bedding material at the time of compaction shall be optimum. The compaction procedures used shall be as described below.

i) The contractor shall place demonstration or test sections of selected bedding material at time and places designated by the Engineer-in-charge to show the adequacy of his construction procedures for placing and compacting the bedding material. The test section shall conform to clause 4.5.2 of IS 3873-1978.

ii) The bedding material shall be placed to sufficient thickness in the test sections to allow practical density testing of the compacted material. The dimensions and densities of the compacted bedding materials shall be acceptable to the Engineer-in-charge. The procedures shall then be used to compact the selected bedding material on the remaining work.

iii) When placing and compacting selected bedding materials on a sloping foundation, the layers may be placed parallel to the surface of the foundation. If at any point the foundation material is disturbed or loosened during the excavation process or otherwise it shall be moistened if required and thoroughly compacted by tamping, rolling or other approved methods to form firm foundations upon which to place the concrete lining. The bottom and side slopes, including the surfaces of compacted embankment, compacted selected bedding materials and compacted back fill over which concrete lining is to be placed shall be furnished accurately to true and even surfaces to the dimensions shown on the drawings. The loading, handling, transporting and placing of the selected bedding material is subject to approval of the Engineer-in-charge and shall be such as will result in a uniform mixture of the material being placed without separation or segregation. Selected bedding materials required shall be obtained from excavation in areas where material in excess of that required to construct the adjacent embankment is available or the material approved by the Engineer-in-charge.

iv) Immediately prior to placing the first lift of bedding material, the surfaces of excavation and embankment to receive the material shall be adequately wetted to a depth of 15cm. or to impermeable material whichever is less as approved by the Engineer-in-charge.

v) Suitable materials trimmed from the canal shall be used to complete canal embankments, to construct road embankment, for selected bedding material in the forward areas. Where material suitable for selected bedding as determined by the Engineer-in-charge is encountered during trimming operations and cannot be placed in one continuous operation, such material shall be stockpiled along the right-of way where designated by the Engineer-in-charge.

15.3.6 MEASUREMENT AND PAYMENT:

All linear measurements shall be in meters corrected to 0.01M. and volume shall be worked out to nearest to 0.01 Cum. The items covered under their are ..

1) Mark out
2) Cost and conveyance of CNS. soil to the site of work.
3) Filing the C.N.S. soil in layers of not exceeding 100 to 150mm. thick and consolidation with appropriate power rollers to a proctor's density of 98% at optimum moisture content.
4) Cutting the canal section, including the thickness of lining in the compacted C.N.S soil
5) Rehandling the extra excavated CNS. soil to the forward reach.
6) Forming and removal of steps and ramps, benching battering, formation of temporary tracks for diversion of surface flows, bailing out seepage water and such other temporary arrangements unless otherwise specified.
7) Shrinkage allowance.
8) No separate payment will be made. It shall be included in the price bid quoted in the Bill of Quantities.

15.4 UNDER DRAINAGE:

15.4.1 General:

For a lined canal where the ground water level is higher or likely to be higher than the water level inside the canal so as to cause damaging differential pressure on the lining or where the subgrade is sufficiently impermeable to prevent free drainage of the under side of lining in case of rapid drawdown, pressure relief arrangements for under drainage shall be provided suitably as indicated in the drawing in accordance with IS: 455-1968.

15.4.2 FILTER DRAINS:

a) Scope : Forming longitudinal/transverse filter drains of Specified size in bed with 10 mm to 40mm machine crushed metal of specified variety and sand including cost and conveyance of all materials, labour charges for laying with leads, lifts, delifts, seigniorage charges, sampling and testing, dewatering, packing and all other incidental and operational charges necessary to complete the finished item of work as per drawings and as directed by the Engineer-in-charge.

b) Whenever necessary, longitudinal/transverse filter drains shall be laid in the concrete lining true to the canal grade as shown in the drawings or as directed by the Engineer-in-charge. The number of layers comprising the filter, thickness of each layer and the materials to be used shall be as shown in the drawings. The filter material shall be clean, round and well graded sand or coarse aggregate the requirements of grading of which will be established in the field laboratory on the basis of mechanical analysis of adjacent materials. Particles of decomposed rock debris, wood vegetable matter or other deleterious materials shall not be permitted in the filter. Before placing the filter the bed shall be prepared as explained in the above paragraphs.

c) The longitudinal drains shall be laid to the grade of the canal while the transverse drains in bed shall have a fall towards the centre of the canal bed from the edge as shown in the drawing. The sand shall be clean, round and well graded. Before placing the filter, the bed shall be prepared as specified in paragraph above.

d)No separate payment will be made. It shall be included in the price bid quoted in the Bill of Quantities.

15.4.3 Pressure relief arrangement:

a) **Scope** : Laying and fixing of porous concrete plugs/flap valves in position in filter pockets including (a) Manufacturing of plugs, using 20 mm size machine crushed/ hand broken aggregate of specified variety and Cement of specified quantity for each plug (or) Manufacturing of flap valves consisting specified internal diameter with P.V.C.Pipe, with P.V.C. flange and rubber flap with all accessories and (b) excavation of pit for laying filter pocket and filling the filter pocket with filter materials including cost and conveyance of cement and all other materials, seigniorage, charges, labour charges for Manufacturing of plugs/flap valves, excavation of filter pocket, filling of pocket with specified grade of filter material, form work ,moulds machine mixing manufacturing, curing, sampling and testing, laying and fixing in position with all leads, lifts, delifts, dewatering, all water leads, and all other incidental and operation charges necessary to complete the finished items of work as per drawings and as directed by Engineer-in-charge.

b) The porous plug/flap valve shall be installed in position in the filter drains in the bed normal to the canal slope in the local filters in the sides at the location shown in the drawings or as directed by the Executive Engineer.

c) **Flap valves:** Flap valves consisting of 40mm internal diameter polyvinyl chloride (P.V.C)pipe with P.V.C. flange and rubber flap shall be fabricated with all accessories as shown in the drawings. The flap valve shall be designed as to open automatically at a differential head of not more than 100 mm of water. The contractor shall arrange the performance tests of all the flap valves and those that do not conform to the specified functioning shall be rejected. Installation of flap valves shall not be permitted without the acceptance test of the same.

The flap valves shall be installed in position in the filter drains in the bed and normal to canal slope in the local filters in the side at the location shown in the drawings or as directed by the Engineer-in-charge.

The tendered unit price for this item of schedule 'A' shall be inclusive of the cost of manufacture, handling, testing and installation in position with excavation of pocket and filling with filter material complete and shall be inclusive of all those operations as well as those defined in the nomenclature of the item.

d) **Porous plug**:

1) Wherever specified, the porous concrete shall be composed of one part of cement and 4parts of coarse aggregate (viz no fine concrete) by weight of not. more than 20 mm. size Only so much water shall be used in concrete as required to produce a paste which will coat the particles without filling the voids. In placing porous concrete in moulds, care shall be taken to ensure that it is not over tamped or compacted so as to reduce its porosity. The porous plugs after hardening (i.e. attains final setting) should be sprinkled and kept most for atleast 14days. The compressive strength of porous concrete at 7days age as determined by tests on 15 cm diameter, 30cm height cylinder should not be less than 70kgs/sq.cm and the porosity at 7days be such that water shall

pass through slab of concrete 30cm thick at a minimum rate of 500liters/min/square meter of the flap with a constant 10cm depth of water on the slab.

2) Pre cast porous concrete plugs of 300 x 300 mm section size extending to full depth of canal lining shall be provided in bed and sides as shown in the drawings with filter materials.

3) The porous plugs shall be so inserted into the lining that their porosity is not lost or reduced when the concrete for the lining is vibrated.

15.5 LAYING OF C.C. LINING:

a) **Scope** :- Laying cement concrete lining of specified thickness in M10 grade using a minimum cement of 310kg/cum. of concrete and 40mm. MSA machine crushed graded metal of specified variety including cost and conveyance of cement and all other materials of approved quality, seigniorage charges, sampling and testing preparing the base for laying concrete with weigh batching plant, machine mixing, conveyance of concrete with transit mixtures, placing of concrete in position and finishing SL 450 with paver finishing upto bed width of 2.00 M for less than 2.00 M bed width with acro gantry either by using machinery or by manual labour as specified in schedule 'A'. vibrating, finishing cutting grooves for panel joints, dewatering, curing, with water with a net work of pipeline system, hire and. operational charges of machinery, all leads, lifts, delifts, all water leads and all other incidental and operational charges necessary to complete the finished item of work of cast - in-site lining in bed/sides as per drawings and as directed by the Engineer-in-charge.

b) The work of laying in-situ cement concrete canal lining shall generally conform to IS. :3873--1978 and all concrete shall be governed by IS: 456-1978 concrete canal lining shall be done in the canal prism as shown in the drawings using well graded aggregate for 10 cm. thick lining shall be 40 mm. It shall be 20 mm. for lining thickness of 7.5 cms.

c) (i) Concrete shall be produced in a stationary weight batching and mixing plants/plants of adequate capacity installed at a suitable place by the contractor and concrete conveyed to the placement site/sites in transit mixes. The slump of concrete at placement site shall range shall from 50 mm. to 65 mm. with a water cement ratio of less than 0.6.

Alternatively : ii) Mobile self loading weigh batching mixing transporting equipment with adequate capacity of mixer drum, shall be deployed by the contractor for production of controlled concrete and transportation to the placement site/sites. Number of such equipment to be deployed shall be such as to achieve the construction schedule targets.

Alternatively., The Engineer-in-charge may allow the use of standard portable/stationary concrete mixes along with weight batching and measuring arrangement proportioning and protection of concrete and placement of concrete with conventional (manual) method.

15.6 Testing :

Concrete cubes at random shall be collected during laying concrete and shall be tested in the labs. If results are substandard, the entire work of the day on which cubes were collected shall have to be replaced by the contractor at his own cost.

15.6.1 Core Test : Securing and preparing test specimens from hardened concrete.

As specified in clause 4.1 of IS 1119-1959 (Bureau of Indian Standards Methods of sampling and analysis of concrete) cores shall be taken at random so as to ascertain the strength, permeability, thickness of concrete layer and cement content used. As the canal lining work progresses testing of output shall be on regular basis. Accordingly, to evaluate the quality of concrete lining completed, cores shall be taken as determined by the Engineer-in-charge. Broadly it could be one core each from bed lining completed and cured for 28 days in respective reaches. Frequency of drill cores shall be determined by the Engineer-in-charge. Broadly it could be one core each from bed lining per 200 Square meters (or even more at the discretion of Engineer-in charge of in -situ lining.

The cores shall be tested for compressive strength and if needed for permeability ,and cement content etc., as well. The cores shall be tested, for 28 days compressive strength.

The contractor shall allow all facilities and cooperation towards collection of cores. The testing of cores shall be carried out at the testing laboratories set up at the site or. at any other laboratory that the Engineer may so decide and the results given there by shall be considered correct and authentic by contractor. The contractor shall be given access to all operations and tests that may be carried out as aforesaid so that he may satisfy himself regarding the procedure and methods adopted . The payments shall be made only after satisfactory core test results acceptable to the Engineer-in-charge.

A standard test cylinder has a diameter one- half of its height (viz the length-L, diameter-D, ratio is 2). However, the cores taken from in situ lining shall not have these relative dimensions and consequently L/D ratio will not be 2. Accordingly the test strengths of the cores need to be corrected. The curve in Attachment- 1 may be used to correct the indicated strengths to make them comparable with those obtained from standard specimens. The contractor shall stack the cores properly in the sheds.

The criteria of acceptance of core strength shall be as outlined in IS : 456-1978.

15.6.2 Placing and compaction :

Sub-Grade well in advance for placement of lining. the sub -grade over which concrete is to be laid should be moistened adequately through very fine water spray so as to be thoroughly moist (but not muddy) so that water cannot get withdrawn from freshly placed concrete. Spray nozzles should be used to assure an even application of moisture and to prevent local erosions.

15.6.2.1

a) Placing of concrete shall not be started until all form work, installation of parts to be embedded and preparation of surface upon which concrete is to be laid have been completed. All absorptive surfaces against which concrete is to be laid shall be moistened thoroughly so that moisture will not be withdrawn from freshly placed concrete. The surfaces, however, shall be free from standing water and mud.

b) In the placement register containing the list of various, work items in sequential order, the contractor or his representative shall write, " completed preparation of sub grade, earth work, installation of parts to be embedded as per specifications and ready for placing concrete and sign. Then the authorized representative of the Engineer-in-charge shall

inspect and write in the Register against the item allowed for concreting; and sign. Then only, placing of concrete shall be commenced by the contractor. If concreting is not started within 24 hours after approval, it shall be got approved again.

c) Concrete shall be placed only in the presence of a duly authorized representative of the Engineer-in-charge.

d) Hand mixing of the concrete shall not be permitted under any circumstances.

e) Concrete shall be deposited in all cases as nearly as practicable in its final position and shall not be allowed to flow in a manner to permit segregation. Excessive separation of the coarse aggregate caused by allowing the concrete to fall freely from. too great height or at too great angle from the vertical shall not be permitted and where such separation would otherwise occur the Contractor shall provide suitable means to convey the concrete without allowing such separation.

f) Concrete shall be deposited and spread on the bed of the canal as indicated on the drawings. Concrete may be so laid as to facilitate placing, vibration, finishing and curing operations. Concrete required for keys as shown on the drawings shall be laid after placing side panels PCC. as directed by the Engineer-in-charge.

g) The design mix for lining shall to secure dense concrete of required strength for that grade.

h) The compaction shall be with suitable vibrators approved by the Engineer-in-charge. and it shall be effective so as to have durable impermeable concrete.

i) The concreting near the joints shall be done with utmost care so as to avoid segregation and collection of loose place of aggregate along form work which may result honey combing.

j) The concrete near the junction of the side concrete panels and bed concrete shall be done as shown in drawings such that both shall rest firmly against each other to resist any back kick from external hydrostatic forces.

k) When concrete placing operations are stopped for the day, interrupted because of break down or delayed by other causes of where the contractor selects to construct a joint such as would result from constructing one of the lining in one pass, the edge of the fresh concrete lining shall be bulk headed to a surface normal to the lining along transverse and longitudinal lines. Before placing operation are resumed the surface of the hardened concrete shall be prepared as construction joint. when ever a substantial break down occurs in the concrete production or concrete transportation system, a joint shall be formed as close to the face of the fresh concrete as possible.

l) The fresh concrete shall then be placed against the existing concrete with the full groove for required contraction joint formed in between them. The completed groove shall be sealed with sealing compounds as per clause 6.3 of IS : 3873-1978 and as shown in the drawings.

m) The contractor should use stationary weigh batching plant, transit mixtures, conveyer belt or any other machinery for transporting concrete and pavers for laying concrete. The

quoted rates shall include hire operational charges of all the machinery, setting of machinery, dismantling of machinery and any other contingent works for the movement of machinery and making good after laying of lining.

n) **Compaction** : The concrete shall be compacted with vibrators to give a dense concrete which is durable and impermeable ensuring the desired strength. Concrete shall not be over vibrated. The vibration shall be sufficient to remove all undesirable air voids from the concrete including air voids trapped against the forms. After consolidation. the concrete shall be free from aggregate pockets and honeycomb areas and shall be classed against all surfaces of forms and embedded materials. All concrete shall be properly consolidated before initial setting and should not be subsequently disturbed.

Form vibrators shall be used in conjunction with slip form lining machines for consolidation. The Engineer-in-charge may remove samples of hardened concrete for testing and examination and the contractor shall replace at no extra cost to the department concrete from which such samples are removed.

15.6.3 Finishing :

a) The Contractor shall notify the Executive Engineer before commencing concrete finishing. Unless inspection is waived in each specific case, finishing of concrete lining shall will be performed only when a representative of the Engineer-in-charge. is present concrete surfaces will be tested by the Engineer-in-charge in accordance with para 5.6.1, where necessary to determine whether the concrete surface is within the specified tolerances. Finished concrete which is not in the specified tolerances shall be repaired as detailed below.

b) Immediately on the removal of forms, unsightly ridges or lips shall be removed and undesirable local bulging on exposed surfaces shall be remedied by tooling and rubbing. All exposed concrete surfaces shall be cleaned of impurities lumps or mortar or grout and unsightly stains.

c) Repairs to concrete surfaces and additions where required shall be made by cutting regular openings not less than 70 mm depth into the concrete and placing fresh concrete to the required lines. The chipped openings shall be sharp. The fresh concrete shall be reinforced and chipped and troweled to the surface of the openings, the mortar shall be placed in layers not more than 20 mm. in thickness after being compacted and each layer shall be compacted thoroughly.

d) The surface of concrete finished against forms shall be even smooth and shall be free from projections, pockets, honeycombing and other objectionable defects.

e) The top portions of the side slopes of the canal lining extending 1.5 meter vertically below the top of the lining shall receive a nonskid, longitudinal brush finish as approved by the Engineer-in-charge.

f) Use of any finishing tool in areas where water has accumulated shall be prohibited and all finishing operations shall be delayed until the water has been absorbed evaporated or removed by draining, mopping or such other means.
(p)

15.6.4. Tolerances :

The permissible tolerances for the canal lining shall be as under in accordance with section 5.3 of IS : 3873-1978.

a) Departure from Established, alignment	± 20mm on straight reaches and + 50mm on partial curves or tangents.
b) Departure from Established grade	± 20mm on small canals.
c) Variation in thickness of lining.	± 10% provided average thickness is not less than specified .

15.6.5 Curing :

The bed lining shall be water -cured for 28days through provision of earth bunds of small height so that a column of water is available above the lining.

The joints of plain cement concrete slabs lining on side slopes shall be water cured through sprinkling of water at regular intervals for at least 21 days.

The Engineer -in-charge may instruct contractor to provide pipe line system and sprinklers for curing of the lining work, if the Engineer-in-charge feels that the manual curing is not sufficient. The contractor shall abide by the instructions and erect the pipe line system the quoted rate shall include for erection of pipe line system and dismantling of the pipes after curing instead of manual curing if the work involved is more in length and quantity.
If the contractor fails to do curing to the satisfaction of the Engineer, the latter shall make arrangements for curing at the risk and cost of the contractor or the lining work will be pulled down. The lining so pulled down shall be rebuilt by the contractor at his own cost.

15.6.6 Testing of Concrete and acceptance of work:

a) General : Systematic testing of the raw materials for concrete as well as the concrete shall be done both while it is fresh and after it has hardened by the quality control and inspection Division on representative samples taken at the site of laying the concrete in accordance with relevant Indian Standard Specifications.

b) Sampling Procedure and frequency :i) Sampling Procedure : A random sampling procedure shall be adopted to ensure that each concrete batch has a reasonable chance of being tested, that is the sampling should be spread over the entire period of concreting and cover all mixing units.

(ii) Frequency : The minimum frequency of sampling of concrete of each grade shall be in accordance with the following.

Quantity of concrete (cubic meter)	Number of Samples
1- 5	1
6-15	2

16-30	3
31-50	4
51 and above	4plus one additional for each additonal 50 cubic meters or part there of

NOTE : At least one sample shall be taken from each shift.

iii) **Test Specimen** : Three test specimens shall be made from each sample for testing at 28 days. Additional cubes may be required for various purpose, such as to determine the strength of concrete at 7days or at the time of striking form work, or to determine the duration of curing or to check the testing error. Additional cubes may also be required for testing by accelerated methods as described in IS: 9013-1978. The specimen shall be tested as described in IS : 516-1959.

iv) Test Strength of Samples : In all cases, the 28 days characteristic compressive strength specified based on laboratory tests shall be the criteria for acceptance or rejection of the concrete in so far as the strength of plain cement concrete lining is concerned.

The test strength of the samples shall be the average of there specimens. The test strength shall be greater than the specified strength. The over all coefficient of variation shall not be more than (+) 15 percent of the average for the three consecutive samples tested, not more than 20 percent of the specimen strength shall be less than 80% of the specified strength.

Contractor shall provide necessary skilled labour and facilities for transport, collection of samples, cores etc., and shall remain present at the time, when the samples, cores etc., are taken. Testing shall be carried out at the testing laboratory at the nearest Lab, or at any other laboratory that the Engineer may decide upon and the results given thereby shall be considered as correct and authentic and acceptable to the contractor. The contractor shall be given access to all operations and tests that may be carried out as aforesaid. All testing charges are to be borne by the contractor.

v) Core test :- The points from which cores are to be taken number of cores required shall be at the discretion of the Engineer-in-charge. In no case however shall, fewer three cores be taken and tested. Core shall be tested as described in IS : 516- 1959.

15.6.7 Acceptance Criteria:

a) The cores shall be tested for 28 days compressive strength. These shall be inspected, examined for segregation /honey combing and checking the thickness of lining. The Engineer-in-charge may also arrange to test the core for permeability and cement content, if considered necessary. Concrete in the member represented by core test shall be considered acceptable if the average equivalent cube strength of cores is equal to at least 85 percent of the cubic strength of the grade of concrete specified for the corresponding age and no individual core has a strength not less than 75 percent.

b) The density of concrete shall not be less than 85 percent of specified density of 2400kg/m3.

c) In case the concrete does not confirm to the accepted criteria for strength as specified above, the Engineer-in-charge reserves the right to reject the work or accept the same at a reduced rate derived from tendered rate and as approved by him after examining all

aspects and provided structural integrity is not effected. In case, the cores taken from concrete lining panels exhibit heavy segregation or honey combing the Engineer shall reject the concerned panels and the contractor shall have to dismantle the same and have to cast new panels at his expense.

Whenever necessary for the purpose of obtaining economy , workability, density, impermeability, durability strength or on account of variation in the quality and gradation of aggregates or other materials, except cement the Executive Engineer shall based on laboratory tests make necessary changes in the proportion of mix and vibrators. Contractor shall have to affect these changes and will not be entitled to any compensation on account of such changes. Relevant para of IS : 456-1978. shall apply.

Regarding particular canal reach/reaches, though the lining be fully completed to acceptable quality levels, such reach/reaches will not qualify for acceptance and payment till the associated works necessary for safety of lining during rains, such as dowel banks, drainage are also completed along with.

d) The final payment shall be made only after satisfactory core tests acceptable to the Engineer-in-charge as per IS : 456-1978.

15.6.8 CONSTRUCTION JOINTS.

a) The concrete for sides and bed lining should be placed in alternate bays of not more than 3mts. Bays remaining in between may be filled after a gap of at least one day. The joint faces shall be treated with a primer at the rate of one litre per 4 sq.meter of joint surface area.

b) The shuttering should be clean, well oiled, smooth and firmly fixed to the sub grade and concrete near the shuttering properly placed and specially compacted.

c) Faces to be painted with sealing compound.

d) The concrete shall be laid continuously and the construction joints shall be left at the close of the day (or) 45 meters whichever is less vide clause in column 26.3 of IS. : 456/-1978.

15.6.9 MEASUREMENT AND PAYMENT :

All linear measurements shall be in meters, correct to 0.01 meter. Areas shall be computed in square meters, correct to 0.01 square, meters. The thickness of lining shall be determined in relation to final sub grade on which lining is to be laid. The thickness shall be cross checked by (i) Volume of concrete placed and area covered (ii) use of probe when concrete is given and (iii) cores if required. No separate payment will be made. It shall be included in the price Bid quoted in the Bill of Quantities.

15.7 JOINTS:

15.7.1 EXPANSION JOINTS:

a) Scope : Expansion joints of 12 mm. width shall be provided on each template where adjacent panels rest. The joints shall be filled in by 12 mm. thick asphaltic pads, when concrete

lining is laid for canals in embankment or in cutting where subgrade does not get physically bonded with the joints. Where concrete lining in physical bond with subgrade such as in case of hard rock reaches, expansion joints need not be provided. The details of joint are shown in the drawings. Sealing compound in the joints shall conform to IS : 5256-1968, including cost and conveyance of all materials, labour charges, all leads, lifts and delifts complete for finished item of work to specifications as per drawings and as directed by the Engineer-in-charge.

b) Expansion joint shall not be provided except where structure intersects the canal lining.

c) In case of sandy soils it is preferable to provided felt/asphalt pad over template and in the vertical joint between the panels to prevent leakage through joint as shown in the drawings.

15.7.2 CONTRACTION JOINTS :

a) Scope : Providing contraction joints in bed, side lining including painting the grove with approved primer and filling grove with hot pour sealing compound of approved quality conforming to IS:5256-1968. including cost and conveyance of all materials, cleaning of groves, placing, dewatering, labour charges, all leads, lifts and delifts complete for finished item of work to specifications as per drawings and as directed by the Engineer-in-charge.

b) Contraction Joints shall be provided at places shown in the drawings or as directed by the Engineer-in-charge in accordance with the provisions laid down.

c) When lining is cast in panels, before laying cement concrete slabs, the top of the sleepers both in bed and side slopes shall be treated with two layers of sealing compound as prescribed in IS : 5256-1968 and as shown in drawings to reduce the leakage across the joints. Slabs shall be laid in alternate compartments with an interval of at least one day for setting and contraction. The faces of the previously placed concrete shall be painted with sealing compound as prescribed in IS : 5256-1968. to ensure that no bonding takes place.

d) The grooves at the joints shall be of the size and shape as prescribed in (b) and filled with hot -applied sealing compound.

e) Filling of the joints with hot- applied sealing compound should be taken up after curing period is over. In the mean time the joints are liable to be filled with earth, which will be difficult to clean. It is, therefore, advisable to fill these joints with coarse sand during the curing period. The sand can be easily blown out from the joints when required.

15.7.2.1 : FILLER :

a) the grooves in canal lining shall be filled with sealing compound conforming to IS : 5256-1968.

b) The grooves shall be clean and free from foreign substances when sealing compound is filled.

c) Grooves shall not be filled while it is raining or when there is free water in the grooves. The grooves shall be filled as soon as the concrete has become sufficiently stiff to prevent appreciable distortion of groove shape or damage to the concrete.

d) The expansion joint shall be filled with the mixture of following materials with proportion specified against each.

Maxphalt 80-100	30% by volume.
Sand	51% by volume
Cement	17% by volume
Hemp cut to into length	2% by volume
	100% by volume

15.7.2.2 MEASUREMENT AND PAYMENT:

No separate payment will be made. It shall be included in the price Bid quoted in the Bill Quantities.

PART B : MS PIPELINE

MS PIPELINES (Part -1)

The pipelines are used in this Project for Delivery Pipes, Manifolds and Pressure Mains. All pipes should be BIS marked only.

The pipeline shall be divided into sections by valves to avoid the necessity of emptying the whole pipeline in case of repair (in compliance with Clause No.6.16.14 of the CPHEEO manual). Each section being provided with an air valve and scouring facilities. The need for scour should be particularly borne in mind when layout of the pipeline and silting of the valves is finalized, as they cannot always be arranged in the best position due to likely difficulty in disposing of the discharge. They are necessary for scouring the mains and hence should be in proportion to the size of the main.

1. Manufacture and supply of M. S. Pipes :

For Delivery Pipes, Manifolds & Pressure Mains, the thickness of MS pipes shall be calculated as per the design requirements and allowances stated in IS:5822 and in AWWA (American Water Works Association) Manual M11- For steel pipes. The thickness provided shall also be subject to upward revision in surge analysis and as per site conditions requirement. No downward revision is permissible.

1.1. Applicable standards / codes

Following standards shall be referred for manufacture of M. S. pipes using **Structural Steel Sheets**. In all cases, latest revision of the standards / codes shall be referred to. If requirements of this specifications conflict with the requirements of the standards / codes, this specification shall govern.

IS 1916 :	Steel cylinder pipe with concrete lining and coating
IS 5822 :	Laying of electrically welded steel pipes for water supply
IS: 4853 :	Recommended practice for Radiographic inspection of fusion welded butt joints in steel pipes.
IS: 4260 :	Recommended practice for ultrasonic butt weld in ferric steel.
IS: 3600 : (Part-1)	Methods of testing fusion welded joints and weld mains in steel: part 1 cruciform fillet weld tensile test
IS: 4711 :	Sampling of pipe for various tests and criteria for conformity.
IS: 1894 :	Methods of tensile testing of steel tubes.
IS: 10748 :	Hot - Rolled Steel Strip for Welded Tubes and Pipes - Specifications
IS: 1730 :	Dimensions for Steel Plates, Sheets, Strips and Flats for General Engineer-in-Charge Purpose

1.2. Grade of steel

The steel used for manufacture of the pipes (HR coils) shall confirm to IS: 2062, grade-B or IS: 10748, grade - 3 or equivalent ISO. The dimension of HR coils shall conform IS: 2062.The quality of steel, chemical composition and tensile strength of the steel plates shall be as specified in IS: 3589 for steel of grade Fe 410. **tolerance as per IS: 3589 shall be allowed for plate thickness.**

1.3. Electrodes

The electrodes used for welding of steel plates shall confirm to IS: 814

1.4. Certificate for Steel Plates

Steel plates should confirmed to IS: 1730, Dimensions for Steel Plates, Sheets, Strips and Flats for General Engineer-in-Charge Purpose. The test certificate for the plates shall be issued by Plate Manufacturer.

1.5. Standard Length of pipes

The MS pipes shall be manufactured in lengths of 10 to 13m with beveled ends. Length of each pipe shall be measured at diametrically opposite four places and average of the four measured lengths shall be considered for measurements of pipe length.

1.6. Welding process

The pipes shall be manufactured by shop welding from steel plates, butt welded spirally or longitudinally by automatic submerged arc welding process using at least two runs, one of which shall be on the inner side of the pipes. Welding shall be so done that there will be through fusion and complete penetration and shall be free from cracks, oxides, and slag inclusion and gas pockets.

Longitudinally welded pipes shall have circumferential weld at not less than 1.8 m centre to centre. Longitudinal weld shall be staggered. Minimum distance between spiral welds should be 1.5 m.

1.7. Deviation in Length

Finished pipe length shall not deviate from straightness by more than 0.2 percent of the total length.

1.8. Radiographic / Ultrasonic test

Three percent of all seams of pipes, welded in the fabrication shop, shall be radio graphed at the end of pipe (as per IS: 4853) to render visible inspection of any internal defects such as blow holes, slag, inclusion of cracks. If any defects are detected, the metal at the location shall be chipped out and re-welded. In addition to the radiography of the joints, 100 percent testing by ultrasonic equipment (as per IS: 4260) shall also be done for welding tests. Any defects found out shall be rectified free of cost. Welds found deficient in quality shall be removed by chipping or melting and remade as per specifications. Chipping or cutting the weld shall not extend to the base metal.

1.9. Hydraulic Test at Works

Each pipe shall be hydraulically tested at manufacturer's works before applying any coating / lining.

1.10. Allowable tolerance

- Allowable tolerance for out side diameter shall be ± 0.75% of the specified diameter.
- Allowable tolerance for ovality shall not be more than 1% of the specified diameter.

1.11. Sampling and testing

Sampling and conformity criteria for various tests shall be as given in IS: 4711. The test samples shall be cut from pipes in the final condition of supply. Tests for tensile strength, percentage elongation, guided bend test, shall be carried out and the test values shall be in conformity with those specified in IS: 4711.

1.12. Inspection

The pipes ready in the manufacturer's work yard shall be inspected and tested before dispatch, by the employer and or inspecting agency appointed by the employer. All the tests including hydraulic test shall be carried out on specified number of samples from each lot as specified in IS: 4711, in presence of the inspecting agency. The internal painting shall be applied to the pipes only after the inspecting agency is satisfied regarding the test results, which shall be in conformity with the limits specified in IS: 4711.

2.0 Cement mortar coating (guniting) for external surface of MS pipes

2.1 General

The outside surface of the MS pipes and bends shall be provided with reinforced cement mortar coating for 25mm thickness, 1:3 proportions, applied by mechanical / pneumatic placement.

2.2 Material

Reinforcement

The reinforcement shall consist of BRC fabric of size 100 mm x 100 mm. x 3 mm. Reinforcement shall be free of oil, grease and other contaminants that may reduce the adherence between the coating and reinforcement. The BRC fabric shall be placed in the middle third of the coating. Mortar cover blocks shall be provided to place the BRC fabric properly. Splicing for fabric reinforcement, if required, shall have minimum 100 mm overlap.

2.3 Cement

Portland cement shall confirm to IS 269 / IS 8041 / IS 1489 and IS 8112.

2.4 Sand

Sand shall consist of inert materials having hard, strong, durable uncoated grains confirming to the requirements of IS 2116.

2.5 Water

The water used for guniting shall be clean, colour less, and free from injurious quantities of organic matter, alkali and salt. The maximum water cement ratio shall not exceed 0.45:1.

2.6 Cement mortar

The mortar applied by mechanical or pneumatic process shall consist 3 parts of sand and 1 part of cement by weight. The water in the mixture shall be carefully controlled so that the mortar will not run, sag or segregate. The soluble chloride-ion (Cl) content of the cement mortar mix shall not exceed 0.15 percent, expressed as a percentage of cement weight.

Rebound not exceeding one fourth of the total mix weight may be used as replacement material for fine aggregate only. Rebound not used within 1 hour shall be discarded.

2.7 Surface preparation

The outer surface shall be cleaned for oil grease etc. The dust shall be removed by compressed air or vacuum cleaner before placement of reinforcement. The BRC fabric reinforcement shall then be placed with required cover on the pipe surface.

2.8 Application

The pipe shall be supported on wooden logs at the ends to keep bottom clearance and to facilitate easy rotation while applying the coating. The mortar coating shall be applied in one or more continuous applications for achieving required thickness. If applied in more than one course, the interval between the first and last course shall not be more than 2 hours. The mortar shall be projected at high velocity against the exterior surfaces of the pipe with a pressure of 2.1 to 2.8 kg / cm^2 to produce a hard, tight adhering coating of specified thickness. The coating shall not be applied on ends of pipes for 100 mm length. Ends of coating shall be uniform and square to the longitudinal axis of the pipe. The rebound material unused shall be disposed off within a lead of 50m.

2.9 Placement temperature

The temperature of the cement mortar mix shall not be less than 4^0 C, nor shall the surface temperature of the MS pipe be greater than 35^0 C at the time of placement.

2.10 Curing

After the initial set of the cement mortar coating has taken place, the mortar coating shall be cured by the moist curing method. The coating shall be kept continuously moist by intermittent or continuous spraying of water for a period of at least 7 days.

2.11 Defective coating

If any sand pockets or porous spots occur, they shall be completely cut out and replaced by mechanical / pneumatic placement or hand application of mortar in proportion of 2 parts of sand and 1 part of cement, by weight.

2.12 Coating cracks

Care shall be taken to minimise the occurrence of cracks in the mortar coating. However, hairline cracks need not be repaired. The cracks, if developed, shall be repaired by brushing or wiping of neat cement in to the cracks, or painting of the cracks with epoxy coating or a combination of these methods shall be adopted.

3.0 Transportation of pipes for laying

Handling of the mortar coated pipes while transporting those from guniting yard, for laying and jointing purpose, shall be done very carefully to avoid any damage or development of cracks to the mortar coating. Any damaged portion shall be cutout and

replaced. The pipes shall be laid in the trenches as early as possible after the curing period is over to avoid hair cracks in the coating due to temperature variations.

4.0 Coating for welded joint portion

After the welding and testing of the welded joints of MS pipeline, the BRC fabric reinforcement shall be provided over the joint. Cement mortar used for the joints shall be composed of one part of cement to not more than two parts of sand, by weight, thoroughly mixed with water to the consistency of thick cream. Sand shall be graded confirming to the requirements of ASTM C33, except that 100% shall pass a US standard sieve number 16.

5.0 Testing

5.1 Adsorption test

Water adsorption tests shall be performed on samples of cured cement mortar coating taken from each working shift. The samples shall have been cured in the same manner as the pipe. A test value shall consist of the average of a minimum of three samples taken on the same day from the same work shift. The test method shall be in accordance with ASTM C497, method A. The average adsorption value for any ten consecutive tests from a working shift shall not exceed 10% and no individual sample shall have an adsorption value exceeding 12%.

Tests for each working shift shall be performed on a daily basis until conformance to the adsorption requirements has been established by 10 consecutive test values not exceeding 10%, at which time testing may be performed on a weekly basis for each working shift. Daily testing shall be resumed for each working shift whenever an adsorption test result exceeds 10%. Daily testing shall be maintained until conformance to the adsorption requirements is reestablished by 10 consecutive test values not exceeding 10 percent.

The contractor shall maintain the record of the adsorption tests and shall submit the same to the Engineer-in-Charge weekly.

5.2 Inspection

The tests performed shall be inspected by the Engineer-in-Charge. If any sample fails to meet the requirements, the contractor shall be notified immediately. Material affected by the test r4esults shall be set aside pending final disposition

5.3 Rejection

Material and pipe that are noticed to be defective or that do not confirm to the requirements will be subject to rejection at any time prior to final acceptance of the pipe. Rejected material and pipe shall be removed from the work site within a week after rejection without any liability to the Govt.

6.0 Internal Epoxy coating to MS pipes and specials

6.1 General

Epoxy coating is proposed for internal surface in all conditions and for external surface of the MS pipes laid above ground on pedestals and outer surface of tees, manholes, covers and eccentric reducers.

6.2 Material

The coating shall have one coat of two-part, chemically cured inhibitive Epoxy primer and two coats of a different two-part, chemically cured, solvent free, and spray applied epoxy paint. The coating system shall meet the performance requirements of relevant IS code or AWWA C-210 standard.

6.3 Surface preparation:

6.3.1 Cleaning

Prior to abrasive blast cleaning, the external surface shall be cleaned to remove oil, grease or other foreign matter. Only approved solvents that do not leave a residue shall be used for cleaning.

6.3.2 Abrasive blast cleaning

The surface shall be abrasive blast cleaned to achieve a white metal surface. Prior to blast cleaning, any sharp protuberances, surface laminations, weld spatter, etc shall be removed by through cleaning and grinding. The abrasive used should be capable of producing a minimum profile of 50-75 microns corresponding to "medium" in accordance with BS: 7079 part C4.

7.0 Application of Epoxy coating:

7.1 Atmospheric conditions

Prepared surfaces must be completely cleaned of dust and dirt by brush or vacuum cleaner and shall be thoroughly dry. Coating shall not be applied in the following atmospheric conditions.

- Relative humidity exceeding 85%
- When the surface to be coated is less than 3^0C above the due point
- The surface temperature is less than 7^0C or greater than 50^0C.

7.2 Successive coats

After application of the first coat, the next coat shall be applied within the time limits, surface conditions, and temperature recommended by the manufacturer.

7.3 Coating thickness

Final thickness of the coating shall not be less than 400 micron DFT. The coating shall be applied leaving 15 cm at the edge of pipes / specials for welding of the joint. Coating on this portion shall be applied after welding the joint.

7.4 Preheating

The temperature of mixed coating and that of the pipe at the time of application shall not be lower than 10^0C. Preheating of the coating material, the use of inline heaters to heat the coating material; or heating of the pipe, fittings or specials may be used to facilitate the application. Heating shall confirm to the recommendations of the coating material manufacturer.

7.5 Touch up and repair procedure

The finished coating shall be inspected for damage or reduced thickness. Any such areas shall be repaired by thoroughly degreasing the surface and abrading using 180 grade abrasive papers, the abraded areas shall extend from the edge of the damage for 50–75 mm on to surrounding sound coating. The prepared surface can then be re-coated.

7.6 Final curing

Sufficient curing period shall be allowed after application of the coating as per standards for the coating to gain required strength. The epoxy applied pipes; specials shall be stored for curing in accordance with the durations given in the specifications.

7.7 Electrical inspection for continuity

After curing, the coating shall be tested for holidays according to the procedures and using the voltage settings. Any holidays indicated by the detector shall be got repaired.

7.8 Coating of joints after welding

The joint portion shall be cleaned thoroughly as stated above and coated in required coats for same thickness i.e. 400 micron DFT.

8. Excavation for Pipe Line Trenches

8.1. Excavation for Pipe Line Trenches

The excavation is carried out by hand or by machine.

8.2. Site Clearance

The pipe line alignment shall be cleared of all bushes, shrubs, roots, grass, weeds and if required trees, coming in the alignment of pipe line in the trench width portion. The rates for excavation shall cover all such site clearance work and no extra payment will be allowed on this account.

8.3. Alignment marking

After the work site is cleared as above, pipe line alignment with required trench width shall be marked on the ground with apex points, curves etc, as shown on the drawings or as directed by the Engineer-in-Charge in charge for the stretch where the work is to be started. The contractor shall provide all labour, survey instruments, and materials such as strings, pegs, nails, bamboos, stones, mortar, concrete etc. required for setting out and establishment of bench marks. The contractor shall be responsible for the maintenance of bench marks and other marks and stakes as long as they are required for the work in the opinion of the Engineer-in-Charge.

8.4. Working survey

Working survey of the pipeline alignment shall be carried out by the contractor before start of the excavation work. The contractor shall provide all the instruments such as leveling instruments, steel tape, ranging rods, strings, pegs etc. for carrying out the survey. Based on the working survey, the alignments, L-section (depth of laying), grade, and location of specials, valves and chambers shall be finalized and got approved from the competent authority. The gradient and alignment shall be such that minimum horizontal and vertical bends shall be required.

8.5 Use of Machinery:

All excavations shall be carried out by mechanical equipments / machinery unless, in the opinion of the Engineer-in-Charge, the work involved and time schedule permit manual excavation.

8.6 Trench Width and Depth:

All buried pipelines shall be minimum 1.2 meter below ground level.
The trench width for respective pipe diameters permissible as required under respective IS code for Pipeline laying and installation.

The trench width shall be constant through out the trench depth, which will provide a clearance of about 0.30 m on either side of the pipe line.
The contractor may, for the facility of work or similar other reasons, excavate and also backfill later, if so approved by the Engineer-in-Charges, at his own cost, outside the allowable trench width specified above. Should any excavation be taken below the specified trench bottom, contractor shall fill it up to required level, at his own cost, with the same material available at the trench bottom including watering and compaction.
The excavation shall be taken down to such depths as shown in drawings. Excavation for extra depth equal to the thickness of proposed pipe bedding shall be done below pipe soffit level for providing bedding below pipe line. The trench bottom shall be excavated to proper grade as shown on drawings. The contractor shall provide site rails and leveling instruments required for checking the grade during excavation, bottom bedding and pipe laying Projections in rock excavation shall be removed by chipping.

The contractor shall carryout extra excavation at the pipeline joints to be welded, as required (minimum 0.6 m deep and 0.9 m lengthwise, all around the pipe), for facilitating proper welding of the bottom joint from out side.
The work of trench excavation should be commensurate with laying and jointing of the pipe line. It should not be dug in advance for a length greater than 500 m ahead of work of laying and jointing of pipeline unless otherwise permitted by the Engineer-in-Charge.
The minimum cover on pipe is to be maintained 1.2 meter. However the cover on pipe may be modified to suite gradients and site conditions as per direction of Engineer-in-Charge.

8.7. Barricading and Guarding:

To protect persons from injury and to avoid damage to property, adequate barricades, construction signs, red lanterns and guards as required shall be placed and maintained during the progress of work, till filling of the trenches after pipes are laid and jointed. The lighting, barricading, guarding of the trenches and the maintenance of watchman shall be done by the contractor at his cost.

All precautions shall be taken during excavation and laying operation to guard against possible damage to any existing structures, under ground cables, pipe lines of water, gas, sewage etc. Any damage done to such properties will have to be repaired / rectified by the contractor at his cost. The Contractor has to ensure the following:

- safety protections as mentioned above have to be incorporated in the work process
- hindrances to the public have to be minimized
- the trench must not be eroded before the pipes are laid
- the trench must not be filled with water when the pipes are laid
- the trench must not be refilled before laying of the pipes

The bed for the laying of the pipes has to be prepared according to the L-Section immediately before laying of the pipes.

8.8. Reuse of surface material

All surface materials, which in the opinion of the Engineer-in-Charge, are suitable for reuse in restoring the surface shall be kept separate from the general excavation material, as directed by the Engineer-in-Charge.

8.9. Stacking of excavated material

All excavated materials shall be stacked in such a manner that it does not endanger the work and avoids obstructing foot paths and roads. Hydrants under pressure, surface boxes, fire and other utility controls shall be left unobstructed and accessible until the work is completed. Gutters shall be kept clean or other necessary provisions made for street drainage and natural water courses shall not be obstructed. All the excavated material shall be the property of the Employer and shall be stacked or disposed off as directed by the Engineer-in-Charge.

8.10. Maintenance of traffic

The work of excavation and pipe laying shall be carried in such a manner that it causes the least interruption to traffic and the road / street may be closed in such a manner that it causes the least interruption to the traffic. Where it is necessary for traffic to cross open trenches, suitable bridging arrangement shall be provided. When the street is closed for traffic, suitable signs indicating that street is closed shall be placed and necessary detour signs for proper maintenance of traffic shall be provided.

8.11. Structure protection

Temporary support, adequate protection and maintenance of all underground and surface structures, drains, sewers and other obstructions encountered in the progress of work shall

be furnished under the direction of the Engineer-in-Charge. The structures which have been disturbed shall be restored upon completion of work.

8.12. Protection of property

Trees, shrubbery fences, poles and all other property shall be protected unless their removal is allowed by the Engineer-in-Charge. When it is necessary to cut roots and tree branches, such cutting shall be done under the supervision and direction of the Engineer-in-Charge.

8.13. Avoidance of existing services

As far as possible, the pipeline shall be laid below existing services, such as water and gas pipes, cables, cable ducts and drains but not below sewers. Excavation of the trenches shall be carried out to the required depth accordingly. If it is unavoidable, the pipeline shall be suitably protected and lesser trench depth in such cases can be allowed. A minimum clearance of 150 mm shall be provided between the pipeline and such other services. When thrust or auger boring is proposed for laying pipeline across roads, railway or other utilities, larger clearance as required shall be provided. Adequate arrangements shall be made to protect and support the other services during excavation and pipe laying operations. The work shall be so carried out as not to obstruct access to the other services for inspection, repair and replacement. When such utilities are met with during excavation, the authority concerned shall be intimated and arrangements made to support the utilities in consultation with them.

8.14. Bailing out of Water

During the excavation if subsoil water is met with, contractor shall provide necessary equipment and labour for dewatering the trenches. If pumping out subsoil water is found necessary, contractor shall provide sufficient number of pumps for the same. The tendered rate shall cover all costs for bailing out of water including hire charges of pumps, cost of diesel and labour etc and hence, no extra payment shall be allowed.

8.15. Disposal of loose boulders etc

All loose boulders, semi detached rocks, (along with earthy stuff which might move therewith), not directly in the excavation but close to the area to be excavated, as to be liable, in the opinion of the Engineer-in-Charge, to fall or other wise endanger the workman equipments, or the work etc, shall be stripped off and removed away form the area of the excavation. The method used shall be such as not to shatter or render unstable or unsafe the portion which was originally sound and safe.

8.16. Disposal of Excavated Material

All the excavated surplus material shall be disposed off on muck area with due consultation of Engineer in Charge.

9. Moorum / Sand Bedding below Pipeline

In case of hard rock before lowering of the MS pipes in trenches, a layer of selected moorum, shall be provided below the MS pipe line to act as bedding. The bedding shall

be compacted properly including required watering and the thickness of well compacted layer shall not be less than 150 mm. The bedding shall be provided for full trench width with proper grade as shown on drawings.

10. Refilling the trenches

10.1. Use of selected excavated material

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

Selected surplus spoils from excavated material shall be used as backfill. Fill material shall be free from clods, salts, sulphate, organic or other foreign material. All clods of earth shall be broken or removed. Where excavated material is mostly rock, the boulders shall be broken into pieces not larger than 150 mm size, mixed with properly graded fine material consisting of murum or earth to fill up the voids and the mixture used for filling.

10.2. Back Filling

All excavations shall be backfilled to the level of the original ground surfaces unless otherwise shown on the drawings or ordered by the Engineer-in-Charge in Charge, and in accordance with the requirements of the specification. The material used for backfill, the amount thereof, and the manner of depositing and compacting shall be subject to the approval of the Engineer-in-Charge in Charge, but the Contractor will be held responsible for any displacement of pipe or other structures, any damage to their surfaces, or any instability of pipes and structures caused by improper depositing of backfill materials.

The back filled layers shall be wetted and compacted to a density of not less than 90 percent of the maximum dry density at optimum moisture content of the surrounding material. Any deficiency in the quantity of material for backfilling the trenches shall be supplied by the Contractor at his expense.

The Contractor shall at his own expense make good any settlement of the trench backfill occurring after backfilling and until the expiry of the defects liability period.

On completion of pressure and leakage tests exposed joints shall be covered with approved selected backfill placed above the top of the pipe and joints in accordance with the requirements of the above specifications. The Contractor shall not use backfilling for disposal as refuse or unsuitable soil.

10.3. Fillings of the trench excavated in rock

In case of excavation of trenches in rock, the filling up to a level of 30 cm above the top of the pipe shall be done with fine materials, such as soft soil, murrum etc. The filling up of the level of the centre line of the pipe shall be done by hand compaction in layers not exceeding 15 cm, whereas the filing above the centre line of the pipe shall be done by hand compaction or mechanical means in layers not exceeding 15 cm. The filling from a level of 30 cm above the top of the pipe to the top of the trench shall be done by

mechanical methods with broken rock filing of size not exceeding 15 cm mixed with fine material as available to fill up the voids.

10.4. Consolidation

The consolidation of the filled material shall be done to attain not less than 90 percent of the maximum dry density. The density of the filled and compacted material shall be tested regularly and record maintained accordingly.

11. Lowering, laying and jointing of MS pipes

11.1. Standards

Except as otherwise specified in this technical specification, the Indian Standards and Codes of Practice in their latest version, National Building code, I & CAD specification of the state of Telangana and Manual of water supply of GOI shall be adhered to for the, handling, laying, installation, and site testing of all material and works.

11.2 Tools and equipment

The contractor has to provide all the tools and equipment required for the timely, efficient and professional implementation of the work as specified in the various sections of the contract and as specified by the instructions of manufacturers of the pipes and other material to be handled under this contract. On demand he shall provide to the Engineer-in-Charge a detailed list of tools and equipment available. If in the opinion of the Engineer-in-Charge the progress or the quality of the work cannot be guaranteed by the available quantity and type of tools and equipment the contractor has to provide additional ones to the satisfaction of the Engineer-in-Charge. The Contractor will always have a leveling instrument on site.

11.3 Handling, transportation of pipes and specials

The Contractor has to transport the pipes and other materials from manufacturer or site store yard / guniting yard to the site of laying as indicated by the Engineer-in-Charge in Charge. Pipes should be handled with care to avoid damage to the surface and the socket and spigot ends, deformation or bending. Pipes shall not be dragged along the ground or the loading bed of a vehicle. Pipes shall be transported on flat bed vehicles/trailers. The bed shall be smooth and free from any sharp objects. The pipes shall rest uniformly on the vehicle bed in their entire length during transportation. Pipes shall be loaded and unloaded by suitable mechanical means without causing any damage to the stacked pipes.

The transportation and handling of pipes shall be made as per IS 12288 and IS 5822. Handling instructions of the manufacturers of the pipes shall be followed. All precautions set out shall be taken to prevent damage to the protective coating, damage of the jointing surfaces or the ends of the pipes.

Whatever method and means of transportation is used, it is essential that the pipes are carefully placed and firmly secured against uncontrolled movement during transportation to the satisfaction of Engineer-in-Charge in charge.

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Cranes or chain shall be used for loading and un-loading of heavy pipes. However, for pipes up to 400 mm nominal bore, skid timbers and ropes may be used. Where using crane hooks at sockets and spigot ends, hooks shall be broad and protected by rubber or similar material, in order to avoid damage to pipe ends and lining / coating. Damage to lining / coating must be repaired before pipe laying according to the specifications mentioned elsewhere and as per instructions of the Engineer-in-Charge in charge. Pipes shall not be thrown directly on the ground.

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When using mechanical handling equipment, 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 shall be controlled by the use of guide ropes in order to prevent damage caused by pipes bumping together or against surrounding objects.

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Rolling or dragging pipes along the ground or over other pipes already stacked shall be avoided.

11.4 Stringing of pipes along the alignment

The pipes shall be laid out properly along the proposed alignment in a manner that they do not create any significant hindrance to the public and that they are not damaged. Stringing of the pipes end to end along the working width should be done in such a manner that the least interference is caused in the land crossed. Gaps should be left at intervals to permit the passing of equipment across the working area. Pipes shall be laid out that they remain safe where placed and that no damage can occur to the pipes and the coating until incorporated in the pipeline. If necessary, pipes shall be wedged to prevent accidental movement. Precautions shall be taken to prevent excessive soil, mud etc. entering the pipe.

11.5 Laying and jointing of pipes- following Specifications are detailed herein for laying and jointing

11.5.1. Laying of pipes below ground - guniting as per IS specifications

11.5.1.1. General

After the trench is made ready with bedding, and after the jointing pits are excavated at the joint position, the gunited and lined pipes shall be lowered in the trenches.

The MS pipe ends shall be cleaned with special care to ensure that they are free from dirt and unwarranted projections. The whole of the pipes shall be placed in position singly and shall be laid true to profile and direction of slope indicated on longitudinal sections. The pipes shall be laid without deflection in a straight alignment between
bends and between high and low points. The alignment and levels shall be checked by the contractor with suitable equipment.

Before pipes are jointed they shall be thoroughly cleaned of all earth lumps, stones, or any other objects that may have entered the interior of the pipes.

Pipes and the related specials shall be laid according to the instructions of the manufacturers and using the tools recommended by them.

Cutting of pipes shall be reduced to a minimum required to conform to the drawings. Cutting has to be made with suitable tools and according to the recommendations of the manufacturer without damage to the external coating and internal lining. The spigot end has to be beveled again at the same angle as the original beveled end. While assembling the pipes the ends shall be brought close enough to leave a uniform gap not exceeding 3 mm. Marginal cutting shall be done if found necessary, for which no extra payment shall be admissible. There shall be no lateral displacement between pipe faces to be jointed. After the pipes are properly assembled and checked for the correct line and level, tack welding for the pipe joint shall be done. Final welding of the joint from inside and outside shall be done thereafter.

11.5.1.2. Straps

Whenever the pipe laying work proceeds from two ends and if gap remained between two faces is less than 30 cm, such gap shall be bridged by providing a strap. Strap shall also be provided during fixing of expansion joint for above ground pipeline. Such strap shall be fabricated on site by cutting a piece from the pipe. This piece shall be split longitudinally and stepped over the gap. A minimum overlap of 2 times of the thickness shall be provided on both the pipe ends to be connected. The strap shall be welded with pipe ends with required number of fillet welds from inside and outside. The gap between ends of the strap shall be butt welded longitudinally.

11.5.1.3. Distance piece

Distance piece shall be provided when the gap between pipe faces to be jointed is more than 30 cm. Distance pieces shall be cut from pipe pieces for required length either on site or in factory. Payment shall be as per the laying and jointing of pipeline item.

All specials like bends, tees etc. and appurtenances like sluice or butterfly valves etc. shall be laid in synchronization with the pipes. The Contractor has to ensure that the specials and accessories are ready in time to be installed together with the pipes.

At the end of each working day and whenever work is interrupted for any period of time, the free ends of laid pipes shall be protected against the entry of dirt or other foreign matter by means of approved plugs or end caps.

When pipe laying is not in progress, the open ends of installed pipe shall be closed by approved means to prevent entrance of trench water and dirt into the line. No pipe shall be laid in wet trench conditions that preclude proper bedding, or when, in the opinion of the Engineer-in-Charge, the trench conditions or the weather are unsuitable for proper installation. The pipe line laid should be absolutely straight unless planned otherwise. The

accuracy of alignment should be tested before starting refilling with the help of stretching a string between two ends of the straight stretch of pipes to rectify possible small kinks in laying.

11.5.2. Laying of pipes above ground

11.5.2.1 General

Above ground pipe line shall have epoxy coating on inner and outer surfaces.

Laying of pipeline shall be started only after sufficient number of chairs / pedestals have been casted as per design which shelled not be less than 0.6 m in width to required level and have achieved their final strength including fixing of the bearing plates and roller bearings.

The contractor shall lay the pipeline to the exact line and level as shown on the drawings, or as directed by the Engineer-in-Charge.

11.5.2.2 Laying procedure

The pipe laying shall start from the successive fixity points towards expansion joint, if proposed in that stretch. Depending upon the distance between the successive chairs, and the length of the pipes fabricated, two pieces may be welded on site before laying so that after laying the pipe rests on next chair and overhangs for at least half the length of pipe.

Normally not more than one pipe shall be aligned, tacked and kept in position on the chairs at a time. During assembly, the pipes shall be additionally supported on adequate wooden sleepers or scaffolding as necessary, kept between the chairs / pedestals. While assembling the pipes, the ends shall be brought to leave a uniform gap not exceeding 3 mm. The ends shall be tack welded to align the pipe properly.

Full welding of the circumferential joint shall be done only after the Engineer-in-Charge has checked the correctness of the alignment and level. Further laying of pipes shall not be undertaken unless full welding of the circumferential joints of the piped laid earlier is completed. Expansion joint shall be fixed at the location shown on drawing or as directed by the Engineer-in-Charge.

11.6. Welding the joints

11.6.1. General

Before aligning, assembling and welding, the pipe faces shall be cleaned by scrapping with wire brushes or by any other approved method.

Welding of pipes in field shall confirm to IS: 816 (code of practice for use of metal arc welding for general construction in mild steel). Electrodes used for welding shall comply with IS:814. In case of variation, specifications hereunder shall have precedence.

Welders shall be qualified and well experienced and shall be approved by the Engineer-in-Charge. Contractor shall remove such of the welders from the job whose work is not satisfactory.

The contractor shall keep record of the welding for each circumferential joint. It shall contain the name of the welder, date of completion of the welding runs internal as well as external.

11.6.2. Gouging and chipping

MS pipes to be jointed are large in diameter and hence the joints shall be welded with required numbers of runs from one side and a sealing run from other side. External sealing run shall be done only after internal welding is completed. Before starting the external welding, the weld material in the joint shall be cleaned by chipping out loose scales. Gauging shall be done before rectification of any defective welding wherever necessary and as directed by Engineer-in-Charge.

Gauging and chipping shall not be paid separately and the rate for welding shall be deemed to include the cost of gauging and chipping.

11.6.3. Electrodes

Welding electrodes shall confirm to IS: 814. The contractor shall use electrodes depending on thickness of the plates to be welded and the type of joint. The contractor shall use standard current and AC voltage required for the machine as per manufacturer's directions.

11.6.4. Type of joints

The circumferential joints of the pipes shall have butt welded with required number of runs externally and internally.

All the fillet welds / lap welds shall have throat thickness not less than 0.8 times the thickness of the pipe to be welded.

11.7. Testing of welded joints

Welded joints shall be tested in accordance with the procedure laid down in IS: 3600, Method of testing fusion welded joints and weld metals in steel.

At least one test specimen shall be taken out for testing for every 50 field joints. Test pieces shall be taken out from the places pointed out by the Engineer-in-Charge. These shall be machined and tested as early as possible.

The shape of the test pieces removed for testing shall be such that it shall give the specimen of the required dimensions with the weld in the middle of the specimen. It must ensure good butt weld.

11.7.1. Tensile test

The test specimen taken perpendicularly across the weld shall be shaped in accordance with IS: 3600 (part 3). The tension test specimen shall be machined. The protruding welded portion from inside as well as outside shall be removed by machining before the specimen is tested. The specimen shall be tested in tension in accordance with IS: 1608

If the specimen shows defective machining or develops flaws not associated with welding, it shall be discarded and another specimen substituted. The welded joint shall show strength not less than the minimum tensile strength for the plate in accordance with IS: 226.

11.7.2. Bend test

Bend test specimen shall also be prepared in the same fashion as the tensile test specimen. The specimen shall be bent cold 180^0 around a pin that has a diameter equal to 4 ½ time the plate thickness, without developing cracks. For this test, face representing inside of the pipe shall be placed next to the pin.

11.7.3. Tree-panned plugs

Tree-panned plugs shall be taken out from any welded portion as pointed out by the Engineer-in-Charge. These plugs shall not show any defects in welding such as inclusion of slag, blow holes, cavities, etc. The plug shall be 12 mm in diameter and shall be taken out by means of suitable electrically operated machine. Such holes in the pipe shall either be filled back by inserting a steel stud and welding around or threading the hole and providing suitable GI plug. This test shall be done if considered necessary by the Engineer-in-Charge.

11.7.4. Non-destructive tests

Non-destructive testing of the completed weld shall be carried out on pipelines by radiographic method as specified under IS: 4853 or ultrasonic method as per IS: 4260. Non-destructive test for every 50 joints shall be carried out.

11.8. Procedure on failure of test specimen

If the test specimen fails in either tensile or bent test or in both, two additional test specimens shall be taken out from the section and shall be tested again for both the tests. If any one of them fails, extensive gouging and repairing shall be carried out for the welded joints in that section to the full satisfaction of the Engineer-in-Charge in charge. However, if both the samples give satisfactory results, the joint from which the original sample was taken and had failed, shall be repaired at contractor's cost.

Welder who has done the welding of the joint that has failed shall be solely held responsible for bad workmanship and failure. Since all other factors like electrodes, current, arc voltage, etc are already controlled; negligence on the part of the welder only is responsible for such failure. For first such failure, the welder shall be warned and if the failure is repeated, he shall be removed from the job.

11.9 Anchoring of the pipeline:

Reinforced concrete thrust blocks shall be provided at each bend, tee, taper, end piece to prevent undue movements of the pipeline under pressure. They shall be constructed as per design done by ENGINEER-IN-CHARGE considering the highest pressure during

operation or testing of the pipes, the safe bearing pressure of the surrounding soil and the friction coefficient of the soil.

12. Field Hydraulic testing of the pipelines

12.1 Sectional tests

After laying and jointing the pipeline shall be tested for tightness of barrels and joints, and stability of thrust blocks in sections approved by the Engineer-in-Charge in Charge. The length of the sections depends on the topographical conditions. Preferably the pipeline stretches to be tested shall be between two chambers (air valve, scour valve, bifurcation, other chamber).At the beginning, the Contractor shall test stretches for suitable lengths to suit the site requirements. The hydraulic testing shall have to be commenced immediately after laying and jointing.

The water required for testing shall be arranged by the contractor himself. The Contractor shall fill the pipe and compensate the leakage during testing. The Contractor shall provide and maintain all requisite facilities, instruments, etc. for the field testing of the pipelines. The testing of the pipelines generally consists in three phases: preparation, pre-test/saturation and test, immediately following the pre-test. Generally, the following steps are required which shall be monitored and recorded in a test protocol.

- Complete setting of the thrust blocks.
- Partial backfilling and compaction to hold the pipes in position while leaving the joints exposed for leakage control
- Opening of all intermediate valves (if any)
- Fixing the end pieces for tests and after temporarily anchoring them against the soil (not against the preceding pipe stretch)
- At the lower end with a precision pressure gauge and the connection to the reciprocating pump for establishing the test pressure
- At the higher end with a valve for air outlet
- If the pressure gauge cannot be installed at the lowest point of the pipeline, an allowance in the test pressure to be read at the position of the gauge has to be made accordingly
- Slowly filling the pipe from the lowest point(s).
- The water for this purpose shall be reasonably clear and free of solids and suspended matter
- Complete removal of air through air valves along the line.
- Closing all air valves and scour valves.
- Slowly raising the pressure to the test pressure while inspecting the thrust blocks and the temporary anchoring.
- Keeping the pipeline under pressure for the duration of the pre-test / saturation of the lining by adding make-up water to maintain the pressure at the desired test level. Make up water to be arranged by Contractor himself at his own cost.

- Start the test by maintaining the test pressure at the desired level by adding more make-up water; record the water added carefully and the pressure in intervals of 15 minutes at the beginning and 30 minutes at the end of the test period.

The pipeline stretch will pass the test if the water added during the test period is not exceeding the admissible limits. No section of the pipe work shall be accepted by the Engineer-in-Charge in Charge until all requirements of the test have been obtained.

12.2. Hydraulic test for MS pipes

12.2.1 Field test pressure

The sections of MS Storm Water Pumping mains shall be tested for the pressures as worked out in detailed designed.

12.2.2 Test requirement

The quantity of water added in order to re-establish the test pressure should not exceed 0.10 liter per mm of pipe diameter per km of pipeline per day for each 30 m head of pressure applied.

All pressure testing at site should be carried out hydrostatically. The pipes shall be accepted to have passed the pressure test satisfactorily, if the quantity of water required to restore the test pressure does not exceed the amount calculated as above.

12.3 Failure to pass the test

All pipes or joints which are proved to be in any way defective shall be replaced or remade and re-tested as often as may be necessary until a satisfactory test shall have been obtained. Any work which fails or is proved by test to be unsatisfactory in any way shall be redone by the Contractor.

12.4 Back filling

Water used for testing should not be carelessly disposed off on land which would ultimately find its way to trenches

On completion of a satisfactory test any temporary anchor blocks shall be broken out and stop ends removed. Backfilling of the pipeline shall be completed.

12.5. Flushing and disinfecting of pipelines

After testing and commissioning the contractor shall flush the pipes with a velocity not less than 1 m/s or as approved by the Engineer-in-Charge in Charge. Disinfection of drinking water pipelines should be done by Contractor.

MS PIPES (Part 2 - SUPPLY OF MS PIPES AND SPECIALS, VALVES, LAYING AND JOINTING OF PIPELINES)

1.1 General

1.1.1 Standards

Except as otherwise specified elsewhere in this tender document, the Indian/International Standards and Codes of Practice in their latest version shall be adhered to for the design manufacturing, inspection, factory testing, packing, handling and transportation of product wherever applicable. Should any product be offered conforming to other standards, the equipment or products shall be equal to or superior to those specified and the documentary confirmation shall be submitted for the prior approval of the Engineer.

This specification requires a reference to the following standard specifications:

IS: 2062	Specification for steel for general structural purposes
IS: 808	Specification for dimensions for hot rolled steel beam, column, channel and angle sections
IS: 814	Specification for covered Electrodes for manual metal arc welding of carbon and carbon manganese steel.
IS: 3613	Acceptance tests for wire flux combination for submerged arc welding.
IS: 7280	Specification for bare wire electrodes for submerged arc welding of structural steel
IS: 1367	Technical supply conditions for threaded steel fasteners
IS: 2016	Specification for plain washers.
IS: 2074	Specification for ready mixed paint air drying, red oxide zinc chrome and priming
IS: 102	Ready mixed paint, brushing, red lead, non-setting, Priming.
IS: 1786	Specification for high strength deformed steel bars and wires for concrete reinforcement.
IS: 432 (Part-I)	Specification for mild steel & medium tensile steel bars and hard drawn steel wire for concrete reinforcement: Mild steel and medium tensile steel bars
IS: 432 (Part-II)	Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement: Hard drawn steel wire
IS: 269	Specification for 33 grade ordinary Portland cement
IS: 8041	Specification for rapid hardening Portland cement.
IS: 383	Specification for coarse and fine aggregates from natural sources for concrete
IS: 12330	Specification for sulphate resisting Portland cement
IS: 456	Code of practice for plain and reinforced concrete
IS: 800	Code of practice for general construction in steel
IS: 816	Code of practice for use of metal arc welding for general construction

	in mild steel
IS: 4353	Recommendation for submerged arc welding of mild steel & low allow steels
IS: 817	Code of practice for training and testing of metal arc welders.
IS: 1182	Recommended practice for radiographic examination of fusion-welded butt joints in steel plates.
IS: 2595	Code of practice for radiographic testing.
IS: 3658	Code of practice for liquid penetrant flaw detection.
IS: 5334	Code of practice for magnetic particle flaw detection of welds.
IS: 3600	Code of procedure for testing of fusion welded joints and weld metal in steel
IS: 4853	Recommended practice for radiographic examination of fusion welded circumferential joints in steel pipes.
IS: 3589	Specification for seamless or electrically welded steel pipes for water gas and sewage (168.3 to 2032mm outside diameter).
IS 5822	Laying of electrically welded steel pipes for water supply.
IS: 6631	Steel pipes for hydraulic purposes
IS: 7343	Code of practice for ultrasonic testing of ferrous welded pipes and tubular products.
IS: 2598	Safety code for industrial radiographic practice
IS: 5822	Code of practice for laying of welded steel pipes for water supply
BS EN 499	Welding Consumables. Covered Electrodes for Manual Metal Arc Welding of Non Allow and Fine Grain Steel Classification
AWS:A-5.1	Specification for Mild steel Covered Arc Welding Electrodes
AWS:A-5.17	Specification for Bare Mild Steel Electrodes and Fluxes for Submerged Arc Welding
ASTM E 94	Guide for Radiographic Testing
ASTM E 709	Guide for Magnetic Particle Examination
ASTM E 165	Test Method for Liquid Penetrant Examination
IS: 5504 & IS: 3589	Code for SW pipes
IS: 10748	Requirement for Weldable Hot Rolled Carbon Steel Strip in Coils

CPHEEO Manual on Water Supply and Treatment, II edition, Ministry of Urban Development, New Delhi – May 1999

MS PIPES (Part 3 APPURTENANCES AND MISCELLANEOUS ITEMS)

1. Double Flanged Valves

1.1. Sluice Valves

1.1.1 General

The sluice valves shall confirm to IS: 14846. Double flanged short body, Gland less (stem sealing rings) type Sluice valves with appropriate pressure rating.

The material to be supplied under this sub-section shall include, but not be limited to, the following: All necessary fittings including bolts, nuts, gaskets, backing rings, counter flanges, jointing material, strainers etc. shall be supplied as required. The entire Gland less (stem sealing rings) sluice valve shall be provided with ball thrust bearing and spur gear **arrangement.**

1.1.2 Scope

The Gland less (stem sealing rings) sluice valves shall be with non rising stem type. The valves will be used for water supply on line installations in upright positions, with double flange, and cap or hand wheel for manual operation. The valves shall be suitable for continuous use at their PN rating within the temperature range of -10^0 C to 65^0 C.

1.1.3 Nominal pressure and dimensions

The working pressure on the valves shall be appropriate to the working conditions and approved by the Employer. The flanges and their dimensions of drilling shall be in accordance with IS: 1538 (part-I to XXII).

1.1.4 Material

The makes given are acceptable makes however the material for different component parts of sluice valve shall conform to the requirements given below:

No.	Component	Material	Ref. to IS	Grade / Designation
1	Body, bonnet, dome, stool cover, wedge, stuffing box, gland, thrust plate, hand wheel and cap.	S. G. iron	1865	Gr.400/ 12
2	Stem	Stainless steel	6603	$12C_r$ 13 $04C_r$ 18Ni 10 $04C_r$ 17Ni 12 MO 2
3.	Wedge, nut, shoe	Leaded tin bronze	318	LTB-2
4	Body seat ring,	Leaded tin	318	LTB – 2

	wedge facing ring and bushes	bronze		
5	Bolt	Carbon steel	1363 (Part 1)	Class 4.6
6	Nut	Carbon steel	1363 (Part 3)	Class 4
7	Gasket	EPDM Rubber	11855	-
8	Gland packing	Stem Sealing Ring	5414	Nil
9	Gear	Spheroidal graphite iron	1865	G_r 500 / 7
10	Gear housing	S.G. iron	1865	Gr.400/12
11	Pinion and pinion shaft	Wrought carbon steel	1570 (Part 3)	C55Mn75

1.1.5. Marking, testing and inspection

The standard marking and packing of the valves shall be done as per Clause 11 and 13of IS: 14846. The direction of rotation for OPEN, CLOSE position shall be marked on the hand wheel and on the bonnet of the valve.

Hydraulic testing of each sluice valve shall be done for close end test in accordance with IS: 14846 Annex B, to the test pressure and test duration as specified in table 5 and 6 of the IS.

All the valves shall be inspected for flaw detection test in accordance with IS: 14846, clause 10.2.The design, construction material, manufacture, inspection, performance and testing shall comply with all applicable Indian Standards and Codes. Nothing in the specification will be construed to relieve the supplier of this responsibility.

1.1.6 Manufacturer's Test certificate

The manufacturer shall provide a test certificate confirming that all the valves have been tested in accordance with IS: 14846 and stating the pressures and medium used in the test.

1.1.7. Inspection

The inspection and testing of the sample valves from a lot will be carried out by the employer and or inspecting agency appointed by the employer, in the manufacture's workshop, before application of any paint. All the tests as required as per the IS: 14846 shall be carried out on samples from each lot (Number of samples from a lot shall be as per the relevant IS for sampling and testing), in presence of the inspecting agency. The valves shall be dispatched only after issue of the test certificate by the inspecting agency for satisfactory performance of the tested valves. The inspection charges for such tests shall be paid by the contractor to the inspecting agency.

1.1.8. Acceptable makes for the valves

Acceptable makes for the sluice valves shall be as approved by Chief engineer.

1.1.9. Installation

The installation of the sluice valves shall be done at the locations shown on L-sections of the pumping main as washout valves and isolating valves for air valves. The job covers supply of the valves at work site with cost of all the required material and all types of taxes and duties, cost of packing, loading, transportation, unloading, stacking and installation at the specified location with cost of all jointing materials such as nuts and bolts, EPDM rubber gaskets etc. The job also covers field hydraulic testing of the valves after installation for the specified test pressure for the respective pipeline section

1.2. Butterfly valves

1.2.1. General

The Butterfly valves shall confirm to IS: 13095. Double flanged short body butterfly valves of required nominal diameter and pressure rating shall be supplied. The material to be supplied shall include, but not be limited to, that as shown in the table given below. All necessary fittings including bolts, nuts, gaskets, jointing material etc. shall be supplied as required.

1.2.2. Scope

The butterfly valves shall be with disc and shaft and shall be designed to withstand the maximum pressure differential across the valve in either direction of flow. The valves shall have no visible leakage past the disc in closed position under test conditions. The shaft may be of one piece design or in two pieces separately attached to the disc. The valves will be used for water supply on line installations in upright positions with manual operation. The valves shall be suitable for continuous use at their pressure rating within the temperature range of -10^0C to 65^0C.

1.2.3. Nominal pressure and dimensions

The working pressure on the valves shall be appropriate to the working conditions and approved by the Employer. The flanges and their dimensions of drilling shall be in accordance with IS: 1538 (part-I to XXII).

1.2.4. Material

The makes given are acceptable makes however the material for different component parts of butterfly valves shall conform to the requirements given below:

S. No.	Component	Material	Ref. to IS	Grade
1	Body	Sphéroïdal graphite Iron. / Ductile Iron.	1865	Gr. 400/12
2	Disc	Sphéroïdal graphite Iron. / Ductile Iron.	1865	Gr. 400/12
3	Shaft	Stainless steel	6603	-

4	Seating ring / Seal retaining ring	Integral Nicol Crominium Welding	-	-
5	Seat	EPDM Rubber	-	-
6	Shaft bearing seals	Bronze / brass bearing with 'O' rings	-	-
7	Internal fastners	Stainless steel	Manufacturer's standard	Suitable for duty
8	External bolting	Carbon steel; tensile strength 390 Mpa	-	-

1.2.5 Operation

All valves shall be capable of being operated at a differential pressure across the disc as marked on the valves. Leaver, worm gear / traveling nut type or any other suitable type of operator can be used.

Manually operated valves shall be closed by turning hand wheel or leaver in a clockwise direction when facing the hand wheel or leaver. The design of leaver when fitted shall be such that the leaver may only be assembled to the valve so that it is parallel to the direction of flow when the valve is open.

All traveling nut operators shall be provided with suitable stops to prevent movement of the shaft beyond the limit corresponding to the fully closed position of the disc.

All gear / traveling nut operators shall be self locking type. All leaver operated valves shall be capable of being locked at at-least three intermediate positions. The operating hand wheels shall be marked 'CLOSE' or 'SHUT' to indicate the direction of closure. The operator shall be provided with arrangement to indicate disc position.

1.2.6. Testing

All valves shall be hydraulically tested by the manufacturer before dispatch. The pressure shall be applied without any significant hydraulic shock. Testing shall be carried out before application of paint or other similar treatment.

1.2.6.1. Body test

The body ends shall be blanked. The valve disc shall be in slightly open position and the pressure equivalent to 1.5 times the maximum permissible working pressure shall be applied with water. The duration of test shall be 5 minutes for 1600 mm diameter valve.

1.2.6.2. Seat test

Seat test shall be carried in accordance with clause 17.3 of IS: 13095 for 3 minute duration.

1.2.6.3. Disc strength test

The test shall be conducted with the body flanges in horizontal position. The test pressure shall be 1.5 times the maximum permissible pressure. With disc in closed position, hydro test pressure shall be applied to the lower face of the disc for duration as per table 3 of the IS: 13095. There shall be no damage to the valve disc or any part of the valve, or disc shall not be permanently deformed.

1.2.7. Manufacturer's certificate

The manufacture shall provide a test certificate confirming that all the valves have been tested in accordance with IS: 13095.

1.2.8. Inspection

The inspection and testing of the sample butterfly valves shall be carried out by the employer and or inspecting agency appointed by the employer, in the manufacture's workshop before application of any paint. All the tests as required as per the IS: 13095 shall be conducted in presence of the inspecting agency on the sample valves from the lot (Number of valves to be tested from a lot shall be as per the relevant IS for sampling and testing). The valves shall be dispatched only after issue of the test certificate by the inspecting agency for satisfactory performance of the tested valves. The inspection charges for such tests shall be paid by the contractor to the inspecting agency.

1.2.9. Marking

Marking shall be cast integral on the body or on a plate securely attached to the body. Marking shall be as specified under clause 21 of IS: 13095.

The design, construction material, manufacture, inspection, performance and testing shall comply with all applicable Indian Standards and Codes. Nothing in the specification will be construed to relieve the supplier of this responsibility.

1.2.10. Acceptable makes for the valves

Acceptable makes for the double flanged butterfly valves shall be as approved by the Chief Engineer.

1.2.11. Installation

The installation of the butterfly valves shall be done at the locations shown on L-sections of the pumping main as online valves. The job covers supply of the valves at work site

including all type of taxes and duties, cost of packing, loading, transportation, unloading, stacking and installation at the specified location with cost of all jointing materials such as nuts and bolts, EPDM rubber gaskets etc. The job covers field hydraulic testing of the valve after installation for the specified test pressure for the respective pipeline section.

1.3. Kinetic Air valves

1.3.1. General

Kinetic air valves are required with pressure rating appropriate for the working conditions and approved by the Employer, confirming to IS: 14845.

1.3.2. Scope and general design features

The air valves shall be capable of exhausting air from pipeline automatically when being filled. Air shall be released at sufficiently higher rate so that there shall be no restriction for the inflow rate. Similarly, the valves shall be capable of ventilating pipeline automatically when being emptied. The air inflow rate should be sufficiently high to avoid development of vacuum in the pipeline.

The design shall be such that, higher the rate of flow the greater the resultant down thrust, keeping the ball 'glued' to its seat until the last drop of air is expelled from the pipe system.

Each air valve shall be provided with an isolating sluice valve with flanged end connection. The possible air velocity (inflow and outflow) must be at least 10 m/s.

1.3.3. Construction features

The flow of air should be as unobstructed as possible. The low pressure orifice shall be in the same axis as the main discharge / incoming air flow and must have a diameter sufficiently large. The valve body shall be designed in such a way that the turbulent air at the time of filling of pipeline shall not circulate and cause the ball to be caught in the discharging air stream and blowing the valve shut permanently. The cone angle of the low pressure (large orifice) chamber shall be such that even at a critical velocity of air escaping at 344 m / sec the total impact force on the vulcanite covered ball is less than the suction force on the annular area between the ball and cone. The annulus around the low pressure vulcanite covered ball is to be generously proportioned for discharge of air under various differential pressures. Normal range of cone angle is 45^0 to 60^0.

The orifice shall be carefully profiled to allow the requisite flow of air under varying differential pressures. It shall be in molded synthetic rubber such that even after extended contact the, vulcanite covered ball does not stick to it, when the line pressure becomes zero.

The high pressure chamber having small orifice shall be so designed that the orifice is effectively sealed in working condition. The orifice shall be profiled in such a manner that the rubber covered ball is not damaged even after extended contact. There should be machined guide in the chamber which ensures that the ball travels vertically and makes contact with the nipple and seals off the orifice without fail. The orifice size shall

Not be less than 2.5 mm and tapering to 10 mm suitable to release accumulated air within the pipeline. High pressure orifice may be fitted from bottom side of the cover.

1.3.4. Material

The makes given are acceptable makes however the material for different components parts of the air valve shall conform to the requirements given below:

S. No.	Component	Material	Reference to IS No.	Grade of designation
1	Body, cover, valve disc, stuffing box, valve guide, cowl,	S. G. iron / Ductile iron	1865	Gr.400/ 12
2	Low Pressure seat ring and face ring	Natural rubber	11855	
3	High pressure orifice	Leaded tin bronze	318	LTB-2
4	Bolts	Carbon steel	1363	Class 4, 6
5	Nuts	Carbon steel	1363	Class 4
6	Gasket	Rubber	638	Type B
7	Float	Stainless steel	-	-
8	Float guide	Leaded tin bronze	318	LTB-2

1.3.5. Floats

Minimum float diameters for kinetic air valves shall be as indicated in table 3 of IS 14845. The inner core of the floats shall be made from stainless steel having sufficient bearing strength and equivalent specific gravity.

1.3.6. Testing

Testing of all the air valves shall be carried out in the suppliers work shop as per IS:14845.

Following tests shall be carried for each valve.

- Function and performance test as per clause 12.4.1
- High pressure orifice test as per clause 12.4.2

- Low pressure orifice test as per clause 12.4.3
- Body test as per clause 12.4.4

The performance of the valve for the above mentioned tests shall be as specified under clause 12.1, 12.2 and 12.3 of IS 14845.

1.3.7. Manufacturer's Test certificate

The manufacturer shall provide a test certificate confirming that all the air valves have been tested in accordance with the relevant standards and performance of the test results observed.

1.3.8. Inspection

The inspection and testing of the sample air valves shall be carried out by the employer and or inspecting agency appointed by the employer, in the manufacture's workshop before application of any paint. All the tests as required as per IS 14845 shall be conducted in presence of the inspecting agency on the sample valves from the lot (Number of valves to be tested from a lot shall be as per the relevant IS for sampling and testing). The valves shall be dispatched only after issue of the test certificate by the inspecting agency for satisfactory performance of the tested valves. The inspection charges for such tests shall be paid by the contractor to the inspecting agency.

1.3.9. Marking

Each valve shall be permanently marked with a plate securely fixed to the body with the information as specified under clause 15.1 of IS 14845.

The design, construction material, manufacture, inspection, performance and testing shall comply with all applicable Indian Standards and Codes. Nothing in the specification will be construed to relieve the supplier of this responsibility.

1.3.10. Acceptable makes for the valves

Acceptable makes for the kinetic double orifice air valves shall be approved by the chief engineer.

1.3.11. Installation

The installation of the air valves shall be done with isolating sluice valve. The job covers supply of the valves at the work site including all taxes and duties, cost of packing, loading, transportation, unloading, stacking and installation at the specified location with cost of all jointing materials such as nuts and bolts, EPDM rubber gaskets etc. The job covers field hydraulic testing of the valves after installation for the specified test pressure for the respective pipeline section

1.4 NON RETURN VALVES

1.4.1 General

Non-return valves generally conforming to IS 5312 Part I & II (Single or Multi Door Type) shall be provided. The valves shall be suitable for continuous use at their pressure rating within the temperature up to 60^0C and shall be conforming to following specifications and requirements.

1.4.2 Design

- The non-return valve shall be swing check reflux valve type with Single or multiple doors.
- The valve shall be suitable for mounting on a horizontal pipeline and flow direction shall be clearly embossed on the valve body.
- Valves shall possess inbuilt high speed closing and non-slam characteristics achieved by suitable disposition of weight on door and the hydraulic passage.
- Valves of multi-door type shall be additionally provided with a supporting foot.
- All faces and seat rings shall be riveted to the machined surface in the Casting. The door shall be integral with the hinge and shall have a flat seating face. Minimum two (2) nos. suspension lugs shall be cast integrally on the diaphragm plate and shall be of adequate strength.
- No spring loaded/ spring return action or external dampening arrangement will be acceptable. All the Non-return valves shall be from the same manufacturer.

1.4.3 Material

The material for different component parts of Multi-door Non return valves shall conform to the requirements given below:

Component	Material of construction
Body / Door (& Diaphragm)	Ductile Iron GGG 40 / IS 1865 Gr. 500/7 to IS 1865 OR Cast steel grade B conforming to IS 1030
Stub pin	SS AISI 410
Seat & Face rings	Soft seated up to 300 mm. 350 mm and above: Gun metal : IS 318 Gr. LTB 2
Rivets	Soft annealed brass
Fasteners	Carbon steel
Painting	Liquid epoxy coating of DFT 300 microns with proper Blast cleaning to near white - SA 2 ½ Grade and 2 coats of epoxy based primer coating, prior to final coating.
Flange Drilling	IS 1538 Table 4 & 6/ BS En 1092 – 2

1.4.4 Nominal pressure

The working pressure on the valves shall be appropriate to the working conditions and approved by the Employer.

1.4.5 Marking

All valves shall be marked to show the following information permanently.

- Manufacturer's name or trade mark.
- PN rating
- Valve size
- Direction of flow

1.4.6 Factory Tests

The following tests shall be conducted on the valves at manufacture's works before painting. The tests shall be generally as per IS 5312 Part 2.

- **Body Test**

Body of each valve shall be hydrostatically pressure tested at 1.5 times its rated working pressure. The test fluid shall be water. Duration of test shall be 2 minutes. There shall be no leakage or permanent distortion of any component under the test.

- **Seat Test**

Each valve shall be tested for seat test by applying hydrostatic test pressure equal to its rated working pressure, on outlet side. Duration of test shall be 2 minutes. During the test, there shall be no leakage of water through the seats.

1.4.7 Manufacturer's certificate

The manufacture shall provide a test certificate confirming that all the valves have been tested in accordance with above specifications and relevant IS 5312 Part II.

1.4.8 Acceptable makes for the valves

Acceptable makes for the double flanged butterfly valves shall be as approved by the chief engineer.

1.4.9 Installation

The job covers supply of the Non-return valves at the work site including all taxes and duties, cost of packing, loading, transportation, unloading, stacking and installation at the specified location with cost of all jointing materials such as nuts and bolts, EPDM rubber gaskets etc. The job covers field hydraulic testing of the valves after installation for the specified test pressure for the respective pipeline section.

1.5 Anti Vacuum Valve:

1.5.1 Scope:

The Anti vacuum valve will be installed to prevent the formation of vacuum in large diameter (having Ø of 1000 mm. and above) water mains to prevent line collapse under

such conditions of flow as may result, for example, from too rapid a closure of an upstream head gate or shut down valve, a down stream burst or ordinary emptying or recharging of a pipeline.

1.5.2 Design features:

Design of the anti – vacuum valve shall automatically allow induction of large volumes of air to prevent vacuum formation; and also provide an automatic means of ventilating a line when it is being emptied of water, and of exhausting air when it is being recharged.

It should be suitable to react automatically, sensitively, and positively even after long periods of inactivity, to changes of pressure within a pipe, and whenever necessary, permit air to flow in at a sufficiently high velocity, and at low enough induction pressure, to safeguard the line against collapse.

Cowled Inlet Type of the anti - vacuum valve should have an annular cowl shrouding the orifice, providing protection to the orifice and the seating. It should be suitable for air to flow through the ports provided around the periphery of the body assembly. Such application is confined to situations where no damage is likely to occur surrounding structures from sudden intakes of air.

1.5.3 Operation :

About Operation, the valve element should be in the form of the disk which is sensitively balanced by a counterpoising mechanism. The disk guide pin should be attached to a crosshead, to which is fitted at either end a cranked lever that should rock about an intermediate pivot pin and should be applicable to carry an adjustable counterweight on its outer arm. The parts should so arranged that by adjusting the position of the counterweights, the valve must be balanced at any desired points on its working travel.

Thus, when swinging freely the valve may be balanced at a partially opened position in which case, if it is closed by hand, it self-opens to the pre determined point of equilibrium, and vice- versa. Also attached to the crosshead should be an oil dashpot which should give free opening, in a downward direction, but offer resistance to closing, in an upward direction, and avoid all possibility of oscillation of the suspended.

In action, therefore, the valve should not remain at either extremity of its travel unless it is acted upon by some external force. During normal operation, the disk should be held shut by the water pressure in the pipe. If the pressure on the underside of the disk falls below that of the atmosphere, the valve should immediately open to admit air and break vacuum. With very small vacuum, say 1 inch of mercury or about ½ psi below atmosphere, should open fully and offer a wide passage for free flow of air. On the cessation of air inflow, the valve must return to a position of slightly open, which is sufficient for the escape of air during refilling of the line. When the rising water makes contact with the underside of the disk, closure is completed: only a very small water pressure should be required to close the valve, consequently, the quantity of water over- flowing through the orifice during final closure will be negligible.

1.5.4 Manufacturer's Test certificate

The manufacturer shall provide a test certificate confirming that all the Anti vacuum valves have been tested in accordance with the relevant standards and performance of the test results observed.

1.5.5 Inspection

The inspection and testing of the sample Anti vacuum valves shall be carried out by the employer and or inspecting agency appointed by the employer, in the manufacture's workshop before application of any paint. The valves shall be dispatched only after issue of the test certificate by the inspecting agency for satisfactory performance of the tested valves. The inspection charges for such tests shall be paid by the contractor to the inspecting agency.

1.5.6 Marking

Each valve shall be permanently marked with a plate securely fixed to the body with the information as specified under relevant standards.

The design, construction material, manufacture, inspection, performance and testing shall comply with all applicable Indian Standards and Codes. Nothing in the specification will be construed to relieve the supplier of this responsibility.

1.5.7 Acceptable makes for the valves

Acceptable makes for the Anti vacuum valves shall be as approved by the chief engineer.

1.5.8 Installation

The job covers supply of the Anti vacuum valves at the work site including all taxes and duties, cost of packing, loading, transportation, unloading, stacking and installation at the specified location with cost of all jointing materials such as nuts and bolts, EPDM rubber gaskets etc. The job covers field hydraulic testing of the valves after installation for the specified test pressure for the respective pipeline section.

1.6 PAINTING SPECIFICATION FOR VALVES :

Final coating on internal and external surface of the Valve shall be carried out after satisfactory testing, prior to dispatch.

Before inspection : Each valve shall be cleaned and surface shall be prepared by Sand blasting to SA 2½ Grade – Near white blast cleaning, and suitably protected by applying one coat of two component high build polyamide cured re-coatable zinc phosphate epoxy primer.

After inspection : One coat of two component high build polyamide crude re-coatable epoxy coating shall be applied to achieve DFT 150 micron, followed by one coat of two component aliphatic polyurethane finish to achieve DFT 80 micron.

2 Surge Control System For Pumping Main shall be as approved after surge analysis.

2.1 Accepted Control System

2.1.1 Following types of control systems are acceptable for control of water hammer pressures in the pumping mains.

a) Zero Velocity Valves

b) Air Cushion Valves.

c) Surge anticipating valves

d) As may recommended by the surge analysis report

2.2 Surge Control System – Requirements

2.2.1. The requirements given are tentative. The contractor, after award of contract, must carry out the surge analysis based on the Longitudinal section, Pump and Motor characteristics of the selected pumps by the contractor. Surge analysis along with the selected system.

2.2.2. During detailed engineering following information must be submitted based on the Surge Control System' selected by the contractor. For design of surge control system limits will be adhered to (The surge pressures will be estimated after all working pumps at designed discharge, trip simultaneously) as may be approved after the surge analysis report from the expert.

2.3 Scour Valve /Silt Ejector

These valves are to be provided at regular interval at suitable location nearby local / natural drainage in the rising main / distribution network

2.4 Pressure sustaining valves / regulating valves.

Suitable size of pressure regulating or sustaining valves to be provided at pump house.

These valves shall be suitable to relief the excess pressure built in the pipe line in the event of some outlet chaks are closed and while pumps are in operation. Or these valves shall safeguard the pipe line by maintaining the defined operating pressure range.

These valves shall be auto regulated type by the pipe line pressures and shall be hydraulically operated by the flowing media, and the bleed of water shall be routed back to the sump / forebay.

PART - C

HYDRO – MECHANICAL WORKS

HYDRO – MECHANICAL WORKS

1.1 Scope of Work

The scope of work includes, but not limited to the following:

1. Designing, supply and manufacture, inspection, shop assembly, testing, painting, transportation etc.

2. Site storage, including insurance transportation and handling, site erection, painting, testing and commissioning including provision of labour, plant material etc. for the above.

3. Handing over to employer/supply of necessary spares of 2 years trouble free operation/ supply of installation of all incidentals not specified but is necessary for proper completion and satisfactory functioning of the system.

It is not the intention of these specifications to specify complete details of equipment. However, the Contractor shall supply the equipment which will meet in all respects, the requirements of employer in regard to performance durability and satisfactory operation. All the equipment supplied shall conform to the relevant Indian Standards. Wherever, Indian Standards are non-existent or silent, relevant International Standards (as agreed between the Employer and the Contractor) shall be followed. The sizes and numbers of units in each case are based upon employer's preliminary design and may vary to suit modified site conditions and design requirements.

1.1.1 Gates :

Suitable number of gates will be provided at the entrance of drain/ canal.

1.1.2 Gates at Draft Tube Tunnels

(a) Gates.
(b) Embedded parts (Primary and Secondary).
(c) Portal frame gantry crane of adequate capacity

1.2 Trash rack Frame

1.2.0 General Description of Equipment

1.2.1 Gate

Gate shall be designed with welded steel fabrication of skin plate supported by stiffener, main girder, vertical stiffener, side track, seals and guide etc. The gate shall be designed to withstand the head corresponding to minimum water level and it shall be suitable to lower under flowing condition and raising under unbalanced condition.

Each unit shall be fitted with bottom seal, side seal, track and guide roller assembly.
The Stoplog gate shall be designed as per IS: 5620.

1.2.2 Embedded Parts

Embedded parts shall be provided. Guides shall be provided up to the suitable height.

1.2.3 Hoisting Equipment

Hoist for Gates – The gates shall be operated by means of dedicated Electrical Operated hoists. The operating equipment shall consist of fixed rope drum type hoist provided on gantry. It shall have all breaking and control arrangement and overload protection devices. Hoist shall also have manual operation facility in case of power failure. Length of drum shall be such that not more than two layer of rope are winded on the drum.

1.2.4 Spare Parts

The mandatory spare for various gate hoist, and cranes shall include one set of rubber seal for all gates, one set of wheel assembly for fixed wheel gate, one set of Brake shoes for rope drum hoist etc. In addition to above mentioned spare if the bidder feel necessary additional spares may also be suggested.

1.2.5 Material

All material incorporated in the equipment shall be new, unused and of first commercial quality, free from defects and as per relevant India standard. Materials for various components of Hydro-mechanical equipment shall conform to the requirements given in Annexure.

1.2.6 Design

All gates shall be designed in accordance with the requirement of relevant India standard. For extra condition of loading such as earthquake condition, storm condition, Brake down torque condition etc. permissible design stress shall be increased by $33^{1/3}$% over the normal storm but limited to 80% of yield point. In case of fastener the increase in the storms for worst loading case shall be limited to 25% only.

The embedded parts of gate shall be designed to limit the bearing pressure on 2^{nd} stage to 25% of compressive strength of concrete.

1.2.7 Embedded Parts

All the sealing faces in the embedded form shall be of stainless steel. The wheel track and sliding track shall be of non-corrosive steel. The BHN of wheel track shall be 50 points higher than wheel rim. The entire track shall be machined after welding. Roller path, seal parts and guide track shall be provided up to height indicated below.

Guide track	-	Full travel of gate.
Track	-	Unbalanced operation – twice the gate height + 1 m
Track	-	Balance operation – gate height + 1 m

1.3 Gate Seals

All gate units, zero shaft gate, draft tube gate shall be provided with natural rubber / Neoprene sealing elements in a sections appropriate to the functional requirements and gate type. In cases where low frictional resistance is necessary, the seals will be provided with a PTFE insert bonded during the moulding process. Thickness of bottom seal shall not be less than 20mm and this shall be of wedge type. All corner seals between lintel seals and side seals shall be of continuous moulded piece. All seals will be clamped to gate units by stainless steel fasteners. Suitable chamfer shall be provided in the base plate and clamps of seal assembly. The properties of natural rubber / Neoprene seals shall be as under:

a) Shore Adurometer hardness 65+5
b) Minimum elongation 450%
c) Ultimate tensile Strength (Minimum) 14.5 N/mm^2
d) The rubber compound shall not absorb more than 10% by weight, of water in 7 day test
e) The tensile strength of the test specimen, after being subjected to an accelerated ageing test of 48 hours in oxygen at 70^o C and 2.1 N / mm^2 pressure, shall be not less than 80% of the strength of the test specimen before ageing.

1.4 Frictional Resistance

The following frictional resistance co-efficient shall be adopted in the Design of gates and associated equipment.

Sl. No.	**Item**	Static	Dynamic
1.	Rubber seal on Stainless steel	1.5	1.2
2.	Seals with PTFE inserts	0.2	0.15
3.	Roller bearing Factor	0.015	0.01
4.	Self –lubricating bearing	0.2	0.15
5.	Plain bearings	0.4	0.3
6.	Steel on steel	0.6	0.4
7.	Brass or bronze on steel	0.5	0.3

1.5 Operating Equipment

The capacity of the hoist and crane for various gates and stoplog units be calculated on the basis of self weight of the gate, weight of lifting beam (where applicable) frictional forces (including static seal friction, wheel / trunnion friction, hoist friction, silt load etc.) and down pull forces. The hoist capacity thus arrived shall be increased by 20 percent to cater for reserve hoist capacity.

Similarly in the case of gates designed for closing under self weight, the downward forces closing the gate while lowering shall be at least 20% higher than the forces opposing down ward motion. However the sealing pressure shall not be less than the values mentioned in the IS code.

1.6 Gate Seal Leakage

The leakage allowance for gate as well as stoplogs and bulkheads shall not exceed the permissible limits.

1.7 Gantry Cranes and Hoists

Mono/double rail cranes and hoists for handling the various stoplogs / gates shall be designed and shall conform to requirements of applicable to Indian codes. Cranes will be classified according to its specific duty, service life and load status gear mechanism. The winding drums shall have single layer of rope, as far as practical.

Mono/double rail cranes shall be supplied complete with rails equipped with necessary anchorage to withstand wind and seismic loads transmitted from the gantry structure. Electro-mechanical hoist shall consist of wire ropes, drums, reduction gear, couplings, brakes, electric motors, limit switches. Both electro-magnetic and thruster brakes shall be provided on hoist drives where LT and CT drives shall be equipped with electro magnetic brakes. Necessary provisions for connections to remote control system shall be provided on local control panels.

1.8 Lifting Beams

The lifting beams for handling the stoplog sections will be of the automatic type, being preset to release or engage the hooks prior to lowering. Presetting is by manual positioning of a central counterweight system, and an interlock arrangement prevents premature release of the hooks during lowering. A probe rod incorporated in each stoplog unit releases the locking arrangement when the section is fully lowered, enabling the hooks to disengage.

1.9 Rope Drums and Wire Ropes

The rope drums and wire ropes shall conform to the Indian Standards in general. The ropes shall conform to IS 2266 improved plow steel and fiber core extra flexible high grade improved wire rope. The ropes shall have a factor of safety of six (6).

The drums shall be made of cost steel of fabricated from steel plates and shall be reinforced to sustain concentrated loads due to rope tensions. The drums shall have a diameter not less than 20 times the rope diameter and shall have sufficient length to adopt full length of rope of specified lift and number of falls, in one layer plus two idle turns at each fastening end and minimum one extra groove. The drums shall be checked for crushing and combined stress as per IS – 6938.

1.10 Electrical Equipment

All electrical equipment, including motors, starters, control panels, Solenoids and associated instrumentation shall be of international standard and shall be suitable for the climatic conditions prevailing at the project site and shall be provided with all necessary anti-condensation heaters and other protection against the ingress of dirt and insects.
All motors shall be induction type with water tight terminals, anti-friction bearings and built in totally enclosed fan ventilated enclosures. All motors have speed not exceeding 1500 rpm. Creep speed motors shall also be continuously rated. All hoists including crane

hoists shall be provided with at least two sets brakes working on different principles viz. Electromagnetic, thruster, eddy current braking system etc.

All motions shall be provided with limit switches at both extreme ends of travel. For hoist motion the system shall be provided with overload limit switches and slack rope limit switches. Indications and protections shall be provided on the control panel.

1.11 Inspection & Tests

All materials shall be of tested quality and all work performed shall be subject to rigid inspection and no articles or materials shall be dispatched until all tests, analysis and shop inspection have been completed or certified copies of reports or results of tests and analysis have been accepted. Duplicate copies of manufacturer's test certificates including chemicals analysis and mechanical properties shall be made available for all materials. In case test certificates are not available for any of the material the same shall be got tested and only these materials which fulfill the requirements of these specifications shall be used. From any part / item, it should be possible to locate its manufacturer's batch / lot mark, which shall be achieved by transferring the batch marks before parting the materials.

All castings shall be annealed and forging shall be normalized.

1.12 Shop Assembly and Testing

During the course of manufacture, the equipment included in the scope of supply shall be subject to rigorous inspection and testing.

All components, sub-assemblies and assemblies will be dimensionally and functionally checked against the relevant drawing.

All gate units shall also be fully shop assembled (with temporary bolting where necessary), and checked for dimensional and flatness checks with all fitments such as wheels, guides, seals, bypass valves etc., attached. The correct Center of Gravity shall be established during shop assembly before final welding of lifting lugs.

Reception frames and guides shall be assembled on the shop floor for dimensional and straightness checks, also alignment of connecting members with the required tolerances.

In all cases the various connecting parts shall be match marked to facilitate site erection.

Hoisting units shall be fully assembled on the hoist platform and test run to at least 20 minutes and load tested to 1.25 times the rated capacity. All lifting beam shall be shop assembled and hooks will be similarly load tested. Automatic engaging and dis-engaging of lifting beam hooks shall also be tested in the shop. During test run all the components of the hoist shall be tested for their performance.

The gantry crane / monorail crane and hoist shall be fully shop assembled and tested to 1.25 times the rated capacity. The hoist shall be operated for 15 to 30 minutes in slowest speed to demonstrate that equipment has been designed for continuous duty. The gantry crane shall be made to travel for a distance of 30 m if so permitted or otherwise the driving wheels shall be rotated under power, by jacking of wheel carriage / crane.

Trashrack cleaning machine, shall be completely assembled and shall be tested for operation with load. The hydraulic thruster winches are to be tested for proper operation with load. Simulation load test at 125% on hoists and gear drive shall be carried out. Raking operation shall be performed above the deck level.

1.13 Site Testing and Commissioning

All embedded reception frames and support frames etc., shall be erected and checked for dimensional accuracy and alignment in accordance with the assembly drawing with the required tolerances and level limits before and after concreting

After site assembly of the gate units within their respective reception frames, all gates will be checked for roller alignment, seal compression and guide clearances.

The operating equipment will be checked for correct positioning and alignment, and undergo full functional tests over the operation range of the particular gate, checking operating speeds and performance of the hydraulic and electrical control systems.

Hydraulic systems will be pressure tested to 1.5 times the maximum rate operating pressure.

Gantry cranes and hoisting winches shall be load tested, all in accordance with standard.

1.14 Non Destructive Test

The fabricated gate / stoplog units, embedded parts, penstocks, hoist components and other load carrying members, shall be subjected to the following Non destructive tests.

1.15 Steel

i)	Butt welds	Rediography	100%
ii)	All fillet welds in the gate beam, end plate and lifting point	Magnetic particle	100%
iii)	Other fillet welds	Magnetic particle	10%
iv)	Root runs of important load bearing joints	Dye-penetrant	100%

1.16 Casting and Forging

Castings Ultrasonic Level I SA 603 ASME Sec. V Forgings Ultrasonic SA388 ASME Sec. V 2.3.20

1.17 Stress Relieving

Trunnion bearing hub casting prior to machining shall be stress relieved, if welded. Yoke girder and the anchor girders shall also be stress relieved. Elsewhere welded plates thicker than 28 mm will also be stress relieved. The procedure for stress relieving shall be per ASME section VIII Division –1.

1.18 Surface Preparation and Painting

All exposed and under water steel works shall be sand blasted to at least Sa 2 ½ quality of Swedish Standards. SIS 055900. The bidder shall clearly indicate the painting system proposed by them for under water as well as exposed surfaces of steel works including liners indicating the type of primers, protective coatings, No. of coats proposed and their dry film thickness. However, the dry film thickness should be around 70-80 microns for primer protections and 400 microns (in two coats) for final paintings.

1.19 General

The bidder shall include necessary ladders, platforms, handrails in and around gate installations in order to provide approach for inspection and maintenance. Removable steel covers shall also be provided on gate openings at deck level wherever required.

Necessary cabling (within this scope of work) for various hoist installations including remote control system shall be provided by the bidder without additional cost to the Employer.

The bidder shall prepare detailed technical specifications, design calculations, general arrangement, assembly, subassembly and detailed fabrication drawings and inspection drawings for various components of works and submit the same for the approval of the employer. Fabrication shall be taken up only after approval of the above by the employer. All schematic wiring diagrams, control circuit, drawings, hydraulic piping and installation drawings and hydraulic circuit diagrams along with detailed write up shall also be submitted for approval.

The meter, kilogram, second (MKS) System shall be used for this contract where manufacturer's products are produced in imperial sizes, substitutions shall be made to nearest metric size. All drawings, calculations, design data and instructions manuals shall be in MKS units. For manufacturer's convenience imperial measurements may be placed in brackets after the MKS units.

Bidder shall indicate the approximate weight of the various components of each gates and its hoists.

a. Weight of gates / stoplogs / bulkhead
b. Weight of embedded parts
c. Weight of hoists / cranes and its capacity
d. Weight of hoist supporting structure
e. Weight of lifting beams

1.20 LIST OF I.S. CODES REQUIRED IN GENERAL

Sl. No.	Description	IS Number
1	Recommendation of structural design of fixed wheel gates	IS 4622
2	Recommendations for structural design criteria for low head slide gates	IS 5620
3	Recommendations for structural design of medium & high head slide gates	IS 9349
4	Code of practice for design of rope drum and chain hoists for hydraulic gates	IS 6938
5	Code of practice for electric overhead Traveling cranes other than steel works cranes	IS 3177
6	Code of practice for design manufacture erection & testing of cranes & hoists.	IS 807
7	Code of practice for use of structural steel in general building construction	IS 800
8	Design criteria for hydraulic hoists for gates	IS 10210
9	Recommendation for inspection testing & maintenance of fixed wheel & slide gates	IS 7718 (Part – I)
10	Recommendation for inspection testing & maintenance of fixed wheel & slide gates	(Part – II)
11	Recommendation for inspection testing & maintenance of fixed wheel & slide gates	(Part – III)
12	Recommendation for Inspection, testing & maintenance of Radial gates & their hoists	IS 10096 (Part – I)
13	Recommendation for Inspection, testing & maintenance of Radial gates & their hoists	(Part – II)
14	Recommendation for Inspection, testing & maintenance of Radial gates & their hoists	(Part – III)
15	Approval test for welding procedures (Part – I)	IS 7307 (Part – I)
16	Approval testing of welders working to welding procedures	IS 7310 (Part – I)
17	Approval tests for welders when welding procedures approval is Not required	IS 7318
18	Code of practice for liquid penetrant flow detector	IS 3658
19	Code of practice for Ultrasonic tube echo testing by contact and immersion methods	IS 3664
20	Code of practice for magnetic flow detector	IS 3703
21	Code for unfired pressure vessels	IS 2825
22	Code of practice for radiographic testing	IS 2595
23	Code of practice for structural safety of buildings : Loading Std.	IS 875
24	Code of practice for plain & reinforced concrete	IS 456
25	Criteria for Earthquake resistant design of structures	IS 1893
26	Steel wire ropes for General Engg. Purposes	IS 2266

1.21 TRASHRACKS

The structural steel for trashrack bearing plates including anchor plates and bolts shall be assembled as shown in the approved drawings. All structural steel for trashrack will be shop fabricated in convenient sizes for transport, accurate positioning and alignment of the bearing, guides will be required to ensure that the rack sections will properly site / slide. The trashrack section will be furnished completely fabricated and will require only setting in position as directed or shown in the drawings. Rack shall be cleaned, painted and installed as shown in the drawing or as directed.

Each trashrack panel shall be so nearly rectangular that the diagonal dimensions will not vary more than 12 mm. Each trashrack shall be properly supported on the supported structures consisting of R.S.J's, channel, angle as specified in the approved drawings. Line level and centers of the supported structure shall be properly checked before final placement of trashrack.

1.22 Measurements for hydro-mechanical works will be made for making the progressive payments against the total contract price for the work.

ANNEXURE A

SPECIFICATION OF MATERIAL

Materials for various components of Hydro-mechanical equipment shall conform to the requirements given below. The successful bidder should submit the exact specification of material proposed by them in this Annexure before execution of work

Sl. No.	Component	Material Conform to
1	Gate, Embedded parts, groove-liner, bonnets etc.	
	a) Steel Plate	Mild steel weldable quality
	b) Rolled section	Mild Steel Weldable quality
2	Main rollers, Guide roller,	
		Cast steel
		Forged Steel
3	Self-lubricating bearings and washers	"Lubrite" or approved equal
4	Main and guide roller axles	Corrosion-resistant Steel
5	Side Guides	
	a) Steel plate	Mild steel weldable quality
	b) Rolled Sections	Mild steel-weldable quality
6	Main Roller track	Corrosion – resistant steel
7	Side and back roller track	Carbon steel
8	Sealing surfaces	Corrosion-resistant steel
9	Seal fasteners	Corrosion-resistant steel
10	Structural members of hoist platforms, columns etc.	
	a) Steel plate	Mild steel- weldable quality
	b) Rolled sections	Mild steel- weldable quality
11	Hoist drums and achieve	Steel platge - weldable quality, cast steel
12	Gears	Cast steel
13	Pinions	Forged steel
14	Pins, shafts, sheave, axles, less than 75 mm dia above 75 mm dia	Cold rolled steel corrosion resistant steel, carbon steel, Forged steel, Corrosion resistant steel
15	Wire rope	6 x 37 construction
16	Bearing Pedestal	Cast steel
17	Bronze bush other than specified above	Plain bronze
18	Lifting pins	Carbon steel Corrosion resistant steel
19	Bolts for connecting flange plates of Hydraulic Hoist	Corrosion – resistant Steel
20	Spherical / roller bearings	SKF, FAG or approved equal
21	Machine bolts and nuts	Carbon steel
22	Steel plate for penstocks	Pressure vessel quality plate

PART D
ELECRTO MECHANICAL WORKS

PUMPS

2.1.1. SCOPE:

I. The scope of this section covers design, manufacture, testing at manufacturer's works before dispatch, supply, delivery at site, erection, testing and commissioning of VT pumps each along with valves (H.O.P.D and E.O.P.D) in delivery line and with all associated auxiliary and ancillary equipment including OPU system for MDV and all other auxiliary equipment like compressed air, electrically operated valve with all associated equipment, dewatering and drainage, lubrication systems, water and air piping with necessary instrumentation, control and safety devices etc. complete with all accessories, mandatory spares, special tools and plant as detailed in the specification The scope of supply shall also include all parts, accessories, and spaares etc., which are required for construction, operation and maintenance of Pump –Motors, even though these are not specifically stated or enumerated. The corresponding parts of all the Pump -Motors, associated equipment and spares shall be of same material dimensions, workmanship and finish and shall be interchangeable.

II. The scope of supply shall also include all parts, accessories, and spares etc., which are required for construction, operation and maintenance of Pump –Motors, even though these are not specifically stated or enumerated. The corresponding parts of all the Pump - Motors, associated equipment and spares shall be of same material dimensions, workmanship and finish and shall be interchangeable

1.2 Tentative Parameters of DPSs:

S. No.	DPS Name	Discharge	Working Pumps	Standby Pumps (50% standby)	Discharge of each pump	Head Total	Required Capacity of each pump
		Cum/sec	No's	No's	Cum/sec	m	HP
1.	Gammon India	3.44	2	1	1.72	11.5	415
2.	Digha Bailey road Junction	3.12	2	1	1.56	10	470

- Pump manufacturer should be an ISO 9001, ISO 14001, ISO 45001 & ISO 50001 Certified organization.

- Pumps manufacture must have at least 5 years manufacturing experience. Bidder must have submit documentary proof after award of contract that same required capacity of storm water drainage pump has been supplied by pump manufacturer in each year.

PUMP -MOTOR:

Type and rating.

I. The pump shall be of vertical shaft, single stage **suitable for direct** coupling to motor of **suitable** capacity with 10% over load rating. The direction of rotation shall be anti-clockwise when viewed from top. Each pump shall be so designed and constructed that all removable parts including runner, shaft, guide bearing, shaft seal, guide apparatus etc., can be easily removed. It shall be possible to repair/replace pump shaft seal without de-watering the Draft tube, for which purpose additional repair seal shall be provided. .

II. The pump shall be capable of giving rated discharge **(approximate)** with maximum of **rated suitable power input** to the motor, at rated voltage and frequency. The bidder shall evaluate the losses in the water conductor system to arrive the dynamic head and shall design pump-motors accordingly. The net head and Gate opening at which the machine gives the best efficiency shall be indicated, while delivering the rated discharge. The pump shall be designed and constructed to operate satisfactorily with complete safety and without objectionable vibrations, noise and cavitation at all heads within the range of head variation indicated above.

III. The maximum discharge and the corresponding gate opening at minimum and maximum net head, best efficiency head shall be stated in the offer. Capability of pump for giving higher output shall also be stated in the offer. Graphical data regarding the gate opening, discharge, efficiency, shall be furnished along with the bid. The pump shall operate satisfactorily for a variation in capacity up to 125% of the rated capacity at a head of indicated above at higher frequencies (50.5 Hz). The bidder shall indicate clearly the suitability of the pump for operation at heads higher than the designed net head

CHECKING GUARANTEES FROM MODEL TEST RESULTS:

Field test as per IEC form the final basis to establish the fulfillment of guarantees. The purchaser shall have option of carrying out the field test by the manufacturer. Such tests shall be to the bidders account

Penalty on account of fall in weighted Average Efficiency and output:

For any shortfall in the tested values of rated output and weighted Average Efficiencies (as determined by the following basis) from the guaranteed values, a penalty shall be applicable at the rate of Rs.2,50,000(Rupees two lakhs fifty thousand only) per pump for each 0.01**% (one hundredth percent)** by which the test figure is less than the corresponding guaranteed figures. The penalties on account of the output and efficiencies shall be computed separately and the total amount of penalty shall be the sum of these two. No tolerance limit shall be permissible over the test figures of rated output. Tolerance on measurement of efficiencies shall be allowed in accordance with the IEC test code or any other equivalent standard for Field tests of pumps

Rejection Limit:

The purchaser has right to reject the equipment if the test values of either weighted average

efficiency (as determined on following basis) or the rated output falls below 3 % of the corresponding guaranteed figures as per IEC standards.

Computation Of Weighted Average Efficiency:

The weighted average efficiency of the prototype machine shall be determined from the guaranteed and field test values of the efficiencies at the rated Static head in accordance with, for the purpose of penalty and rejection limits of efficiencies guaranteed.

RECTIFICATION TO MEET GUARANTEES:

The bidder shall make good and meet the guarantees again within a period of 4 (Four) months from the date of witnessing the original tests, should the original test be unsuccessful in meeting the guarantees. However, no delay in the original delivery schedule shall be allowed due to this reason

The penalty or rejection shall be applied if the second attempt is also unsuccessful in meeting the guarantees.

CAVITATION GUARANTEE:

I. The Bidder shall guarantee the runner, discharge ring and other hydraulic passage against excessive pitting caused by cavitation for 60 months from date of commissioning or 12,000 hrs. of actual operation, whichever is earlier.

II. Excessive pitting shall be defined as the removal of metal from runner and other passages exceeding a weight of $W = 0.1D^2$ per 1,000 hrs of operation during the guarantee periods defined above, where W is weight in kg. and D is the throat diameter of runner in meters. The bidder shall indicate the method which he proposes to use for measuring the amount if the metal removed on account of cavitations, which shall be subject to the approval of purchaser.

III. If the 60 months guarantee period expires prior to the completion of 12000 hrs. of actual operation, the bidder shall guarantee, that the weighted loss shall not exceed the value proportional to the number of hours actually operated.

IV. In case of excessive cavitations being present, the Bidder at his cost shall correct the condition and rectify and/or replace the part thus affected. The pump after such modifications and repairs and/or replacements of part or parts shall be subject to the same cavitations guarantee as for the original equipment.

V. In determining whether or not excessive pitting has occurred, metal removed by erosion, corrosion by the presence of injurious foreign element in water or by chipping and grinding preparatory to repairing the pitted area, shall be excluded. The manufacturer shall adopt necessary improvements modifications in the designs, manufacturing to minimize the cavitations pitting within the permissible limit.

CRITICAL SIGMA:

Values of critical sigma as calculated by IEC code or any other equivalent standard on the basis of model test for pump shall be given in the form of curves efficiency versus sigma for different heads of operation. Plant sigma curves shall also be plotted on it to clearly show the safety margin available. Cavitations model tests shall also be given.

SPEED REGULATION:

The limits on speed rise shall not exceed the values given in the schedule of guaranteed t echnical particulars of this section.

RUNAWAY SPEED AND NOISE GUARANTEES:

The maximum runaway speed of the pump under any combination of cistern water and surge pool water conditions shall be stated. The pump shall be capable of running safely at the maximum runaway speed, without damage to its parts for not less than 15 minutes, on every such occurrence. The duration for which the pump can run at runaway speed safely shall be stated in the offer.

Maximum noise level of operation shall be 120 decibels, and the guaranteed value shall not exceed 120 decibels in the machine hall. The bidder shall supply necessary instruments for recording & analyzing vibration levels & shall include these in the bid.

MODEL TESTS

I. Model test shall be performed by the bidder (before commencement of manufacture of the prototype) in the presence of the Purchaser's representative to demonstrate the efficiency and other guarantees as well as requirement of specification for the performance of pump shall be met. Model tests shall be carried out as per IEC test codes or any other equivalent standards which is more stringent.

II. The hydraulic parts of the model shall be completely homologous with the corresponding parts of the prototype units as per relevant IEC recommendations or any other equivalent standard.

III. Hydraulic performance Tests shall be made to determine machine characteristics. Values of unit torque and unit discharge shall be plotted against unit speed. These tests shall include determinations of capacity, efficiency, cavitations limits, hydraulic thrust, runaway speed etc., and shall be in accordance with relevant IEC or other equivalent test codes.

IV. In deriving prototype step-up efficiencies from model tests data formula given in relevant IEC test or any other equivalent standards shall be used. Similarly, head-discharge relationship shall be stepped up from the model by the affinity law with an additional correction to the discharge as per relevant IEC code or any other equivalent standards recommendations. Cavitations limits of critical sigma shall be determined from the model test.

V. Other model tests as considered desirable to check guarantees or determine operating characteristics under unusual conditions shall be carried out as agreed jointly between the purchaser and the bidder.

VI. Copies of model test reports giving performance of pump operation shall be furnished after completion of model tests to Engineer-in-charge.

VII. The manufacture of prototype pump shall be commenced on approval of model test results by the purchaser.

VIII. Detailed graphs regarding plant sigma and machine sigma shall be finalised at the time of model test.

IX. Photographs and sketches of cavitations phenomena shall be furnished.

2.1.2. GENERAL ARRANGEMENT OF PUMP:

The pump shall be so constructed that all removable parts including runner, shaft, guide and thrust bearings and supports, gate-operating mechanism etc., can easily be removed.

The design of pump shall permit a vertical movement of the runner shaft by an amount sufficient for adjustment of the thrust bearing and for clearing the joints at the coupling of the pump and motor shaft.

The bearing arrangement of the pump/motor shall be so designed as to ensure trouble free operation of the unit and permit repair/replacement of parts without disturbing the adjacent components.

All equipments shall be readily accessible for operation and maintenance. All necessary walkways ladders, hand rails, chequered plates required for the equipment covered under the specification shall be provided.

Pumps shall be vertical and shaft-driven by vertical-shaft motors. Impellers shall be of the mixed or axial-flow multi-stage type, driven at a maximum speed of 960 rpm unless otherwise specified.

Operation of pumps shall be automatic with working and standby pumps operated in rotation such that no pump shall be operated short duration.

The minimum clearance between adjacent pumps and between pump and wall shall be as per Hydraulic Institute Standards.

For all the pumps the selected model shall be such that the operating point shall lie nearest to best maximum efficiency point but towards the left of the maximum efficiency point.

The impeller diameter selected shall be such that there shall be a minimum of one diameter higher and one diameter lower size impeller is available for all the pumps.

The pump installation shall include SS 316 suction strainer, suction bell mouth, suitable length column pipe, discharge head, motor stool, lower stool, all the accessories, etc. complete.

The total suspension length shall be from suction point at bell mouth up to delivery point at common header as per design. The vertical column shall be suitably supported and anchored to prevent vibrations / movement.

The pumps shall confirm to IS: 1710 and IS: 5120. The pumps shall be capable of handling raw water from a reservoir with expected turbidity up to 1000 PPM.

Vertical-shaft driving motors shall be mounted on the discharge head above the discharge bend. Unless otherwise specified or approved, they shall be of the hollow shaft type, fitted with an axially-adjustable thrust bearing designed to carry the combined weight of pump and motor rotating parts, the drive shaft with couplings, and hydraulic loadings.

Support bearings shall be provided between each impeller stage. The impeller shaft shall be corrosion-resistive low-alloy steel, designed for low stress and long life.

The drive-shaft couplings shall be designed to preserve true shaft alignment in all operating conditions and shall be close to bearings. Coupling design shall provide for accurate assembly and re-assembly within the limits of the permissible end-float of the shaft.

The drive shaft and couplings shall be designed to withstand the maximum accelerating torque of the motor, with a factor of safety of at least two. When required, the Agency shall provide his design calculations to demonstrate that the shaft size chosen meets the requirement for safety factor.

Unless otherwise specified or approved, the drive arrangement shall incorporate an approved ratchet arrangement to ensure that Pump not rotating reverse direction, if the pumps are driven in reverse for any reason, the motor is uncoupled from the pump. Unless otherwise specified, the discharge pipe work shall include an automatic air inlet/release valve, designed to vent the pipe work on pump start and to allow air ingress when the pump stops. The valve shall be sized to ensure that accumulated air shall not be passed to the delivery pipe work on starting. If draining the column pipe on pump stopping could result in reverse rotation of the pump, means shall be incorporated to ensure that the pump cannot be restarted before reverse rotation stops.

2.1.3. CODES AND STANDARDS

The design, manufacture and performance of the pumps shall comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment will be installed. The equipment shall also conform to the latest applicable Indian or equivalent international standard. Some of the relevant standards are:

IS 1710	:	Vertical Turbine Pump for clear cold fresh water
IS 5120	:	Technical requirement for rotodynamic special purpose pumps

2.1.4. FEATURES OF CONSTRUCTION

The hydraulic design of the pump shall meet the requirements of high efficiency at least 85%, low submergence, high reliability, optimum system design.

The shut off head shall be at least 110% of the total head and maximum of 130 % of total head.

The first critical speed for the pump rotor shall be at least 30% above the operating speed.

Pumps shall run smooth without undue noise and vibrations. The velocity of vibrations and the noise level shall be as per latest IS code. To detect excessive vibrations exceeding design limits as per standards, three axis vibration monitors shall be installed on the motor at top. The motor shall stop automatically when the vibration exceeds the limits.

The power rating of the pump motor shall be higher of the following:

115% of the power input to the pump at duty point at a speed corresponding to given frequency.

Maximum power input while operating single pump corresponding to the speed of 50 Hz.

Pump impeller shall be both statically and dynamically balanced.

The pumps of a particular category shall be identical. Components of identical pumps shall be interchangeable.

Pump shall be provided with non-reversible ratchet to prevent reverse rotation.

All pumps shall be provided with suitable protections including protection against overload, bearing failure, increase in bearing temperature etc.

All accessories required for proper and safe operation shall be furnished with the pumps.

Pump and motor shall be selected for VFD operation in variable frequency.

2.1.5. REVERSE ROTATION

Non-reverse ratchet arrangement shall be provided to prevent reverse rotation. However, the unit shall be designed to operate safely at the maximum speed attainable in the reverse direction of rotation due to water returning through the pump at times when the power supply to the motor is interrupted and the valve fails to disallow reverse flow and non-reverse ratchet arrangement fails.

2.1.6. NOISE AND VIBRATION LEVEL

Pumps shall run smooth without undue noise and vibration and noise level shall be limited to

a) Sound : 85db at a distance of 1.5 m.

b) Vibration : 4.5mm/s velocity. (Measured vertical, Horizontal and axial)

2.1.7. COLUMN PIPE

i. Column pipe shall be steel Manufactured from tubes confirming to either IS 1978:1982 or Gr A of IS 2062: 1984 for depths greater than 80m, the column pipe shall be manufactured from tubes confirming to IS 4270:1983.
ii. The Standard lengths of column pipes shall be 1.5, 2.5 or 3m.
iii. The column pipe may be threaded, flanged or provided with other methods of connection.

2.1.8. GASKET, SEAL AND PACKING'S

Gaskets, seals and packings used for clear, cold water pumps shall confirm with those specified in IS: 5120:1977.

2.1.9. IMPELLER:

i. The impeller shall be ASTM A 743 CF8M may be of the enclosed or semi-open type impeller shall be fastened securely to the impeller shaft with keys, taper bushings, lock nuts or split thrust rings.
ii. They shall be adjustable vertically by means of a nut in the driver or an adjustable coupling between the pump and the driver.
iii. Impeller shall be properly balanced dynamic balancing is recommended. Closed impellers may have a renewable sealing/wear ring fitted on to the front shroud or in the bowl or both.

2.1.10. BOWL

i. The Bowl shall be Cast Iron conforming IS 210:1978 and casings of bowl shall be free of blow holes, sand holes and other detrimental defects, the bowls shall be capable of withstanding a hydrostatic pressure equal one and a half times maximum discharge pressure (this included shut off head).

ii. The bowls may be equipped with replaceable seal rings on suction side of enclosed impellers. Water passages shall be smooth and the bowls may contain bushes to serve as bearings for the impeller shaft.

2.1.11. IMPELLER SEAL RING:

The Wearing shall be ASTM A 743 CF8M wearing ring providing seal to enclosed impeller. It may be either on the impeller or in the bowl or on both.

2.1.12. TRANSMISSION BEARING RING:

The Bowl-bearing/top bowl bearing shall be rubber; bronze conforming IS 318:1981 and bearing used for impeller shafts in each bowl.

2.1.13. IMPELLER/LINE/HEAD SHAFT:

Impeller Shaft shall be stainless steel conforming IS 1570 (Part 5):1895 and it holds the rotating impellers and coupled to the line shaft.

2.1.14. MATERIAL OF CONSTRUCTION

The material of construction for various components shall be as under:

Casing & Suction bell: Cast Iron IS: 210, Grade FG 260

Bowl	: Cast Iron IS: 210, Grade FG 260
Impeller	: ASTM A 743 CF8M
Impeller Shaft	: AISI 410
Head Shaft	: AISI 410
Line Shaft	: AISI 410
Discharge Head	: MS IS 2062 Fe 410WA
Column pipe	: MS Fabricated
Transmission Bearing	: Rubber backed Bronze
Wearing Ring	: ASTM A 743 CF8M
Suction strainer	: SS 316

All fasteners including anchors bolts, foundation bolts, washers, nuts etc. in both in wet and dry areas Stainless Steel SS 316

2.1.15. DISCHARGE HEAD AND MOUNTING PLATE

The discharge head shall be a composite fabrication or casting. The supporting-plate assembly shall consist of a steel base plate, strong enough to carry the weight of the complete pumping unit without significant deflection. The assembly shall provide the motor mounting arrangement and support the pump. If required, the supporting plate shall be supplied with a flanged sleeve to facilitate mounting, with a puddle flange for building in.

The following shall be included:

- supporting plate with holding down bolts or studs;
- Bedplate ring with leveling screws and plates;

- Lifting lugs
- Fixings for motor and coupling;
- Provision for insertion of cables and level-recording equipment if required;
- Provision for access to service the shaft seal.

The discharge-head shaft seal shall be selected for long life with minimum maintenance and may be of the mechanical. The pressure limit of mechanical seals shall be at least 50% greater than the pump closed-valve delivery pressure. Provision shall be made to return to the pump well any water leaking past the head seal.

2.1.16. WATER-LUBRICATED LINE-SHAFT BEARINGS

Bearings shall be spaced at the intervals needed to ensure vibration less running at all possible pump operating speeds, with a maximum distance of 2.5 m apart. Guide bearings shall be of resilient synthetic rubber, mounted in spider bearing-retaining assemblies.

The arrangements for supplying filtered water shall ensure:

a) That filters used are duplex type so that one filter can be cleaned while the second remains in service;

b) That if required by the bearing design, a filtered water supply is provided to each bearing before the shaft begins to rotate.

c) That if the installed arrangement makes any reverse rotation possible on pump stopping, if required by the bearing design a filtered water supply is provided to each bearing until reverse rotation stops.

2.1.17. REJECTION

If the shop testing at factory premises, the guaranteed efficiency considering the zero percent negative tolerance, is not met, the pump shall stand rejected.

2.1.18. TECHNICAL DATA SHEET

The bidder shall submit detailed technical data sheet pump with their technical proposal during bidding covering all the details of pumps.

2.1.19. NAME PLATE

All Pumps shall have a stainless-steel nameplate on the body. Project name shall be printed by original manufacture.

EOPD & HOPD VALVE

2.1.20. EOPD VALVES:

Butterfly valves shall be of flanged construction and shall be complete with actuating mechanism, matching counter flanging, bolts, nuts, gaskets, lifting lugs, sole plate for supporting feet in the valve body etc.

2.1.21. DESIGN / CONSTRUCTION / MATERIALS PARTICULARS

The valves shall be designed for the design pressure / temperature as specified and in accordance with IS13095/BS5155.

i. The vales shall be suitable for installation in any position (horizontal / vertical etc.).
ii. All valve components and accessories of the same type shall be perfectly identical in size and material so as to guarantee interchangeability of the parts.
iii. This specification is valid also for the spare parts.
iv. The actuator-operated valves shall be designed on the basis of the following prescriptions.

- The internal parts shall be suitable to support the stresses due to the actuator, the valve-actuator unit shall be suitably stiff so as not to cause vibrations, misalignments, etc.
- All flanged ends shall comply with the standard specified.
- The valve flanges shall be flat faced.
- The Contractor shall furnish the coefficient of capacity of each valve (CV in metric units) and the characteristic curves.
- Necessary shaft seal shall be provided and adequately designed to ensure no leakage across the seal. This seal shall be designed so that they will allow replacement without removal of the valve shaft.
- The operating mechanism shall be mounted directly on or supported from the valve body.
- The Sealing ring on the disk shall be continuous type and easily replaceable.
- Rubber seal shall be fitted on the periphery of the disc by clamping between the disc and clamping ring. The seal design shall be T type and shall be held in machined grooves on the disc and clamping ring. Seal design with clamping bolts passing through seal shall not be acceptable.
- The shaft shall be solid type and shall pivot on bushings. Bushings/sleeve type bearings shall be contained in the hub of valve body.

The material of bearing shall be self-lubricated type with low coefficient of friction that does not have any harmful effect on water and on valve components. Bearing shall be provided beyond the shaft seal. The housing for this bearing shall be rigidly attached to the valve body.

The minimum length of the disk hubs shall be at least 1.5 the diameter of the shaft or of the stems. The shaft shall be connected to the disk through keys or taper pins or screws of stainless steel. The connections shall be designed so as to avoid looseness during the operation; moreover, they shall be provided with suitable disassembling systems. The design of the shaft shall be such that it will safely sustain maximum differential pressure across the closed valve. The shaft and any key (taper pin or other) for transmitting the torque between shaft and disk shall be capable of with standing the maximum torque required to operate the vale.

The disc shall rotate from the full open to the tight shut position. The disc shall be contoured to ensure the least possible resistance to flow and shall be suitable for throttling operation. While the disc is in the throttled position, valve shall not create any noise or vibration.

All butterfly valves shall have permanent arrow inscription on the valve body indicating direction of flow. All valves shall be complete with:-graduated position indicator (located in a visible place for the operation).Adjustable mechanical stop limiting devices to prevent over travel of valve disk in open and closed position.

Valves shall have integrally cast supporting feet.

2.1.22. ACTUATORS OPERATED VALVES

Actuators will be with Limit and Torque switches for either end of travel for control and interlocking purpose.
The characteristics of the actuators to be located on the valves are indicated in the actuators specification.
Should the actuator be located on the control column, all connecting accessories shall be supplied (extensions, joints, articulations, etc.). The valves 350Nb and above shall also be provided with hand wheel drive arrangement suitable for manual operation. Manual operation of valve shall be through worm and gear arrangement having totally enclosed gearing with hand wheel diameter and gear ratio designed to meet the required operating torque. It shall be designed to hold the valve disk in intermediate position between full open and full closed position without creeping or fluttering. Adjustable stops shall be provided to prevent over travel in either direction.

Limit and torque switches shall be enclosed in water tight enclosures along with suitable space heaters.

MATERIALS / DESIGN DETAIL

Materials, design and other specific requirements of various categories of BF valves shall be as indicated below.

Sl. No.	Description	Requirement.
a)	Design	As per IS 13095/ BS 5155
b)	Type	Double flanged
c)	Material	
	i) Body and Disc	Cast steel grade ASTM-A 276 74 d Gr.WCB or SG Iron as per IS 1865 gr. 500/7
	iii) Shaft	Stainless steel AISI: 431
	iv) Body Seat	Monel 60 integral
	v) Disc Seat	EPDM
	vi) Bearing	PTFE LINED ST.ST.
	vii) Testing	AWWA-C-504/ IS
	viii) Other Requirement	Tight shut off

SPECIFIC PERFORMANCE GUARANTEE

For the rubber seated valves, the Contractor shall guarantee that in the closed position and with a disc differential pressure as specified the valves shall be water tight.

The Contractor shall guarantee that the operating mechanism shall open and close the valve under the specified maximum differential pressure within the time specified.

The valve shall be suitable for frequent operation during initial commissioning operation after a long period of inactivity.

MARKING

The mark stated by the Employer in the Material Request shall be printed on the body of all valves and relevant accessories (control columns and relevant connecting elements to the valve, counter flanges, valves for the auxiliary control if separately supplied, etc.).

The face of each hand wheel shall be clearly marked "Open" and "Shut" with arrows indicating the direction of rotation to which they refer. Each handwheel shall also be fitted with a circular name plate indicating the service for which the valve is intended and valve tag number. The name plates shall be engraved in black lettering.
Each spare part shall be individually marked with metal plates suitably punched for an easy identification.

TESTING AND INSPECTION

All valves shall be checked for correctness in respect of flange details as specified. The valves shall be tested as per the requirement of AWWA C-504 (latest version)/IS.Proof of design-tested valve shall not be supplied for the project.

For cast construction : Body and Disc shall be subjected to MPI/LPI and shaft shall be subjected to UT and LPI.

For Fabricated Construction: All Butt welds having thickness 20mm and above shall be subjected to Radiography and stress relieving. Only qualified welders shall be used for the purpose of carrying out welding. Shaft shall be subjected to UT and LPI.

Site Test

The valves shall be tested at site for opening and closing time, valve operation etc. The valve should operate without any flutter, noise, and vibration.

2.1.23. ACTUATORS FOR BUTTERFLY VALVES

DESIGN REQUIREMENTS:

- Electric actuators shall essentially consist of electric motors, limit switches, hand wheel and gear trains, mechanical position indicators, internal wiring and terminal block.
- The electrical actuator assembly inclusive of drive motor and unit switches compartment shall conform to IP 55 degree of protection.
- Actuators shall be sized so as to open / close the valve at the rated speed against the design differential pressure at 90% of the nominal voltage.
- Lost motion hammer blow feature shall be provided for seating / unseating the valve when the operating torque exceeds 11 kg/m.
- Operators shall be designed to be self locking (i.e. maintains the stem position) upon loss of electric power supply.
- Motors shall be installed on the operator prior to shipment to the valve manufacturer.
- Actuators shall be provided with lifting lugs for handling it along with the bonnet. Actuator assembly shall have all metal gear trains.

- Operators shall be flange mounted on the valve bonnet. Welding of operators onto bonnets is not permitted.

OPERATING SPEED:

All actuators shall have operating speeds as per the manufacturer's standard. However, this shall meet operating requirement of the system. Actuator operating times (opening and closing) shall be furnished with actuator details.

SERVICE CONDITIONS

i. The actuator shall be suitable for operation in a hot, humid and tropical atmosphere.

ii. Unless otherwise stated in the equipment specification, the ambient air temperature shall be taken as 50 dg. C, relative humidity 100% and mean sea level less than 1000 meters.

RATING

The actuator shall be designed for operation on a 415 V + 10%, 3-Phase 50 Hz + 5% solidly grounded system. The combined voltage & frequency variation shall be +/- 10%. The control circuit voltage shall be 240/110 V A.C. or 220V D.C.

The actuator shall be rated for three successive open-close operation of the valve or 15 minutes, whichever is longer.

The normal torque rating of each drive unit shall have adequate margin and at least equal to theoretical brake torque required to drive the equipment under full load, including all losses in speed reducers and power transmission.

The drive shall take into account valve operating speeds and differential and static pressures required for the service. The Contractor shall select operating speeds and design pressure to satisfy requirements of the equipment furnished and acceptable to the Employer. Motor actuator assemblies shall have all metal gear trains. Fibre gears are not acceptable.

PERFORMANCE

- The actuator shall open and close the valve completely and make lead-tight valve close, without jamming.
- The actuator shall attain full speed operation before valve load is encountered and impart an unseating blow to start the valve in motion (hammer blow effect).
- The actuator shall operate the valve stem at standard stem speed and shall function against design differential pressure across the valve seat.
- The motor reduction gearing shall be sufficient to lock the shaft when the motor is de energized and prevent drift from torque switch spring pressure.
- The entire mechanism shall withstand any shock resulting from closing with improper setting of limit switches or from lodging of foreign matter under the valve seat.

2.1.24. SPECIFIC REQUIREMENT

Construction

The actuator shall essentially comprise of the drive motor, torque/limit switches, gear train, clutch, hand wheel, position indicator / transmitter, space heater and internal wiring. The actuator enclosure shall be totally enclosed, dust tight, whether proof suitable for outdoor use without

necessity of any canopy. All electrical equipment, accessories and wiring shall be provided with tropical finish to prevent fungus growth. The actuator shall be designed for mounting in any position without any lubricant leakage or operating difficult.

Motor Drive

The drive motor shall conform to sub-section E2 of this specification.

The drive motor shall be three phase, 415V, squirrel cage, induction machine with class B insulation and IPW-55 enclosure, totally enclosed and self ventilated and designed for high torque low inertia and reversing service suitable for operation at 50 deg. C ambient temperature. The motor shall be designed for full voltage direct on-line start, with starting current limited to 6 times full-load current.

All motors shall have TEFC enclosures with space heaters to maintain the internal temperature above dew point when the motor is idle. Space heaters shall be rated for 240V AC. The motors shall be capable of operating the valve against the maximum load on the valve disc. with drive bearings in dry and dirty condition. Each motor shall be provided with two direct temperature-sensing thermostats to prevent thermal overload. All motors shall have O-ring seals to provide complete environmental protection when the motor is idle. Earthing terminals shall be provided on either side of the motor. Double shielded grease pre-lubricated, regreasble, antifriction bearings having a minimum life rating of 1,00,000 hours shall be furnished.

Limit switch

Position Limit Switches:

Each actuator shall have rotary drum position limit switches, two (2) for open and two (2) for close position, each with adjustable setting between fully open and fully close positions. Each rotary drum position limit switch shall have two normally closed (NC) and two normally open (NO) independent contacts. The adjusting mechanism for the limit switches shall be easily accessible.

Torque limit switches:

Each actuator shall have two torque limit switches with suitable arrangement to limit the opening / closing thrust. The torque switch, actuated by the torque clutch when the valve is restricted during opening / closing shall stop the motor thereby protecting the motor from overloading torque. The torque switches shall be set as near as possible to the pull out torque of the motor without damaging the valve of the operation. Each torque switch shall have two normally open (NO) and two normally close (NC) independent contacts. The torque limit switch adjusting mechanism shall be easily accessible. Limit switches along with all necessary electrical wiring shall be housed in a weather proof NEMA-3 enclosure and shall have gasketted cover and space heater to maintain the temperature above dew point. Each torque / position limit switch shall have 2 No + 2 NC potential free contacts. Contacts shall be rated to make and carry continuously 10 A at 110 V AC and 0.5A (inductive) 220 V DC.

Manual operation: All actuators shall have mechanically independent manual drive arrangement with hand wheel and motor declutching mechanism. The manual drive shall be provided with clutch and gearing as required to limit hand wheel effort to 25 kgt maximum along with suitable latch and locking arrangement to keep the hand wheel in engaged position using manual operation. The hand wheel shall disengage automatically during motor operation.

Position indicator/Transmitter: All actuators shall have one (1) built-in local position indicator for 0-100 % travel. All actuators shall be provided with mechanical 3-point dial position indicators. Rising steam valve shall additionally have visual position indication through plastic stem covers. Where required, valves shall be provided with continuous remote position indicators of the potentiometric type. The available voltage sources for the potentiometric position transducers are

220V DC and 240 V AC. The tranducer shall be suitable for stablished 4-20 mA current signal. The associated wiring for the transducers shall be housed in the limit switch compartment.

Space Heater: A space heater shall be included in the limit switch compartment suitable for 240 V AC, 50 Hz supply 220 V DC.

Wiring: All electrical devices shall be wired up to and terminated in a terminal box. The internal wiring shall be of sufficient size for the power rating involved but no case less than 1.5mm copper. All wiring shall be identified at both ends with ferrules. Internal wiring diagram shall be neatly pasted on the rear side of the terminal box cover. Motor power, heater and all control wiring shall be wired at shop to suitably rated master terminal blocks located within the limit switch compartment. All internal wiring shall be of 650/1100 V grade flexible standard copper conductor cables with tropical fungicidal treatment and the insulation shall be flame resistant. The limit switch terminals should be capable of terminating two nos. 2.5 mm copper cable. Terminal boxes shall be provided with removable undrilled gland plates to terminate following sizes of cable.

. I) 1 no. - 14 core 2.5^2 (Cu)
ii) 1 no. -10 cores - do -
iii) 1 no. - 2 pair
iv) 1 no. - 10 pair
v) 1 no. - Power cable

Terminal Box

Actuator terminal box shall be suitable to receive and terminate the following cables:

a) 1 No. power cable details of this shall be intimated later.
b) 3 Nos. 19 C x 2.5 copper conductor PVC insulated unarmoured control cable.

Actuator terminal box shall be provided with a removable front cover plate, and an undrilled detachable gland plate.

Data to be furnished: Motor data sheet for each type of actuator shall be furnished along with internal wiring diagram, suggested control schematic and torque / limit switch contact development.

2.1.25. HYDRAULIC OPERATED VALVE (DISCHARGE VALVE) FOR FULLY CLOSING AND OPENING FUNCTIONS DURING STOPPING AND RUNNING OF PUMP

Type and description

Each pump shall be provided with oil pressure operated butter fly valve or through flow type valve, and oil pressure operated needle valve or sluice valve as by pass use. The valve shall have maximum capacity to allow maximum flow of pump discharge. The valve shall be designed to withstand the maximum transient pressure and shall be free from vibration and abnormality under the whole operating range of pump including any transient conditions of operations. The inside diameter of the valve shall be recommended by the bidder. The valve shall be so designed as to be capable of closing from fully opened position under the condition of maximum flow at every head with minimum oil pressure supplied to servomotor.

The opening and closing time of the valve shall not be more than 60 seconds including the operating time of bypass valve with normal operating pressure.

Amount of leakage passing through the gaps shall not exceed 5 litres/min. under a static head of 9.00 M including leakage through the bypass valve.

Valve Body

Valve body shall be fabricated of rolled steel plate welded structure or made of steel casting, and shall be sectionalized if required to suit transportation limitations if any. Each section shall be jointed at site by flange and bolts with sufficient strength to with stand the maximum hydraulic pressure of 100m. as well as to withstand the maximum static head without any distortion or deformation. Both ends of the valve body shall be provided with grooves for grease lubrication.

The bearings shall be provided with necessary packing glands to prevent inflow of sand or other foreign material contained in the water.

The valve shaft shall be horizontal type and the bearings shall support the full weight of the valve disc and shaft, and assure smooth opening and closing operations. The bearings shall be suitable for lubricating with grease from the grease supply device. All bearings shall be so constructed that the replacement of the liner and packing can easily be carried out.

The joint between the valve and the spiral case shall be made by flanges packing and shall be free from any leakage. The contractor shall furnish all the bolts, nuts, packing and other necessary material and bolts for making perfect tightness of the joint. Necessary connecting pipes, flanges, bolts, nuts, packing and other required parts shall be furnished by contractor. The valve body shall be provided with a set to mount the bypass valve.

Valve Disc

The valve disc shall be made of carbon steel casting or fabricated of rolled steel plates. The disc shall be designed with sufficient strength not to cause any distortion or deformation nor to cause any abnormal vibration when the valve is in open position or during operation. The disc shall be supported by forged steel turnions through the disc. on the peripheral surface of the disc a rubber ring shall be provided to seal off leakage together with a stainless steel seat provided on the valve body inner surface. The rubber ring shall be firmly fixed to the valve disc by metal fitting. The fitting bolts shall be made of stainless steel. The design shall fabricate easy renewal of the rubber ring on the spiral case side with the valve in its position. And also a maintenance seal shall be provided so that the seal replacement can be carried out without emptying the delivery line in case the regular seal is not effective.

Bypass Valve

Bypass valve shall be designed to assure the least amount of corrosion due to cavitation and cause the least noise or vibration during operation.
Metal sealing shall be provided to obtain a leak-proof seal when the valve is closed. The operation shall be provided to obtain a leak-proof seal when the valve is closed. The operation of the bypass valve shall be carried out by oil pressure commonly used for discharge valve. One end of the bypass valve shall be connected to the seat provided on the discharge valve body and a manual gate valve shall be provided on upstream of the hydraulic operated bypass valve. The valve shall be of such construction to permit easy manipulation by one man. The other end shall be connected to the seat provided. The valve shall be made of stainless steel.

Connection to Pipe to Delivery Line

In order to facilitate erection of the discharge valve, connecting pipe between the discharge valve (H.O.P.D / E.O.P.D) and the delivery line shall be furnished. The connection pipe shall be fabricated with rolled steel connection between delivery line and connecting pipe at a suitable distance away from the pump center line shall be done by welding at site. Specifications of material for connecting pipe shall be determined during detailed engineering stage. Particulars of the connection shall be decided after award of contract. The connecting pipe shall be provided with pipe seats and taps for delivery line drain, pressure gauge pipe etc. The location and inside diameter of those pipe seats and taps shall be decided during detailed engineering stage.

Discharge Valve Operating Mechanism

Discharge valve operating mechanism shall consists of servomotor, rod, link and lever. The cylinder and head of servomotor shall be made of carbon steel casting or rolled steel for welded structure. The servomotor piston shall be made of carbon steel casting or cast iron. The operating mechanism, including that for the bypass valve shall be provided with manual locking devices which can lock both the inlet and bypass valve when they are closed. When the valve is locked, both opening and closing operation by oil pressure shall be blocked.

Operation of the valve shall be such that ,in opening, the bypass valve is opened first and the discharge valve shall be opened after the delivery line is filled with water and in closing, the discharge valve is closed first and the bypass valve is closed after the discharge valve is closed.
The bypass valve shall be provided with a hydraulic oil distribution valve to establish a condition to open or close the discharge valve in conjunction with the operating.

Two limit switches shall be provided for the discharge valve. Each limit switch shall be provided with two normally open auxiliary contacts and two normally closed auxiliary contacts.

A scale plate and a needle shall be provided to indicate the discharge valve position in percentage of 100 , when the valve is fully open.

OPU system for discharge valve shall be complete in shape and quantity and shall cover oil Pressure oil pumps valves.

Oil Pressure Unit System for Main Discharge Valve

A) **Oil Pressure Vessel**

i) The oil pressure tank shall be designed and tested in accordance with the ASME code (Section-VIII), for unfired pressure vessels or any other approved equivalent code considering the maximum working pressure of the system. The interior surface of the pressure tank shall be coated with oil resistant paint or other suitable coating to prevent deterioration of the metal. It shall also be ensured that oil characteristics in regard to its functions are not affected chemically or otherwise.

ii) The capacity of the oil pressure vessel shall be sufficient to meet all the pressure oil requirements of the servomotor and even below pump shut down oil level. It shall have an oil volume capable of performing three full operations that is close-open-close, with the oil pumps being out of operation.

iii) Means shall also be provided to prevent entry of air into the oil piping system under conditions of lowest oil level in the sump tank or receiver.
iv) The oil pressure vessel shall be provided with the following safety / control / operation switches:
a) Pressure switches for automatic starting of oil in flow into the OPU receiver when oil pressure in the vessel falls below a predetermined value and for automatic stopping of oil inflow when pressure rises above a predetermined value, and for alarm and trip under low pressure or abnormally high pressure conditions. Necessary unloader valves shall be included in scope of supply.
b) Level switches, differential pressure switches for giving alarm and shutting down the pumps when oil level falls below predetermined value.
c) Level switch / differential pressure switches for giving alarm when oil level rises above the predetermined value.
v) The oil pressure vessel shall be equipped with a float type dial gauge for indicating oil level in the tank.
vi) The oil pressure vessel shall be complete with compressed air inlet, auto air replenishing system, air relief valve (safety valve), pressure gauges, piping, oil drain connections with valve, manhole, etc.

Oil Sump-Tank and Pumps

i) Two nos. screw type oil pumps shall be provided and located on the tank top itself, one serving as main and other as standby, with a manual selector switch to changeover their functions. The standby pump shall automatically start on failure of the main pump in service.

ii) The pumps shall be of continuously running type with adequate capacity during unit running time, with pressure switch control and shall continue to run intermittently with pressure switch control, when the unit is shutdown. A set of smoothly operating unloader valve, non-return valve and safety valve shall be provided to regulate the oil level.

iii) The pump motors shall be of continuous rated and shall be provided with 415V, 3 Phase, 50 Hz. squirrel cage induction motors.

iv) Oil sump tank shall be provided with float type dial level indicator, oil contamination detector, level switches for low/high oil level alarms, oil filter, air vent and filter, oil inlet/ outlet connection and drain valves etc. The interior surface of the sump tank shall be coated with oil resistant paint or other suitable coating to prevent deterioration of the metal. It shall also be ensured that oil characteristics in regard to its functions are not affected chemically or otherwise.

v) The sump tank provided shall have a sufficient capacity with not less than 50% margin to hold all the oil in the system.

vi) The sump tank shall be provided with a manhole for access to interior of the tank and shall have suitable connections for oil purifier.

vii) The sump tank shall be provided with oil level gauge and oil level switches for indication of oil level low/ high and alarms.

LEAKAGE OIL TANK AND PUMPS

Oil leakage tank with screw type pumps and necessary piping and valves shall be provided and located at suitable location. The tank shall be provided with suitable float type dial level indicator level switches for automatic start/stop of the pumps. The pump motors shall be suitable for 415 V, 3 phases, 50 Hz, AC supply. An alarm shall also be provided to indicate high & low oil level in the tank.

DISCHARGE VALVE OIL PIPING AND VALVES

Oil piping and valves complete with flanges, bolting materials, gaskets; packing etc. required for inter-connections between the various equipment shall be included in the offer. All piping shall be steel, suitable for maximum oil working pressure. All valves shall be cast or forged steel valves having flanged ends.

EOPD:
EOPD Shall be electrically operated gate valve and shall be provided and limit switches end limit switches, torque switches along motors of suitably rated with terminal block arrangements. The cable sizes shall be as detailed above.

INSTRUMENTATION AND CONTROLS FOR PUMP AND PUMP CONTROLLER.

Instrumentation, alarms, safety devices and controls necessary for automatic control, monitoring and efficient operation of the pump with its associated equipment shall be supplied by the manufacturer so as to constitute a complementary part of the complete and coordinated set of such instruments, gauges, controls and safety devices required for supervision and controls of the unit during normal running and in emergencies.

Tentative requirements of the instrumentation etc. are given in the schedule of requirement. The Bidder shall however, offer any additional instruments and safety devices which the bidder considers, necessary for the unit and the bidder shall guarantee the sufficiency and adequacy of the provisions in this regard. The Pump-motor is normally started from the SCADA system in the control room and brought to synchronous speed and then synchronized with the grid and pumping of water is done. In general the instrumentation and control scheme shall be such as to provide for manual mechanical control, manual local electrical control and automatic remote control and emergency shut down. The local electrical control and emergency shut down from unit control panel(Local control panel) and the remote electrical control from unit control board / MMI panel to be mounted in the control room shall be provided.

All necessary indicating instruments, gauges and controls etc. for the pump and controller shall be mounted on the unit control board and wherever necessary on unit control panel. All temperature indicating/recording instruments, associated relays, certain electrical instruments on the unit control board shall be provided by the manufacturer.

For remote control of the units from the main control room, all necessary items of the controller and also alarm/safety devices shall be provided on the main control panels in control room. The controller controls and indicating instruments shall be provided. The control which are provided both on the unit control board/Machine control panel and the controller cabinet (Main control Board) shall be so interlocked electrically as to eliminate the possibility of simultaneous operation of any control from both the boards.

One set of apparatus for measurement and recording of the pump discharge shall be supplied with each pump. The apparatus shall be complete with all necessary instruments, peizometers, tapings,

interconnecting tubing etc. and shall be calibrated at the time of efficiency and out-put tests on the pump.

One set of pressure transducer type water level transmitter and indicator/recording instrument shall be provided for cistern. The signal for the head variation should be transmitted to the gate opening limiter of the controller. This device shall be able to prevent operation of pump at non-rated duties restricting extra gate openings at higher heads.

SPECIAL TOOLS, SLINGS, CONSUMABLES ETC.

All special tools, slings, lifting devices, jacks, turn-buckles, foundation plates, bolting materials etc. required for assembly, erection, dismantling of the pump, controller and other equipment of bidder's supply shall be included by the bidder. A list of the special tools and equipment required for assembly/erection and maintenance of pump components as listed in "Schedule of Requirement", item-4 shall be supplied. First filling of the controller and lubrication oil with 10% spare capacity, for pump shall be supplied by the manufacturer and the brand and grade of the oil shall be specified.

SPARES

Spare parts for the pump, controller equipment and instrumentation as listed in item 2 schedule of spares of this section shall be supplied along with the main equipment. All spare parts supplied shall be interchangeable with and shall be of the same material and workmanship as the corresponding parts of the equipment. The spares shall be supplied along with the first unit. The bidder shall also indicate additional spares considered essential by him for five (5) years normal operation and maintenance.

TESTING DEVICES AND INSTRUMENTS FOR TESTING DURING ASSEMBLY, ERECTION AT SITE AND FOR FIELD ACCEPTANCE TESTS

Testing tools and equipment required for testing during assembly/erection at site and all instruments and devices required for field acceptance tests for fulfillment of efficiency and output guarantees, shall be supplied.

SHOP ASSEMBLIES AND TESTS

The first pump shall be completely assembled in shop and properly match-marked and dowelled to ensure correct assembly and alignment in the field except that where necessary suitable dowels shall be furnished for insertion after field assembly and drilling.

In the case of subsequent pumps, part assemblies to the required extent shall be done and match marked to avoid any problem of matching during erection at site.

The equipment such as pressure tank, gate, servomotors, piping, coolers etc., which shall be subjected to oil (or water) pressure shall be shop tested as a pressure equal to 150 percent of the maximum operating oil (or water) pressure inclusive of maximum water hammer in such equipment.

The bidder shall give a list with details of the shop assembly tests to be performed on the components of the pump such as runner, guide bearing etc. including controller and other accessories etc. These shall be subject to the approval of the purchaser.

The purchaser or his authorized representative shall have access to the manufacturer's works for all purpose of witnessing the manufacture, Inspection of various assemblies and for testing of all components. The equipment shall be assembled and shop tested in the presence of the purchaser or his authorized representative, prior to dispatch. Any work found defective or unsatisfactory shall be rejected.

The bidder shall conduct non-destructive tests on components of pump.

FIELD ACCEPTANCE AND OTHER SITE TESTS

Hydraulic pressure tests, leakage tests and operation tests where applicable shall also be performed on components such as the pump components, pressure tanks, controller , sump tank, pumps, motors etc.
The manufacturer shall furnish a list of all the field tests to be performed during site assembly and erection of the pump prior to commissioning.
Field Acceptance tests shall be performed on the fully erected pump-motor units to determine the actual performance of the unit vis-à-vis the guaranteed performance. The field acceptance test shall be performed as per IEC test code for Hydraulic pumps or any other equivalent standard.

The pump shall be given a over speed test for a period of 15 (fifteen) minutes to demonstrate their ability to withstand successfully the mechanical stresses and hydraulic performance incident to maximum runaway speed at an effective maximum head with wicket gates fully open. The cost for any component replacement/rectification that may be required shall be to the account of manufacturer.

DRAWINGS, DATA, MANUALS ETC., AND DOCUMENTATION TO BE FURNISHED BY THE BIDDER

The bidder shall furnish all drawings, data, manuals and other necessary literature in six copies. The Bidder shall, in addition, supply the documentation for the design and manufacture of the pumps as given below:

I. Supply of complete information on Scheme design including basic data on Scheme information, model test report, characteristic curves etc. for operation.
II. Supply of detailed design drawings and calculations, strain gauging results, computer programmes, plate development data for draft tube assembly, dimensional tolerances particulars
III. Complete specifications of materials. Copies of specifications relating to inspection and testing of material and finished components
IV. Detailed manufacturing drawings for various pump components and information.
V. Tooling information.
VI. Recommended list of suppliers for supply of components.
VII. All information necessary for co-ordination of station and control equipments.
VIII. Drawings clearly showing the various components/ assemblies of the pump, governing equipment draft tube etc. in plan and elevation.
IX. Layout drawings of the pump house both in section and plan showing the overall dimensions and layout of the pumps, auxiliaries, general run off pipes etc. clearly indicating unit spacing dimensions of draft tube etc. and all important elevations.

X. Comprehensive operation, maintenance and installation instructions along with O&M manuals of all bought out items.

XI. Supply of dimensional drawing of all the vital hydraulic passages. No load to full load pump performance curves, efficiency and cavitation characteristic curves. Plant and machine sigma curves for pump operation.

XII. A complete list of equipments, Auxiliaries etc. covered in the offer.

XIII. Schematic drawings for electrical controls, instrumentation and Hydraulic controls.

XIV. Physical and schematic drawings and descriptive literature on the Pump controller and control mechanism.

XV. The bidders shall furnish all the data, especially guaranteed and other technical particulars called for in the schedules and also include their experience in the manufacture, erection, testing and commissioning of pump giving details of their technical particulars. Any offer lacking complete information in this respect is likely to be rejected.

(t)

TRAINING OF EMPLOYER'S ENGINEERS

The bidder shall arrange training for 6 engineers of the purchaser for a period as mutually agreed upon during the design and manufacture of the pump at the manufacturer's design and drawing office and manufacturing shops to familiarise with all aspects of design and manufacture of , associated auxiliaries, control systems etc. All expenses including to fro, lodging and boarding charges for training the engineers of the purchaser shall be borne by the bidder.

COMPLETENESS OF EQUIPMENT

All the fittings and accessories of the pump and associated auxiliary and ancillary equipment though may not have been specifically mentioned in the specification but are usually necessary for completeness of the above equipment shall be deemed to be covered by the specification and shall be indicated and furnished by the bidder with out any extra cost to the purchaser.

DEVIATIONS FROM SPECIFICATIONS

The deviations from the specification shall be listed in the Annexure A, absence of which it shall be presumed that the provisions of specifications are completed with by the bidder.

SCHEDULE OF REQUIREMENTS

Item No.1. pump

I. suitable type pumps each for discharging not less than of water and each pump comprising with the following.

II. One runner of stainless steel and cast steel boss complete.

III. One shaft of forged electric furnace steel properly heat-treated and forged with connecting flanges at both ends, keys coupling bolts, nuts, covers etc. for connecting to the runner and to the auxiliary shaft and motor rotor.

IV. One Set of guide bearing of oil-lubricated type with bearing housing and with temperature detector, temperature detection relay, oil piping, pressure gauges, cooling water piping, water flow indicators differential pressure relay and other accessories.

V. One Stuffing box with sealing water piping, differential pressure relay, and water flow indicators, for alarm annunciation in U.C.B. and local indication.

VI. One Draft tube of steel plate suitably sectionalized and equipment for assembly of sections access door with hinged cover and provision for connecting to discharge ring.

VII. One Set of embedded piping including leakage water drain piping, pump sets and other miscellaneous piping.

VIII. One Discharge ring with a provision for connecting to the draft tube on one side and to the guide vane supporting cover on the other side with necessary connecting bolts etc. A manhole with bolted cover for access shall be provided in the discharge ring.

IX. One Stay ring of cast steel or welded plate steel, which shall be embedded in the concrete.

X. One Inner stay vane welded with stay column and one outer stay vane with drain piping, peizometer tapings.

XI. One controller (controller) equipment comprising motor drive, gate control arrangement etc. with a complete set of instrumentation, controls, and automatic safety devices, mounted on the actuator and at the Unit Control Board and equipment for necessary remote control and indication at the main control board.

XII. One Discharge valve with oil pressure system for control, comprising oil pressure pumps, driving motors complete with starting equipment, instrumentation and automatic controls, oil piping, necessary stop valves, check valves, blow off valves, by pass valves, unloading valves, safety valves, fittings etc. and arrangement for replenishment of air in the oil pressure receiver including compressor plant etc. valves (H.O.P.D and E.O.P.D)

XIII. One Speed indicator motor.

XIV. One complete system of equipment, piping, connecting pipes, valves, bends, drains etc. for cooling water, oil and High-pressure compressed air systems for pump and controller equipment.

XV. One complete system of draft tube, drainage and dewatering system.

XVI. One Set of water level indicator for indication of cistern water levels which are common to all the three units with instruments/transmitters, sensing element, piping, valves, complete system for monitoring the reservoir level. The wells for water level sensors and wiring materials between each equipment shall be supplied.

XVII. Two Sets of erection tools common to all the three units.

XVIII. One Set of special tools, slings and consumables etc.

XIX. One Set of tools and plant for maintenance of the plant to be provided immediately after commissioning of pump-I for operation & maintenance.

EXPANSION JOINT / DISMANTLING JOINT

2.1.26. GENERAL

Expansion Joint will be provided in the discharge piping as shown in the G.A. drawings enclosed with this tender.

2.1.27. CODES AND STANDARDS

The design, manufacture and performance of metallic expansion joints shall be as FSA, USA or equivalent standard and comply with or all currently applicable statues, regulations and safety

codes in locality where the equipment will be installed. The equipment shall also conform to the latest editions of fluid sealing association.

2.1.28. OPERATING CONDITIONS AND DESIGN REQUIREMENTS:

For operating conditions and design requirements refer to design data sheet enclosed.

2.1.29. CONSTRUCTIONAL FEATURES

All parts of expansion joints shall be amply proportioned for all stresses that may occur during continuous operation and for any additional stresses that may occur during installation and also during transient conditions.

The expansion joints shall be single bellow metalic expansion joints. The arches of the expansion joints shall be filled with soft metalic.

The design shall be suitable for the pressures and type of fluid i.e. raw river water.

The tube (i.e. inner cover) and the cover (outer) shall be made of natural or synthetic metallic of adequate hardness. The shore hardness shall be less than 50 deg. A for outer and 50 deg. A for inner cover.

The carcass between the tube and the cover shall be made of high quality cotton duck, preferably, square woven to provide equal strength in both directions of the wave. The fabric plies shall be impregnated with age resistant metallic or synthetic compound and laminated into a unit. Reinforcement, consisting of solid metal rings embedded in carcass, shall be provided.
Expansion joints shall be complete with stretcher bolt assembly to absorb piping movements and accommodate mismatch between pipelines.

Main Body

The expansion joints shall be of heavy-duty construction made of high-grade abrasion resistant natural or synthetic metalic compound. The basic fabric for the “duck” shall be either a superior quality braided cotton or synthetic fiber having maximum flexibility and non-set characteristic
Note: Slip type metallic joint should be provided with relevant specifications instead of metallic expansion joint.

Reinforcement
The expansion joints shall be adequately reinforced, with solid steel rings, to meet the service conditions under which they are to operate.

Retaining Rings
All expansion joints shall be provided with stainless steel retaining rings for use on the inner face of the metalic flanges, to prevent any possibility of damage to the metalic when the bolts are tightened. These rings shall be of split and beveled type for easy installation and replacement and shall be drilled to match the drilling on the end metalic flanges and shall be in two or more pieces. The split retaining rings shall be of 10 mm thick stainless steel of tested quality. Steel washers shall be provided at the boltholes where retaining rings are split.

End Flanges
The expansion joints shall be integral fabric reinforced full-face metallic flanges. The bolt hole on one flange shall have on eccentricity in relation to the corresponding bolt hole on the flange on the other face. The end metallic flanges shall be drilled to suit the companion pipe flanges.

Outer Cover
All exposed surfaces of the expansion joints shall be given a 3 mm thick coating of neoprene. This surface shall be reasonably uniform and free from any blisters porosity and other surface defects

Control Units
Each control unit shall consist of two (2) numbers of triangular stretcher bolt plates, a stretches bolt washers, nuts and lock nuts. Each plate shall be drilled with three holes, two for fixing the plate on to the companion steel flange and the third for fixing the stretcher bolt.

Expansion joint tag no. & name plate
Each joint shall have a permanently attached brass or stainless steel metal tag indicating the tag numbers and other salient design features which will be indicated by the engineer in the expansion joint drawing submitted for his approval by the Contractor.

2.1.30. TESTING FOR METALIC EXPANSION JOINTS

Manufacturer's standard test shall be performed during manufacture and after the completing the manufacturing. Tests shop shall include but not limited to the following.

All bear bellows shall be subjected to deflection test under pressure, pressure being raised from zero to design pressure in regular steps and deflection measured at each step.

Material test shall be conducted as given below:

a) Metallic compound test slab after vulcanizing shall be tested for tensile strength, elongation and hardness.
b) Fabric strength of synthetic fibre for reinforcement shall be checked and test for metalic to fabric, metallic to metal adhesion shall be carried out. Test on metallic shall include hydraulic stability check as per ASTM D- 471.

2.1.31. VACUUM TEST

All expansion joints shall be subjected to an absolute internal pressure of 25 mm Hg. The test shall be conducted in three different positions for a minimum period of thirty (30) minutes duration in each position.

Immediately after the vacuum test, a hydraulic test, as per the relevant, standards shall be conducted on the expansion joints. The rate of pressure duration the test shall not be less than 1 bar/ second. The hydraulic tests shall be conducted on the expansion joint in three different positions for duration of 30 minutes (minimum) in each position.

Either during the hydraulic test or during the vacuum test, the expansion contraction or deformation shall not be move 1.5%. However, a cumulative error is not allowed. The purpose of conducting hydraulic test or vacuum test is to ensure the stability to withstand deflection in axial and transverse direction.

Twenty four (24) hours. After the above test, the permanent set (variation in dimensions with respect to its original dimensions) shall be measured and recorded. The permanent set shall not be more than 0.5%.

Test Results
The record of the test results to establish the tensile strength, permanent set hardness and adhesion characteristics of the metalic used in the construction of the expansion joint shall be made available to the engineer for his approval.

2.1.32. SHOP INSPECTION

The surface of the expansion joints shall be examined by the engineer and/or his representative and abnormalities, if any, noted**.** The Contractor shall arrange training on the equipment supplied for engineers of the purchaser, as mutually agreed upon during the design and manufacture of the equipment to familiarise with all aspects of design and manufacture of Pumps, associated auxiliaries etc. All expenses like living, traveling and other expenses of the trainee engineers of the purchaser shall be borne by the Contractor. The supplier shall also arrange and meet the expenses of stay of Engineers of the purchaser for witnessing the Model Tests

AC MOTORS FOR VFD

2.1.33. SCOPE

The scope covers design, manufacture, testing at manufacturer's works before dispatch, supply, erection at site, testing and commissioning of motors of **suitable** capacity each complete with associated auxiliary equipment like VFD. and other ancillary equipment, like cooling water, associated piping and valves, necessary instrumentation, controls, safety devices etc. and spares as well as special tools and plants for pumping station as described in this specification and annexed schedule of requirement. The scope of supply shall also include all parts, accessories, and spares etc., which are necessary for erection, operation and maintenance of complete motors for **five** years, even though they are not individually or specifically stated in the specification. Corresponding parts of the motors, associated equipment and spares shall be of same material, dimensions workmanship and finish and shall be interchangeable.

Class of Insulation: The ac motors for VFD application shall have windings of class `F' insulation with temperature rise limited to class B unless otherwise specified [see 'IS 1271:2012 'Electrical Insulation – Thermal evaluation and Designation']

2.1.34. RATED VOLTAGE, FREQUENCY AND PERFORMANCE VALUES

Voltage and Frequency Variation - The motors shall be capable of delivering the rated output with The terminal voltage differing from its rated value by not more than +6%, -10% in general

cases but in special cases if desired by the purchaser. The frequency differing from its rated value by not more than +3 /-3% in general cases but in special cases if desired by the purchaser, frequency fluctuation of +3% / -6% shall have to be provided, or
Any combination of (i) and (ii).In the case of continuous operation at extreme voltage limits, the temperature-rise limits specified in Table-1 of IS 325:1996 shall not exceed by more than 10oC. Motors, when operated under the extreme conditions of voltage and frequency variation, may not necessarily have their performance in accordance with this standard.

The motor shall be suitable for operating in the frequency range as per requirement with corresponding voltage variation for obtaining rated torque when used for variable speed application.

The motor shall be suitable for direct-on-line starting for non-inverter application. The starting current shall be limited to max. six times the full load current.

The motor shall be suitable for operation in all respects and shall deliver the rated output over the rang of voltage and frequency variation as specified above.

Each motor shall be star connected and the main and neutral leads shall be brought out of the stator frame for insertion of current transformers for protection and metering and surge protection apparatus. The motor shall be grounded though a Resistance grounding device to limit the ground fault current to less than 10 (ten) Amps.

The moment of inertia of the motor shall be coordinated with pump parameters, to meet the requirement of pressure and speed rise as specified in Section-I. The inertia constant shall preferably be not less than 1.5. The flywheel effect shall be built into pump-motor and not added in the shape of weights.

TYPE OF ENCLOSURE : The degree of protection to be provided by the enclosure shall be IP 55 of IS 4691:1985 `Degrees of protection provided by enclosures for rotating electrical machinery (first revision)' or better as required by the purchaser.

METHOD OF COOLING : The method of cooling used shall be IC 0041(fan cooled) / IC 43(separately powered force cooled by fan) / IC411(TEFC)/IC 416(A), IC416R in accordance with IS 6362:1995 `Designation of methods of cooling of rotating electrical machines'. In case of separately cooling motor, the motor speed is to be limited to 1500 rpm (synch).

MOUNTING : The mounting shall conform to any one of the designations IMB 3 ,IMB 5, IM 1001, IM3001 specified in IS 2253:1974 `Designations for types of construction and mounting arrangement of rotating electrical machines (first revision)'. If specified, hollow shaft extension may be provided according to the drawing provided by the purchaser

2.1.35. CORRECTION FACTORS FOR TEMPERATURE

Ambient temperature deg C	**Output correction factor%**
55	80
60	75

The motors shall also be suitable for operation on direct online starting.

The motors shall be suitable for type of duty S4, S5, S6 and S7 as specified in IS 12824:1989 `Type of duty and classes of rating assigned to rotating electrical machines [withdrawn]'.

Motor shall be suitable for Total harmonic distortion of 5%.

2.1.36. EFFICIENCY AND OUTPUT GUARANTEES

EFFICIENCY GUARANTEES: The efficiency of the motor at full discharge of pump shall be above 95% percent at the rated voltage and power factor and combined efficiency shall be above 85%. The weighted average efficiency shall be stated and guaranteed. The above efficiencies shall be subject to penalty and rejection as defined in clause 1.4.5

DETERMINATION OF EFFICIENCIES: The efficiencies shall be determined by summation of losses method in accordance with the latest issue of IEC: 34-2 or IS: 4889. The static excitation equipment losses shall also be included in the motor losses. No tolerance in the quoted efficiency for guarantee purposes shall be permitted.

OUTPUT AND TEMPERATURE RISES: The motor shall be guaranteed to be capable of giving its rated output and maximum output without exceeding the temperature rises.

2.1.37. PENALTY FOR SHORT-FALL IN EFFICIENCY AND OUTPUT:

While testing each pump-motor, for any short-fall in the tested values of rated output, maximum output and weighted average efficiency from the guaranteed values, penalty shall be applied Rs.2,50,000 (Rupees two lakhs fifty thousand only) for each 0.01%(one hundredth percent) by which the test figure is less than the corresponding guaranteed figure.

The penalties on account of shortfall in output and the efficiency shall be computed separately and the total amount of the penalty shall be algebraic sum of these two.

No tolerance shall be permitted over the test figures of output. Tolerance in computation of losses for determining efficiency shall be allowed in accordance with IEC.

2.1.38. REJECTION LIMIT:

The purchaser has a right to reject the motor equipment if the test values of either of the maximum output or the weighted average efficiency is less than the corresponding guaranteed value by 3 (three) percent or more.

The motor is also liable for rejection if either of the stator or rotor winding temperature exceeds the specified limits while operating corresponding to maximum output. This guarantee shall be without bonus in case of temperature raises being less than those specified

2.1.39. DIMENSIONS

The basic dimensions of foot-mounted and flange mounted ac roller table motors and their shaft extensions shall correspond to IS 1231:1974 `Dimensions of three-phase foot-mounted induction motors (third revision)' and IS 2223:1983 `Dimension of flange-mounted ac induction motors (first revision)' respectively.

2.1.40. SPECIAL CONSTRUCTIONAL FEATURES

Material of Body - Material of the motor body shall be cast iron grade FG-260 conforming to IS 210:2009 `Specification for grey iron castings (fourth revision)', or SG iron conforming to IS 1865:1991 `Specification for iron castings with spheroidal or nodular graphite (second revision)' or fabricated steel conforming to IS 2062:2011 `Hot rolled medium & high tensile structural steel'. Non ferrous material for motor body is not acceptable.

For foot-mounted motors with cast iron / Spheroidal Graphite iron body, the feet shall be integrally cast with the body.

Separately screwed eyebolts or lifting lugs of suitable sizes shall be provided on the motor for the purpose of lifting. Eyebolts conforming to IS 4190:1984 `Specification for eyebolts with collars' shall be used.

Shaft Extension - All motors shall have a single shaft extension unless otherwise specified.
Bearings - All bearings shall have an L10 life of at least 40000 h according to IS 3824:2002 `Rolling bearings – Dynamic load ratings & rating life.' The bearings shall be selected so as to take care of the thrust to which the motors are likely to be subjected. The actual thrust value shall be indicated by the user.

Lubrication of Bearings – Re-greasing facility through a grease nipple conforming to IS 4009(Parts 1 & 2):1981 `Specification for grease nipples (first revision)', along with facility for excess grease removal shall be provided for motors of frame sizes 200 and larger.

The provisions of the terminal box shall be in accordance with clause 5 of IS 1231:1974. It shall be possible to turn the terminal box to any of the four positions at 90o intervals to permit cable entry from any of these four positions.

Interchangeability of Parts - The motors of identical rating supplied in a lot by the same supplier shall have the interchangeability in the following parts:
a) Rotors,
b) End shield,
c) Bearing capsules
d) Bearing cups
e) Self cooling fans.

2.1.41. EARTHING

Two separate earthing terminals of proper size suitable to receive galvanized iron conductor shall be provided on the bottom half of the motor body. In addition to the two outside earthing terminals, provision for one more earthing terminal inside the terminal box is to be kept. Size of earthing terminal shall conform to clause 12.2.2.2 of IS 3043: 1987 `Code of practice for earthing (first revision)'.

TEMPERATURE-RISE TEST
The temperature-rise test shall be carried out at full load in accordance with 22 of IS 325:1996 by subjecting the motor to the rated acceleration value (B). The permissible limits of temperature-rise shall not exceed the relevant values given in Table-1 of IS 325:1996.

Temperature Rise Test Under Stalled Rotor Condition – The temperature shall be measured by applying rated voltage to the motor with rotor locked. The temperature-rise shall not exceed the permissible value for the relevant insulation class.

LIMITS OF VIBRATION
Limits of vibration intensity shall be in accordance with normal class of Table 1 of IS 12075:2008 `Mechanical vibration of rotating electrical machines with shaft heights 56 mm and higher – measurement, evaluation and limits of vibration severity.'

NOTE: The manufacturer shall indicate in the test certificate that rotor has been dynamically balanced with half key.

LIMITS OF NOISE LEVEL The noise level shall not exceed the limits specified in IS 12065:1987 `Permissible limits of noise level for rotating electrical machines', if required by the user

TERMINAL MARKING Terminals shall be marked in accordance with IS/IEC 60034-8 (2002) [in supersession to IS 4728:1975]. Identical markings shall be provided both on the leads and the terminal blocks.

RATING PLATE Rating plate made of stainless steel stating the following particulars shall be fixed on the body of the motor:
a) Reference to this interplant standard, i.e. IPSS:1-03-039-14
b) Rated output in kW,
c) Name of the manufacturer and trade mark,
d) Manufacturer's serial number and frame reference,
e) Rated voltage and winding connection of the motor,
f) Rated current in Amps. at rated voltage,
g) Speed in rev/min at rated output,
h) Rated frequency,
i) Class of insulation,
j) Type of duty,
k) Bearing designation,
l) Type of enclosure,
m) Mass of motor in kg,
n) Year of manufacture.
o) Motor suitable for VFD,
NOTE: An additional name plate may be used to indicate the designation of bearings, lubrication details (type, quantity and frequency).

TESTS : The tests applicable to the motors covered by this standard shall be in accordance with Table-2. A certificate indicating the routine tests conducted on each motor including thermal withstand capability shall be supplied with the motors. The manufacturer shall supply type test certificate with each order whenever required by the user.

MOTOR INSTRUMENTATION AND CONTROLS AND SAFETY DEVICES:

The supplier shall furnish all ancillary equipment relating to the motor as outlined under schedule of requirements. This equipment together with the other motor equipment supplied, shall constitute a complete and co-coordinated set of instruments, gauges, controls and safety devices for the supervision and control for the units during normal running and in emergencies. The instrumentation and controls of the units shall be provided on machine control panels/unit control panels and the main control board. The bidder shall provide equipment in accordance with schedule of requirements for mounting on these boards and locally on the equipment of his supply. The instruments and controls shall have to be suitable and adequate for manual control, automatic sequential control. The bidder may, however, provide any additional instruments, alarm control or safety devices that are considered necessary.

The unit control panels shall be supplied by the bidder. Indicating instruments, gauges, and controls for the motor as detailed in the schedule of requirements shall be provided by the motor manufacturer and shall be mounted on the unit control panel

SPARES:
Spare parts for the motors as listed in the schedule of requirements shall be supplied along with the first motor. All spare parts supplied shall be interchangeable, and shall be of the same materials and workmanship as the corresponding parts of the equipment. The bidder shall also recommend any additional spares consider essential for 5 years of normal operation

TESTS AT WORKS:
The first motor along with the excitation system and other auxiliaries shall be completely assembled at the manufacturer's works. The following tests shall be carried out on the motor at works in accordance with IS 4722/1968 and IEEE 115 or relevant IEC:

a) Temperature rise
The test shall be carried out in accordance with Indian Standards, IEC or any other equivalent standard.

b) Insulation Resistance Test:
The above test shall be carried out on all machines, both before and after high voltage test. The insulation resistance shall be measured between open windings and between windings and frame. The test for insulation resistance shall be carried out as prescribed in the "Guide for Testing Insulation Resistance of Rotating machines" - IS 7816 - 1975 or its latest revision.

c) Dielectric tests (on all machines):
The high voltage test shall be applied between the winding and the frame with the core connected to the frame and to the windings not under test. Connections between the windings (e.g. neutral point) shall be separated before making the tests. It shall be applied to the complete machine with all its parts in place under conditions equivalent to normal working conditions and shall be carried out at the manufacturer's works after the temperature rise test of the machine. The test voltage shall be alternating and shall be as nearly a sine wave as possible. Tan-delta tests shall also be conducted on specified number of coils in accordance with relevant standard.

d) Efficiency:
The efficiency of the motor shall be determined by the summation of losses method. All the losses shall be measured in accordance with the approved standards.

f) Short Circuit Tests (in Works)

To verify the capabilities of the motor to withstand short circuit stresses without injury, short circuit tests shall be carried out.

g) Characteristics tests (In Works)

1) Direct axis transient time constants
   - i) Open Circuit.
   - ii) Short Circuit.
2) Direct axis transient reactance.
   - i) Rated current
   - ii) Rated voltage.
3) Sub transient reactance.
4) Negative phase sequences reactance.
5) Moment of Inertia of rotating parts (WR)
6) Short Circuit ratio.
7) Phase sequence tests.

TESTS AT SITE:

The following tests shall be carried out on the motors at site in accordance with IS

I. Dielectric Test: In case of motor already tested at the manufacturer's works, the dielectric test shall be carried out with 85% of the test voltage where as all other motors shall be tested at the full test voltage.
II. Determination of the resistance of armature and all field windings.
III. Phase sequence test.
IV. Temperature rise test
V. Visual inspection and wiring check.
VI. Insulation test voltage withstand test.
VII. Checking of control and relay logic.

TESTING EQUIPMENT:

Field-testing equipment required for testing of the equipment shall be supplied by the bidder.

SPECIAL TOOLS AND DRAWINGS:

All necessary special tools and devices such as lifting devices for motor. for erection and maintenance of the motor shall be supplied in accordance with the "schedule of requirements".

The following drawings and data shall be submitted by the bidder with in one month from the date of signing of contract.

I. The general drawings and overall dimensions of the motor showing position of main and neutral leads, important elevation etc.
II. Graphs showing predicted characteristics of the motor (capability Curve).
III. General layout drawings showing overall dimensions and layout and relative position of all auxiliaries, ducts spaces for cables and piping etc.
IV. Details of fire fighting protection -schematic diagram, literature, etc.
V. Start/stop sequence logic diagrams.
VI. Protection and Metering systems.

PROGRAMME OF SUPPLY OF ENGINEERING INFORMATION:

Within six weeks of the effective date of the contract the bidder shall furnish The schedule of issue of documents and drawings.

A detailed scheduled listing out all major assemblies and critical parts and dates by which the related information shall be supplied should be appended to the bid.

The supply of above information should be in the form of CDs of all drawings along with one full size print of each drawing.

Twelve copies of the comprehensive, erection, operation and maintenance instruction books for the motor and its auxiliaries equipment should also be supplied, free of cost.

The bidder shall indicate requisite capacity, span, lift etc. in respect of E.O.T. crane required for installation and maintenance of the pump -motor units. These items are also in the scope of supply.

RESPONSIBILITY FOR SCHEME CO-ORDINATION:
The motor supplier shall be completely responsible for overall Scheme co-ordination comprising of the station layout, control schematics, and machine protection.

TRAINING OF ENGINEERS:
The bidder shall arrange training for 6 engineers of the purchaser for a period as mutually agreed upon during the design and manufacture of the motor at the manufacturer's design and drawing office and manufacturing shops to familiarise with all aspects of design and manufacture of , associated auxiliaries etc. All expenses including boarding and lodging , to and fro charges for training of engineers of the purchaser shall be borne by the bidder.

The supplier shall also arrange and meet the expenses of stay of Engineers of the purchaser for witnessing the Model Tests.

SCHEDULE OF REQUIREMENTS:
Item 1 (a) motors

vertical shaft 3 Ph., 0.415 KV, 50 c/s, 0.95 pf Lagging/leading induction motors of suitable capacity each, directly coupled to pump. Each motor shall consist of the following:
One Stator & Rotor consisting of stator core, frame (part of shell of steel plates) stator windings, space heaters with control switch, cooling ducts and other necessary accessories.
One set of vibration detectors.
One set of VFD The equipment shall be complete with suitable cubicles for housing external wiring, cables, etc.
The equipment shall be complete with suitable cubicles for housing external wiring, cables etc.
Fire Extinguishing Equipment: Two sets CO2 type fire extinguishing system

2.1.42. CODE & STANDARDS:

All equipment and material shall be designed manufactured and tested in accordance with the latest applicable IEC standards. The 12kV Package Substation Design must be as per IEC 62271-202.

The Package Sub-station offered shall in general comply with the latest issues including amendments of the following standards.

Title	**Standards**
High Voltage Low Voltage Prefabricated Substation	IEC:62271-202
High Voltage Switches	IEC 60265
Metal Enclosed High Voltage Switchgear	IEC 60298/ IEC62271-200
High Voltage Switchgear	IEC 60694
Low Voltage Switchgear and Control gear	IEC 60439
Power Transformers	IEC 60076

2.1.43. DESIGN CRITERIA

Package Sub-station consisting of **11kV Non-Extensible SF_6 Ring Main Unit with VCB as protection + Transformer + Low Voltage Switchgear** with all connection accessories, fitting & auxiliary equipment in an Enclosure to supply Low-voltage energy from high-voltage system as detailed in this specification. The complete unit shall be installed on a substation plinth (base) as **Outdoor substation** located at very congested places. The Vacuum Circuit Breaker shall be used to control and isolate the 11kV/433V Distribution transformer. The transformer Low Voltage side shall be connected to Low Voltage switchgear. The connection cables to consumer shall be taken out from the Low Voltage switchgear.

The prefabricated-package substation shall be designed for a) Compactness, b) fast installation, c) maintenance free operation, d) safety for worker/operator & public.

The Switchgear and component thereof shall be capable of withstanding the mechanical and thermal stresses of short circuit listed in ratings and requirements clause without any damage or deterioration of the materials.

For continues operation at specified ratings temperature rise of the various switchgear components shall be limited to permissible values stipulated in the relevant standard and / or this specification.

S. No.	**DPS Name**	**Required capacity of each Transformer (KVA)**	**Required HT side-VCB**	**Required LT Side-VCB**
1.	Gammon India	1500	800 A	800 A
2.	Digha Bailey road Junction	1600	800 A	800 A

2.1.44. SERVICE CONDITIONS:

The Package substation shall be suitable for continuous operation under the basic service conditions indicated below

Ambient Temperature:	50 Deg C
Relative Humidity	upto 95%
Altitude of Installation	upto 1000m

The Enclosure of High Voltage switchgear-control gear, Low Voltage switchgear-control gear & Transformer of the package substation shall be designed to be used under **normal outdoor service condition** as mentioned. The enclosure should take minimum space for the installation including the space required for approaching various doors & equipment inside.

2.1.45. SPECIFIC REQUIREMENT

The main components of a prefabricated- package substation are Transformer, High-voltage switchgear-control gear, Low-voltage switchgear-control gear and corresponding interconnections (cable, flexible, bus bars) & auxiliary equipment. The components shall be enclosed, by either common enclosure or by an assembly of enclosure. All the components shall comply with their relevant IEC standards.

Ratings:

Description	**Unit**	**Value**
Rated Voltage / Operating Voltage	kV rms	11
Rated frequency & Number of phases	Hz & nos.	50 & 3
Rated maximum power of substation	kVA	As per Requirement
Rated Ingress protection class of Enclosure	IP:	IP-23 for Transformer Compartment and IP:54 for LT & HT Switchgear Compartment.
Rated temp Class of Transformer Compartment		K10 upto 1250kVA
HV Insulation Level		
Rated withstand voltage at power frequency of 50 Hz	kV rms	28
Rated Impulse withstand Voltage	kV peak	75
HV Network & Busbar		
Rated current	Amp	630A

Rated short time withstand current	kA rms / 3 sec	21
Making capacity for switch-disconnector & earthing switches	kA peak	50kA
Breaking capacity of Isolators (rated full load)	A	630A
LV Network		As per requirement.

2.1.46. OUTDOOR ENCLOSURE

Outdoor enclosure:

The outdoor enclosure shall be made of galvanized Sheet Steel tropicalized to local weather conditions.

The enclosure shall be of partially modular design of GI sheets fastened by riveting.

The thickness of enclosure shall be 1.5 mm for non-load bearing members & 2mm for load bearing members.

The enclosure shall be painted with Powder Coating/polyurethane paint.

The metal base shall ensure rigidity for easy transport & installation.

Substation will be used in outdoor application hence to prevent enclosure from rusting/corrosion, welding should be avoided.

The protection degree of the Enclosure shall be IP54 for LT & HT switchgear compartment & IP23 for Transformer compartment. Proper / adequate ventilation aperture shall be provided for natural ventilation by way of Louvers etc.

Considering the outdoor application of the substation the doors shall be provided with proper interlocking arrangement for safety of operator and to avoid corrosion door should have stainless steel hinges. Door should be provided with stoppers.

Interconnection between HT switchgear and transformer shall be using 1Cx3x95 sq.mm al. unarmored XLPE cable and between transformer and LT switchgear shall be using busbar.

Internal Fault: Failure within the package substation due either to a defect, an exceptional service condition or mal operation may initiate an internal arc. Such an event may lead to the risk of injury, if persons are present. It is desirable that the highest practicable degree of protection to persons shall be provided. The Design shall be tested as per IEC62271-202. **Type test report of arcing due to internal fault should submitted with offer. The Compact substation shall be tested for internal arc test – AB for 21KA for 1 sec (A-operator, B-pedestrian)**

Covers & Doors: Covers & doors are part of the enclosure. When they are closed, they shall provide the degree of protection specified for the enclosure. Ventilation openings shall be so arranged or shielded that same degree of protection as specified for enclosure is obtained. Additional wire mesh may be used with proper Danger board for safety of the operator. All covers, doors or roof shall be provided with locking facility or it shall not be possible to open or remove them before doors used for normal operation have been opened. The doors shall open outward at an angle of at least 90^0 & be equipped with a device able to maintain them in an open position. **The doors shall be lockable type with cylindrical shooting bolt and the locking arrangement shall be covered by magnetic flap.**

The roof of the transformer compartment shall be detachable type to access the transformer for maintenance purpose

Earthing: All metallic components shall be earthed to a common earthing point. It shall be terminated by an adequate terminal intended for connection to the earth system of the installation, by way of flexible jumpers/strips & Lug arrangement. The continuity of the earth system shall be ensured taking into account the thermal & mechanical stresses caused by the current it may have to carry. The components to be connected to the earth system shall include:

a) The enclosure of Package substation,
b) The enclosure of High voltage switchgear & control gear from the terminal provided for the purpose,
c) The metal screen & the high voltage cable earth conductor,
d) The transformer tank or metal frame of transformer,
e) The frame &/or enclosure of low voltage switchgear,

There shall be an arrangement for internal lighting activated by associated switch for HV , Transformer & LV compartments separately.

Labels: Labels for warning, manufacturer's operating instructions etc. shall be durable & clearly legible.

Cleaning & Painting:
The paints shall be carefully selected to withstand tropical heat and rain. The paint shall not scale off or crinkle or be removed by abrasion due to normal handling. **The enclosure shall be painted with powder Coating.**

11KV SF6 METAL ENCLOSED, INDOOR RING MAIN UNIT (RMU).

This RMU should be complete with all components necessary for its effective and trouble-free operation along with associated equipment etc. such components should be deemed to be within the scope of supplier's supply.
The RMU should be fixed type SF_6 insulated with Vacuum circuit breakers with O/C & E/F relay for the protection of the transformer. It should be maintenance free equipment, having stainless steel robotically welded IP67 enclosure.

2.1.47. STANDARDS AND REFERENCE DOCUMENTS

Codes and Standards

The **RING MAIN UNIT (RMU)** should be designed, manufactured and tested to the latest version of:

IEC 60694 Common specifications for high-voltage switchgear and control gear standards.
IEC 62271-200: A.C metal-enclosed switchgear and control gear for rated voltages above 1KV and up to and including 72KV and the IEC Codes herein referred.
IEC 60129/ IEC 62271-102: Alternating current disconnections (isolators) and earthing switches
IEC 60529: Classification of degrees of protection provided by enclosures
IEC 60265 High-voltage switches-Part 1: Switches for rated voltages above 1kV and less than 52 kV
IEC 60056: Circuit breakers
IEC 60420 High-voltage alternating current switch-fuse combinations
IEC 60185 Current transformers
IEC 60186 Voltage transformers
IEC 60255 Electrical relays
□□Any other codes recognized in the country of origin of equipment might be considered provided that they fully comply with **IEC standard**s.

The design of the switchgear should be based on safety to personnel and equipment during operation and maintenance, reliability of service, ease of maintenance, mechanical protection of equipment, interchangeability of equipment and ready addition of future loads.

2.1.48. SALIENT TECHNICAL FEATURE OF "SF6 RMU."

11KV SF6 INDOOR, NON-EXTENSIBLE, Ring Main Unit (RMU), comprising of 1No. 630 A Vacuum Circuit Breaker & 1 No Air Insulated Metering Module with (3 O/C & 1E/F) Relays.

(A) Circuit Breaker. (630A)
Circuit Breaker should have the following:
- Manually operated 630 A Vacuum circuit breaker and Earthing Switch with making capacity
- Mechanical tripped on fault indicator
- Auxiliary contacts 1NO and 1NC
- Anti-reflex operating handle
- "Live Cable" LED Indicators thru Capacitor Voltage Dividers mounted on the bushings.
- 3O/C + 1E/F self powered relay with Low and High set for Over current and Earth Fault. Relay should have facility to display the maximum loaded phase current also. Relay should have facility to trip the breaker from remote commands without shunt trip coil.
- Mechanical ON/OFF/EARTH Indication

2.1.49. INDOOR RMU

1. Modular design, panel type with front cable access.
2. RMU must be made of robotically welded Non Ferrite, Non magnetic stainless steel with thickness of 2.5 mm with all live parts inside stainless steel tank
3. Offered RMU must be Non extensible.
4. Maximum Modules can be accommodated in a single robotically welded Stainless steel Tank so as to make it more compact and reliable.
5. Cable covers must be interlocked with Earth switch to have complete safety of operating person. The cable bushings shall be bolted type design.

DIELECTRIC MEDIUM

SF6 GAS shall be used for the dielectric medium, **Arc quenching should take place in vacuum** for 11KV RMU's in accordance with IEC376. It is preferable to fit an absorption material in the tank to absorb the moisture from the SF6 gas and to regenerate the SF6 gas following arc interruption. The SF6 insulating medium shall be constantly monitored via a temperature compensating gas pressure indicator offering a simple go, no-go indication.
The RMU should have provision of Gas filling at site , in case there is some leakage of the gas.

2.1.50. GENERAL TECHNICAL REQUIREMENTS

Fixed type Vacuum breakers insulated in SF6 gas. It should be maintenance free, having stainless steel robotically welded enclosure for INDOOR RMU application.
Low gas pressure devices- 1.4 Bar pressure. RMU should have full rating with Bar gas pressure.

i. Live cable indicators- High operator safety.
ii. Fully Rated integral earthing switch for Switches and Breakers.
iii. Self powered Microprocessor Based 3O/C + 1E/F self powered relay with Low and High set for Over current and Earth Fault - Does not require any external source of power.
iv. Units fully SCADA Compatible. Retrofitting at site possible at a later date. Line switches (Load break switches) as well as T- OFF circuit Breaker can be operated by remote.
v. Cable boxes should be front access and interlocked with earth switch. No rear access required.
vi. Cable testing possible without disconnection of cables.
vii. Compact in dimension.
viii. Low pressure, sealed for life equipment,
ix. Cable earthing switch on all switching device-standard, for operator safety.
x. All live parts should be inside a hermetically sealed Stainless Steel enclosure for indoor RMU.
xi. Indoor unit should be classified as sealed pressure system with gas leak rate of less that 0.1% per year requiring no gas filling for 30+ years of functional life.

2.1.51. TECHNICAL AND GUARANTEED PARTICULARS.

The bidders shall furnish all guaranteed technical particulars as called for this specification.

DESIGN CRITERIA

Service conditions

The offered switchgear and control gear should be suitable for continuous operation under the basic service conditions indicated below. Installation should be in normal indoor conditions in accordance with IEC 60694.
Ambient temperature -1oC to +45oC
Relative humidity up to 95%
Altitude of installation up to 1000m, IEC 60120

General structural and mechanical construction

The offered RMU should be of the fully arc proof metal enclosed, free standing, floor mounting, flush fronted type, consisting of modules assembled into one or more units. Each unit is made of a cubicle sealed-for life with SF6 and contains all high voltage components sealed off from the environment. The overall design of the switchgear should be such that front access only is required. It should be possible to erect the switchboard against a substation wall, with HV and LV cables being terminated and accessible from the front.

The units should be constructed from robotically welded NON Ferrite Non Magnetic grade stainless steel sheets of 2.5mm thickness to ensure very high degree of precision in sealing of SF6 tank. The design of the units should be such that no permanent or harmful distortion occurs either when being lifted by eyebolts or when moved into position by rollers.

The cubicle should be have a pressure relief device. In the rare case of an internal arc, the high pressure caused by the arc will release it, and the hot gases is allowed to be exhausted out at the bottom of the cubicle. A controlled direction of flow of the hot gas should be achieved.
The switchgear should have the minimum degree of protection (in accordance with IEC 60529)
- IP 67 for the tank with high voltage components
- IP 2X for the front covers of the mechanism
- IP 3X for the cable connection covers

The RMU shall be internally arc tested for 20kA for 1 sec for the gas tank & it should be internally arc tested for cable compartment. Relevant type test reports should be submitted by the manufacturer.

TECHNICAL DATA

Ring Main Unit, Electrical data

Electrical data and service conditions

No *Rated voltage*	KV	***12KV***
1 Power frequency withstand voltage	KV	28
2 Impuls withstand voltage	KV	95
3 Rated frequency	Hz	50
4 Rated current busbars	A	630
5 Rated current (cable switch)	A	630
6 Rated current (T-off)	A	630

Breaking capacities:

7 active load	A	630
8 closed loop (cable switch)	A	630
9 off load cable charging (cable switch)	A	135
10 earth fault (cable swich)	A	200
11 earth fault cable charging (cable switch)	A	115
12 short circuit breaking current (T-off circuit breaker)	kA	21
13 Rated making capacity	kA	52.5
14 Rated short time current 3 sec.	kA	21

Ambient temperature:

15 Maximum value	°C + 45
16 Maximum value of 24 hour mean	°C + 35
17 Minimum value	°C 0
18 Altitude for erection above sea level	4m ...1000
19 Relative humidity	Max 95%

Ring Main Unit Technical data(11KV) INDOOR

General data, enclosure and dimensions

1 Standard to which Switchgear complies	IEC
2 Type of Ring Main Unit	Metal Enclosed, Panel type, Compact Module.
3 Number of phases	3
4 Whether RMU is type tested	Yes
5 Whether facility is provided with pressure relief	Yes
6 Insulating gas	SF6
7 Nominal operating gas pressure	1.4 bar abs. 20° C
8 Gas leakage rate / annum %	0.1% per annum
9 Expected operating lifetime	30 years
10 Whether facilities provided for gas monitoring can be delivered	Yes, temperature compensated manometer
11 Material used in tank construction	Stainless steel sheet

No Operations, degree of protection and colours

1 Means of switch operation	separate handle
2 Means circuit breaker operation	separate handle and push buttons
3 Rated operating sequence of Circuit Breaker	O –3min-CO-3min-CO
4 Total opening time of Circuit Breaker	approx. . 40-80ms
5 Closing time of Circuit Breaker	approx. . 40-70ms
6 Mechanical operations of switch	CO 1000
7 Mechanical operations of CO earthing switch	1000
8 Mechanical operations of circuit breaker	CO 2000
9 Principle switch / earth switch	3position combined switch

Degree of protection:

10 High Voltage live parts,	SF6 tank IP 67
11 Front cover mechanism	IP 2X for Indoor
12 Cable covers	IP 3X for Indoor

Colours:

14 Front cover	7035
15 cable cover	7035

PANEL CB DESCRIPTION

CIRCUIT BREAKERS

Vacuum bottles should be use as interrupters of the currents. The circuit breaker main circuit should be connected in series with a three-position disconnector –ear thing switch. The operation between circuit breaker and disconnector ear thing must be interlocked.

1.VCB must self tripping and has a self powered relay

2.The RMU must be nonextensible type

OTHER MAIN FEATURES

Bus bars*:*

Comprising the 3 single phases copper bus bars and the connections to the switch or circuit breaker. The bus bar should be integrated in the cubicle Bus bars should be rated to withstand all dynamic and thermal stresses for the full length of the switchgear.

Earthing Switch

Earthing switches should be rated equal to the switchgear rating.

Earthing switches should be quick make type capable of making Rated Fault Current. Ear thing switch should be operated from the front of the cubicle by means of a removable handle.

The mechanisms

All mechanisms should be situated in the mechanism compartment behind the front covers outside the SF6-tank. The mechanism for the switch and the earthing switch is operating both switches via one common shaft. The mechanism provide independent manual operation for closing and opening of the switch, independent closing of the earthing switch and dependent opening of the earthing switch.

The mechanism for the T-off switch and earthing switch is operating both switches via one common shaft. The mechanism has stored spring energy and provide independent manual operation for closing and opening of the switch, independent closing of the ear thing switch and dependent opening of the ear thing switch. The mechanism for the vacuum circuit breaker (VCB) and disconnector- earthing switch is operating the VCB and the disconnector earthing switch via to separate shafts. The mechanism for the VCB has stored spring energy and provides independent manual operation for closing and opening of the VCB. The mechanism has a relay with related CT's and/or remote tripping device. The mechanism for the disconnector earthing switch provide independent manual operation for closing and opening of the disconnector, independent closing of the earthing switch and dependent opening of the earthing switch.

Front covers

The front cover contains the mimic diagram of the main circuit with the position indicators for the switching devices. The voltage indicators are situated on the front panels. Access to the cable bushings is in the lower part of each module.

Position indicators

The position indicators are visible through the front cover and are directly linked to the operating shaft of the switching devices.

Voltage indicator

The voltage indicators are situated on the front cover, one for each module, and indicate the voltage condition of each incoming cable. Identification of the phases is achieved with labels L1, L2 and L3 on the front of the voltage indicators. The voltage indicator satisfies the requirements of IEC61243.

Cable compartment

The Cables access in the RMU shall be from the front. **The cable bushings shall be easily site-replaceable type.**

It should be possible to terminate up to a 1x 3c x300sqmm core HV cables in each cable compartment. The access to the compartment will be possible by removing the cable cover, Hinged to the main frame only when earth switch is ON. Cable Compartments of Indoor RMU should be Arc Proof tested for 20kA for 1sec (the type test report for the same shall be submitted by the vender) and interlocked with respective Earth Switches.. Each module has a separate cable compartment that is segregated from each other by means of a partition wall. A partition wall should be fitted to divide the cable compartment from the rear side of the switchgear. In case of an arc inside the tank, followed by the opening of the pressure relief, the partition wall prevents the hot gases flowing out from the pressure relief to enter the cable compartments. All covers are removable.
Interconnection between HT switchgear and transformer shall be using 1Cx3x95 sq.mm Al. unarmoured XLPE Cable.

Power connection.

The cables are installed in the dedicated compartment below the mimic front cover. At the bottom of the cable compartment, an earthing bar system made of copper/GI with a minimum cross section of 120 mm^2 should be fitted. In each compartment the earthing bar should be fitted with 4 screws M10. The earthing system is connected to the tank by a copper/GI bar, which rises up to the connecting point of the tank behind the rear partition wall on the middle of the switchgear.

INTERLOCKING.

The mechanism for the cable switch should be provide a built in interlocking system to prevent operation of the switch when the earthing switch is closed, and to prevent operation of the earthing switch when the switch is in the closed position.

The mechanism for the T-off switch should be provide a built in interlocking system to prevent operation of the switch when the earthing switch is closed, and to prevent operation of the earthing switch when the switch is in the closed position. The mechanism for the VCB and the disconnector-earthing switch should be has a built in interlocking system to prevent operation of the disconnector-earthing switch when the VCB is in the closed position.

Further is should not be possible to Open the Cable doors unless the Earthing Switch is Turned ON. In case the Cable door is accidentally left open a positive interlock shall prevent operation of Load Break Switch and Isolators / Breaker from any operation.

Current Transformers

All current transformers should be complying with IEC 60185.

Current transformers should be of dry type, with ratings and ratios as required.

Cable current transformers used in circuit breaker modules should be maximum 100mm wide. Current transformers used in metering cubicles should be having dimensions according to DIN 42600, Narrow type. Current transformer shall be placed in the cable covers so that it can be easily replaced at site without removing the bushings.

Auxiliaries.

The switchgear should be prepared for options like motor operation, auxiliary contacts and short-circuit indicators. Necessary terminal blocks and wiring etc. should be placed behind the front cover of each module.

Fault Passage Indicators.

These shall facilitate quick detection of faulty section of line. The fault indication may be on the basis of monitoring fault current flow through the device. The unit should be self-contained requiring no auxiliary power supply. The FPI shall be integral part of RMU to avoid thefts. The FPI shall have clear display, automatic reset facility and shall be SCADA compatible.

TESTING AND CERTIFICATION.

TYPE TESTS.

Units should be type tested in accordance with IEC standards 60056, 60129, 60265, 60298,60420,60529 and 60694. The following type tests should perform on the HT Switchgear and report should submit with offer.

- Short time and peak withstand current test
- Temperature rise tests
- Dielectric tests
- Test of apparatus i.e. circuit breaker and earthing switch
- Arc fault test
- Measurement of resistance of main circuit.
- Mechanical endurance test.
- Duty cycle test.
- Internal arc test for HT chamber.

- Type test reports for above type shall be submitted with the offer.

ROUTINE TESTS.

Routine tests should be carried out in accordance with IEC 60298 standards. These tests should be ensure the reliability of the unit.

Below listed test should be performed as routine tests before the delivery of units;

- Withstand voltage at power frequency
- Measurement of the resistance of the main circuit
- Withstand voltage on the auxiliary circuits
- Operation of functional locks, interlocks, signalling devices and auxiliary devices
- Suitability and correct operation of protections, control instruments and electrical connections of the circuit breaker operating mechanism
- Verification of wiring
- Visual inspection
- Time travel characteristics measurement facility for Breaker should be available with the manufacturer to asses the quality of RMU.

Distribution Transformer

Oil filled Transformer :

Requirement: 11000/433 Volt Oil immersed hermetically sealed, corrugated tank and without conservator type design ONAN cooled suitable for installation at outdoor in Enclosure for ground mounting.
Voltage Ratio: No load voltage 11000/433 volts within tolerance as stipulated in IEC 76.
Rating: The transformer shall have a continuous rating as specified at any of the specified tapping position and with the maximum temperature rise specified.
Temperature Rise: The maximum temperature rise at the specified maximum continuous output shall not exceed 40°C by thermometer in the hottest portion of the oil or 45°C measured by resistance of winding above ambient temperature, not exceeding 50°C maximum.
Connections: H.V. Delta and L.V Star connected with neutral brought out on the secondary side for connection to earth; Vector group DYn11.
Tapping : Each transformer shall be provided with **sliding/rotary type tap switch** so as to provided for a voltage adjustment on H.V. from +5% to –10% of rated voltage of 11000 volts in 4 equal steps (5 position) to obtain rated voltage of 433 volts on LV side. Refer clause no:4.5.4 for details of rotary switch. The tapping shall be provided for following voltage ratios at no load.

Cleaning & Painting :

a) All steel surfaces shall be thoroughly cleaned by sand blasting or chemical agents, as required to produce a smooth surface free of scales, grease and rust.
b) The internal surfaces in contact with insulating oil shall be painted with heat resistant insulation paint which shall not react & be soluble in the insulating liquid used.
c) The external Surfaces, after cleaning, shall be given two coats of high quality epoxy based rust resisting primer followed by filler coats.
d) The transformer shall be furnished with coats of weather resisting battleship gray epoxy based enamel paint specially recommended for transformer use.
e) The paints shall be carefully selected to withstand tropical heat rain, effect of proximity to the sea etc. The paint shall not scale off or crinkle or be removed by abrasion due to normal handling.
f) Special care shall be taken by the manufacturer to ensure against rusting of nuts, bolts and fittings during operation. All bushings and current carrying parts shall be cleaned properly after final painting.

Both H.V. and L.V. bushings shall have creepage corresponding to **very heavily polluted atmosphere**.
Oil: New transformer oil used shall be according to relevant IEC standards

Phase Marking & Danger Plate: Phase markings in fluorescent paint on small non-corrodible metallic tags shall be permanently fixed for H.V. and L.V sides. Phase markings tags shall be properly fixed with proper alignment. Danger plates shall be provided on the H.V & LV sides, mentioning the Corresponding Voltages.

Core and Coil :

Core : The core shall be constructed from high grade, cold rolled, non-ageing, low loss, high permeability, grain oriented, cold-rolled grain oriented silicon steel laminations. The transformer shall be so designed as to have minimum humming noise. The percentage

harmonic potentials with the maximum flux density under any conditions shall be such that capacitors connected in the system shall not be overloaded.

The core and coil assembly shall be securely fixed in position so that no shifting or deformation occurs during movement of transformer. The core and coil assembly shall be capable of withstanding without injury, the thermal and mechanical effects of short circuit at the terminals of any winding.

Noise: The Contractor shall take special precautions to ensure that the noise and vibration level does not exceed which is obtained in good modern practice.

Impedance Volts: The Percentage impedance value at 75 Deg. C at any tap shall be as per IS/ IEC subject to tolerance as specified in relevant IEC standards. i.e. 4.5% upto 630kVA and 5% upto 1250kVA The value of the impedance volts at each tapping over the specified range shall be specified in the bid.

Regulation: The regulation at 75° C at full load at unity and 0.8 power factor subject to the usual tolerance as per IEC standards shall be specified in the bid.

Power Freq. High Voltage & Insulation Level (Impulse voltage): The distribution transformer shall be designed so that they are capable of withstanding high voltage & impulse voltages as given below:

a) Impulse Voltage for 11kV winding: 75 kV (1.2/50 Microsecond wave shape).
b) High Voltage : 28kV rms.

10.4.0 RATINGS (Summary) :

	Application	**Dist. Tfr. with Corrugated Tank**
4.4.1	Service	Outdoor application inside enclosure Step down
4.4.2	Type	Oil immersed corrugated tank
4.4.3	Cooling system	ONAN
4.4.4	No. of Phases	3
4.4.5	No. of winding per phase	2
4.4.6	Rated output (MVA) With ONAN cooling	HV / LV
4.4.7	Rated voltage in KV (Line to Line	HV-11 kV LV-0.433 kV
4.4.8	Rated frequency	50 Hz
4.4.9	Temperature rise above 50°C	
A	In winding by resistance	45°C
B	In Oil by thermometer	40°C
4.4.10	Guaranteed losses at 75°C and at normal tap position as pe IS tol.	
	Losses as per IS1180 level 2	**As per IS1180 level 2**
A	50% Loading (W)	
B	100% Loading (W)	
4.4.11	Insulation level	

A	H.V. Power Freq. KV rms	28 kV
B	H.V. (kVpeak) Impulse	75 kV
C	L.V. (kV)	-
4.4.12	Vector Group	Dyn11
4.4.13	Type of taps provided	Off Load full capacity
A	Taps provided on	H.V. winding
B	Range of taps	+5% to – 5% in steps of 2.5% (6 steps, 5 position)
C	Method of Tap Change control	Rotary /sliding Switch
D	Manual load	Yes 'Off Circuit'
4.4.14	Percentage impedance at 75 Deg. C	As per IS.
4.4.15	System earthing	
A	H.V.	Solidly earthed
B	L.V.	Solidly earthed
4.4.16	Terminal arrangement	
A	H.V.	From H.V. Bushing on Top.
B	L.V.	From L.V. Bushing on Top.
C	L.V. Neutral	From L.V. Neutral Bushing on Top.
4.4.17	Transformer-bushing voltage class a) H.V. (kV) b) L.V. (kV)	 12 kV class 1.1kV class
4.4.18	System fault level a) H.V. side b) L.V. side	 500 MVA (11 kV) -
4.4.19	Short circuit withstand capability duration	3 sec.

Fittings & Accessories For Corrugated Tank Transformer :
The following accessories shall be provided for 11 kV/0.433 kV, distribution transformer.

Two earthing terminals with copper lugs. The lugs shall be provided in such a way that they shall not obstruct the movements of rollers. The earthing continuity for all the connected equipments shall be properly done.

Two lifting lugs for complete transformer as well as enclosure.

Off circuit tapping switch shall be rotary/sliding type, 3 pole gang operated, top mounting draw out type only. Tap switch shall be suitable for operating voltage of 11kV and above and shall have rated current of 16.53A/26.54A/39.64Amps. Switch shall be provided with externally operating hand wheel handle with indicator and locking device, with direction changing facility and locking arrangement. Bidders shall submit with the bid, technical catalogue for the off load tap switch for Purchaser's approval.

Rating plate and diagram plate of durable non-corroding metal giving information as required under IEC 76. Rating plate shall also include Transformer **Actual %Z, No-Load Loss & Full-Load Loss at 75°C** along with details like Purchase Order Number, date. The name plate marking shall be done with fluorescent colour. Each equipment shall carry individual name-plate with proper instructions & affixed with screws.

Four plain rollers fitting so that the transformer can suitably moved in any direction along with roller direction changing and locking facility shall be provided.

Skid with Haulage lugs.

Instructions & affixed with screws.

Skid with Haulage lugs.

L.T. PANEL

System:-

a) **Declared voltage** :– 3 Phase,400V (±6%) 50 Hz,
b) **Neutral** :– Solidly earthed at substation.
c) **Busbar** – Aluminum

General finish:- Tropical, totally enclosed, metal-clad, weather-proof, vermin and dust proof.

Construction :

Enclosure:- Dead Front type of enclosure shall be able to provide the degree of Protection IP:2X.

Circuit Ways: As per BOQ

- Air Circuit breaker will be of 3P/4P, 36kA fixed manual microprocessor based over current, short circuit and earth fault release.
- Molded case circuit breaker will be of 3P/4P,35kA fixed manual microprocessor based
- Overload and short circuit release.
- The design of the LT panel should be type tested for the short circuit , temperature & Ingress protection test and type test report should submit with offer**.**

GENERAL CHARACTERISTICS OF ACB

Conformity with Standards

The air circuit-breakers used in low voltage installations are constructed and tested in accordance with the IEC 947/IS 947 Standards and respect the following EC directives:

– "Low voltage Directive" (LVD) No. 73/23 EEC
– "Electromagnetic compatibility Directive" (EMC) No.89/336 EEC

Functional characteristics

– The circuit-breakers must have a rated service voltage of 690 V AC and a rated insulation voltage of 1000 V.
– The circuit-breakers must have a rated impulse withstand voltage of 12 kV.
– The rated uninterrupted current must be between 800 and 6300 A with the possibility of selection of ratings from 400 A.
– Different versions shall be available with rated ultimate short circuit breaking capacity(Icu) from 50kA at 415V and shall have rated short circuit service breaking capacity(Ics) equals to Icu.
– Different versions of circuit-breakers shall be available with rated short-time withstand

current (Icw -1 sec) for 50kA for 1sec in category B.

– It must be possible to supply the circuit-breakers both from the top and bottom terminals without derating their performances and without jeopardising their functionality.
– The mechanical life must be at least 12000 operations, without the need for maintenance of the contacts and arcing chambers.
– The electrical life at a voltage of 440 V AC must be and without the need for maintenance of the contacts and arcing chambers:
  – at least 9000 operations up to 2000 A
  – at least 6000 operations up to 3200 A
  these values are intended to be valid only for CAT B circuit-breakers.

Environmental characteristics

– Operating temperature: -25 °C...+70 °C (-13 °F...158 °F)
– Storage temperature: -40 °C...+70 °C (-40 °F...158 °F)
– Altitude: operation without derating up to 2000 m a.s.l. (6600 ft), and with derating up to 5000 m a.s.l. (16500 ft)
– Suitability for use in a hot-humid environment. With regard to this, the circuit-breakers must undergo a tropicalisation process which makes them suitable for use in a hot-humid environment, as established by the prescriptions of the main shipping registers and in accordance with the international IEC 60068-2-30 Standards.

Construction characteristics

– The circuit-breaker structure must be made of steel sheet.
– There must be total segregation between power and front shield, using double insulation where suitable so as to guarantee maximum operator safety.
– Total segregation between the phases must be guaranteed for safety reasons.
– The main contacts must be separate from the arcing contacts in cat. B circuit-breakers only.
– It must be possible to inspect easily the arcing chambers easily and to check main contact wear with the circuit-breaker racked-out, by removing the arcing chambers.
– All the circuit-breakers in the range have the same height and depth with the aim of standardising the supporting structures of the switchgear and the switchgear itself as far as possible.
– The circuit-breakers must indicate the precise position of the main contacts and the condition of springs charged/discharged on the front, by means of certain and reliable signals.
– The operating mechanism must be of the stored energy type with operation by means of precharged springs fitted with antipumping device. The springs are charged manually by activating the front lever, or by means of a geared motor, supplied on request.
– The whole range of air circuit-breakers must be fitted with electronic protection releases. It must be allowed the interchangeability of protection releases from skilled personnel.
- ACBs shall have minimum watt losses in order to restrict temperature rise inside the breaker.

RELEASES

1) Release (Protection functions)

– The release must not require auxiliary power supplies since the power is taken from the

current transformers.

– The signals supplied by the release must not operate with power supply supplied by internal batteries.The basic version of the release must provide:
– protection against overload with trip with inverse long time delay (L)
– protection against instantaneous short-circuit (I)
– Selective short-circuit (S)
– Earth fault (G)

The setting ranges shall be:

– Protection against overload (L)
Characteristic t=k/I2
Trip threshold I1=(0.4...1)xIn with timing adjustable from 3 to 144 sec. (value referred to a current equal to 3xI1)

– Protection against selective short-circuit (S)
Characteristics t=k and t=k/I2
Trip threshold I2=(1...10) xIn with timing adjustable from 0.1 to 0.8 sec.
(value referred to a current equal to 10xIn for curves at t=k/I2 and referred to currents >I2 for curves at t=K)

– Protection against instantaneous short-circuit (I)
Trip threshold I3=(1,5...15) xIn

– Protection against earth fault (G)
Characteristics t=k and t=k/I2
Trip threshold I4=(0.2...1) xIn with timing adjustable from 0.1 to 0.8 sec. (value referred to a current equal to 4xI4)
– Neutral protection level:
50% - 100% - 200% - excluded

All the protection functions except protection against overload must be excludable

User interface and signalling LEDs
– The release shall allow parameterisation of the trip thresholds and timing by means of dipswitches.
– alarm and trip signalling for all the protection functions by means of LEDs located on the release shall be available. No batteries or external power supplies shall be necessary for powering these indicators. The indication shall be available for not less than 48 hours after the trip, even with the circuit-breaker open
– An alarm shall indicate by means of LEDs located on the release the disconnection of opening solenoid and current transformers. A trip shall also occur, after a short time delay, when the disconnection is detected.
– It shall be possible, with the aid of external devices, to read currents, and information on last 10 trips (currents, protection tripped) occoured to the unit.

General aspects of MCCB with microprocessor based release

Standards conformity

Molded case circuit-breakers (MCCB) installed in the low voltage plant must be designed, manufactured and tested according with the international standards IEC 60947-1, IEC

60947-2, IEC 60947-3, IEC 60947-4-1, IEC 61000 or with the corresponding harmonized national standards, the CE “Low Voltage Directives” (LVD) n° 73/23 EEC and “Electromagnetic Compatibility Directive” (EMC) n° 89/336 EEC.

Molded case circuit breakers functional features

- Rated insulation voltage (Ui) for MCCB shall be 800 VAC or more.
- Rated Impulse withstand voltage (Uimp) for mccb’s shall be 8kV.
- Rated service voltage(Ue) for the moulded case circuit breaker shall be standard as 690V, however performance on short circuit level shall be consider based on system operating voltage.
- Rated uninterrupted current between varying from 160 and 3200 A with trip units settings starting from 10A
- Rated short circuit breaking capacity shall be considered as per bill of material and the rated service short circuit breaking capacity (Ics) shall be in 100% of rated ultimate short circuit breaking capacity (Icu). (Ics=Icu)
- According to IEC 60947-2 (§ 4.4) starting from 400 A the circuit breakers must be category B, however other small rating category A shall be confirmed.
- MCCBs must be available with different ultimate short breaking capacities between 16kA and 200kA @ 380/415 V AC.
- Both line up and line down supplying must be possible without decreasing MCCBs performances or functionality
- MCCB shall confirms to current limiting type and this feature shall ensure less amount of let through energy at the time of opening on fault. The mccb shall have opening time less then 10msec for current rating upto 630A, and less them 15msec for current rating upto 1600Amps.
- A test bottom for the correct functionality checking (moving contacts opening) must be place in front of the breaker.

Ambient characteristics

- Operating temperature: -25 °C .. +70 °C (ambient temperature)
- Storage temperature: -40 °C .. +70 °C (ambient temperature)
- Maximum relative humidity: 98%
- Maximum altitude: 2000 m above sea level, 5000 m above sea level with derating
- Suitability for being used in hot-humid places.
- Circuit-breakers fitted with electronic trip units must comply with the prescriptions of the International Standards on electromagnetic compatibility.

Construction characteristics

– The range of moulded case circuit-breakers must cover a range of rated uninterrupted currents from 160 to 3200 A.

– By means of the double insulation technique, moulded case circuit-breakers must guarantee complete separation between the power circuits and the auxiliary circuits.

– Moulded case circuit-breakers must have an operating lever which always indicates the exact position of the circuit-breaker contacts (positive operation), by means of safe and reliable signals (I= closed, O= open, yellow-green line= open due to trip unit).

– Moulded case circuit-breakers must be suitable for isolation in compliance with § 7.2.7 of the IEC 60947-2 Standard. This indication must be clearly and indelibly marked on the circuit-breaker (in accordance with § 5.2 of IEC 60947-2) and in a position where it is visible with the circuit-breaker installed.

– Moulded case circuit-breakers with rated uninterrupted current up to 250 A shall have a 45 mm high face which makes them suitable for installation on modular panels.

– The same depth must be guaranteed from 320 A up to 1000 A, in order to standardize both switchboards and their supports.

– All the installation positions must be possible without jeopardizing the function of the apparatus. Starting from 630 A up to 1600 A the withdrawable version shall be mounted and operated horizontally.

– For the front parts of the circuit-breakers the degree of protection of at least IP20 (excluding the terminals) must be guaranteed.

Protection trip units

– From the 250 A size circuit-breakers, the trip unit must be interchangeable.

Electronic overcurrent releases

– The electronic overcurrent trip units must be self-supplied and must be able to guarantee correct operation of the protection functions even in the presence of a single phase supplied with a current value equal to 20% of the phase current.

– They must be unaffected by electromagnetic interference in compliance with the EMC directive on the matter.

– The basic version shall be fitted with protection functions against overload (function L) and against short-circuit. The latter function can either be of the instantaneous type (function I) or, alternatively, with intentional delay (function S). The function of protection against short circuit must be excludable. A basic version shall also be provided with only the protection threshold against instantaneous short-circuit which cannot be excluded.

– The minimum performances of the protection functions of the electronic protection trip unit for distribution, where present, must be:

1. Function **L**:adjustable trip threshold I1= (0.4...1) x In, trip curves for the basic version with times from 3 to 12 seconds – 2 different trip curves - (at 6 times the set threshold). Cannot be excluded.

2. Function **S**: adjustable trip threshold I2= (1...10) x In, trip curves for the basic version with times from 0.1 to 0.25 seconds – 2 different trip curves – (at 8 times the rated current of the trip unit.Can be excluded.

3. Function **I**: adjustable trip threshold I3= (1...10) x In for the basic version (instantaneous trip). Can be excluded.

- All the protection functions must be characterized by threshold and time tolerances according to the International Standards.

- The size of the current sensors must be a minimum of 10 A to a maximum of 3200 A so as to cover the widest possible current range.

Earthing:

Earthing arrangement shall be provided for earthing each cable, PVC cable gland, neutral busbar, chassis and frame work of the cubicle with separate earthing terminals at two ends. The main earthing terminals shall be suitably marked .The earthing terminals shall be of adequate size, protected against corrosion, and readily accessible. These shall be identified by means of sign marked in a legible manner on or adjacent to terminals.

Neutral bus bar strip shall be connected to Earthing terminal with help of GI strip of suitable capacity & nut-bolt arrangement.
Earthing Strip of Size 50x6mm GI is require for CSS internal Earthing.

2.1.52. TYPE / ROUTINE TEST ON PACKAGE SUBSTATION

TYPE TESTS FOR THE PACKAGE SUBSTATION:

The Package Substations offered must be type tested as per IEC 62271-202. The copy of type test summary should be submitted along with the tender. CSS manufactured at in JV consortium/system integrator/OEM shall not be accepted.

Routine Tests: The routine tests shall be made on each complete prefabricated substation.

a) Voltage tests on auxiliary circuit.
b) Functional test.
c) Verification of complete wiring.

Test Witness: Routine test shall be performed in presence of Owner's representative if so desired by the Owner. The Contractor shall give at least fifteen (15) days advance notice of the date when the tests are to be carried out.

Test Certificates:

Certified reports of all the tests carried out at the works shall be furnished in three (3) copies for approval of the Owner.

Performance Certificate to Qualify Technical Bid: Manufacturer should submit CSS performance Certificate from Any Utility/Pvt organization/Industry of similar or higher rating.

Packaged Substation Enclosure:

- Tests to verify the degree of protection.
- Arcing due to internal fault
- Test to prove enclosure class - Temperature rise of the transformer inside the enclosure.
- Short circuit test to prove the capability of the earthing circuits to be subjected to the rated peak and the rated short time withstand currents.
- Tests to verify the withstand of the enclosure of the prefabricated substation against mechanical stress.

VFD PANEL

2.1.53. SCOPE OF SUPPLY

Scope of supply shall cover design, engineering, manufacture, test at manufacturer's works, packing and transportation to site of the panel in accordance with the stipulations mentioned hereunder.

2.1.54. CODES STANDARDS

The panel shall generally comply with the relevant International Standards (IEC) Specifications and relevant codes and practices.

Panel wiring	Insulation:	IEC	60664.
MPCB/HRC cartridge	fuses:	IEC	60947-3.
Control switches,	Contactors:	IEC	60947-4-1.
Circuit Breakers &	Relays:	IEC	60898.
Degree of	protection:	IEC	60529.

Electrical safety & Human protection IEC 61140.

2.1.55. GENERAL CONSTRUCTIONAL FEATURES

The panel shall be completely metal clad enclosed, free standing, non draw out, sheet steel Cubicle, indoor free floor mounting, non compartmentalized, **single front,** individual vertical **c**ompartmental type and shall be dust tight, moisture, vermin proof, highly corrosive- resistive. Under normal operation and maintenance, the modules and cable connections shall be accessible from both sides of the feeders. The panel shall be maximum height of 2100mm from floor level and depth of 500mm maximum. All feeders of panel shall be suitable for bottom cable entry only. Copper bus bars for PCC panls and Aluminum bus bars for MCC panels shall be used with adequate sizes.

The panel shall be free from undulations, dents and flaws and sufficiently reinforced to provide Level surfaces, resistance to vibration and rigidity during transportation or installation. The perimeter of all doors and removable cover plates shall be provided all around with Neoprene perimeter of all doors and removable cover plates shall be provided all around with Neoprene. Lifting hooks shall be provided. All hardware shall be Zinc plated and passivated. Mounting height of components requiring operations and observations shall not be lower than 350 mm and higher than 1800 mm.

Feeder doors shall be interlocked with isolator switches so that, the door should not open when the feeder is ON.

Base frame shall be of ISMC-100 channels with 4 Nos. Holes to suit M12 foundation bolts.

All panels' feeders shall be fully DCS compatible. It shall have sufficient potential free contacts for digital signals as per our control circuits. From SCADA It should also be possible to control various functions of panel feeders through hardware connections.

Provision shall be made for cable entry.

Space heater with thermostat and lamps for interior illumination shall be provided for each column section of panels wherever is required.

All the panels shall be Free Standing, Floor mounted, Dead Rear type, common base frame (Internal open). The entire load bearing members shall be 2.0mm thickness sheet steel and all non-load bearing members shall be 1.6 mm thickness. All the panels shall be dust and vermin proof to meet with IP42 protection.

The cable entry shall be from bottom only. Suitable removable gland plate shall be provided.

All the Busbars, whenever used shall be of copper material only. Terminations shall be ferruled and Properly numbered.

The earthing arrangements shall be as per IEC standards which shall be furnished by you at the time of approvals.

All VFD panels shall be individual floor mounted type.

PAINTING: Exterior & Interior of the panel shall be painted with RAL-7032/7035 shade with MATT finish applicable as per IEC standards Powder coated (Nine tank process). All panels shall be protected against corrosion and sea. Base frames shall be painted with black.

Tests and Inspection:- Routine tests shall be conducted as per IEC 146. Required Control & Communication cables between VFD panels to plant DCS shall be in your scope of supply only.

1) Moulded Case Circuit Breaker (MCCB).

The circuit breaker shall conform to IEC 60947-2 and having rupturing capacity as specified in specification sheet and mounted on a draw out chassis.

The circuit breaker shall be provided with spring assisted quick make break type, manually operated trip- free mechanism, mechanical "ON, OFF" position indicators, thermal tripping devices of inverse characteristics, instantaneous short circuit tripping devices and necessary auxiliary and alarm switches. The MCCB chassis shall be provided with service, test and isolated position and automatic safety shutter.

The thermal and short circuit tripping devices shall be adjustable type.

When used for motor circuits, shunt trip device shall be provided and the let through power of controlling MCCB shall be lower than the respective contactor.

In addition, under voltage trip shall be provided, if specified in the specification sheet.

2) Switches / MPCB.

The switches/MPCB shall be motor duty type AC 23 category and Class-III (AC-3) duty type Comply with the requirements laid down in IEC 60947-3. Switches upto 63 Amps shall be rotary type and those of 100 Amps and above link type with Type-II coordination. Shall be consider MPCB's upto 30HP rating and SFU's for the above rating.
"ON and OFF" position of the switches shall be indicated on the module. Provision shall be made to Lock the switch in the "OFF" position. Switch ON/OFF feedback PF element shall be provided.

The fixed contacts shall be shrouded type. The moving contacts shall be silver-plated.

3) Fuses.

The fuses shall be of non-deteriorating HRC cartridge link type and shall conform to IEC 60947-3. They shall be suitable for the load and service required in the circuit.

4) Air Break Contactors.

The Air break contactors shall be of Class III, Category AC3, unless otherwise specified, conforming to IEC 60947-4-1 and flapper type with type-II coordination.

Each contactor shall be provided with auxiliary contacts as required. The rating of the auxiliary contacts shall be 5 Amps AC or 1 Amp DC at the specified control voltages. Spare contacts shall be wired to the terminal blocks.

5) Bimetal Thermal Overload Relays

The contactor shall be provided with three pole bimetal thermal overload relays, unless otherwise specified. The bimetal relays shall be of suitable range, ambient temperature compensated and shall be separate mounting type. They shall be adjustable through graduated scale and shall be provided with change-over contact. Thermal relays having long time / current characteristics operated through saturated CTs shall be supplied, wherever required.

Bimetal thermal relays shall conform to IEC 60898 and shall have built-in Single Phasing Preventer.

The bimetal relays shall be provided with a manual-resetting device, resistible after opening module door. Auto reset thermal relays are not acceptable.

6) Panel Wiring

Wiring shall be carried out with 650/1100-volt grade, single core, stranded copper conductor wires with PVC insulation. The minimum Size & Code of stranded copper conductor for wiring shall be as follows:

Control AC circuit - 1.5 mm² Black Flexible.
CT circuit - 2.5 mm² Black Flexible.
For R-Phase - CT-Red Sleeve
For Y-Phase - CT Yellow sleeve
For B-Phase - CT Blue Sleeve
For Neutral of CTs - Green Sleeve
Potential circuit - 1.5 mm² Red, Yellow, Blue and Black Flexible.
DC circuit - 2.5 mm² Grey Flexible.
For Positive – Red Sleeve
For Negative – Black Sleeve
Earthing circuit - 2.5 mm² Solid Green Flexible.

Panel wiring shall be securely supported, neatly installed by lacing and tying or in wiring channels. Flame retardant, plastic wiring channels / troughs with strap on wiring covers shall be used.
Terminals for A.C. supply and D.C. supply shall not be terminated on adjacent terminal blocks.

All spare contacts of breakers, switches, push buttons and relays shall be wired to terminal block.

Wiring terminations shall be made with solderless, crimping type of tinned copper lugs which firmly grip the conductor and insulation. Insulated sleeves shall be provided at the wire terminations. More than one control wire should not be crimped together. Engraved core identification plastic ferrules, marked to correspond with the panel wiring diagram shall be fitted at both ends of wire. Ferrules shall fit tightly on the wires and shall not fall off when the wire is disconnected.

7) Terminal Blocks

All the terminal blocks shall be Elmex make CATM4 type and for disconnecting type terminal blocks (CT terminal blocks) shall be CATDM4 type.

At least 20% spare terminals shall be provided and these shall be uniformly distributed on all rows of terminal blocks.

There shall be minimum clearance of 250 mm between the first row of terminal block and associated cable gland plate for easy termination of cable. The clearance between two rows of terminal block shall be minimum 150 mm.

8) **Labels**

All front mounted equipment as well as equipment mounted inside the panel shall be provided with individual labels with equipment designation engraved. The labels shall be mounted directly below the respective equipment.

Labels shall be provided at the rear / inside the panel for all front mounted equipment. It shall be mounted by the side of the respective equipment wiring. The labels shall correspond to wiring diagram and GA.

Label shall be made of non-rusting metal or 3-Ply lamicoid. Labels shall have white letters on black background. Labels shall be fastened using screws. Use of adhesive is not permitted.

9) Earthing.

The panel shall be fitted with an earth bus, securely fixed along the inside base of the panel. Earth Busbars shall be inside the panel only. Material and size of earth bus shall be as specified in the specification sheet.

All metallic cases of relays, instruments and other panel-mounted instruments shall be connected to earth bus by independent insulated copper wires as per applicable standards.

PT and CT secondary neutral or common lead shall be earthed at one place only at the terminal blocks where they enter the panel.

Insulation between the live terminal and earth prior to connection of the earth to the Purchaser's earth grid shall withstand a test voltage of 500V for one minute (or have resistance of not less than one mega Ohm of 500V).

10) PAINTING

Exterior & Interior of the panel shall be painted with light Siemens gray of shade No.631 IS 5, Powder coated (Seven tank process). All panels to be protected against corrosion. Base frames shall be painted with black.

11) Inspection & Testing

We / our client's representative will visit works during manufacturing to assess the progress of work as well as to ascertain the quality as per the approved QAP.

The following typical **TYPE TEST** reports shall be submitted along with the bid.
A. Verification of Temperature Raise limits.
B. Verification of Dielectric properties.
C. Verification of Short circuit strength.

All Routine tests shall be performed at your works as per relevant IEC 60439-1/EN 60439-1norms. All routine test certificates shall be submitted to our consultant for his approvals prior to dispatch of the equipment.

We / our client reserve the right to witness final test at the works. To enable us to depute our representative, prior notice as agreed shall be given by the vendor.

Inspection by us, however will not absolve the vendor from their responsibility for good design, material and for the satisfactory performance of the equipment and as such, they have to make good any defects noticed subsequently.

12) Quality Assurance Plan

The panel shall be manufactured as per approved supplier QAP.

VARIABLE FREQUENCY DRIVE

2.1.56. GENERAL FEATURES

This feature is to cover a complete Variable Frequency Drive (VFD) consisting of a pulse width modulated (PWM) inverter. Configuration of a variable frequency drive is as follows:

a. Automatic Voltage Regulation (AVR) function
b. Automatic PFI regulation function
c. Auto energy savings mode
d. Four line digital display with info key (for four parameters)
e. Dual rating design (Light duty & Normal duty)
f. Built-in real time clock
g. Hot plug LCD keypad offers a user-friendly operation interface. The display screen can be defined by the user with customized software & adjustable pulse frequency
h. Networking drives system
i. Built-in Automation Application
j. Design should be flexible and ease maintenance

2.1.57. PRODUCT QUALITY STANDARD

a. National Electric Manufacturers Association (NEMA)
   Or Under writers Laboratories Inc (UL)/CSA
b. CE low voltage directive EN50178 Electrical Equipment for use in power installation
   Or EMC Directive 89/336/EEC or 2004/108/EC (See also EN 5008102 and EN 50082-2).

2.1.58. MAIN CONTROL FUNCTIONS

a. Fault Reset
b. Speed Search
c. S-curve Acceleration/Deceleration control
d. Slip Compensation
e. PID control (with slip function)
f. Parameter Copy
g. Energy Saving mode
h. 3-wire Sequence
i. Torque Compensation
j. Torque limit
k. Over torque Protection
l. Auto tune (rational and stationary)
m. JOG frequency control
n. MODBUS Communication (RS-485)

Communication loss functionality to ensure uninterrupted operation. It shall be possible to set the VSD to change the control location from PLC to other external location identified by user, e.g. drive's embedded PID/loop controller and change back when communication is recovered.

o. Frequency Upper/lower limit setting
p. Momentary power loss ride through Acceleration/Deceleration. Time Switch

The VSD shall include a switching frequency control function. This reduces the switching frequency, based on actual VSD temperature and allows the highest carrier frequency without

de-rating the VSD or operating at high carrier frequency only at low speeds (temperature fold-back). It shall be possible to set a minimum and a reference switching frequency.

q. Cooling Fan Auto mode
r. DC injection braking at start/stop
s. Variable Frequency Drive (VFD) Efficiency: Above 98%
t. Auto phase sequence changing mode (Forward/Reverse rotation mode)

The VFD should have IEC 60721-3-3. Class 3C2 as standard Class 3S2 (solid particles) coated boards as standard delivery.

u. The VFDs shall have in-built Dry pump protection and end of curve protection, Flow Compensation and No flow detection features.
v. The VFDs shall have in-built sleep mode and Auto tuning of the PI controllers
w. Harmonic Current suppression (DC Reactor Facility)
   The drive shall be equipped with a dynamic control solution that adapts to changes in the motor load and reduces the energy needed to deliver the required torque.
x. The VFD should have the option to use up to cable length minimum 150 meters without additional output choke and above 150 meters to 450 meters with additional output choke.

2.1.59. GENERAL SPECIFICATION:

a. Input Phase : Three Phase
   Frequency: 50 Hz
b. VFD Capacity : 110±3% kW (106.70 kW to 113.30 kW)
c. VFD efficiency: ≥98%
d. Input Voltage Range:
   380 to 480 VAC, +10%...-15%
   Power Factor (cos Φ) at nominal load 0.98
e. Output Frequency: 0 to 320 Hz
f. Frequency Resolution Digital Command: 0.01 Hz
g. Analog Command: Maximum output frequency x 0.03/60 Hz (±11 bit)
h. Carrier Frequency Range: 2 ~ 15 kHz (depends on motor output)
i. Input Frequency Tolerance: 50 ±5% Hz
j. Frequency Setting Signal: 0 ~ 10 V, 4 ~ 20 mA. Analog Signal
k. Control mode: V/F control, sensorless Vector control (SVC)
l. Acceleration/Deceleration Time: 0.01~360/0.01~360 seconds (Adjustable)
m. Communication Protocols: Built-in (RS-485, MODBUS, BAC net)
n. EMI Filter: Built-in (Standard IEC 61800-3:2004,C2)
o. Harmonics Filter:

Built-in swinging choke as standard and shall meet the requirements of IEC 61000-3-12: 2011. The chokes shall be capable of delivering 25% fewer harmonics at partial loads.

p. Restart after instantaneous power failure: Up to 15 Seconds (Auto/Manual)
q. Cooling Method: Fan Cooling
r. Short circuit current rating: ≥ 100 KA (50,000 AMP)

2.1.60. SAFETY PROTECTION:

The VSDs shall support 'Safe Torque Off' (STO) function capable for safety related applications up to SIL 3, SILCL 3 and PL e.

There shall be 3rd party statement of compliance available to confirm VSD compliance. Manufacturer's statements are not accepted to confirm compliance.

a. Motor Protection: Electronic Thermal Relay Protection
b. Over Current Protection for 150% of rated current
c. Over Voltage Protection: For 1(one) Phase (230Vac): Drive will be stopped when input voltage exceeds 20% of the rated Voltage. For 3(three) Phase (410Vac): Drive will be stopped when the input voltage exceeds 20% of the rated Voltage.
d. Overload Tolerance: Light Duty: 120% of rated current for 1 minute:
e. Normal Duty: 120% of rated current for 1 minute;
f. 160% of rated current for 3 Seconds
g. Over Temperature Protection: Built-in temperature sensor
h. Torque Limit Normal Duty: Maximum 170% torque current

2.1.61. ENVIRONMENTAL PROTECTION:

a. Ambient Temperature (Storage/Transportation: 0°C- +50°C without derating
b. Air Pressure (Operating/Storage): Atmospheric Pressure
c. Pollution Level: Class 3C2: Class 3S2 (Operation), Class 2C2:Class 2S2 (Storage)
d. Protection Level: Minimum IP 20/UL Open Type (above 45 kW)
e. Sound Level: Up to 75 db
f. Humidity: Up to 95%
g. Allowable maximum temperature rise inside the panel box: ≤ 15 °C

L. T. PANELS / P.C.C. / M.C.C.

This scope shall cover design, manufacture, check test, and supply, installation, testing (Scope to assist the Ele.Contractor for installation, all the sections of panels & Internal Control wiring should be done by panel vendor on site), testing and commissioning of various medium voltage Panel Board as described in Bills of quantities and drawings. The Panel manufacturer should have a design validated by CPRI / ERDA for breaking capacity of at least 100 KA for 1 Sec.
Panels shall be suitable for operation on 3 Phase/single phase, 415/240 volts, 50 cycles, 4 wire system, neutral grounded at transformer. All Distribution panels shall be CPRI approved and / or manufactured by an approved manufacturer.
Distribution panels shall comply with the latest Relevant Indian Standards and Electricity Rules and Regulations and shall be as per IS-13947-1993.

9.6.1 SERVICE CONDITIONS AT SITE

Ambient Temperature: Max. / Min. = 55° C. / 3° C.
Design temperature: 60 Degree C.
Relative humidity: 100%
Voltage: 415+/- 10%, TPN
Frequency: 50 Hz. + 3% to -6%
Neutral: Solidly / earthed neutral.
Fault level: 18.4KA, Symmetrical at 415V solidly earthed.

9.6.2 GENERAL SPECIFICATIONS:

All the Panels shall be metal clad, totally enclosed, rigid, floor / wall mounting, air insulated,

cubicle type suitable for operation on three phase / single phase, 415 V / 230 V / 240 V, 50 Hz., neutral effectively grounded at transformer and short circuit level.
Degree of protection for following type of distribution panel enclosure shall be as per IS:13947-1993. IP 52 for indoor panels. The painting of all the metal part shall be with seven tank process followed by powder coating as per the standard. The Panels shall be designed to withstand the heaviest condition at site, with maximum expected ambient temperature of 50° c., 95% humidity.

9.6.3 STANDARDS AND CODES:

The Panels shall comply with the latest edition of relevant Indian Standards and Indian Electricity Rules and Regulations. The following Indian standards shall be complied with:

STANDARD NO.	PARTICULAR
IS: 4237	General requirements for switchgear and control gear for voltages not exceeding 1000 V a.c. or 1200 V d.c..
IS: 5578	Guide for marking of insulated conductors.
IEC 61439-1&2	Specifications to Low-voltage switchgear and control-gear assemblies
IS/IEC 60947-2: 2003	Low Voltage Switchgear & Controlgear, Circuit Breakers
IS 2147-1962	Degree of protection provided by enclosure for Low Voltage Switchgear & Control-gear
IS 3043	Earthing codes
IS: 11353	Guide for uniform system of marking and identification of conductors and apparatus Terminals.
IS: 13947	Low voltage switchgear and control gear.
IS: 8197	Terminal marking for electrical measuring instrument and their accessories.
IS: 2551	Danger notice plates
IS: 10118	Code of Practice for selection, installation and maintenance of switchgear and control gear
IS: 8623	Specification for factory built assemblies of switchgear and control gear for voltage upto and including 1000 V A.C. and 1200 V D.C.
IS: 8828	Miniature circuit breakers.
IS: 9224	HRC fuse links
IS: 2705	Current transformer
IS: 3156	Voltage transformer
IS: 3231	Electrical relay for protection
IS: 1248	Indicating instrument
IS: 722	Integrating instrument

Indian Electricity Act and Rules (as amended up to date) and approval of FIA of India.
The Panels also require approval of the consultant at various stage of their manufacture such as design, selection, construction, testing, shipping etc..

Every cabinet shall be provided with Trifoliate or engraved metal name plates. All panels shall be provided with circuit diagram engraved on PVC sheet. All live accessible connections shall be shrouded and shall be finger touch proof and minimum clearance between phase and earth shall be 20 mm and phase to phase shall be 25 mm.

2.1.62. TECHNICAL PARAMETERS

System Details

- System Voltage : 415V ± 10% 3-phase, 4 wire solidly grounded
- Frequency : 50Hz ± 3%
- Control Supply : 230 Volts AC ± 10% (tapped from phase & neutral) 110V DC ± 10%

2.1.63. STRUCTURE :

- The PCCs, MCCs & PDBs shall be metal clad enclosed and be fabricated out of high quality CRCA sheet, suitable for indoor installation, front operated and floor mounting type.
- CRCA sheet steel used in the construction of PCCs / MCCs / PDBs shall be 2 mm thick for structure, 1.6 mm thick for doors, covers shrouds and 3 mm thick for gland plate and shall be folded and braced as necessary to provide a rigid support for all components. Joints of any kind in sheet shall be seam welded, all welding slag grounded off and welding pits wiped smooth with plumber metal.
- The PCCs / MCCs / PDBs shall be totally enclosed, completely dust and vermin proof and degree of protection being no less than IP-54 confirming to IS 2147. Gaskets between all adjacent units and beneath all covers shall be provided to render the joints dust proof. All doors and covers shall be fully gasketted with neoprene gaskets and shall be lockable.
- All panels and covers shall be properly fitted and secured with the frame, and holes in the panel correctly positioned. Fixing screw shall enter into holes taped into an adequate thickness of metal or provided with bolts and nuts. Self-threading screws shall not be used in the construction of PCCs / MCCs / PDBs.
- A base channel of 75 mm x 75 mm x 5 mm or as per the weight of the panel shall be provided at the bottom.
- PCCs / MCCs /PDBs shall be arranged in multi-tier formation. The PCCs / MCCs / PDBs shall be of adequate size to facilitate enough space for maintenance and cooling. The size of the PCCs / MCCs / PDBs shall be designed in such a way that the internal space is sufficient for hot air movement, and the electrical component does not attain temperature more than 40 degree Celsius. Openings shall provide for natural ventilation, but the said openings shall be screened with fine weld mesh.
- Knockout holes of appropriate size and number shall be provided in the PCCs / MCCs/ PDBs in conformity with number, and size of incoming and outgoing conduits / cables.

- Alternatively the PCCs / MCCs / PDBs shall provided with removable sheet plates at top and bottom to drill holes for cable / conduit entry at site.
- The PCCs / MCCs / PDBs shall be designed to facilitate easy inspection, maintenance and repair.
- The PCCs / MCCs / PDBs shall be sufficiently rugged in design and shall support the equipment without distortion under normal and short circuit condition they shall be suitable braced for short circuit duty.

2.1.64. PROTECTION CLASS:

All the indoor PCCs / MCCs / PDBs shall have protection class of IP - 54

2.1.65. POWDER COATING:

All sheet steel material shall undergo seven-tank process after all the necessary shearing and other mechanical works are completed. After the seven-tank process powder coating treatment shall be adopted using powder of reputed make. After the powder coating is complete welding in the panel or any sort of shearing, bending or cutting activity shall not be done. The colour shall be Siemens Grey 631

2.1.66. CIRCUIT COMPARTMENT:

Each circuit breaker and switch fuse units shall be housed in separate compartments and shall be enclosed an all sides. Sheet steel hinged lockable door shall be duly inter locked with the breaker / switch fuse units in ON and OFF position. Safety interlocks shall be provided for non-opening of the door when the breaker is in ON position.
The door shall not form integral part of the draw out position of the circuit breaker. All instruments and indicating lamp shall be mounted on the compartment door. Sheet steel barriers shall be provided between the tires in a vertical section.

2.1.67. INSTRUMENT COMPARTMENT :

Separate and adequate compartment shall provided for accommodating instruments, indicating lamp, control contactors, relays and control fuses etc. These components shall be accessible for testing and maintenance without any danger of accidental contact with live parts of the circuit breaker, switch fuse units, bus bars and connections.

2.1.68. BUSBARS :

Bus bar and interconnections shall be of high conductivity electrolytic grade copper as indicated in the bill of quantities complying with requirement of IS: 5082 – 1981 and of rectangular / Square cross section suitable for carrying the rated full load current and short circuit current and shall be extendable on either side. Bus bars and interconnections shall be insulated with heat shrinkable sleeve of 1.1 KV grade and shall be colour coded.
Bus bars shall be supported on glass fiber reinforced thermosetting plastic insulated supports at regular intervals to withstand the force arising from in case of short circuit in the system. All bus bars shall be provided in a separate chamber and all connections shall be done by connected by means of bus bar connectors to avoid tapings on solid bus bars. Additional cross-sectional area to

be added to the bus bar to compensate for the holes if required. All connections between bus bars and breakers shall be through solid / Flexible copper strips of proper size to carry full rated current and insulated with insulating sleeves.
The busbar shall be air insulated and made of high quality, high conductivity, high strength electrolytic grade Copper. The busbar shall be of 3 phases and neutral system with separate neutral and earth bar. The size of neutral busbar in all panels or lighting panels and feeders shall be equal to phase busbar. The busbar and interconnection between busbars and various components shall be of high conductivity Copper.
The busbar shall be of rectangular / square cross-section designed to withstand full load current for phase busbars and half rated current for neutral busbars in case of APFCR panels only and shall be extensible on either side.
The busbar size shall be as per drawing. The busbar shall have uniform cross-section throughout the length. The busbars and interconnections shall be insulated with epoxy coated bus sleeves. The busbar shall be supported on glass fiber reinforced thermosetting plastic insulated supports type at sufficiently close intervals to prevent busbars sag and shall effectively withstand electromagnetic stresses in the event of short circuit capacity of 18.4 KA RMS symmetrical for 1 sec.
The busbar shall be housed in a separate compartment. The busbar shall be isolated to avoid any accidental contact. The busbar shall be arranged such that minimum clearances between the busbars are maintained as below:
Between phases : 30 mm. minimum
Between phases and neutral : 30 mm.
Between phases and earth : 30 mm.
Between neutral and earth : 30 mm. Minimum
Busbar shall be calculated on 55 deg. C. ambient temp. and 85 deg. C. for continuous and short time rating Busbar surrounding air temperature shall be considered 70 deg. C. for busbar calculation
All joint shall have non-flammable insulation shrouds for secondary insulation purpose

2.1.69. TEMPERATURE - RISE LIMIT

Unless otherwise specified, in the case of external surface of enclosures of bus bar trunking system which shall be accessible but do not need to be touched during normal operation, an increase in the temperature rise limits of 25° C above ambient temperature shall be permissible for metal surface and of 15° C above ambient temperature for insulating surfaces as per IS 8623(Part-2) 1993. All main distribution panels and sub distribution panels shall be provided with MCCB of appropriate capacity as per Single Line Diagram. All final Distribution boards shall be provided with Miniature Circuit Breakers. Final Single-Phase Distribution boards shall be connected to the incoming supply through double pole MCB units & earth leakage circuit breakers.

All wiring for final distribution boards shall be concealed behind 5 mm thick bakelite sheet or M S sheet cover. All Distribution boards shall be completely factory wired, ready for connection. All the terminals shall be of proper current rating and sized to suit individual feeder requirements. Each circuit shall be clearly numbered from left to right to correspond with wiring diagram. All the switches and circuits shall be distinctly marked with a small description of the service installed. Continuous earth bus sized for prospective fault current shall be provided with arrangement for connecting to station earth at two points. Hinged doors/ frames shall be connected to earth through adequately sized flexible braids.

2.1.70. ELECTRICAL POWER & CONTROL WIRING CONNECTION :

Terminal for both incoming and outgoing cable shall be suitable for 1100 volts grade, aluminum/copper conductor PVC insulated and sheathed, armoured cable and shall be suitable for connections of solder less sockets for the cable size as indicated on the appended drawing for the PCCs, MCCs, PDBs.
Both control and power wiring shall be brought out in cable alley for ease of external connections, operation and maintenance.
Both control and power terminals shall be properly shrouded.
10% spare terminal shall be provided on each terminal block. Sufficient terminals shall be provided on each terminal block so that not more than one outgoing wire connected per terminal.
Terminal strip for power and control shall preferably be separated from each other by suitable barriers of enclosures.
Wiring inside the module for power, control protection and instrument etc. shall be done with use of 1100 V confirming to IS 694 and IS 8130. Power wiring inside the starter module shall be rated for full current rating of contactor, but not less than 4 sq mm cross section area. For current transformer circuits, 2.5 sq mm-copper conductor wire shall be used. Other control wiring shall be done with 1.5 sq mm copper conductor wires. Wires for connections to the door shall be flexible. All conductors shall be crimped with solder less sockets at the ends before connections are made to the terminals.
Control power for the motor starter module shall be taken from the respective module switchgear outgoing from R phase and Neutral. Control wiring shall have control fuse (HRC type).
Particular care shall be taken to ensure neat and orderly laying of the wiring. Identification ferrules shall be tagged to all the wire termination for ease of identification and to facilitate and testing.
"CUPAL" washers shall be used for all copper and aluminum connections.
Final wiring diagram of the PCC, MCC, PDB power and control circuit with ferrules number shall be submitted along with the PCC/MCC/PDB as one of the documents.

2.1.71. TERMINALS :

The outgoing terminals and neural link shall be brought out to a cable alley suitably located and accessible from the panel front. The current transformer for instrument metering shall be mounted on the disconnecting type terminal blocks. No direct connection of incoming and outgoing cables to internal components connection of the distribution board is permitted. Only one conductor may be connected in one terminal.

2.1.72. WIREWAYS :

A horizontal PVC wire way with screwed covers shall be provided at the top to take interconnecting control wiring between different vertical sections.

2.1.73. CABLE COMPARTMENT:

Cable compartment of adequate size shall be provided in the Distribution panels for easy clamping of all incoming and outgoing cables entering from the top/bottom. Adequate supports shall be provided in cable compartment to support cables. Minimum 200 mm gap should be provided in the Panel from Metal Enclosure Gland plate to Polycarbonate Cable compartment gland plate. In Polycarbonate Cable compartment minimum 150 mm gap should be provided from bottom of the

cable connector. Minimum 75 mm gap Should be provided between connectors of every cable. All the cable gland plate should be detachable (on both Panel enclosure as well as Internal IP 65 Box). Provide glands at both the detachable gland plate to maintain complete IP 65. All cable terminals should be of Hensel / Spelsberg make only & Terminal size should be 2 sizes higher than required current capacity.

2.1.74. EARTHING :

Copper earth busbar of minimum 25 mm x 6 mm size shall be provided in the PCCs & MCCs for the entire length if panel. As per the rating of the main busbars the size of earthing busbar shall be decided. The framework of the PCCs & MCCsshall be connected to this earth busbar. Provisions shall be made for connection from earth busbar to the main earthing bar coming from the earth pit on both sides of the PCCs, MCCs, PDBs.

The earth continuity conductor of each incoming and outgoing feeder shall be connected to this earth bar. The armour shall be properly connected with earthing clamp and the clamp shall be ultimately bounded with the earth bar.

2.1.75. LABELS:

Engraved Aluminium sheet labels shall be provided on all incoming and outgoing feeders. Single line circuit diagram showing the arrangements of circuit inside the distribution board shall be pasted on inside of the panel door and covered with transparent laminated plastic sheet.

2.1.76. NAME PLATE :

A name plate with panel designation in bold letter shall be fixed at top of the central in panel. A separate name plate giving feeder details shall be provided for each feeder module door.

Inside the feeder compartment, the electrical component, equipments, accessories like switchgear, contactor, lamp, relays etc. shall suitably be identified by providing stickers. Engraved nameplates shall be of Aluminium strip of black colour and silver letters format.

Nameplate shall be fastened by counter sunk screws / riveted and not by adhesives.

2.1.77. DANGER NOTICE PLATE :

The danger plate shall be affixed in a permanent manner on operating side of the panel.
The danger notice plate shall indicate danger notice both in Hindi and English and with a sign of skull and bones.
The danger notice plate in general shall meet to requirements of local inspecting authorities.
Overall dimension of the danger notice plate shall be 200 mm wide and 150 mm high. The danger notice plate shall be made from minimum 1.6 mm thick mild steel sheet and after due pretreatment to the plate, the same shall be painted white with vitreous enamel paint on both front and rear surface of the plate.
The letter, the figure, the conventional skull and bones shall etc. shall be positioned on the plate as per recommendations of IS : 2551-1982.
The said letter, the figure and the sign of skull and bones be painted in single red colour as per IS: 5-1978.
The danger plate shall have rounded corners. Locations of fixing holes for the plate shall be decided to suit design of the panel.
The danger notice plate, if possible, be of ISI certification mark.

2.1.78. INTERNAL COMPONENTS:

The PCC / MCC / PDB shall be equipped complete with all type of required number of air circuit breakers, switch fuse unit, contactor, relays, fuses, meters, instruments, indicating lamps, push buttons, equipment, fittings, busbar, cable boxes, cable glands etc. and all the necessary internal connections /wiring as required and as indicated on relevant drawings. Components necessary for proper complete functioning of the PCC / MCC but not indicated on the drawings shall be supplied and installed on the PCC / MCC .
All part of the PCC / MCC carrying current including the components, connections, joints and instruments shall be capable of carrying their specified rated current continuously, without temperature rise exceeding the acceptable values of the relevant specifications at any part of the PCC / MCC .
All units of the same rating and specifications shall be fully interchangeable.

2.1.79. MINIATURE CIRCUIT BREAKER (MCB):

Miniature circuit breakers shall be quick make and break and break type conform with British standard BS: 3871 (Part-I) 1965 and IS: 8825 (1996). The housing of MCBs shall be heat resistant and having high impact strength. The fault current of MCBs shall not be less than 10000 amps, at 230 volts. The MCBs shall be flush mounted and shall be provided with trip free manual operating mechanism with mechanical "ON" and "OFF" indications.
The circuit breaker dollies shall be of trip free pattern to prevent closing the breaker on a faulty current.
The MCB contact shall be silver nickel and silver graphite alloy and tip coated with silver. Proper arc chutes shall be provided to quench the arc immediately. MCB's shall be provided with magnetic fluid plunger relay for over current and short circuit protection. The over load or short circuit devices shall have a common trip bar in the case of DP and TPN miniature circuit breakers. All the MCB's shall be tested and certified as per Indian Standard, prior to Installation.

2.1.80. MOULDED CASE CIRCUIT BREAKER:

The MCCB should be current limiting type with trip time of less than 10 msec under short circuit conditions. The MCCB should be either 3 or 4 poles as specified in BOQ. MCCB shall comply with the requirements of the relevant standards IS13947 – Part 2/IEC 60947-2 and should have test certificates for Breaking capacities from independent test authorities CPRI / ERDA or any accredited international lab.

MCCB shall comprise of Quick Make -break switching mechanism, arc extinguishing device and the tripping unit shall be contained in a compact, high strength, heat resistant, flame retardant, insulating moulded case with high withstand capability against thermal and mechanical stresses The breaking capacity of MCCB shall be as specified in the schedule of quantities. The rated service breaking capacity (Ics) should be equal to rated ultimate breaking capacities (Icu). MCCB’s for motor application should be selected in line with Type-2 Co-ordination as per IEC-60947-2, 1989/IS 13947-2. The breaker as supplied with ROM should meet IP54 degree of protection.

Protection Functions

- MCCB's with ratings up to 200 A shall be equipped with Thermal-magnetic (thermal for overload and magnetic for short-circuit protection) trip units
- Microprocessor MCCB's with ratings 250A and above shall be equipped with microprocessor based trip units.
- Microprocessor and thermal-magnetic trip units shall be adjustable, and it shall be possible to fit lead seals to prevent unauthorised access to the settings
- Microprocessor trip units shall comply with appendix F of IEC 60947-2 standard (measurement of rms current values, electromagnetic compatibility, etc.)
- Protection settings shall apply to all poles of circuit breaker.
- All Microprocessor components shall withstand temperatures up to 125 °C

Testing

- Original test certificate of the MCCB as per IEC 60947-1 &2 or IS13947 shall be furnished.
- Pre-commissioning tests on the switch board panel incorporating the MCCB shall be done as per standard specifications.

Interlocking

Moulded, case circuit breakers shall be provided with the following interlocking devices for interlocking the door of a switch board.

a) Handle interlock to prevent unnecessary manipulations of the breaker.

b) Door interlock to prevent the door being opened when the breaker is in ON position.

c) Defeat-interlocking device to open the door even if the breaker is in ON position.

- The MCCB shall be current limiting type and comprise of quick make – Break switching mechanism.
- MCCB's shall be capable of defined variable overload adjustment. All MCCB's rated 200 Amps and above shall have adjustable over load & short circuit pick-up both in Thermal magnetic and Microprocessor Trip Units.
- All MCCB with microprocessor based release unit, the protection shall be adjustable Overload, Short circuit and earth fault protection with time delay.

The trip command shall override all other commands.

2.1.81. CONTACTORS:

The contactor shall meet with the requirements of IS: 2959 and BS: 775.
The contactors shall have minimum making and breaking capacity in accordance with utilization category AC 3 and shall be suitable for minimum class II intermittent duty.
If the contactor forms part of a distribution board then a separate enclosure is not required, but the installation of the contactor shall be such that it is not possible to make an accidental contact with live parts.

2.1.82. TRIVECTOMETER:

Flush mount 96 x 96 x 80 mm load manager type Enercon EM 6400 or equivalent meter of accuracy class 1 as per IS 13779 shall be provided. The meter shall be accurate on distorted waveforms; simultaneous sampling of voltage and amperes shall be done. It shall have low burden on PT and CT shall have bright display, shall view 3 parameters together shall have auto scaling from kilo to mega to giga units, shall have programmable CT, PT ratios with built in phase

analyser. Auto scrolling shall be programmable as per user choice and communication with PC; PLC DCS shall be possible through RS 485 serial port. It shall be dust proof, tamper proof with data import export option and 10 years back up of integrated data.
Parameters to be monitored shall be Frequency, Line to line and average and line to neutral and average voltage, phase wise and average current, phase wise and total KVA, KW and P.F. reading and KWH monitoring.
User programmable facility for delta 2e and star 3e measurement, C.T. and P.T. ratios, sliding window auto sync. And auto scrolling of parameters shall be available.
Sensing shall be 3 phase, 4 wire measuring True RMS with voltage input range of 110 to 415 V nominal and current input of 5 amps or 1 amps as per field configuration. Current range shall be from 50 mA to 7.5 A and burden on PT or CT shall be app 0.2 VA.
Accuracy for kW / kWh shall be as per IS 1377 / CBIP88 and for all other parameters shall be +/- 0.5% of full scale + 0.5% of reading + 1 digit. Digital readout shall be of 3 rows of 4 digits each (12.5 mm size) with 7 segments bright red LED. Input frequency shall be 50Hz / 60Hz +/- 5%. Power factor range shall be 0.5 lag – unit – 0.8 lead.
Resolution for power parameters shall be for 4 digits and energy parameters shall be 8 digits. Display update shall be at every 15 seconds for demand parameters and 1 sec for other parameters. Display sequence shall be parameter followed by value.
Temperature range shall be 0-50oC and humidity <95% non-condensing.

2.1.83. CURRENT TRANSFORMER:

Where called for, CT's shall provide for current measuring. Each phase shall be provided with separate CT of class I accuracy and VA burden as shown in SLD for operation of associated metering and controls. Current transformer shall be in accordance with IS: 2705 - 1964 as amended up to date.

2.1.84. PUSH BUTTON:

The push button unit shall comprise of the contact element, a fixing holder, and push button actuator. The push button shall be momentary contact type. The contacts shall be of silver alloy and rated at 10 Amps. Continuous current rating. The actuator shall be of stranded type and colour as per its usage for ON, OFF and Trip.
The push button unit shall comprise of the contact element, a fixing holder, and push button actuator. The push button shall be momentary contact type. The contacts shall be of silver alloy and rated at 10 Amps. Continuous current rating. The actuator shall be of stranded type and colour as per its usage for ON, OFF and Trip. Push button shall be of self-glowing type with LED lamp.
Indicating Lamp shall be LED type and shall supplied complete with translucent covers to diffuse the lamp light. Indicating lamps shall be part of push buttons.
Colour shade for the indicating lamps shall be as below:
ON indicating lamp : Green
OFF indicating lamp : Red
TRIP indicating lamp : Amber
PHASE indicating lamp : Red, Yellow, and Blue.

2.1.85. TESTING

The following drawings shall be submitted before procurement for approval from the client / consultant.

1. General arrangement and Fabrication details.
2. Power wiring diagram of the panel.
3. Control wiring diagram of panel.
4. C.T. ratios with connection.
5. Material list with make, catalogue nos.

Testing and setting the relay set – point and co-ordination between relay on LT/HT fuses, breaker, setting shall be done by contractor. The downstream of the setting should be provided.

The relay should be tested by reputed agencies and test report of the relay should be submitted by the contractor.

Testing of panels shall be as per following codes:

IS: 8623 (Part -I) 1977 for factory built assemblies of switch gear for voltages upto and including 1000 VAC.

IS: 13947: 1993 Degree of protection

IS: 5578 & 11353:1985 Arrangement of bus bars.

1.1 KV & 6.35/11 KV GRADE L.T & H.T CABLES AND CABLE TERMINATION:

Technical specifications for design, engineering, manufacturing, inspection, testing at manufacturer's works, packaging and delivery by road (properly packed in nonreturnable steel drums), various sizes of aluminum, XLPE insulated, voltage upto and including 1100 Volts, extruded PVC inner sheathed, extruded FRLS PVC outer sheathed, GI round wire armoured cables, suitable for solidly grounded system. The cables shall confirm to IS 7098-Part 1 with latest amendments.

Technical specifications for design, engineering, manufacturing, inspection, testing at manufacturer's works, packaging and delivery by road (properly packed in nonreturnable steel drums), 6.35 / 11 KV (E) Voltage Grade, 3-Core, 400Sq. mm Stranded Compacted Circular Shaped Aluminum Conductor of H4 Grade, Shielded with extruded Semi-conducting compound, XLPE insulated, PVC sheathed, GI Round wire armoured Power Cables for effectively grounded system. The cable shall confirm to the latest revisions of IS: 7098 (Part –2).

2.1.86. GENERAL TERMS & CONDITIONS

1. Climatic Condition: The site is located about 500 meters from the seacoast and the atmosphere is laden with salt spray. The climate is tropical with high humidity, heavy rainfall and prone to rust and fungus growth
2. Ambient Air Temperature:
   i. Maximum 45^0C
   ii. Maximum Daily Average 40^0C
   iii. Max. Weighted Yearly Average 32^0C
   iv. Max. Relative Humidity 90%

   The maximum temperature and relative humidity likely to occur simultaneously are 420C and 80% respectively
3. Installation Location: The cables may be laid/buried directly in ground, covered cable trenches, Cable racks/ladders in open air

2.1.87. 1.1 KV,6.35 / 11 KV (E) GRADE, ALUMINUM CONDUCTOR, POWER CABLES

This section covers the technical specifications for design, engineering, manufacturing, inspection, testing at manufacturer's works, packaging and delivery by road (properly packed in non-returnable steel drums), 1.1KV & 6.35/11 Kv grade, Multi-stranded Aluminum conductor, XLPE insulated, extruded PVC inner sheathed, GI round-wire armoured, extruded FRLS PVC ST2 outer sheathed. Power Cables for effectively grounded system, conforming to the latest revisions of IS: 7098 (Part –I), 1988 & as per the technical specifications attached herewith.

2.1.88. STANDARDS

The design, manufacture and testing of the cable shall comply with the latest editions/amendments of the following Indian Standards, unless otherwise specified. Equipment's complying with equivalent standards shall also be acceptable.

IS-7098, 1998 (Part-I):	Cross linked polyethylene insulated PVC sheathed cables for working voltages upto 1100V.
IS-7098 (Part –2):	Specification for cross linked polyethylene insulated PVC sheathed cables for working voltages from3.3 kV up to and including 33 kV
IEC-60502-2 1998:	Power Cables with extruded insulation and their accessories for rated voltages from 1 kV up to 30 kV
IS-5819:	Recommended Short circuit Current ratings for High voltage cables
IS-396:	Recommended current ratings for cables
IS 8130-1984:	Specification for conductors for insulated electric cables and flexible cords.
IS-3975, 1999:	Low Carbon galvanized steel wires, formed wires & tapes for armoring of cables
IS-4759:	Specifications for Hot dipped galvanized coating on round steel wires
IS-5831:	PVC insulation and sheath of electric cables.
IS-10418:	Drums for electric cables.
IS-10810 (Part 0 to 64):	Method of test for cables.

2.1.89. SERVICE CONDITION

The cable shall be designed with the following service conditions into consideration:

a) Cables shall be capable of satisfactory operation under a power supply system frequency variation of +3% and voltage variation of ±10%.
b) Cables shall be suitable for laying in conduits, ducts, trenches, channels, trays, racks or for direct buried in ground in both dry and wet locations with chances of flooding by water.
c) The cables shall be suitable for the following ambient condition: Ambient Air temperature: 400C
d) Ambient ground temperature: 300C
e) The current rating shall be based on maximum conductor temperature depending on the type of insulation for continuous at the rated current.

f) The one second short circuit current rating values shall be furnished and shall be subjected to the purchaser's approval.
g) The cables will have current ratings and de-rating factors as per relevant Indian Standards.

Full technical details and descriptive literature shall be furnished indicating the construction details, standard applicable for the components of the cable and current ratings of the cables in air and ground. De-rating factors to be considered for the ambient temperature, ground temperature, de-rating due to cable location in air and ground shall also be furnished. The certificates for the type tests conducted on cables similar to the cables covered herein shall be submitted along with the tender.

2.1.90. DESIGN AND CONSTRUCTION PERTICULARS

- **General**

The cables supplied under this specification shall be adequate insulated to operate continuously at the specified voltage with a high degree of safety and reliability throughout the life of the cables. The sheathing material shall be high quality PVC based compound. The construction of cable shall be as per IS: 7098 (Part I &2) – 1988. Cable shall be designed and manufactured to prevent damage during transportation, installation & operation under all climatic & operating conditions to which cable may be subjected to.

Technical parameters

- **Cable Insulation Level**

The power cables shall withstand power frequency voltage, impulse voltage and partial discharge extinction level as per IS: 7098 part – 2.

- **Cable Current Carrying capacity**

The cable shall be suitable for use where combination of ambient temperature and temperature rise due to load, results in conductor temperature not exceeding 90oC under normal operation. The cables shall have the following continuous current ratings when laid in ground 1100 mm below ground level and in air with the ground temperature being 30oC and air temperature being 40° C and assuming that thermal resistivity of soil is 150°C.cm/W and a maximum operating temperature of 90o C.

- **Cable Short Circuit withstand capacity**

The cable shall withstand the short-circuit current of 11Kv-31.5KA & 415V -25KA for 1 second, assuming the initial conductor temperature of 90° C and final temperature of 250° C.
The cables shall be suitable for Voltage grade 6.5 / 11 KV (E) & 650/1100 VOLTS, 3 phase, 50 Hz frequency, effectively grounded system and capable of continuous operation at their rated currents.

- **Cable Voltage Rating**
  - **Conductor**
    - ALUMINIUM

The Aluminium conductor used shall be of H-4 grade (Tensile strength above 150 N/mm2). High conductive aluminium, stranded (Class-II, stranded circular shaped), uniform in quality and free

from scale, inequalities, spills, splits and other defects. The aluminium used shall have purity meeting the criteria for maximum resistance allowed. *Two sample conductor randomly selected from finished lot of cables, shall be tested for its purity at any 3rd party NABL accredited lab.*

- **Cable Joints:**

Joints shall be permitted in the individual wires of which the conductor is formed, but no joint shall be within 300 mm of any other joint within the same layer. The joints shall be made by resistance butt welding, fusion welding, cold pressure welding,
electric welding, gas welding, brazing or silver soldering. No joint is allowed in the conductor after stranding. A maximum of two joint shall be allowed in any strand forming complete length of the cable.

The conductors shall conform to appropriate dimensions, resistance and number of wire in the conductor (number of strands) as given in IS 8130 (Part I): 1984.

- **Conductor Screening**

The Conductor screening shall be provided over the conductor by extrusion of semiconducting compound and shall be so applied that it fits closely on the conductor and it shall be possible to remove it without damaging the conductor. Strippable screening shall be provided. The screening material shall be non-metallic semi-conducting compound.

- **Insulator**

The conductor insulation shall be of extruded layer of water tree free cross-linked polyethylene (XLPE), meeting the requirements of IS: 7098 (part–2). The method of cross-linking of polyethylene shall be indicated in the offer. Cross linking will be by Dry Gas Curing process.
The average thickness and tolerance of insulation when measured in accordance with IS shall not be less than the values specified in IS: 7098- Part -2.

- **Insulator Screening**

Insulation screening shall be by means of extruded bonded strippable semi-conducting layer followed by a semi-conduction-water swell able tape and metallic screening by means of wrapped copper tape.
The cable core shall be triple extruded and cross-linked in fully enclosed process such that the inner semiconducting screen, XLPE insulation and outer semi-conducting screen are applied simultaneously on the pre-heated cable conductor. In-line inspection mechanism shall continuously monitor the dimensional accuracy of the extruded core.
The cable will be tested for partial discharges after application of the copper tape screen
as part of the Quality Control Procedure.

- **Insulation**

The insulating material for power cables shall be extruded cross-linked polyethylene (XLPE) compound as per **IS-7098(Part-I)-1988**. The minimum thickness of insulation shall not be less than the values specified in Table-2 of IS-7098 (Part-I)- 1988. No negative tolerance shall be applicable for the thickness. The insulation of the cable shall be designed and manufactured for the specified system voltage. The manufacturing process shall ensure that insulation shall be free from voids. The insulation shall withstand mechanical and thermal stress under steady state and transient operating conditions.
The cores shall be identified as per the following
colour scheme:
3-Core - Red, Yellow & Blue
3 ½ or 4-Core - Red, Yellow, Blue & Black

- **Core Layout**

The core identification for the 3-core cable shall be done by using coloured strips of Red, Yellow & Blue colours respectively for each phase. The three cores shall be laid up together with a suitable right hand lay as per IS: 7098 (Part-2).
The interstices shall be filled with Non-hygroscopic material. The filler at the centre of the three cores shall be of vulcanised rubber. The filler shall be fresh material, recycled PVC material is not acceptable. The filling material shall be suitable for the operating temperature of the cable and compatible with the insulating material. The filler material should be non-hygroscopic, fire retardant and compatible with sheath.

- **Inner Sheath**

The inner sheath shall be extruded FRLS PVC, Type ST2, compatible with thermal rating of insulation conforming to IS-6380-1984. The sheath shall have adequate thickness, mechanical strength and elasticity, as specified in IS 5831. The material shall be soft thermoplastic type, applied by extrusion method. The thickness of the inner sheath shall be as per IS: 7098 (Part I & II) and the color of the inner sheath shall be Grey. The inner sheath shall be so formed that it fits closely on the laid up cores and could be easily removed without damaging insulation. One or more layer of proofed plastic tape shall be provided over the laid up core before extrusion.

- **Armouring**

The armouring arranged over the inner sheath shall consist of one layer of galvanized round steel wires for all sizes of cable. The armour round wire used on the cable shall conform to IS: 3975 for all requirements. The direction of lay of armour shall be opposite to that of the cores. The zinc coating on the galvanized steel strip shall comply with relevant standards. The joints in armour wires/strips shall be made by brazing or welding and the surface irregularities shall be removed. A joint in any wire/strip shall be at least 300 mm away from the nearest joint in any other wire/strip in the completed cable.

- **Outer Sheath**

Extruded outer sheath shall be provided over the armouring. The material used for sheathing shall be FRLS PVC sheath, Type ST-2 base compound conforming to IS 1554/ IS 5831 for power cable. The outer sheath shall be so formed that it fits closely on the laid up armour and could be easily removed without damaging the intermediate sheath and insulation. The colour of the outer sheath shall be black. The thickness of outersheath shall be in accordance with the IS 1554 (Part-I & II)-1988. Suitable additives shall be added to prevent attack by rodents and termites. All serving must be given anti-termite treatment. The PVC compound used shall be abrasion proof, chemical resistant, provide protection against ants, termites, rodent and fungal growth.

Cables shall have suitable fillers laid up with the conductor to provide a substantially circular cross section before the sheath is applied. Fillers shall be suitable for the temperature of the cable and compatible with the insulating material. The material shall be of the best quality and workmanship. The fillers and sheath material shall be non-hygroscopic. All materials shall be new, unused and of the finest quality.

- **End Sealing, Joining and Joining Material**
  - **End Sealing Materials:**

The two ends of the cable shall be sealed by means of non-hygroscopic sealing materials preferably by Heat shrinkable end caps. Each drum shall be supplied with two numbers additional heat shrinkable end caps.

- **Jointing & Jointing Materials:**

Supplier shall indicate jointing procedures for terminal joints / straight joints of XLPE cables at motors, transformers and in switchgear. Detailed write-up shall be given along with the bid detailing the procedure for jointing along with drawings.

2.1.91. INSPECTION & TESTING

All the tests specified below shall be carried out in accordance with the Indian Standards by the manufacturer in the presence of Purchaser's representative. If the cable fails to pass the test specified, the Purchaser shall have the option to reject it. Shipping release shall be obtained from the Purchaser's representative. The Purchaser, however reserves the right to waive off the inspection.

The tests at works shall include electrical, mechanical and hydraulic tests in accordance with the appropriate clauses of Statutory Regulation, relevant codes and standards, in addition any test called for by the Purchaser or his representative to ensure that the equipment being supplied fulfils the requirement of the specification. For test not covered by any code or specifically mentioned in this specification, the test procedures are to be agreed with the Purchaser.

- **Stage Inspection**

i. The Purchaser's representative shall have access to the Supplier's works for the purpose of witnessing the tests and to ascertain that the cable being manufactured conforms to the requirements of this specification.

ii. The Purchaser's representative shall have a stage inspection during the following, important stages of production processes at manufacturer's works.

a. During Triple Extrusion process.
b. The cables will be tested for partial discharges after application of the copper tape screen as part of the stage inspection.

iii. During stage inspection the following tests shall be carried out.

a. Tensile strength
b. Elongation at break
c. Hot set test
d. Permanent set
e. Partial discharge test
f. IR before and after HV test
g. High voltage test
h. Conductor resistance test.

iv. Purchaser will witness triple extrusion process. Advance intimation shall be given to the Purchaser before starting of triple extrusion process. Ensure that online thickness monitoring unit (SIKORA) is in working condition. If online thickness monitoring unit is not working at triple extrusion point then production and as well as stage inspection shall not be carried out.

v. The customer will see the stabilizing point during triple extrusion process. Bubbles and other uneven surfaces shall not appear on the cable coming out of CCV line. If any bubbles or any other abnormality observed on the triple extruded single core cable at the end of the triple extrusion process then upto that point cable shall be cut and shall not become part of supply.

vi. After completion of water cooling of triple extruded line, residual moisture on the cable shall be removed with sufficient number of heaters. At the end of the CCV line, heaters in all the angles shall be placed to remove the residual moisture on the cable.

vii. Hot air blower shall be provided at the end of the CCV line, so that moisture on surface of the triple extruded core will get evaporated. It has to be ensured that there shall not be any water on surface of the core of the cable before winding it on to a cable drum. Sufficient delay (1 day) shall

be given between end of triple extrusion process and winding of water swellable tape. & copper foil. (To avoid trapped moisture in copper foil).

- **Pre-Dispatch Inspection**

The manufacturer shall be given at least 15 days advance notice prior to the commencement of testing, so that Purchaser's representative can plan to witness the tests.
All the tests indicated in the test clause of this specification shall be carried out in the presence of Purchaser's representative by the manufacturer and shall provide all the facilities and equipment for testing.
Six copies of the Test Certificate shall be furnished to the Purchaser for approval prior to dispatch of cables from factory.
Visual check to conform the details given in this specification is to be done. In addition to the above, the general workmanship of the cable drums and cables laid in drums shall be checked.
Manufacturer shall have proper test set up for testing all the routine tests & type tests on finished cables as per IEC.

- **Type Test**

Type tests on four randomly selected cable drums will have to be conducted in the presence of the department's representative. The test samples will be taken from finished cables. This test shall be in accordance to IS: 7098, Part-1,1988.

a. Test on Conductor
- · Annealing test for copper conductors
- · Tensile test for aluminium conductor
- · Wrapping test for aluminium conductor
- · Conductor Resistance Test

b. Test on Insulation
- · Physical dimension measurement
- · Tensile strength and elongation at break
- · Hot set test
- · Shrinkage test
- · Ageing in air oven
- · Water absorption test

c. Test on round Armour
- · Physical dimension measurement
- · Tensile strength
- · Elongation at break
- · Torsion test for round wires
- · Winding test for firmed wire
- · Mass of zinc coating.
- · Uniformity of zinc coating
- · Resistivity measurement, Resistance test for armour

d.Test on Sheath
- · Physical dimension measurement
- · Tensile strength & Elongation at break test
- · Ageing in air oven
- · Loss of mass in air oven
- · Shrinkage test
- · Hot deformation test
- · Heat shock test
- · Thermal stability test

e. Partial discharge test
f. Dielectric power factor test

- As a function of voltage
- As a function of temperature

g. Insulation resistance (volume resistivity test)
h. Heating cycle test
i. Impulse withstand test
j. High voltage test
k. Flammability test
l. Water tightness test in longitudinal and radial direction (Manufacturer shall submit detailed procedure for this test and shall take prior approval of the engineer-in-charge).
m. Conductor purity test
One sample of aluminium shall be taken from any of the finished set of cables at random and the sample shall be tested for its purity at a NABL accredited lab.

i. *Test requirement of FRLS inner and outer sheath*

The inner and outer sheath of cables shall meet the following test requirements related to flame retardant, low smoke emission, low acid and toxic gas emission. The BIDDERs shall have proper test apparatus to
conduct all the relevant tests as per the applicable standards:

· Flame retardant test on single cable
· Oxygen Index Test

The critical oxygen index value shall be minimum 29 when tested at 27+2ºC as per ASTMD-2863

· Temperature index test

Temperature index value shall be minimum 250ºCat oxygen index of 21 when tested as per NES 715.

· Flammability test

Cables shall pass test under fire conditions as per IS-10810- Part-53. Cables shall also pass tests as per IS-10810 Part- 61 & Part-62. Flammability shall be as per IEC 332-1 and IS 694: 1990.

. Smoke Density Test

The cables shall satisfy the tests conducted to evaluate the percentage obscuration by smoke in an optical system placed in the path of the smoke. The maximum smoke density rating shall not be more than
60% when tested as per ASTM-D-2843.

· Acid Gas Generation test (halogen acid gas evolution)

The hydrochloric acid generation when tested as per IEC 754-1 shall be less than 20% by weight.

· Test for specific optical density of smoke
· Anti termite and rodent property test

The sequence of electric tests shall be as per the relevant Indian/International standards. The Bidder shall submit the sequence of tests for the approval of the purchaser before conducting the tests. A copy of the adopted standard shall also be supplied.

Routine Test (On each drum)

The following routine tests shall be carried out by the Manufacturer on each and every length of the cable in the presence of Purchaser's representative at manufacturer's works.
a. Resistance test for conductors
b. Insulation resistance (Dry) test
c. High voltage test
d. Partial discharge test.

- **Conductor purity test**

Two samples of aluminium and copper shall be taken from any of the finished set of cables at random and the sample shall be tested for its purity at a NABL accredited lab.

Qualifying Criteria:

The test results should be within limits as per IS 7098. All the routine tests as per IS 7098 / IEC shall be conducted and passed as per the limits given in the standards. All the bought-out certificates will be verified, and the test results shall be as per respective standards.

- **IDENTIFICATION**

The following details shall be marked sequentially for each meter run length of the cable by non-erasable embossing on the outer sheath:

a. Reference to Indian Standard
b. Name of the manufacturer/ Trade Name
c. Name of the project: **CWMF, BARC (K)**
d. Configuration of the cable: viz. Voltage grade, no. of Core, Sq. mm, A2XWY/2XWY/YWY / YY as applicable
e. Year of manufacturing
f. Sequential marking of running meter length
The running length of the cable shall be identified at regular intervals of one meter (Increasing order from inner end to outer end of the cable.

- **PACKAGING**

  - Each drum shall consist of single length cable ≥ 500 metres.
  - The cable shall be wound on *non-returnable steel drums* of suitable size, packed and marked.
  - Packing shall be sturdy to protect the cable from any injury during transportation, handling and storage. The cut ends of the cable shall be sealed by means of non-hygroscopic sealing material preferably Heat shrinkable end caps.
  - One end of the cable shall be brought out of the drum and suitably clamped to the drum flange with proper mechanical protection. Location of the other end may be marked on the drum.
  - The cable shall be placed on drums in such a manner that it will be protected from injury during transit. Each end of the cable shall be firmly and properly secured to the drum. No undue stress shall appear on cables when laid on drums.

- The cable drum shall carry the following information stencilled on a metallic label, securely attached to each end of the drum:

i. Reference to the Indian standard
ii. Manufacturer's name, brand or trade mark
iii. Type of cable and voltage grade
iv. No. of cores
v. Nominal cross-sectional area of conductor
vi. Cable code
vii. Length of cable on drum
viii. No. of lengths on reel, drum or coil (if more than one)
ix. Gross weight
x. Country of manufacture
xi. Year of manufacture

xii. Direction of rotation of drum (an arrow)
xiii. ISI certification mark

- **PREFERRED MAKE**

Reputed brand possessing system certification of ISO 9001:2008, ISO14001:2004, OHSAS18001:2007 & EN 16001- 2009 and product certifications IS: 7098 (Part-I), CE, UL etc. Quotations without these certification details will not be considered for technical evaluation.
Preferred make of bought out material:
a. Aluminium for Conductor: Reputed brands
b. Copper for Conductor: Reputed brands
c. XLPE compound of Insulator: Reputed brands
d. Armour Steel: Reputed brands

- **GUARANTEE**

All the cables shall be guaranteed against faulty material, defective design & poor workmanship for a period of 18 months from the date of supply. The materials becoming defective during the guarantee period shall be replaced free of cost and the defects arising out of the works shall be rectified free of charge without delay.

TECHNICAL DATA SHEET

TECHNICAL DATA SHEETS FOR 6.35 / 11 KV (E) 3 CORE ARMOURED, SCREENED HT XLPE CABLES

S.No.	Description	cores x sq.mm	3 C x 400
1	**GENERAL**		
	Cable Type / Code	sq.mm.	A2XFY
	Voltage Grade		6.35 / 11 KV (E)
	Standards Applicable		IS:7098 (P-2) 2011, IS:5831-1984, IS:8130-1984, IS:3975
	Extrusion method	mm	Triple Extrusion
2	**CONDUCTOR**		
	Material		Stranded (Class 2) Compacted Circular Aluminium Conductor as per IS 8130
	Cross Sectional Area	mm	400
	Min No of strands	ohm - cm	53
3	**CONDUCTOR SCREEN**		
	Material		Extruded Non-Metallic Semi Conducting Compound
	Thickness (Min)		0.3
4	**INSULATION**		
	Material		Extruded, XLPE as per IS: 7098 Part-2
	Thickness (Nom.)	mm	8.8
	Volume Resistivity		
			1 x 10^14
5			1x 10^12
	at 27 deg C		90 Deg .C.
6	at 90 deg C		250 Deg. C.
7			
8	**CONDUCTOR TEMPERATURE**	mm	Extruded Non-Metallic Semi Conducting Compound
	Rated		0.3
	During short circuit	mm	
9	**INSULATION SCREEN**		0.04 mm Copper Tape
	Material		Red, Yellow & Blue Stripes Below Copper Tape
	Thickness (Nom)	ohm/km	
10	**METALLIC SHIELD**	ohm/km	
	Material & Thickness		Extruded PVC Type ST-2 as per IS:5831
	CORE IDENTIFICATION	Amps	0.7
	INNER SHEATH	Amps	Black

S.No.	Description	cores x sq.mm	3 C x 400
11	Material	µF/km	
	Thickness (Min.)	Ohm/km	Galvanised Steel Flat Strip as per IS:3975
	Colour		4 x 0.8
12	**ARMOUR**		
	Material		Extruded, PVC Type ST-2 as per IS: 5831
	Thickness(Nom)		3.00
	OUTER SHEATH		Black
	Material		
	Thickness (Min.)		0.0778
	Colour		0.1000
	ELECTRICAL DATA		
	Max.D.C. resistance at 20deg.c.		395
	A.C. resistance		530
	at 90 deg C		0.250
	Current rating		0.0971
	in ground at 30		
	deg C in air at 40		
	deg C		
	Approx. capacitance		
	Approx reactance at 50 Hz		
	Short circuit current rating	KA	37.60
	Impulse voltage withstand capacity		170 KV
		mm	103.0
			+/- 3mm
	CABLE DATA		CABLE ELECRTIC, Voltage Grade, CABLE SIZE, YEAR OF MFR.
13	Approximate overall dia of cable		
	Tolerance on overall dia		15 x D mm
	Printing / Embossing		250 mtrs
	Min. Bending radius		+/- 5
	Drum Length (Non-returnable	shall be prov	+/- 5
14	wooden drum)	one mtr	
	Drum Tolerance (%)		
	Overall Tolerance (%)		
15	Sequential length marking		

Cables are conforming to IS: 7098(Part - 2)2011

TECHNICAL DATA SHEET

DATA SHEETS FOR LT XLPE 3.5C ALUMINIUM ARMOURED CABLES

S No	Description	cores x sq.mm	3.5 C x 240 to 400
1	**GENERAL**		

			A2XFY
	Voltage Grade		650/1100 volts
	Standards Applicable		IS: 7098 (Part I) 1988, IS:5831-1984, IS:8130-1984, IS:3975
2	**CONDUCTOR**		
	Material		Stranded Compacted Setor shaped Aluminium conductor as per Class-2 of IS:8130-1984
	Cross Sectional Area (M/N)	sq.mm.	240/120
	Max.C.R.@ 20°c.(M/N)	ohms/km	0.125/0.253
3	**INSULATION**		
	Material		Extruded Cross-linked polyethylene (XLPE) as per IS:7098 Part-1
	Thickness (Nom.)	mm	1.7/1.2
	Volume Resistivity	ohms-cm	
	at 27 deg.c.		1 x 10^14
	at 90 deg.c.		1x 10^12
	CONDUCTOR TEMPERATURE		
	Rated		90 Deg .C.
	During short circuit		250 Deg. C.
4	**INNER SHEATH**		
	Material		Extruded PVC Type ST-2 as per IS: 5831-1984
	Thickness (Min.)	mm	0.60
	Calculate dia over laid up cores	mm	46.90
	Colour		Black
5	**ARMOUR**		
	Material		Galvanised steel Flat Strip as per IS: 3975
	Size	mm	4 x 0.80
	Calculated dia under armour	mm	48.10
6	**OUTER SHEATH**		
	Material		Extruded PVC Type ST-2 as per IS: 5831-1984
	Thickness (Min.)	mm	2.04
	Colour		Black
	Approx.overall dia of cable	mm	51.70
	Tolerance on overall dia		+/- 3mm
7	**ELECTRICAL DATA**		
	Max DC resistance at 20 deg C	Ohm /Km	0.1250
	AC Resistance at 90 deg C	Ohm/km	0.1600
	Capacitance	µF/Km	0.63
	Reactance at 50Hz	Ohm/Km	0.072
8	**Current Ratings**		
	In ground at 30 deg C	Amps	327
	In air at 40 deg C	Amps	392
	Short circuit rating for 1 second	KA	22.6
9	**Cable Data**		

	Drum Length (Non-Returnable Wooden Drum)	meters	500
	Drum Tolerance (%)		+/- 5
	Overall Quantity Tolerance (%)		+/- 5
	Core indentification		3.5 Cores - Red,Yellow,Blue, Black
	Printing / Embossing		CABLE ELECTRIC, Voltage Grade, Cable Size ,Year Of Mfg
	Min. Bending radius		15 x D
10	Sequential Marking		Shall be provided

Cables are conforming to IS: 7098(Part-1) 1988

2.1.92. CABLE TERMINATION:

Cable terminations shall be made with aluminium crimped type solder less lugs for all aluminium cables and stud type terminals. For copper cables copper crimped solder less lugs shall be used. Crimping shall be done with the help of hydraulically operated crimping tool.
For joints where by cable is with aluminium conductor and bus bars are aluminium, bimetallic lugs shall be used with compound. CUPAL type of washers shall be used. Crimping tool shall be used for crimping any size of cable.

2.1.93. CABLE GLANDS:

Cable glands shall be of brass single compression type. Generally single compression type cable glands shall be used for indoor protected locations and double compression type shall be used for outdoor locations.

2.1.94. FERRULES:

Ferrules shall be of self-sticking type and shall be employed to designate the various cores of the control cable by the terminal numbers to which the cores are connected, for ease in identification and maintenance.

2.1.95. CABLE JOINTS:

Kit type joint shall be done and filled with insulating compound. The joint should be for 1.1 KV grade insulation.

2.1.96. CABLE LAYING

The scope consists of Design, manufacture, shop testing, supply at site, storage, cable trays, cable supporting angles, and accessories for trays, cable supporting angles, and accessories for cable erection such as glands, lugs, Hume pipes etc. tray covers, cable route markers for buried cable trench, including all accessories, fittings and sundry materials to make the job complete.

The scope includes supply of Perforated type cable trays for control room cables including all accessories, fittings and supports. Successful we of this contract shall be responsible for any loss or damage or additional cost for completion of control room.

This section covers laying of cables, in cable trenches cable jointing, termination at both ends and testing of the complete cable installation. The trench shall be leveled to the formation level of the

yard. The cable route is shall be marked at regular intervals of 10 M by providing cable route marking pegs.

Cable schedules and drawing indicating the cable routing shall be furnished by the for approval. The cable laying shall be done strictly as per approved schedules.

Cable lugs shall be provided by the we for cables. We shall supply all other cable terminating accessories, like jointing ferrules, cable clamps, cable grips, cable compound flux, tapes, etc., as necessary and shall include supply of such accessories in the quoted rates. Dressing/bunching of all individual cores of the cables shall be done in a neat fashion. The we shall drill holes suitable for the cables in cable gland plate.

Cable lugs shall be compressed on the conductor ends by means of tools. Insulating sleeves shall be furnished and covered over the bare ends of the connections so as to prevent accidental contact with the ground or with the adjacent terminals.

The insulating sleeve shall be fire resistant, and long enough to over pass the conductor insulation and shall be of correct size of the conductor used.

Cable entering the control room from out door areas shall be sealed.

Standard cable grips and seals shall be utilized for cable pulling after pulling cable, the we shall put and attach aluminum cable markers at both ends of the cables and at the control room entry. The cable number and other data shall be punched and the cable markers are shall be securely attached to the cables.

Cable shall not be jointed and used for laying purpose. When necessary the approval of the Engineer at site should be taken before resorting at jointing.

Sharp bending cables shall be avoided. Cables shall cross control room basement wall in 4" A.C. Pipe embedded in cement concrete in basement wall. These pipes shall be supplied and installed by we.In each cable run some extra length shall be kept at a suitable point to enable one or two straight through joints shall be made.
The bidder shall put sufficient lengths of each cable to permit neat arrangement of all cables.

Cable splices shall not be permitted except where called for or where permitted by the purchaser.

At cable terminal points where the conductor and cable insulation shall be terminated, termination shall be made in a neat, workman like and approved manner by men specialized in this class of work.

Before any cable terminal connections are made, conductor's insulation shall be pulled out, at the end and identifying ferrules shall be fixed according to the wiring diagrams. Connection shall be made according to the wiring diagram

Polarity, or phasing shall be checked before connections are made and the we without additional cost shall make corrections of polarity, phasing or rotation.

Control cable terminations shall be made in accordance with wiring diagram using color codes established by the purchaser for the various control circuits, by code marked wiring diagrams

furnished to the we for this purpose or any other approved means of identification. It is the intent that the we shall terminate the cable where the contractor lays.

Additional work of testing and reconnecting where leads have been brought to the terminal boards and connected, but where on further testing, reversed or other rearrangement of load turns out shall be necessary shall be performed by the we without additional cost.

Jointing of cables shall be in accordance with Indian Standard codes. The we shall arrange the manufacturers special instructions on materials and tools required for cable jointing work. Metal sheath and armour of the cable shall be connected to the Earthing system of the station by a steel strip wire. The we shall furnish two sets of marked up cable layout drawings after installation, indicating altered cable routes and location of straight joints.

Cable from equipment to trench shall run in GI conduits. Necessary conduits of adequate sizes and length shall be supplied and installed by the we. Flexible conduit should be used between fixed conduit/cable trays (perforated type) and equipment terminal boxes, where vibration is anticipated. The flexible conduit shall be as per relevant IS.

11.12 POST INSTALLATION CHECKS ON CABLE TRAYS:

The following shall be checked before laying the cables on the trays:-

1. Check for proper painting and identification numbers of cable trays.
2. Check for continuity of power and control cable trays over the entire route.
3. Check that oil, sharp washers, bars and waste material have been removed from the trays.

Check for earth continuity and earth connection of cable trays.

INTERNAL WIRING

Providing fixing and layout of electrical system unit including fixtures, wiring, cabling conduting fixing & connecting to the mains panel distribution boards, power points, light points and earthing system. The work to be carried out as per electricity safety rules and practices materials used shall be ISI approved only.

2.1.97. TECHNICAL SPECIFICATIONS

- **GENERAL SCOPE OF WORK**

The electrical scope of work covers the followings:
a. Internal electrification through concealed/surface PVC conduit and provide light points and socket outlets as shown in the detailed drawings.
b. Provide telephone outlets as shown in the detailed drawings.
c. Provide Distribution panel at convenient locations to facilitate power for lights, fans, sockets, power plugs data points through UPS supply. UPS supply shall be separate..
d. Provide Power distribution network including Panels, cabling, mains and sub-main wiring.
e. Scope of work shall include supply installation, testing and commissioning of complete

electrical installation
f. Earthing of electrical installations complete in all aspects.

2.1.98. REGULATIONS AND STANDARDS

The installation shall conform in all respects to Indian Standard Code of Practice for Electrical wiring installation IS:732-1963 and IS:2274-1963. It shall also be in conformity with Indian Electricity Rules and the Regulations, National Electric Code and National Building Code. CPWD specifications and requirements of the Local Electric Supply Authority. In general, all materials, equipment and workmanship shall conform to the Indian Standards, specifications and code. Some of the applicable codes/standards are as under:

The following standards and rules shall be applicable:

IS: 1646 Code of practice for fire safety of buildings (General) Electrical installation

IS: 4648 Guide for electrical layout in residential building Indian electricity act and rules.

IS 375 – 1963 Marking and arrangements for switchgear: Bus bars, main connection and auxiliary
wiring.
IS 2675 – 1983 Specifications for enclosed distribution

IS10118-1982 Installation and maintenance of switchgear.

IS 1554 – 1988 Specifications for PVC insulated (heavy duty) electric cable Part-I for voltage up to 1100 volts.
IS 694-1990 Specifications for PVC insulated: Cables for voltage up to 1100V with Aluminium conductors.

IS 9537 – 1981 Specifications for Rigid Steel conduit for electrical wiring.

IS 3837-1976 Specifications for accessories for rigid steel conduits for electrical wiring.

IS 5133 – 1969(Part-I) Boxes for the enclosure of electrical accessories, Steel and CI boxes.

IS 1293 – 1988 3 pin plugs and socket outlets

IS 1913 – 1978 General and safety requirements for electric lighting fittings.

IS 374 – 1979 Electric ceiling fans and regulators.

IS 3043 – 1987 Code of practice for earthing

IS 1646 – 1982 electrical installation.

IS 2705 – 1992 Current transformers

IS 1248 – 1983 Direct acting electrical indicating instruments.

IS 8623 Factory built assemblies of switch gear & control gear.

IS 8828 MCB

IS 2516 MCCB

IS 13947 SFU

IS 12640 ELCB

2.1.99. INTERNAL ELECTRIFICATION OF BUILDING

SCOPE

Under this head, the bidder is to carry out the internal electrification of the auditorium as mentioned under para 1.0.

The scope covered under this head includes concealed/surface conduiting, wiring, provision of distribution boards, submains/mains and fittings.

- **GENERAL**

The electrical Installation work shall be carried out in accordance with Indian Standard Code of Practice for Electrical Wiring Installation IS: 732-1989 and IS: 2274-1963. It shall also be in conformity with the current Indian Electricity rules and regulations and requirements of the Local Electricity Supply Authority and Fire Insurance regulations, so far as these becomes applicable to the installation. Electrical work in general shall be carried out as per following CPWD Specifications with up to date amendment.

General Specifications for Electrical Works. (Part I - Internal) – 1994.
Wherever this specification calls for a higher standard of material and or workmanship than those required by any of the above mentioned regulations and specification then the specification here under shall take precedence over the said regulations and standards.

2.1.100. DISTRIBUTION BOARDS

Distribution Board shall be standard type as per the CPWD specifications. All distribution boards shall be of three phase (415 Volts) or single phase (240 volts) type with incoming isolator or MCB as in Schedule of quantities. Distribution boards shall contain plug in or bolted type miniature circuit breaker mounted on busbars. Miniature circuit breakers shall be quick make and quick break type with trip free mechanism. MCB shall have thermal and magnetic short circuit protection. MCB shall conform with IS 8828-1978. Neutral busbars shall be provided with the same number of terminals as there are single ways on the board, in addition to the terminals for incoming mains. An earth bar of similar size as the neutral bar shall also be provided. Phase barrier

shall be fitted and all live parts shall be screened from the front. Ample clearance shall be provided between all live metal and the earth case and adequate space for all incomingand outgoing cables. All distribution board enclosures shall have an etched zinc base stove painted followed by synthetic stoved enamel, colour light gray.

A circuit identification card in clear plastic cover shall be provided for each distribution board. Miniature Circuit Breakers for lighting circuits shall be of "L" series where as `G' series MCB's shall be invariably used for motor loads, halogen lamps fitting, sodium/mercury discharge lamps and for all power circuits. All miniature circuit breakers shall be of 9 KA rated rupturing capacity.

2.1.101. SURFACE CONDUIT

Conduit pipes shall be fixed by heavy gauge saddles, secured to suitable wood plugs or other approved plugs with screws in an approved manner at an interval of not more than one meter but on either side of the couplers or bends or similar fittings, saddles shall be fixed at a distance of 30cm from the center of such fittings. The saddles should not be less than 24 gauge for conduits upto 25 mm dia and not less than 20 gauge for larger diameter conduits. The corresponding widths shall be 19 mm & 25 mm. Where conduit pipes are to be laid along the trusses, steel joint etc. the same shall be secured by means of special clamps made of MS. Whereas it is not possible to drill holes in the trusses members suitable clamps with bolts and nuts shall be used.

For 25 mm diameter conduit width of clip shall be 19mm and of 20 SWG. For conduit of 32 mm and above, width of clip shall be 25mm and of 18 SWG.
Where conduit pipes are to be laid above false ceiling, either conduit pipes shall be clamp to false ceiling frame work or suspended with suitable supports from the ceiling slab. For conduit pipe run along with wall, the conduit pipe shall be clamped to wall above false ceiling in uniform pattern with special clamps if required to be approved by the Engineer-In-Charge at site.

2.1.102. RECESS/CONCEALED CONDUIT

The chase in the wall shall be neatly made and of ample dimensions to permit the conduit to be fixed in the manner desired. In the case of building under construction, conduit shall be buried in the wall before plastering and shall be finished neatly after erection of conduit. Incase of exposed brick/rubble masonry work, special care shall be taken to fix the conduit and accessories in position along with the building work. Entire work of chasing the wall, fixing the conduit in chases, and burring the conduit in mortor before plastering shall form part of point wiring work.

The conduit pipe shall be fixed by means of staples or by means of saddles not more than 60cm apart or by any other approved means of fixing. Fixing of standard bends and elbows shall be avoided as far as practicable and all curves maintained by bending the conduit pipe itself with the long radius which shall permit easy drawing in of conductors. Suitable inspection boxes to the barest minimum requirements shall be provided to permit periodical inspection and of facilitate replacement of wires, if necessary. These shall be mounted flush with the wall. Suitable ventilating

holes shall be provided in the inspection box covers. Wherever the length of conduit run is more than 10 meters, then circular junction box shall be provided.

2.1.103. OUTLET BOXES & COVERS

The switch box shall be made of metal on all sides except on the front. Boxes shall be hot dip galvanised mild steel. Upto 20 x 30 cm size M.S. box shall have wall thickness of 18 SWG and MS boxes above 20 x 30 cm size shall be of 16 SWG. The metallic boxes shall be painted with anticorrosive paint before erection. Clear depth of the box shall not be less than 60mm. All fitting shall be fitted in flush pattern. Phenolic laminated sheet of approved shade shall be used for switch box covers.
These shall be of 3 mm thick synthetic phenolic resin bonded laminated sheet as base material and conform to grade P-I of IS: 2036-1994.

2.1.104. ERECTION AND EARTHING OF CONDUITS.

The conduit if used metallic of each circuit or section shall be completed before conductors are drawn in. The entire system of conduit after erection shall be tested for mechanical and electrical continuity throughout and permanently connected to earth conforming to the requirement by means of special approved type of earthing clamp effectively fastened to conduit pipe in a workmen like manner for a perfect continuity between the earth and conduit. Gas, water pipe shall not be used as earth medium.

2.1.105. SWITCHES.

All 5 and 15 Amp switches shall be piano type of 240 volts A.C. grade. All switches shall be fixed on 3 mm thick laminated sheet cover. All 5 Amp socket shall be 5 pin type. All 15 Amp socket shall be 6 pin type suitable for 15/5 Amp. All switches, sockets, telephone outlets, etc. shall be in off white finish. The switches controlling the lights or fans shall be connected to the phase wire of the circuit. Switches shall be located at 1200 mm above finished floor level unless otherwise indicated on drawings. In dean, professor and lecturers rooms switches and socket outlets shall be modular type in modular metal box.

2.1.106. FLUSH COVER PLATE.

All switches, sockets, telephone outlets etc. shall be fixed on 3 mm thick phenolic laminated sheet cover. Flush cover plate shall be secured to the box with counter sunk brass screws & cup washers.

2.1.107. WALL SOCKET PLATE.

All 5 and 15 Amp socket outlet shall be 5 and 6 pin respectively. Each outlet shall have a switch located beside the socket preferably on the same flush cover plate. The earth terminal of the socket shall be connected to the earth wire.

2.1.108. WIRING

All PVC insulated stranded copper conductor wires shall conform to relevant IS Codes.

All internal wiring shall be carried out with PVC insulated FRLS wires of 650/1100 volts grade. The circuit wiring for points shall be carried out in looping in system and no joint shall be allowed in the length of the conductors. Circuit wiring shall be laid in separate conduit originating from distribution board to switch board for light/fan. A light/fan switch board may have more than one circuit but shall have to be of same phase. Looping circuit wiring shall be drawn in same conduit as for point wiring. Each circuit shall have a separate neutral wire. Neutral looping shall be carried out from point to point or in light/fan switch boards.

A separate earth wire shall be provided alongwith circuit wiring for each circuit. For point wiring red colour wire shall be used for phase and black colour wire for neutral. Circuit wiring shall be carried out with red, yellow or blue colour PVC insulated wire for RYB phase wire respectively and black colour PVC insulated wire for the neutral wires. Bare copper wire shall be used as earth continuity conductor and shall be drawn alongwith other wires. No wire shall be drawn into any conduit until all work of any nature, that may cause injury to wire is completed.

Care shall be taken in pulling the wires so that no damage occurs to the insulation of the wire. Before the wires are drawn into the conduit, the conduits shall be thoroughly cleaned of moisture, dust and dirt. Drawing and jointing of copper conductor wires and cables shall be as per CPWD specifications.
Maximum number of PVC insulated 650/1100 V grade aluminium/copper conductor cable conforming to IS: 694 – 1990

- **JOINTS.**

All joints shall be made at main switches, distribution board socket and switch boxes only. No joint shall be made in conduits and junction boxes. Conductors shall be continuous from outlet to outlet.

- **MAINS AND SUBMAINS.**

Mains and sub-main cable where called for shall be of the rated capacity and approved make. Every main and sub-main shall bedrawn into an independent adequate size conduit. Adequate size draw boxes shall be provided at convenient locations to facilitate easy drawings of the sub-main & main cables. Cost of junction box/drawn box is deemed to be included in the rates of sub main wiring. As independent earth wire of proper rating shall be provided for every sub-main. Single phase sub main shall have single earth wire whereas three phase sub main shall be provided with two earth wire. The earth wire of proper rating shall be fixed to conduits by means of suitable M.S. clips at not more than 1000 mm distance. Where mains and sub-mains cables are connected to the switchgear, sufficient extra lengths of sub main and mains cable shall be provided to facilitate easy connections and maintenance. For termination of cables creeping type cable socket/lugs shall be provided. Same color code as for circuit wiring shall be followed.

Nominal Sectional area of conductor in Sq.mm.	25mm S	25mm B	32mm S	32mm B	38mm S	38mm B	51mm S	51mm B	64mm Cross- S	64mm Cross- B
1	4	5	6	7	8	9	10	11	12	13
1.5	10	8	18	12	-	-	-	-	-	-
2.5	8	6	12	10	-	-	-	-	-	-
4	6	5	10	8	-	-	-	-	-	-
6	5	4	8	7	-	-	-	-	-	-
10	4	3	6	5	8	6	-	-	-	-
16	2	2	3	3	6	5	10	7	12	8
25	-	-	3	2	5	3	8	6	9	7
35	-	-	-	-	3	2	6	5	8	6
50	5	-	-	-	-	-	-	5	3	6
70	-	-	-	-	-	-	4	3	5	4

NOTE:

1. The above table shows the maximum capacity of conduits for a simultaneous drawing in of cables.
2. The columns headed `S' apply to runs of conduits which have distance not exceeding 4.25m between draw in boxes and which do not deflect from the straight by an angle of more than 15 degrees. The columns headed `B' apply to runs of conduit which deflect from the straight by an angle of more than 15 degrees.
3. Conduit sizes are the nominal external diameters.

- **LOAD BALANCING**

Balancing of circuits in three phase installation shall be planned before the commencement of wiring and shall be strictly adhered to.

- **COLOUR CODE FOR CIRCUIT & SUBMAIN WIRING.**

Colour code for circuit and submain wiring installation shall be Red, Yellow, Blue for three phases. Black for neutral and yellow/green or green only for earth incase of insulated earth wire.

2.1.109. CLASSIFICATION OF POINTS.

- **General**

Classification and measurement of Point wiring shall be as per CPWD specification for Electrical Works (Part-I-Internal)1994.

- **CONDUCTOR SIZE.**

Wiring shall be carried out with following sizes of PVC insulated stranded single core copper conductor wire/cable.

i. Light point. - 1.5Sq.mm
ii. Ceiling /Cabin/Exhaust Fan Point - 1.5Sq.mm
iii. Call Bell Point - 1.5Sq.mm
iv. Plug Point (5 A S.S. outlet) - 1.5Sq.mm
v. Circuit Wiring - 2.5Sq.mm
vi. General Power Point – 4Sq.mm

2.1.110. LIGHTING FIXTURE AND FANS

- **GENERAL**

a) The Contractor shall supply and install lighting fixtures including but not limited to lamps, ballasts, accessories fixing hardware necessary for installations, as shown on the Drawings, as required, and as herein specified.
b) All fixtures shall be delivered to the building complete with suspension accessories, canopies, hanging devices, sockets, holders, reflectors, ballasts, diffusing material, louvers, plaster frames, recessing boxes, etc. all wired and assembled as indicated.
c) Full size shop detail drawings of special fixture or lighting equipment, where called for in the fixtures schedule, shall be submitted to the Engineer in-charge for approval.
d) Fixtures, housing, frame or canopy, shall provide a suitable cover for fixture outlet box or fixture opening.
e) Fixtures shall comply with all applicable requirements as herein outlined
f) Manufacturer's name and catalogue number of lighting fixtures are given for general reference only. It shall be understood that the actual fixtures supplied shall meet all the requirements of the specification, and, if necessary, the standard fixture indicated for reference, shall be modified accordingly.
g) Fixtures shall bear manufacturer's name and the factory inspection label.
h) Fixtures shall be completely wired and constructed to comply with the IEE wiring regulations requirements for lighting fixtures, unless otherwise specified.
i) Revamping the fixture shall be possible without having to remove the fixture from its place.
j) Lamps of the proper type, wattage and voltage rating shall be furnished and installed in

each fixtures.

- **WIRING WITHIN THE FIXTURES**

a) Fluorescent fixtures shall be wired with not smaller than 1.5 sq. mm asbestos-covered wire. No splice or tap shall be located within an arm, stem or chain. Wire shall be continuous from splice in outlet box of the building wiring system to lamp socket or to ballast terminals.
b) Wiring within incandescent fixtures and for connection to the branch circuit wiring up to the outlet box of lighting point shall not be less than 1.5 sq. mm silicone rubber insulated wire. (150oC temperature).

- **INSTALLATION**

Fixtures shall be installed at mounting heights as detailed on the Drawings or as instructed on site by the Engineer-In-charge.

Pendent fixtures within the same room or area, shall be installed plumb and at a uniform height from the finished floor. Adjustment of height shall be made during installation.

Flush mounted recessed fixtures, shall be installed so as to completely eliminate leakage of light within the fixture and between the fixture and adjacent finish.

Fixtures mounted outlet boxes shall be rigidly secured to a fixture stud in the outlet box. Hickeys or extension pieces shall be installed where required to facilitate proper installation.

2.1.111. ENERGY EFFICIENT LED BASED LUMINAIRE UNIT FOR INDOOR & OUTDOOR LIGHTS

- **SCOPE**

The scope of work includes design, development, manufacturing, testing, supply, installation and commissioning of energy efficient luminiar complete with all accessories, LED lamps with suitable current control driver circuit including mounting arrangement for recessed type & ceiling mounting arrangements. The luminiar shall be suitable for rugged service under the operational and environmental conditions encountered during service. The following types of luminaries are required to be provided:
1. LED Tube Light/ LED Line fitting
2. LED Bulb

Sl No	Place/Location	Type of lighting Fixture	Lighting level
1	Main control room	LED	300 lux
2	Other areas inside The pump house	-Do-	100 lux
3	Machine hall (high bay)	LED	250 lux

4	Transformer bay	LED	200 lux
5	Switch yard and other approach Roads	LED	150 lux

Each type of luminarie shall be supplied with associated driver circuit compatible with LEDs in all respect as required including complete optics.

- **SERVICE CONDITIONS:**

Indoor lights on pipe/Recess mounting type light unit complete with luminaries and mounting accessories shall be suitable for Buildings(indoor) of pump hous under the following environmental conditions: -

Environmental conditions

Maximum ambient air temperature: 45□ C

Minimum ambient air temperature: -5□ C

Max. Relative humidity 100%

Atmosphere Extremely dusty and desert weather and desert terrain in certain areas. The dust contents in air may reach as high values as 1.6 mg/m3

Coastal area: The equipment shall be designed to work in coastal area in humid, salt laden and corrosive atmosphere.

- **REFERRED STANDARDS**

IS: 513 Cold-rolled low carbon steel sheets and strips

IEC 60529 Classification of degree of protections provided by enclosures.

EN 55015, CISPR15 Limits and methods of measurement of radio disturbance characteristic of electrical lighting and similar equipment

IEC 62031 LED modules for general lighting-Safety requirements

EN 61547 Equipment for general lighting purposes – EMC imunity requirement.

EN 60929 Performance, AC supplied electronics ballast for tubular fluorescent lamps performance requirement.

IEC 60598-2-1 Fixed general-purpose luminaries

IEC 60598-1 Luminaires - General requirement and tests

IEC 61000-3-2 Electro Magnetic compatibility (EMC) -Limits for Harmonic current emission –– (equipment input current ≤ 16 Amps. per phase.

IEC 60068-2-38 Environmental Testing: Test Z- AD: composite temperature/ humidity cyclic test

IEC 61347-2-13 Lamp control gear: particular requirements for DC or AC supplied electronic control gear for LED modules

IS 10322 Specification for the luminaries

IS 4905 Method for random sampling

LM 79 LED luminaire photometry measurement

LM 80 Lumen Maintenance

IEC 62384 DC or AC supplied electronic control gear for LED modules performance requirements

IEC/PAS 62612 Self-ballasted LED lamps for general lighting services- Performance requirements

- **CONSTRUCTION**

a. All the luminiars shall be finalized based on the performance feedback. The detailed calculation for lux level as per clause no.5.8 with uniform distribution including the lux distribution curve /graph distribution shall be submitted in support of the dimensions selected and variation thereof. Housing, if not used as a heat sink shall be made of at least 0.8 mm thick sheet Steel conforming to IS: 513 (Grade O)/CRCA polyester powder coated of at least 60 microns) and high U.V. & corrosion resistance. Heat sink used should be aluminum extrusion having high conductivity preferably to grade 6061 alloy or better having thermal conductivity of at least 170-180 W/m.K or Aluminium die cast having high conductivity preferably ADC 12 or LM 24. Efforts shall be made to keep the overall outer dimensions as minimum as possible.

All luminaires shall be provided with toughened glass of min. 0.8 mm thickness of sufficient strength and high efficiency (90%) prismatic diffuser under the LED chamber to protect the LED and luminaries. And shall not show yellowness during luminarie life time.

1.Tube Light /Line fitting
2. LED Bulb

Suitable number of LED lamps shall be used in the luminiars. LED lamps of Reputed make shall be used for the purpose. The manufacturer shall submit the proof of procurement of LEDs from above OEMs at the time of testing. Suitable reflector / lenses may also be provided to increase the illumination uniformity and distribution. Supplier will be solely responsible for testing and performance of the luminaries after installation and shall also ensure the specified and uniform illumination and comfort level on the work desk/ floor. Design of the thermal management shall be done in such a way that it shall not affect the properties of the diffuser.

High power and high lumen efficient LEDs suitable for following features shall be used:

- The efficiency of the LED lamps at 85 Deg C junction temperature shall be more than 85%.
- The working life of the lamp at junction temperature of 85 Deg C at rated current shall be more than 50,000 working hours of accumulative operation and shall be suitable for

continuous operation of 24 hours per day. These features shall be supported with datasheet.

- Adequate heat sink with proper thermal management shall be provided.
- Colour temperature of the proposed white colour LED shall be 5700k (nomonal CCT) and the color variation should be 5665 +/-365K (ANSI binning)
- Minimum view angle of the LED shall not be less than 1200.
- The output of LED shall be more than 100 lumen per watt at minimal operating current and shall ensure guaranteed operation life of 50,000 burning hours with controlled junction temperature of 850C.
- Lumen maintenance report as per LM 80 guidelines shall be produced for the power LEDs used.

Power factor of complete fitting shall be more than 0.9 at full load 240V. Thermal management shall be in such a way that LED soldering point temperature shall not go beyond 75 degree centigrade. Input frequency range shall be between 50Hz±3%.

The LED luminaire shall be free of glare.

Color rendering index CRI >=75

LED DRIVER specification used for street light

- Input voltage Range within 180Vrms to 270Vrms
- Operating input voltage 240Vrms
- No load power consumption ≤ 500mW
- Output voltage 105VDC±3%
- Output voltage ripple should be within 3%
- Output over voltage protection 125VDC
- Power factor 0.95
- Full Load Efficiency ≥ 90%
- THD ≤8 %
- Hot swapping
- Load regulation ±5%
- Current waveform should meet EN 61000-3-2
- Led Driver shall withstand, withstand voltage of 440V for 2 hours and restore normal working
- when normal voltage is applied
- Maximum Temperature rise <= 30ºC @ 45ºC Tamb with safety margin of 10oC
- The driver should comply to CISPR 15 for limits and methods of measurement of Radio
- Disturbance characteristics
- The equipment should comly
- The controlgear should be compliant to IEC 61347-2-13, IEC 62031 and IEC 62384 as per the
- requirements
- The equipment should be compliant to IEC 60598-1, IEC 62031and IEC/PAS 62612 depending on
- the type of luminaire.

TECHNICAL REQUIREMENTS

The driver of the luminiars should have

- 2 x 2 Fixture- Shall have Short Circuit, Over Voltage, String Open protections.
- 1 x 1 Fixture- Shall have Short Circuit, Over Voltage, String Open protections.
- Tube Light – Shall have Over Circuit, Over Voltage protections.

The electronic components used shall be as follows: -

- IC (Integrated circuit) shall be of industrial grade or above.
- Metallic film / Paper/Polyester Capacitor shall be rated for a temperature of at least 105ºC.
- The resistors shall be preferably made of metal film of adequate rating. The actual loading versus rating shall be 3.
- The junction temperature of the Switching devices such as transistors and MOSFETs etc. shall not exceed 125ºC (allowing thermal margin of 25 ºC).
- The conformal coating used on PCBs must be cleared and transparent and shall not affect colour code of electronic components or the product code of the company. The LED must be mounted on MCPCB, which should be made up of Metal core (Aluminum metal core) and should have the alumina coating with aerosol spray process of manufacturing to have the better heat conduction or dissipation.
- MCPCB shall be made with OPA dielectric thickness of 0.1mm and Al 5052H34. MCPCB must comply with IPC-A-600G and IPC-6012A class 2. UL approved solder mask and silkscreen must be used.
- The heat sink compound used should be of silicon with high thermal conductivity with 3W/mk.
- The heavy components shall be properly fixed. The solder connection shall be with good finish.
- The electronics covered for this equipment shall pass all the tests called for in the specification
- The infrastructure for Quality Assurance facilities as called for in the specification shall be available for the manufacturing of this product.

The connecting wires used inside the luminiar, shall be low smoke halogen free, fire retardant PTFE
cable and fuse protection shall be provided in input side. Care shall be taken in the design that there is no water stagnation anywhere. The entire housing shall be dust and water proof having IP20 protection as per IEC 60529.
The control gear shall be designed in such a way so that temperature rise of MCPCB shall not be more than 200C with respect to ambient temperature when measured half inch away from the component. Luminiar shall be such that the glare from individual LED is restricted and shall not cause inconvenience to the people. The Diffuser should be used in the luminiar to restrict the glare of LEDs. And should have no yellowness during the entire life of the luminaire.
All the material used in the luminiar shall be halogen free and fire retardant confirming to UL94 V.0
Illumination Level: The fitting shall be so designed that the illumination level shall be evenly distributed and shall be free from glare. Illumination level of different types of luminiar shall be as below:

Sl. No.	Place to be illuminated	Vertical Distance of fittings from the floor level(Mtrs)	Average Illumination Level (Lux)	Colour Temp in oK

Indoor Light				
1	Work areas	2.743	250 at 1mtr above ground level	5500 to 7000
2	Corridors	2.743	125 on the floor	5500 to 7000

* Illuminance at center is assumed for single luminaire.

Note:
1. Variation in illumination level shall be ±2% is allowed in input voltage range from 180VAC to 270VAC.
2. The illumination shall not have infra-red and ultra-violet emission. The test certificate from the NABL approved laboratory shall be submitted

TESTS:
Tests are classified as:
Type test
Acceptance test
Routine rest.

Type Test
Type tests shall be carried out to prove confirmation with the requirement of specification and general quality/design features of the unit. In case of any change in Bill of Material or design of unit, complete type test shall be repeated. If any sample fails in any of the type tests, two fresh samples shall be taken and tested. If any sample again fails in that test, the whole lot shall be rejected.

Acceptance Tests:
These tests are carried out by an inspecting authority at the supplier's premises on sample taken from a lot for the purpose of acceptance of a lot. Acceptance tests shall not be carried out from particular size from the lot on which type tests have already been conducted. Recommended sampling plan is given below.

Sample size and criteria for conformity
The luminaries shall be selected from the lot at random. In order to ensure randomness of selection, procedures given in IS 4905-1968 (Reaffirmed 2001) may be followed.

Routine Tests:
These tests shall be performed by the manufacturer on each complete unit of the same type and the results shall be submitted to the inspecting agency, prior to offering the lot for acceptance test. the firm shall maintain the records with traceability.

Method of Testing
Visual and Dimensional Check:
The unit shall be checked visually for all dimensions as per approved design and drawing. General workmanship should be good; all the components properly secured and sharp edges shall be

rounded off. Check the marking and quality of the workmanship visually. Check the rating and make of electronic / electrical items.

Checking of documents of purchase of LED

Check Document of purchase of LED lamps of approved sources viz. NICHIA/ OSRAM/ SEOUL/ PHILIPS LUMILEDS / LEDNIUM/AVAGO/CREE.

Resistance to humidity test

This is carried out by suspending the painted panels in corrosion chamber maintained at 100% RH and temperature cycle of 42 to 48 deg. C for 7 days and examining it for any sign of deterioration and corrosion of metal surface.

Insulation resistance test

The insulation resistance of the unit between earth and current carrying parts shorted together shall not be less than 2 M□ when measured with 500V megger.

HV test

Immediately after insulation resistance test, an AC voltage of 1.72 KV rms (1500 + 2 x rated voltage) of sine wave form of 50 Hz shall be applied for one minute between the live parts and frame. There shall not be any kind of break down, flashover or tripping of supply.

Over voltage protection

The Luminaire shall withstand at 300V AC for two minutes.

Surge protection

It shall withstand a surge of 1.5kV „b 3% for 50 microseconds „b 20 % at the input terminals for all types. (Tests shall comply with Clause 5.4 of latest IEC 60571-1).

Reverse polarity

The Luminaire shall withstand polarity reversal. It shall be operated with reverse voltage for 5 minutes at maximum value of voltage range. At the end of this period, the supply shall be made correct polarity and Luminaire shall operate in a normal way.

Temperature rise Test:

Temperature rise Test shall be conducted at 100VAC with full load. The temperature rise shall be recorded by temperature detectors mounted at the specified reference points on the body of semiconductors, capacitors and other components as agreed between purchaser and manufacturer. The maximum-recorded temperature under worst conditions shall be corrected to 550C and compared with maximum permissible temperature (for power devices at junction). Under loading conditions as specified above, the corrected temperature of the power devices shall have a safety margin of minimum 100 C. Temperature at junction shall not exceed 100 0 C when corrected to 550 C. The Luminiar shall also be subjected for short time rating after continuous loading to ensure the temperature rise is within the permissible limit. The maximum temperature rise of the electronics devices on the PCBs shall be in limit for industrial grade components suitable for 850C environment. In case of exceeding limit, use of MIL-grade component shall be considered keeping

RDSO informed.

Ra (Colour Rendering Index) measurement test

- The lumen is the unit of luminous flux, which is equal to the flux emitted in a solid angle of
- one Steradian by a uniform point source of one candela.
- The initial reading of the chromaticity co-ordinates x & y shall be within 5 SDCM (Standards
- Deviation for Colour matching) from the standardised rated value as per Annex. D of IEC
- 60081 – 1997.
- The initial reading of the general colour-rendering index (Ra) shall not be less than the rated
- value decreased by 3.
- The lumen maintenance of the lamp shall not be less than 80% of the initial lumen after
- 20000 burning hours and 70% of the initial lumen after 50000 hours . The initial lumen will be
- taken after 100 hours aging
- Photometric test shall be conducted as per Annexure B of IEC 60081-97.
- The lumen maintenance test shall be done as per Annexure C of IEC 60081-97.

Lux measurement

Lux measurement with the help of Lux meter shall be done at a distance. Value obtained shall not be less than the Lux specified in the table considering 10% Lumen is absorbed by the reflector.

Fire retardant Test

Fire Retardant test shall be conducted as per IEC 60332-1 of the wire used in the fittings.

Test for IP20 protection

This test shall be conducted as per IEC 60529.
Environmental tests
The Luminiar shall meet the following tests as prescribed in IEC – 60571.
a) Dry heat test.
b) Damp heat test
c) Test in corrosive atmosphere
d) Combined dust, humidity and heat test

Reliability Test

The reliability can only be determined in actual service. However, the following tests shall be carried out on the prototype to simulate as close as possible, the service conditions. There shall be no failure during this test.
a) The light unit shall be mounted in an oven maintained at 45°C.
b) The light will be operated at the specified maximum voltage and at 45°C for a period of 100 hours.

Life Test

The lumen maintenance & life test shall be done as per Annexure C of LM 80 Report of LEDs.

Endurance Test

The Luminiar shall be kept "ON" with input voltage of 250VAC for 200 hours. After this the Luminiar is subjected to 20,000 cycles of "ON" and "OFF", each cycle consisting of 3 seconds "ON" and 10 seconds "OFF" period. Luminiar should survive this test. Test is to be continued for 20,000 cycles, followed by performance test.

Safety:

The Luminaire shall comply with the safety requirements as per IEC 61195.

MARKING:

The following information shall be distinctly and indelibly marked on the housing:
a) Year of manufacture/Batch Number/ Serial Number
b) Name of Manufacturer
c) Rated watt and voltage
d) Input frequency

APPROVAL

The manufacturer shall also submit details like make, type, reliability grade, rating and loading of various electronic components used in the circuit. The temperature rise of the various components under the most adverse conditions shall also be declared.

- Technical specification for LED STREET LIGHT & FLOOD LIGHT of – 80 Watts
- Input voltage: 90 V to 270 V
- LED lamp efficacy: Min 95 to 130 lumens/watt
- Power factor: >0.90
- Life expecting: 50,000 hours
- No of hours usage / day: 10 to 12 hours/day
- Rated watt: 80 W (cool white)
- Luminous flux: 7500 to 10500 lumens
- LED type: High power LED (1 Watt)
- Working Humidity: 10% to 90%
- Colour Temperature: 4,500 to 7,000 K with test certificate
- Ingress protection: IP 65/IP 66 as per IS/IEC60529-2001 with test certificate.
- Total harmonic distortion (THD): <15% with test certificate
- Colour rendering index: Ra > 80
- Working Temperature: 20 deg to 50 deg C
- Average lighting/ beam angle: 120 to 160 deg
- Control Circuit: Compatible to LED
- Lamp starting time: Not more than 5 sec
- Energy consumption: Not more than 1.2 times at rated voltage
- System power efficiency: > 85 %
- Luminary Casing: Pressure die cast Aluminum with toughened glass cover and water proof fixture.

LED thermal management: LED shall be mounted on heat sink conductive aluminum with fins to

dissipate the heat to ambient air

Driver board: Details shall be given for getting spare

Pole entry/ Retro fitting: Suitable for fixing in existing lighting pole (30 mm to 55 mm dia with bracket and locking bolt & nut.

Applicable Standard: IESNA LM 79 for fixture and with stand to wind velocity 150 mph with test certificate

Electrical connector: Connecting wires with minimum one-meter length

Warranty: 2 Years

2.1.112. CEILING FANS

All ceiling fans shall be provided with suspension arrangement in the concrete/slab/roof members. Contractor to ensure that provision are kept at appropriate stage at locations shown on the drawing. Fan box with MS hook shall be as per CPWD specification. Ceiling fan shall be double ball bearing type, copper wound motor complete with canopy, down rod, blades etc. and shall conform to relevant IS standards ceiling fan shall be white in color. Ceiling fan shall be provided with standard regulator. Regulator shall be suitable for 240 volts A.C supply 50 Hz and shall be of continuous duty type

2.1.113. EXHAUST FANS

Exhaust fans shall be heavy duty type with double ball bearing and conforming to IS 2312-1967. Exhaust fan shall be complete with copper wound motor, capacitor, Louver/shutter, frame and mounting bracket. Exhaust fan shall be suitable fan operation on 240 volts single phase A.C supply.

2.1.114. EARTHING/GROUNDING

Earthing
All the non-current carrying metal parts of electrical installation shall be earthed properly. All metal conduits trunking, cable amour, switchgear, distribution fuse boards, lighting fittings and all other parts made of metal shall be bonded together and connected by means of specified earthing conductors to an efficient earthing system. All earthing will be in conformity with the relevant Indian Electricity Rules 1956 and Indian Standard Specifications IS:3043-1966.

EARTHING CONDUCTOR

Earth continuity conductor alongwith submain wiring from Main/Sub Distribution boards to various distribution boards shall be of copper. Earth continuity conductor from distribution board onward upto outlet point shall also be of bare copper. Earth continuity conductor connecting Main

& Sub Distribution boards to earth electrode shall be with galvanised MS strip.

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Connection of Earthing conductors

Main earthing conductor shall be taken from the earth connections at the main distribution panel to the earth electrode with which the connection is to be made. Distribution boards, earthing conductor shall run from Main Distribution Boards. Circuit earthing conductor shall run from the exposed metal of equipment and shall be connected to any point on the main earthing conductor, or its distribution boards. Cable sheathing and armouring shall be earthed at the ends adjacent to switch boards at which they originate, or otherwise at the commandment of the run by an earthing conductor in effective electrical contact with cable sheathing. Where equipment is connected by flexible cord, all exposed metal parts of equipment shall be earthed by means of and earthing conductor enclosed with the current carrying conductor within the flexible cord. Switches, accessories, lighting fittings etc. which are rigidly secured in effective electrical contact with a run of metallic conduit hall not be considered as a part of earthing conductor for earthing purposes, even though the run of metallic conduit is earthed.

2.1.115. LIGHTING DISTRIBUTION BOARDS

The Distribution Panel and Distribution boards shall be suitable for operation on 3 phase/single phase 415/230 Volts, 50 cycles, neutral grounded at transformer and short circuit level not less than 31 MVA at 415 Volts. The Distribution Panel/Boards shall comply with the latest addition of relevant Indian Standards and Indian Electricity Rules and Regulations.

CONSTRUCTION FEATURES

The Distribution Panels/Boards shall be metal enclosed sheet steel cubical, indoor, dead front, floor mounting/wall mounting type. The Distribution board shall be totally enclosed completely dust and vermin proof. Gaskets between all adjacent units and beneath all covers shall be used to render the joints dust proof. Distribution Boards shall be preferably arranged in multitier. All MS sheet steel used in the construction of Distribution Boards shall be 2 mm thick and shall be folded and braced as necessary to provide a rigid support for all components. Joints of any kind in sheet metal shall be seam welded, all welding slag grounded off and welding pits wiped smooth with plumber metal. All the panels and covers shall be properly fitted and square with the frame, and holes in the panel correctly positioned. Fixing screws shall enter into holes tapped into an adequate thickness of metal or provided with bank nuts. Self-threading screws shall not be used in the construction of Distribution boards. A base channel of 75 mm x 75 mm x 9mm thick shall be provided at the bottom. Knockout holes of appropriate size and number shall be provided in the distribution board in conformity with the location of incoming and outgoing. Removable sheet

steel plates shall be provided at top and bottom to drill holes for cables entry at site if required.

BUS BAR CONNECTIONS

The bus bars and interconnections shall be electrolytic copper and of rectangular cross sections suitable for full load current for phase bus bars and half rated current for neutral bus bar and shall be extensible on either side. The bus bars and interconnection shall be insulated with insulation tapes and color coded. The bus bars shall be supported on unbreakable non-hygroscopic insulated supports at regular intervals to withstand the forces arising from short circuit in the system. All bus bars shall be provided in a separate chamber and properly ventilated. All bus bar connections shall be done by clamping. No holes shall be drilled in the bus bars for mounting clamps. All connections between bus bars and switches and between switches and cable alley terminal shall be through solid copper strips of proper size to carry full rated current and insulated with insulating tapes.

FIXING OF MCB'S

All TPN Distribution Boards shall be provided with SP MCB's as outgoing. Separate neutral bus bars shall be provided for TPN distribution boards for each phase. MCB's shall be provided on the phase of each circuit. The individual banks of MCB's shall be detachable. There shall be ample space behind the banks of MCB's to accommodate all the wiring. All the internal wiring of distribution boards shall be concealed behind 5 mm thick Bakelite sheet. All the distribution boards shall be completely factory wired, ready for connections. All the terminals shall have adequate current rating and size to suit individual feeder requirements. Each circuit shall be clearly numbered from left to right to correspond with wiring diagram. All the switches and circuits shall be distinctly marked with a small description of the service installed.

CABLE COMPARTMENTS

Cable Compartments of adequate size shall be provided in the distribution panel/boards for easy termination of all incoming and outgoing cables entering from bottom. Adequate supports shall be provided in cable compartments to support cables. All incoming and outgoing switches, terminals shall be brought out to terminal blocks in cable compartments.

INSTRUMENT ACCOMMODATION

Separate and adequate compartments shall be provided for accommodating instruments, indicating lamps, control contractors and control fuses etc. These shall be accessible for testing and maintenance without any danger of accidental contact with live parts of circuit breaker, bus bars and contact.

TERMINALS

The outgoing terminals of the breaker and neutral link shall be borough out to a terminal block suitably located at the rear side of the panel. Separate cable compartments shall be provided for incoming and outgoing cables.

WIRE WAYS

A horizontal wire way with screwed covers shall be provided at the top to take interconnecting control wiring between different vertical section.

SWITCH FUSE UNITS

The switch fuse units shall be 3 pole double break type (AC-23A) suitable for load duty quick make and break action. Separate neutral link shall be provided in the switch. All switch fuse units shall be provided with hinged doors duly interlocked with operating mechanism, so as to prevent opening of the door when the switch is in `On' position and also to prevent closing of the switch when the door is not properly secured. All contacts shall be silver plated and all live parts shall be shrouded. High rupturing capacity (HRC) fuse links shall be provided with switch fuse units and shall be in accordance with IS: 2208 - 1962 and having rupturing capacity of not less than 31 MVA at 415 volts. HRC fuse links shall be provided with visible indicators to show that they have operated.

FUSES

Fuses shall be high rupturing capacity (HRC) fuse links and shall be in accordance with IS:2208-1962 and having rupturing capacity of not less than 31 MVA at 415 Volts.

PAINTING

All sheet steel shall undergo a process of degreasing, picking in acid, cold rinsing, Phosphating, pasivating and then sprayed with a high corrosive resistant primer. The primer shall be baked in an oven. The finishing treatment shall be with powder coating..

LABELS

Engraved PVC labels shall be provided on all incoming and outgoing feeder switches. Circuit diagram showing the arrangement of the circuit inside the distribution board shall be pasted on inside of the panel door and covered with transparent laminated plastic sheet. All the distribution boards shall be subject to tests specified in relevant Indian Standards and test certificates shall be furnished.

METERS

All the meters shall be housed in a separate compartment and accessible from front only. Lockable doors shall be provided for the metering compartments. The distribution boards shall be provided with indicating panel comprising of 1 No.(0-500V) 90 cm x 90 mm square type voltmeter with 3 way "OFF" selector switch and CT operated ammeter with 3 way and neutral selector switch of appropriate range and scale. Wiring for motors shall be colour coded and labeled with approved plastic beads for identification.

Point Wiring (Internal & External Telephones)

The point wiring shall be carried out with Double pair telephone wire/cable, unarmoured, PVC insulated and sheath. 0.61 mm dia annealed tinned copper conductor (IS: 2532-1965)in suitable size conduit (one pair always remaining spare for one point)

Minimum Dia of Conduit for Internal/External Telephone Wiring - 20mm.

If more than one telephone point has to be provided at one point, multicore, unarmoured telephone cable shall be used (pairs required are equal to 2 No. of points) in suitable size of conduit.

The point shall commence from the main telephone tag box/sub tag box and would terminate at outlet box of point. Connection at both ends included in point wiring.

Fixing of conduit, conduit accessories draw out boxes and outlet box etc. in concealed/surface conduit works) shall be applicable for telephone wiring conduit system also.

EARTHING

(AS PER IS 3043-1987)

Earthing shall generally be carried out in accordance with the requirements of Indian Electricity Rules 2003 amended from time to time and relevant regulations under Electricity Supply Authority concerned.
In case of high and extra high voltages, the neutral points shall be earthed by not less than two separate distinct connections with earth, each having its own electrodes sub-station and will be earthed at any other point provided no interference is caused by such earthing. If necessary, the neutral may be earthed through suitable impedance. As far as possible, all earth connections should be visible for inspection. Each earthing system shall be so designed, that, the testing of individual earth electrodes is possible. It is recommended that the value of any earth system resistance shall be such as to conform to the degree of shock protection desired.

It is recommended, that a drawing showing the main earth connections and earth electrodes be prepared for each installation and submitted to Employer. No addition to the current carrying system, either temporary or permanent, shall be made which will increase the maximum available fault current on its duration until it has been ascertained that the existing arrangement of earth electrodes, earth bus-bar etc., are capable of carrying the new value of earth fault current which may be obtained by this addition.

All materials, fittings etc., used in earthing shall conform to Indian Standard Specifications, wherever they exist.

2.1.116. GENERAL REQUIREMENTS AND PROCEDURES FOR EARTHING

The ground resistance for sub-stations should not exceed a value 2(two) ohms. The joints/connections in the earthling, system shall be welded only, except the connections, which require opening for testing/maintenance. Such connections should be bolted tightly, using spring and ring washers for proper contact pressure.

The G.S. flats to be provided for the horizontally laid earth grid should have overlap welded joints, with length of welding at least twice the width of the flat, e.g., 100 MM for 50x6 MM G.S. flats. There should not be any dirt, grease, oil, enamel, paint or any such non-conductive coatings on the surfaces being joined/ connected. Only the finished joints/connections above ground may be provided with red-oxide or any other protective coating. Underground earth electrodes and earth grid elements, when laid, should have a clean metallic surface, free from paint, enamel, grease or any such non-conductive coatings.

As far as possible, all earth connections should be accessible for visual inspection. No cut-outs, links or switches, other than linked switches arranged to operate simultaneously on the earthed or

earthed neutral conductor and the live wire shall be inserted in the supply system. Earth electrodes or mate should not be installed in close proximity to metal fence to avoid possibility of fence becoming live. Separate earth electrodes, isolated from the earth grid, are to be provided for grounding the fence wires. Pipes or rods used as electrodes should be in one piece, as far as possible, with a minimum allowable length of 3 mtrs. Except where rock or hard stratum is encountered, the pipe/rod electrodes should be driven into the ground to a minimum depth of 3 mtrs. The strip electrodes, forming the horizontal gild, should be buried underground to a minimum depth of 0.5 mtrs. The path of earth wire should be out of normal reach of any person, as far as possible.

For high resistivity soils, above 100 Ohm-mtrs., attempts should be made to bring the soil resistivity in the range of 50 to 60 Ohm-mtrs. By digging and treating the soil mass around the earth grid/electrodes

with a mixture of salt and charcoal. In case of rocky top soil and sub-stratum, having very high resistivity, with no scope of improvement by other means, the procedure given below should be followed:

- At least two bores of diameter little less than 40 mm, with a minimum distance of 10 mtrs. between them, should be made in the ground at suitable locations inside the S/S yard. The boring should be done until soil sub-stratum rich in moisture and low in resistivity is encountered. G.I. pipes of 40 MM dia. should be descended in each bore, such that, the soil mass around the pipes grips them tightly, Back – filling of bores, if required, with wet soil/clay may be done to ensure this condition. The G.I. pipes in these deep bores should be interconnected with the main earthing grid of the S/S through 50x6 mm G.S. flat, with all the joints/connections and terminations being either fully welded, or clamped/bolted and welded simultaneously. The G.I. pipes in the bores should also be interconnected with each other. In extreme cases, the bores may have to be made at remote locations i.e. outside the S/S yard, with inter-connections, through 50x6 MM flats, as explained before.
- The procedures to be observed stringently for making connections and joints between various elements of the earthing system are as follows:

  G.S. flat to Structure/flat - The G.S. flat should be welded to the metallic portion (leg) of the structure after thoroughly cleaning the surfaces to be welded. The length of the welding should be at least twice the width of the G.S. flat, e.g.-minimum 100 mm for 50x6 mm G.S. flat. Exactly similar procedure is to be adopted for joints between two G.S. flats.

  G.I. wire to structure. The G.I. wire should be bolted to the structure after making an eye formation and kept tight with the help of spring and ring washer. Then, the entire arrangement should be welded.

  G.I. wire to G.S. flat- The G.I. wire should be bolted and then welded to G.S. flat, as explained above.

  G.I. rod to G.S. flat- The G.I. rod should be securely clamped to the G.S. flat with the help of bolts and washers and the entire arrangement should then be welded.

  G.I. wire to G.I. pipe – GI wire should be bolted to the G.I. pipe and then welded, keeping in view the relevant precautions, mentioned before.

  G.I. flat to G.I pipe – The GI flat should be bolted tightly to the G.I. pipe and then the connection should be welded.

Before making connections and joints, it should be ensured that, the elements to be joined have a

clean metallic contact surface without any non-conductive coating.

2.1.117. EARTH GRID SYSTEM

Grid system of interconnected conductors forming a closed loop mesh is to be installed using 75x8 mm MS flat for peripheral and branch conductors. Interconnections are made by welding them. This earth grid will be laid at a depth of about 0.5 mtr. bonded to general mass of the earth by 3 mtrs. long earth electrode of solid MS rod (or pipe) of dia 25mm. The G.I. pipe 40 mm. dia 3 mtrs. long in the earthing pits, driven vertically.
It is to this earth grid that the transformer neutral, apparatus, frame work and other non-current carrying metal work associated like transformer tank, switchgear frame etc. are to be connected. All these connections should be made in such a way that reliable and good electrical connection is ensured. Aluminum/ other paint, enamel, grease and scale should be removed from the point of contact before connections are made. No part of the ground connection leads should be embedded in concrete.
Arrangement of connection of earth connection shall be as follow:

2.1.118. GI EARTHING PIPE

Earthing pipe should be made of 40 mm diameter ISI marked B class GI Pipe. 12 mm dia suitable holes on its circumference shall be made as per approved drawing. The pipe should be in one piece. No joints or welding would be allowed on its length. Clamps made of 50x6mm GI flat duly drilled with 12 mm size holes should be welded at the top end for connection of earth conductor.
Pipe used shall be 40mm NB diameter, ISI marked Galvanized Mild Steel Tubes continuously welded Electric Resistance Welded ERW/High Frequency Induction welded (HFIW)/Hot finished welded (HFW) type, conforming to IS-554-1985 with latest amendment of MEDIUM quality (Class B).

2.1.119. MANUFACTURE:

GI earth pipe (40 mm diameter & 3 metre long) shall be made of tubes which shall be made from tested quality steel manufactured by any approved process as follows:

a) Electric Resistance Welded (ERW).
b) High Frequency Induction Welded (HFIW) and
c) Hot finished Welded (HFW).

Tubes made by manual welding are not acceptable.

2.1.120. DIMENSIONS:

The dimensions and weights of tubes shall be in accordance with Table-I and Table-II of IS: 1239 (Part- I)/1990 with latest amendments, subject to tolerance permitted therein. Necessary 12 mm diameter holes across the circumference shall be provided as per approved drawing. Drawings shall be approved by the owner before start of the manufacturing work. The tube, earthing pipe shall be provided with 50x6mm GS clamps on one end, one clamp is to be welded with the pipe and another is removable to enable measurement of earth resistance of the pit. Other end of the earth pipe should be cut half in slop to make it a sharp.

2.1.121. GALVANIZING:

Tubes shall be galvanized in accordance with IS-4736-1986 with latest amendment for not dip zinc coating of Mild Steel Tubes. The minimum mass of zinc coating on the tubes shall be in accordance with clause 5.1 of IS-4736-1986 (specification for hot dip zinc) and when determined on a 100mm long test piece in accordance with IS: 6745:1972 shall be 400 g/m2. The zinc coating shall be uniform adherent reasonably smooth and free from such imperfections as flux, ash and dross inclusions, bare patches, black spots, pimples, lumpiness, rust, stains, bulky white deposits and blisters.

2.1.122. HYDRAULIC TEST:

(Before applying holes) Each tube shall withstand a test pressure of 5 M Pa maintained for at least 3 seconds without showing defects of any kind. The pressure shall be applied by approved means and maintained sufficiently long for proof and inspection. The testing apparatus shall be fitted with an accurate pressure indicator

2.1.123. TEST ON FINISHED TUBES AND SOCKETS:

The following tests shall be conducted by the manufacturer of finished tubes and sockets.
a) The tensile strength of length of strip cut from selected tubes when tested in accordance with IS-1894-1972, (Method for tensile testing of steel tubes), shall be at least 320N/mm2.
b) The elongation percentage on a gauge length of 5.65/so (where so is the original cross-sectional area of test specimen) shall not be less than 20%.
c) When tested in accordance with IS-2329-1985 (Method for Bend test on Metallic tubes) the finished tube shall be capable of withstanding the bend test without showing any sign of fracture or failure. Welded tubes shall be bent with the weld at 90 degree to the plane of bending. The tubes shall not be filled for this test.
d) Galvanized tubes shall be capable of being bent cold without cracking of the steel, through 90 degree round a former having a radius at the bottom of the groove equal to 8 times the outside diameter of tube.
e) Flattening Test on Tubes above 50 mm Nominal Bore: Rings not less than 40 mm in length cut from the ends of selected tubes shall be flattered between parallel plates with the weld, if any, at 90 degree (point of maximum bending) in accordance with IS-2328-1983. No opening should occur by fracture in the weld unless the distance between the plate is less than 75 percent of the original outside diameter of the pipe and no cracks or breaks in the metal elsewhere than in the weld shall occur, unless the distance between the plates is less than 60% of the original outside diameter. The test rings may have the inner and outer edges rounded.

f) **GALVANISING TEST:**
Weight of zinc Coating: For tubes thickness upto 6 mm the minimum weight of zinc coating, when determined on a 100 mm long test piece in accordance with IS-4736-1986 shall be 400 grm/m2.
The weight of the coating expressed in gram/m2 shall be calculated by dividing the total weight of the zinc (inside plus outside) by the total area (inside plus outside) of the coated surface.
Test specimen for this test shall be cut approximately 100 mm in length from opposite ends of the length of tubes selected for testing. Before cutting the test specimen, 50 mm from both ends of the

samples shall be discarded.
g) Free Bore Test: A rod 230mm long and of appropriate diameter shall be passed through relevant nominal bore of the sample tubes to ensure a free bore.
h) Uniformity of Galvanized Coating: The galvanized coating when determined on a 100 mm long test piece [see V (a) (iii)] in accordance with IS-2633-1986 (Method for testing uniformity of coating on zinc coated articles) shall with stand 4 one minute dips.

- **WORKMANSHIP:**

The tubes shall be cleanly finished and reasonably free from injurious defects. They shall be reasonably straight, free from cracks, surface flaws, laminations, and other defects, both internally and externally. The screw tubes and sockets shall be clean and well-cut. The ends shall be cut cleanly and square with the axis of tube.

- **MARKING:**

The medium class of tubes shall be distinguished by Blue colour bands which shall be applied before the tubes leaves the manufacturers‟ works. Tubes shall be marked with the standard mark.

BATTERY CHARGER & DC DISTRIBUTION BOARDS.

2.1.124. SCOPE OF SUPPLY:

One set of 220 V Maintenance free sealed DC Batteries of 500-Ampere Hours capacity and one set of 24V maintenance free sealed DC Batteries of 500AH, one set of battery charger for 220V and 24 V system and one set of DCDBs for each system shall be provided The battery shall be able to support the complete station load for a period of 10 hrs, without AC supply.

2.1.125. BATTERY, BATTERY CHARGER AND DCDB

GENERAL :
This section covers the salient aspects and technical particulars of design, manufacture, testing, erection and commissioning of 220V, 500AH and 24V, 500 AH capacity, high discharging performance, maintenance free sealed stationary batteries, along with battery charging equipment consisting of silicon controlled rectifier type float chargers, Silicon diode type boost charger and D.C. distribution boards along with accessories.

SCOPE OF SUPPLY :

The scope of supply against this specification covers manufacture, assembly, testing at works, packing, supply by Road, delivery at Project site, erection, testing and commissioning of 220V D.C & 24 D.C. system .

1. **a.** 220V Bank, 500AH capacity high discharging performance, maintenance free sealed batteries along with accessories, fittings etc.1 No.

b Battery charging equipment for the above consisting of 1 No

i) Silicon controlled rectifier type float charger. 1nos.

ii) Silicon diode rectifier type boost charger 1nos.

c) D.C Distribution Board (220V) 1nos.

2 (a) 24V Bank, 500AH capacity high discharging performance maintenance free sealed lead acid batteries along with necessary accessories, fittings etc. 2nos.

(b) Battery charging equipment for the above (item 2) consisting of : 1 No

i) Silicon controlled rectifier type float charger : 1 nos.

ii) Silicon diode rectifier type boost charger. : 1 nos.

c) DC Distribution Board (24V) : 1 No.

The batteries with associated equipment and accessories are required to provide continuous and reliable supply to respective boards of 220V and 24V DC Boards for various applications, viz control, protection, indication, annunciation, regulation panels of pump house and also for pump house emergency lighting.

SPECIFICATIONS AND STANDARDS FOR BATTERIES:

a)	Stationary cells and batteries, lead acid type with tubular positive plates :	I.S.1651
b)	Stationary cells and batteries, lead : acid type with plant positive plates	I.S.1652
c)	Sealing compound for lead-acid batteries	I.S.3116
d)	Valve Regulated Batteries	BS: 6290 Part IV

SPECIFICATIONS AND STANDARDS FOR BATTERY CHARGERS.

a)	Degrees of protection provided by enclosure for low-voltage switchgear and control gear	: I.S.2147
b)	Air Break switches, air break disconnectors and fuse combination units for voltages not exceeding 1000 Volts AC or 1200 V DC	: I.S 4064
c)	Contactors for voltages not exceeding 1,000V AC or 1,200V DC	: I.S.2959

SALIENT FEATURES OF 220V, 500AH BATTERY :

1. Type of battery : Maintenance free sealed lead acid high discharging performance indoor type station battery.

2. Design ambient temp : 50 deg. C.

3. Rating :

   i) Ampere hour capacity : 220V, 500AH at 10Hr.

   ii) End cell voltage after 10 hour discharge (Electrolyte temperature 27 deg.C.) Voltage of 1.75 V

   iii) Rated voltage of Battery.

   a) Nominal Voltage : 220V
   b) Maximum : 243 V
   c) Minimum Voltage : 189V

4. Number of cells : 110 (May vary depending upon the voltage of each cell at fully charged condition to maintain the nominal voltage)

5. Discharge current and cell end voltage of battery :

		Amperes	cell end voltage.
a)	1 minute load :	460A	1.85V
b)	2 Hr.emergency load :	135A	1.85V
c)	10Hr.continuous load: without trickle or boost charging.	40A	1.85V

6. Nominal Cell voltage :2 Volts.

7. Ampere Hour efficiency : 90% Minimum

8. Watt Hour efficiency : 82% Minimum

9. Float charge current : 40A

10. Boost charge current: 100A (will not be less

than the rate of Boost charge required for batteries plus station load of 40A)

11. Time required for Boost charging from discharge condition. : 8-10 Hrs.

SALIENT FEATURES OF 24V, 500AH BATTERY

1. Type of battery : Maintenance free sealed lead acid high discharging performance indoor type station battery.

2. Design ambient temp: 50 deg.C.

Rating :

i) Ampere hour capacity 24V, 500AH at 10H

ii) End cell Voltage at 10 hour discharge rated (Electrolyte Voltage of 1.86V Temperature 87 deg.C) .

iii) Rated voltage of Battery. :

a) Normal Voltage : 24 V
b) Maximum Voltage : 27 V
c) Minimum Voltage : 21 V

4. Number of cells : 12 (May vary depending upon the voltage of each cell at fully charged condition to maintain the nominal voltage).

5. Discharge current : Cell end of battery Voltage and cell end voltage Amperes

a) 1 minute load	: 345A	1.85V
b) 2 Hr. emergency load	: 100A	1.85V
c) 10 Hr. continuous load: without trickle or boost charging.	30A	1.85V

6. Nominal Cell voltage :2 Volts.

7. Ampere Hour efficiency: 90% Minimum

8. Watt Hour efficiency : 82% Minimum

9. Float charge current : 30A

10. Boost charge current :80-100A.(will not be less than the rate of boost charging required for batteries) plus station load of 30A)

11. Time required for Boost charging from discharge condition. : 8-10 Hours.

CONSTRUCTIONAL FEATURES (COMMON FOR 220V AND 24V BATTERIES):

1. Container and cover : Flame retardant special material grade policy propylene

(v)

2. Thickness : 2-3 mm.

3. Separator Type : Highly absorbent glass mat separator.

Material : Spun glass microporous matrix.

Thickness :3 mm (approx.)

4. Electrolyte : Prepared from the battery grade sulphuric acid confirming to IS 266:1961

5. Specific gravity of electrolyte at 27 deg. (with cells fully dis-charged) : 1.1

6. Specific gravity of fully : 1.2 +/- 0.005 corrected to 27 deg.C.

7. Type of positive plates : Flat pasted plate type with MFX alloy

8. Type of negative plates : Flat pasted plate type with lead calcium alloy.

9. Rack material : Mild steel.

10. Self discharge rate of capacity per week. : Less than 0.5% Battery.

11. Life of the battery : 20 Years.

12. Terminals : Integral lead terminal with solid copper core.

13. Connectors : Heavy duty, lead plated copper connectors.

CONSTRUCTIONAL DETAILS OF BATTERY(COMMON FOR BOTH 220V AND 24V SYSTEM:

Plates: Positive plates shall be made of flat pasted type using lead cadmium patented MFX alloy.
Negative plates shall be heavy, durable flat plate using lead calcium alloy pasted box grid. Negative palates shall be designed to match the life of positive plates and combination of positive and negative plates will ensure long life, durability and trouble free operation of battery.
Separators: Separator shall be made of spun glass, micro porous matrix and shall be resistant to sulphuric acid. It shall be capable of keeping all the electrolyte absorbed in the separator with no free electrolyte. It shall be electrically insulated. Internal resistance will ensure discharge characteristics under all operating conditions. Sufficient separator overlap to edges of the plate is to be provided to prevent short circuit formation between the edges of adjacent plates.

. **Containers and lids:** The containers and lids shall be made or a flame retardant special grade copolymer polypropylene. They shall be sufficiently robust and not liable to deformation under internal operating pressures and with in the temperature range naturally encountered, leak proof, non absorbent and resistant to the acid.
Containers will have adequate space at the bottom for collecting sediments for the entire life of the batteries.
Provision for by passing any defective cell during service for replacements etc may be made.
For identification each container shall be marked in a permanent manner to indicate the following information:

a) Cell number
b) Type of plate
c) AH capacity at 10 hour rate
d) Type of container
e) Manufacturer's name
f) Month and year of manufacture.

Sealing & Venting: Vent plug shall be made of suitable plastic material, pressure regulating, explosion proof and self resealing. Venting will only occur through porous disc. The vents will release excess pressure and reseal when the pressure is low.

Electrolyte: The electrolyte shall be prepared from the battery grade H2SO4 confirming to ISS:266. The batteries shall be supplied in factory filled and charged condition.

Water: Water required for preparation of electrolyte will confirm to IS :1069

Connectors: Connectors may be supplied either as separate bars or alternately as part of the cell structure i.e. as suitably elongated group bars or terminal lugs. The connectors shall be lead coated copper of suitable size to join the cells. The connectors which shall be of suitably designed copper connectors and suitably coated to withstand corrosion due to

sulphuric acid may be used where the cells are called upon to discharge at very high rates. The coating should be adequate and tenacious.

Plate connections: Lugs of plates of like polarity shall be connected by lead burning to a horizontal strap having an upstanding terminal post adopted for connection to external circuit. Strap and post shall be cast with lead antimony alloy. The positive and negative terminal posts shall be clearly marked for unmistakable identification.

Nuts and Bolts: Nuts & Bolts for connecting the cells shall be effectively lead coated to prevent corrosion.

Terminals: Terminals shall be of Integral Lead terminal with Solid Copper Core.
Supporting racks: Batteries shall be installed on MS racks to be supplied by the contractor to fit in the battery/battery charger room. Layout of batteries in the battery room shall be approved by the Board.Racks shall be so designed that cells are located within easy reach at convenient height.
Minimum number of bolts and nuts should be used primarily for anchoring and joining. Joining will ensure proper and tight fit. Racks shall be painted with 2 coats off anti corrosive paint and supplied in unassembled state. Racks will also be provided with spray or dip coating for protection against fungus growth and other harmful effect due to tropical environment.

Charging:
Lower optimum voltage shall be maintained by chargers to maintain batteries in fully charged condition, for minimum evaporation and maximum battery life for both 220V and 24V DC systems. The tenderer will also specify life as well as boost charging cycling of the batteries is not envisaged.

Suitable means shall be provided for indicating and annunciating the fully discharged condition of the Battery of both 220V and 24V DC systems in control room.

Voltage:
The cell voltage will not exceed 2.25V with a continuous low rate of floating charge and will not be less than 1.85V at the end of emergency discharge.

Operation:

The DC battery shall be operated without an intentional ground. For indicating the incidence and degree of a ground fault on the DC control circuitry, the midpoint of the battery shall be earthed through a high resistance with an ammeter. The high resistance shall be so proportional that the current flowing under the worst earth fault will not exceed 100mA for 220V DC system and 25 mA for 24V DC system.

Ventilation:
The requirement of ventilation of the Battery room shall be finalized at the time of finalization of layout plant
Both 220V and 24VDC battery banks are proposed to be installed in the same Battery room. The layout of the battery (both for 220V and 24V) keeping in view the working space required. shall be finalized at the time of finalization of layout of plant.

CONTRUCTIONAL FEATURES OF BATTERY CHARGING EQUIPMENT:

a) BOOST CHARGER:

The boost charger shall be suitable for 3 phase, 50HZ, A.C. input supply. The charger shall be manual control type consisting of full wave silicon diode rectifier with suitable transient voltage suppression.
Suitable ripple filtering circuits shall be provided for the boost charger to limit ripple content in DC output.
The boost charger shall have dry type double wound transformer of suitable rating with adequate no. of taps on both primary and secondary sides for the change of output voltage/current control. OFF load tap changer will also be provided for boost charger transformer on primary side.
The boost charger shall have the control gear consisting of 2/4 position rotary switch for coarse and fine control of output voltage.
The boost charger shall have necessary protection to prevent the failure of diodes due to heavy currents from the boost charger when the battery is fully in discharged condition.
The boost charger shall be designed to charge a fully discharged battery without over loading or causing over voltage or without causing interruption of operation of AC or DC system. After the batteries recharged, the charger will maintain the battery at full charge.

The charger shall be provided with all necessary equipment and devices to protect the charger from short circuits, transient voltage surges, load and supply fluctuations including sudden loss of input or load.

b) FLOAT CHARGER :

The float charger shall be suitable for 3 phase, 415V, 50HZ AC input supply. The float charger shall be invariably Automatic type employing silicon controlled rectifiers with full half controlled bridge for voltage and current limit control.
The float charger will have built-in automatic voltage control and load limiting feature. The voltage regulator will automatically sense, monitor and regulate the DC voltage to within + or - 10% of the set value, from no load to full load and under supply voltage and frequency fluctuating conditions.
The float charger shall be designed to give higher output currents thus allowing a margin for future increase in load current or battery capacity.
Suitable control gear (Auto/Manual) shall be provided for smooth control of the voltage.
Suitable ripple filtering circuits shall be provided for the charger to give smoothing for DC output.
The boost charger will have dry type double wound transformer of suitable rating with adequate no. of taps on both primary and secondary side for the change of output voltage current control.
The charger shall be current limited at 125% of full load to reduce output voltage for charger circuit protection and protection of battery from over charge. The current limit shall be continuously adjustable from 80% -125%.
The float charger shall be provided with soft start feature which will make the DC output voltage to raise gradually to its rated value over a duration of 6-10 seconds whenever the charger is powered or at the time of restoration of supply.

COMMON FEATURES OF BATTERY CHARGING EQUIPMENT:

The battery charging equipment will capable of operating satisfactorily and delivering the rated DC output (220V/24VDC) with input A.C. supply voltage variation of + -5% of rated value.
The input supply for the battery chargers is 3 phase,415V, 50HZ A.C. supply for both 220V and 24VDC systems.

The ripple content of the battery charger will not exceed 3%

The battery charger equipment shall be supplied complete with all devices, bus bars, output terminals, earthing, links, cable glands for all external cables, rating plates etc.
The tenderer will also supply necessary equipment like relays for adequate protection of the charger against faults.

Bidder shall furnish schematic diagram showing the general protection features provided for the charger along with the general layout diagram.

While boost charging the battery normal load shall be fed by float charger. In the event of failure of float charger the load shall be fed from 90% tap of the battery through suitable means.
In the event of incoming AC supply failure, when the battery is being boost charged the available battery capacity shall be automatically transferred to the DC bus.

The float and boost chargers shall be housed in individual panels, separately in complete shape with all necessary accessories mounted. The panels shall be indoor, floor mounting, free standing type. They shall be totally enclosed, complete dust tight and vermin proof. The thickness of the steel sheet of the panel shall be 3.0mm. The internal power and control wiring of the charger shall be carried out with PVC insulated 1100V grade stranded copper conductor wires. The control wiring shall be carried out with 2.5 sq.mm. copper conductor cable. Power and control wiring shall be wired in separate bunches/troughs.

The terminal blocks shall be stud type terminals of ELMEX make type cat M4 suitable for connecting external cables to be provided by the purchaser. The size of all such cables shall be finalized with the successful tenderer. All external cables to be connected to the charger shall be arranged for bottom entry.

Space heaters suitable for operation on single phase 240VAC system in both the charger panels along with the ON/OFF switch shall be provided

Illumination in the charger panels shall be provided with a tube light operated on single phase 240VAC system. Suitable earthing lugs shall be provided for each of the charger panels.
Padlocks shall be provided for the panels to prevent unauthorised access or operation of any equipment.

MCCBS :

MCCBS used shall be non draw out type. They shall be quick make/ brake type and shall be provided with thermal overload magnetic short circuit releases. The operating mechanism must be trip free.

FUSES :

All fuses shall be HRC non-deteriorating type. Unless otherwise specified, the fuses shall be of class 4 (80KA breaking current) for AC circuits and class 2 (33KA DC current) for DC circuits

INSTRUMENTS :

The instruments shall be moving coil type ISS and will withstand over loads as experienced in system without injury or change in calibration. They shall be flush mounting type and dust proof.

BUS BARS :

The bus bars shall be of tinned copper having adequate current rating and shall be continuous throughout each section.

CONTACTORS :

The DC contactors shall be suitable for uninterrupted duty, making & breaking the current of the associated circuits. Each contactor will have not less than 2 No and 2 No auxiliary contacts in addition to those required for contactor operation.

ACCESSORIES :

All accessories of batteries, battery charger and DC distribution board required for installation, operation and maintenance of the both and charger shall be provided.

PROTECTION SYSTEM :

1. AC overload protection. A thermal overload relay is to be provided at AC input side which on over current trips and opens the input contactor.
2. Over voltage protection: Over voltage Protection for any failure in regulating circuit is to be provided.
3. Protection against earth fault indicating continuous earth leakage shall be provided.
4. Fully discharged condition of the battery shall be indicated on battery charger panel.
5. The equipment should restart automatically on restoration of AC supply. The DC output will raise gradually to its rated value over a duration of 8-10 seconds.

DETAILS OF COMPONENTS OF BATTERY CHARGING EQUIPMENT

The Battery charging system will consist of the following equipment.

METERS :

Float charger panel :

a) AC Input voltmeter with selector switch	500V.
b) DC Ammeter.	0-50A
c) DC Voltmeter.	0-300V

Boost charger panel :

a.	AC input voltmeter with selector switch	0-500V
b.	DC Ammeter	0-60A
c.	DC Voltmeter	0-300V

(vi) d. Battery ammeter with centre Zero. with suitable shunt 125 -0- 25A 150-0-150A

INDICATIONS :

1. Neon type indication lamps shall be provided for
a. Boost charger AC input ON (R,Y,B phases)
b. Float charger AC input ON (R,Y,B phases)

2. Long life LED indicators shall be provided for the following conditions with audio alarm for fault conditions.
   a) A.C. input fuse fail
   b) D.C. output fuse fail
   c) Contactors ON
   d) A.C. input over load
   e) Charger fail
   f) Charger fuse fail
   g) Charger over voltage
   h) Output over load
   i) Filter condenser fuse fail
   j) Rectifier fuse fail
   k) System output over voltage
   l) System output under voltage
   m) 105th cell in circuit/ 12th cell circuit
   n) Battery low
   o) Battery discharging
   p) Battery earth fault
   q) D.C leakage indicator (centre zero meter with -100 MA to +100 MA scale)

POTENTIAL FREE CONTACTS:

Potential free contacts (No contacts) shall be provided for following conditions in the respective panels.

a. Float charger fail
b. Boost Charger On
c. Battery low
d. Battery discharging
e. System under voltage.

MCCBS

a) For float charger input
b) For float charger output
c) For Boost charger input
d) For Boost charger output

SWITCHES :

a) Tap changing switch on B.C (Coarse/fine)
b) Battery input ON/OFF switch
c) system output ON/OFF switch
d) Space heater power supply ON/OFF switch
e) Panel illumination power supply ON/OFF switch

PUSH BUTTONS FOR THE FOLLOWING:

A) Float charger ON and OFF
B) Boost charger ON and OFF
C) Lamp test
D) Alarm silence

CONTACTORS FOR :

a) Boost charger
b) Float charger
c) D.C. contactor to connect 220VDC/24VD bus.

PROTECTION :

a) HRC Fuses at AC Input
b) Fast acting fuses for semiconductor devices protection.
c) AC Input over load
d) DC over voltage
e) Float charger over current
f) Thermal O/C relay Boost Charger.
g) Thermal O/C relay Float charger.

TRANSFORMERS :

a) Boost charger Transformer
b) Float Charger Transformer
c) Transformer for gate pulse power supply.
d) Current Transformers to limit over load
e) Filter choke.

PROTECTION CLASS : IP 42

CONSTRUCTIONAL FEATURES OF D.C DISTRIBUTION BOARDS:

The D.C. distribution Boards shall be rated for 600VDC and 30VDC respectively distinct from charger equipment. D.C. distribution boards shall be supplied separately both for 220V and 24V D.C. Systems.

The D.C. distribution board will consist of DC MCCBS for controlling the incoming supplies and for various out going feeders along with indication lamps to indicate `ON' condition of MCCB.

The D.C. distribution Boards will comprise necessary earth leakage indication device, bus bars, all internal connectors, earthing connections wiring etc., as required.

The distribution boards to be supplied shall be made of cold rolled sheet steel and suitably dimensioned. The thickness of the steel will not be less than 3.0mm.

DETAILS OF 220V D.C. DISTRIBUTION BOARDS:

The D.C. distribution Boards offered will comprises of two sections two numbers incoming feeders (one shall be closed at a time) with 400A DC MCCB, of 220V DC shall be provided for connecting to Battery Bank which shall be common for both sections.

a) 220VDC Distribution Board: Section-I

Out going feeders :

1) 15 Amps DC Double pole MCCBs : 32 Nos.
(16 Nos for each unit, Total for 3 pumps)

2) Under voltage relay : 1 No.

b) 220V DC Distribution Board : Section-II

1) 30 A feeders : 2 Nos.
2) 15 A feeders : 40 Nos.
(common for all pumps and switchyard equipment)
For each feeder "ON" indication lamp or LEDs hall be provided

c) 24VDC distribution Board

Incoming feeder from 24 V Battery bank with 100 A DC MCCB : 1 No.

The 24VDC distribution shall be provided with the following outgoing feeders on the suitable MCCBs

16Amps DC double pole MCCBs : 15 Nos.
30 Amps DC double pole MCCBs : 4 Nos.

For each feeder "ON" indication lamp or LED shall be provided

.The prior approval shall be taken for the drawings before manufacturing the distribution Boards.

TESTS :

The routine and type tests on the equipment viz. battery, battery chargers, DC distribution boards shall be carried out at works. The capacity test on Battery at site shall be carried out after commissioning. Should the capacity test of battery is found lower than the specified, the supplier will rectify defects at his cost. The Purchaser reserves the right to reject the battery, if ultimately the battery is found lower than the specified rating.

BID DATA, DRAWINGS, AND INSTRUCTION BOOKS:

Layout of battery room, calculations for battery capacity, operation and maintenance instruction books shall be submitted.at the time of detailed engineering

NOISE: All apparatus will operate without excessive vibrations and with the least practicable amount of noise. Terminal Blocks.

Sealed Maintenance Free (SMF / VRLA) battery and charger with static control circuits and Thyristor bridge rectifiers with complete automatic voltage, current regulation.

Type of battery : Maintenance free sealed lead acid high discharging performance indoor type station battery.

Nominal Voltage : 220 Volts
AH efficiency : 90% minimum
Watt Hour efficiency : 82% minimum

Time required for Boost charging from completely discharged condition	:	8-10 Hrs
Nominal life of battery	:	20 Years
Terminals	:	Integral lead terminal with solid copper core
Connectors	:	Heavy duty lead plated copper connectors.

The battery charger will consists of boost and float chargers. The rectified DC shall be fed into Main DCDB. From this the DC supply shall be extended to individual panels through MCBS of suitable rating ONE MCB shall be provided for each function panel independently.

1. **List of Mandatory spares for VT Pumps.**

I.	Complete impeller with impeller Nut	1 no for Each type of Pump
II.	Impeller wear ring	1 no for Each type of Pump
III.	Set Shaft sleeve	1 no for Each type of Pump
IV.	Set of Thrust bearings	1 no for Each type of Pump
V.	Set of Throdan bearings	1 no for Each type of Pump
VI.	Set of wearing rings	1 no for Each type of Pump
VII.	Set of couplings	1 no for Each type of Pump
VIII.	Gland packing/mech. Seal set	1 no for Each type of Pump
IX.	Set of packings and gaskets	1 no for Each type of Pump
X.	Set of fasteners	1 no for Each type of Pump

List of Mandatory Spares for EOPD/HOPD Valve:

I.	Seats ring and seal ring	1 no for Each type of Valve
II.	Actuator gear box `	1 no for Each type of Valve.
III.	Actuator complete unit	1 no for Each type of Valve
IV.	Actuator control cards	1 no for Each type of Valve
V.	Actuator Power cards	1 no for Each type of Valve
VI.	Limit switches for actuators	1 no for Each type of Valve.

2. **List of Mandatory Spares for Motor:**

I.	Motor Bearing set	1 no for Each Rating
	RTDs used for air circuits & bearings	20% of total quantity.
II.	Cooling Fans	1 no for Each Rating.

3. **List of Mandatory Spares for VFD:**

I.	VFD	1Nos. for Each Rating
II.	Bypass contactors	1Nos. for Each Rating
III.	Multipliers Contactors	1Nos. for Each Rating
IV.	Thermal Relays	1Nos. for Each Rating.
V.	Timers	1Nos. for Each Rating

4. **List of Mandatory Spares for Switch gear Panels**:

I.	Circuit Breaker	1Nos. for Each Rating
II.	Current transformers	1Nos. for Each Rating
III.	Potential Transformers	1Nos. for Each Rating
IV.	Spring Charge Motors	1Nos. for Each Rating
V.	Protection relays	1Nos. for Each Rating
VI.	Indicating and recording Meters	5% of total quantity
VII.	Selector switches (each type)	5% of total quantity
VIII.	Indicating Lamps	20 Nos for each type and color

5. **List of Mandatory Spares for LT Distribution Panels(SAB):**

I.	LT Contactors	1 No. for Each Rating
II.	MCB/MCCB	1 No. for Each Rating

III.	Switch fuse Unit	1 No. for Each Rating
IV.	Indicating and recording Meters	5% of total quantity
V.	Selector switches	5% of total quantity
VI.	Indicating Lamps	20 Nos for each type and color

6. **List of Mandatory Spares for Battery and Battery charger:**

I.	Thyristors/SCR	5% of total quantity
II.	Diodes	5% of total quantity
III.	Multipliers Contactors	5% of total quantity
IV.	Multipliers Contactors	5% of total quantity
V.	Control cards	1 No. for Each type
VI.	Control transformers	1 No. for Each type
VII.	Indicating Lamps	5 Nos for each type and color
VIII.	All types of PCB	1 set

7. **List of Mandatory Spares for EOT Cranes:**

I.	Thrust Breaks	7 Nos.
II.	Coils for Break solenoids	1 Set
III.	Control contactors	5% of total quantity
IV.	Brake pads/Linings	5% of total quantity
V.	Fuses	5% of total quantity
VI.	Limit switches	2 Nos.
VII.	Bearings	1 No. for Each type
VIII.	Oil seals	1 No. for Each type
IX.	Carbon Brushes	1 set
X.	Fuses all ratings	1 set

List of Special Tools, Instruments and T&P.

1)	Chain block (special)	1 set
2)	Separating bolts (Special)	1 set
3)	Special Spanners for Pumps	1 set

List of testing instruments for electro mechanical equipment

The following testing instruments and equipment shall be supplied for testing of Pump Motor sets (units).

1) A.C. Analog / digital Voltmeter,
   a. 0-150 / 300V — 1No.s each
   b. 0-75 / 150V — 1No.s each
2) A.C. Analog / digital Ammeter, 0-1/5A, 0-5/25A — 1 No.s each
3) Analog Watt meter 3 Phase, 1/5A, 600 V 0.5 class — 1 No. each
4) Frequency meter (Digital), 45-55 Hz & — 1 No.
5) D.C. Analog / digital Voltmeter, 0-100m V. 0-100V/300 V — 2No.s
6) D.C. Analog / digital Ammeter 0-1/5A. 0-5/25 A — 2 No.s
7) Phase angle meter Analog, 120/240 V. 50/60 Hz 0.5/1A. & 2.5/5A. — 1 No
8) Phase rotation meter, AC, 60 V-500V — 1 No.
9) Wheatstone Bridge, 0.0001-10 ohms — 1 No.
10) VAR Meter Analog 2.5/5A, 120V, 0.5 Class — 1 No.
11) Earth megger 500V — 1 No
12) Single Phase Variac, 0-250 V, 15 A — 2 Nos.
13) 3 Phase Variac 0 -500V, 15A — 1 No.
14) Testing Transformers:
   a. 1 Ph. 30 KVA, 220/30 V, 1000A — 1 No
   b. 3 Ph 440 V, 0 to 50 A. — 1 No.
15) DC High voltage testing kit, 0 to 60 KV/10 mA — 1 No.
16) Megger Digital, 500 V, 1000 M ohm — 2 Nos.
17) Megger Digital, 1000V, 2000 M ohm — 2 No.
18) Motor operated Megger 2.5 KV/5 KV (Digital) — 2 No.
19) Oscilloscope dual champed storage — 1 No.
20) Stop watch, 1/5 sec. (60 sec.) — 4 Nos.
21) Electric Hand tachometer (Digital) (0-3000 rpm) — 7 Nos.
22) Manometer Gauge Tester 0.05 kg/cm2 — 7 set
23) Manometer Gauge Tester 2.50 kg/cm2 — 7 set
24) Manometer for oil use, 0-50 kg/cm2 — 7 sets.
25) Manometer for water use — 7 sets.
26) Resistance box, 6 element — 7 No.
27) Open Angle measuring tool — 7 set
28) Shunt, 5A or 7.5 A/50 mV — 7.No.
29) Bell, 220 V DC. — 7 Nos.
30) Elec. Soldering iron, 230 V AC 100W (with temp. control). — 7 Nos.
31) Noise Meter A/B/C range — 7 No.
32) Hand Operated crimping tool — 2 Nos
33) Hydraulic operated criping tool — 2 Nos
34) Vernier calipers 150mm, 300mm — 2 Nos.
35) Pitch gauge — 2 Nos.
36) Depth micro meter 0 to 50mm, 0 to 400mm — 2 Nos.

37) Inside micro meters 25 mm to 1 meter 2 Nos.
38) Out side micro meters 0 to 150mm, 0 to 300mm 2 Nos.
39) Slip gauge up to 100mm 1 No.
40) Straight edge 150mm, 300mm and 1 meter 1 No.
41) Telescope gauge up to 150mm 1 set
42) Dail gauges 8 Nos
43) Vibration Meter 2 No.

Range 1 to 1000 mm/sec2, Velocity 0.1 – 100 mm/sec. with recorder.

I. List of Tools and plant:

The following tools and equipment shall be supplied for regular operation & maintenance of pump units.

1) Double end ring spanners 6mm to 36mm 7 sets
2) Open end type spanners 6mm to 36mm 7 sets
3) Box spanners with ratchet handle and extension rod. 6mm to 36mm 7 sets
4) Feeler gauge 0.01mm to 2.5mm 7 sets
5) Screw drivers with insulation 150mm to 600mm 7 sets
6) Cutting player with insulation 7 sets
7) Bearing Pullers varies sizes 7 sets
8) Aluminum ladders 30 feet, 50 feet,100 feet 7 No.
9) Drilling machines 6mm, 13mm and 25mm 7 Nos.
10) Welding Transformer 230 V, 300 A to 600 A 7 No.
11) Portable welding machine 0 to 150 A 7 Nos.
12) Bench grinder 150mm 7 Nos.
13) Horizontal grinder 100mm 7 Nos.
14) Angel grinder 180mm 7 Nos.
15) Flexible shaft grinder 7 Nos.
16) Vacuum cleaners heavy duty, 230 V. 7 Nos.
17) 'D' shackles 3T, 5T and 10T 7 Nos.
18) Slings (Steel) 8 mtrs. Length 3T, 5T and 10T 7 Nos.
19) Portable Hot air blower 7 Nos.
20) Oxygen regulators 7 sets
21) Blow pipe set 7 sets
22) Tap sets 6, 8, 12, 16, 20, 24mm 7 sets
23) Hammers (Steel) 2, 6, 8 LBS 7 Nos.
24) Hacksaw frame 300 mm 7 Nos.
25) Sheet metal cutters 300 mm 7 Nos.
26) BSP taps ¼ , ½, ¾ and 1inch 7 sets
27) Chain block pulleys. 1 T, 3 T and 5 T 7 Nos.
28) Bench vise 8 inches 7 No.
29) Surface plate 400 mm 7 No.
30) Pipe bending Kit. 7 No
31) Align keys 7 set

All the above spares, T&P, Testing instruments to be supplied 2 sets in total.

Pre-commissioning Trials

4.1 START UP

On completion of the erection of equipment and before start up, each item of the equipment shall be thoroughly cleaned and then inspected by the Engineer in charge and the contractor jointly for correctness and completeness of installation and acceptability for startup leading to initial pre-commissioning tests at site. The list of pre commissioning tests to be performed shall be mutually agreed and included in contractor's quality assurance Programme. The contractor's commissioning /start up engineers specially identified as far as possible shall be responsible for carrying out all pre-commissioning tests. On completion of inspection, checking and after pre-commissioning tests are satisfactorily over the complete equipment shall be placed on initial operation during which period, the complete equipment shall be operated integral with sub-system and supporting equipment complete plant.

4.2 COMMISSIONING SPARES

The contractor shall make Arrangements for an adequate inventory at site, of necessary commissioning spares prior to commissioning of equipment furnished and erected so that any damage or loss during these commissioning activities necessitating the requirements of spares will not come in way of timely completion of works under contract.

4.3 REGISTRATION AND STATUTORY INSPECTION

All the registration and statutory inspection fees if any in respect of work pursuant to this contract shall be to the account of contractor. Should any such inspection on registration need to be re-Arranged due to the fault of contractor, the additional fees for such inspection shall also be borne by the contractor.

4.4 PROGRESS REPORTS AND PHOTOGRAPHS

During various stages of works in pursuant of the contract the contractor shall at his own cost submit periodic progress reports as may be reasonably required by the Engineer in charge with such materials as charts, networks, photographs, test certificates etc. Such progress reports and photographs shall be in the form and size as may be required by the Engineer in charge and shall be submitted in at least three copies and shall contain the date, the name of the contractor and the title of the photographs. The report shall also indicate reasons for variance between the schedule and actual progress and the action proposed for corrective measures whatever necessary.

4.5 WORK AND SAFETY REGULATIONS

a) The contractor will notify the Engineer in charge of his intention to bring on to the site any equipment or any container with liquid or gaseous fuel or other substance, which may create hazards. The Engineer in charge shall have right to prescribe the condition under which such equipment or container may be handled and used during the performance works and the contractor shall strictly adhere to such instructions. The Engineer in charge shall have the right to inspect any construction plant and to forbid its use if in his opinion it is unsafe, no claim due to such prohibition shall be entertained by the owner.

b) Where it is necessary to provide and / or store petroleum products or petroleum mixtures and explosives the contractor shall be responsible for carrying out such provision and/or storage in accordance with the rules and regulations laid down in Petroleum Act 1934 Explosive Act 1948 and petroleum and carbide of calcium manual. All such storage shall have prior approvals necessary from chief Inspector of Explosives or any Statutory Authorities. The contractor shall be responsible for obtaining the same.

4.6 ELECTRICAL SAFETY REGULATIONS

a) In no circumstances will the contractor interfere with the fuses and electrical equipment belonging to the owner or other contractor

b) Before the contractor connects any electrical appliances to any plugs or sockets belonging to owner or other contractor he shall

1) Satisfy the Engineer in charge that the appliances are in good working conditions.
2) Inform the Engineer in charge of maximum current rating voltage and phases of the appliances.
3) Obtain the permission of the Engineer in charge, detail the sockets to which appliances may be connected.

c) The Engineer in charge will not grant permission to connect until he is satisfied that

1) The appliance is in good condition and is fitted with suitable plug.

2) The appliance is fitted with suitable cable having two earth conductors one of which shall be an earthed metal sheath surrounding the core.

d) No electric cable in use by the contractor shall be in use by the contractor/owner will be disturbed without prior permission.

No weight at any description will be imposed on any such cable and no ladder of similar equipment will rest against or to be attached to it.

e) No work will be carried out on any live equipment. The equipment must be made safe to work issued before any work is carried out.

f) The contractor shall employ the necessary number of qualified full time electricians to maintain the temporary electrical installation.

Contractor shall make necessary Arrangements for the following

I) It is necessary to carry out the testing of number of equipments in the manufacturers works. This is stated in the item wise specification. However the items, which require third party inspection as tested below with brief requirement of tests.

II) The Arrangements for this shall be Arranged by the contractor, the cost of testing in factory payable to manufacturer (including power charges etc.) The testing fees of inspecting authorities etc. shall be Arranged by the contractor without any extra cost to the department.

Whenever department Engineers will be attending the inspection and testing to and fro charges will be born by the department as per Govt. civil service rules. However all other Arrangements shall be made by the contractor.

5.1 Pipe work

M.S. pipe work shall be fabricated from M.S. plates confirming to IS 226. The fabrication pipe shall generally confirm to IS 3589 pipe and specials shall be fabricated from 10 mm and 8/6 mm thick plate as per drawing. Layout of valve and pipe work shall be got approved from the department. Dished end shall be provided at the end of the common manifold and thickness of dished end shall not be less than 12 mm.

Air release Arrangements shall be provided after the discharge head by using 50mm diameter G.I./ M.S. pipe and cock. Joints connecting the valves shall be flanged with flange thickness not less than 25mm joint rubber ring for these joints shall not be less than 3 mm.

The pipe work shall be subject to test pressure of 1.5 times the actual working pressure in the presence of the Engineer in charge.

All the pipes and valves shall be painted with the primer red oxide paint after the surface is cleaned and two coat of enamel paint of approved quality and shade to have finished aesthetic appearance. Cost of breaking the holes in walls and remaking the same as it was is included in this item.

5.2 Dismantling joints –

These shall be provided connected to the flange outlet or discharge head of the pump and Non Return valve. The diameter of this joint shall be same as Non Return valve. This shall be fabricated from M.S. plate designed to withstand pressure of 25 kg/cm2. The plate thickness shall not be less than 10 mm. The design of the joint shall ensure that no forces are transmitted to the pump foundation and flanges of dismantling joints are held rigid during normal working. For dismantling it shall be possible to slide the flanges at one end by at least 25 mm to enable dismantling refitting, General Arrangements drawing shall be got approved before actual fabrication of the joint.

6 ELECTRICAL EQUIPMENTS

I) Electric motors

There shall be vertical, hollow/solid shaft flange mounting type, to operate on 415 volts +/- 10% 3 phase 50 Hz. A.C. supply. The design of motors shall confirm to IS 325. The torque speed and current speed characteristics of motor shall be suitable for pump starting characteristics. The motor shall be designed such that there shall be minimum 10/15% reserve power over the entire head range of pump specified. H.P. of the motor. Starting time and locked rotar with stand time under hot conditions shall have suitable discrimination for proper selection of protection relays. The locked rotar withstand time under hot condition and at 85% rated voltage shall be more by at least 3 seconds than the starting time with driven equipment coupled at 85% rated voltage.

The motor shall be suitable for restricted operation at following conditions.

(a) Accelerating the driven equipment from stand still to full speed within duration of 1 minute or less at 85% of rated voltage.

(b) Operation on load at 75% of rated voltage for five minutes

(c) Two starts at quick succession for cold condition

(d) One hot restart at maximum steady state temperature over ambient temperature 45^0c .

(e) Three starts per hour equally spaced over the duration after attaining thermal equilibrium.

(f) The motor shall be of continuous duty 'S-1' class. The class of insulation of motor shall be 'F' class.

1.1.1.1. Constructional features

The motor shall be vertical, hollow shaft. The motor shall be statically and dynamically balanced and critical speed shall not be in the range of 80% to 120% of motor speed R.P.M. and direction or rotation of motor shall be same as that of pump.

The motor shall be squirrel cage induction type, with S.P.D.P. construction with degree of protection confirming to IP 24. At least two drain holes shall be provided at the bottom end of the frame.

The motors shall be provided with special designed heavy duty thrust bearing anti friction grease lubricated type to take entire load of pump and motor static and dynamic type. Terminal box shall be designed suitably to accommodate armored aluminum conductor of required rating and shall be manufactured by the motor manufacturer. Suitably designed non-reverse ratchet Arrangements shall be provided to the motor to stop reverse rotation.

(Note – As the V.T. pumps provided are suitable for hollow shaft motor necessary provision of special thrust bearing to take entire thrust a motor pump set shall be made along with non reverse ratchet and clutch type pump motor coupling at top as specified in the pump) as required.

1.1.1.2. Testing

The motor shall be offered for routine test to the inspecting Authorities and test certificates shall be submitted to the Engineers in charge.

Following document shall be furnished after contract is awarded.

a) General Arrangements drawing
b) Instruction manual for erection and maintenance
c) Test report
d) Torque speed curve

(ii) Auto transformer starter –

Fully automatic A. T. starter motor control panel assembled locally with the contactors of approved makes sheet metal clad enclosure, floor mounting type suitable for operation on 400/440 volts 3 phase 50 cycles A.C. power supply and fitted with

1. Oil immersed Autotransformer with 40%, 50%, 65% and 80% tapings. (Winding of transformer shall be copper only) with withstand capacity for at least six starts per hour. **Transformer will be inspected by third party before dispatch.**

2 Air break contractors of suitable rating, as under of AC3 duty class shall be provided.

3. Bimetallic thermal over load relay.

4 Timer on delay OFF

5 Ammeter and voltmeter with C.T.'s and selector switch

6 No volt release

7 Single-phase current sensing relay.

The wiring on the contactors shall invariably be carried out by using solid copper conductors. The appearance and layout in the panel shall be aesthetic and specious to facilitate easy working. The enclosure shall be factory finished specious and elegant looking and provided with ISMC 75 M.S. base channels painted with best quality enamel paint or powder coated. Interlocking shall be provided so that the panel door shall not be opened when panel is on or alternately the panel should trip in case of opening of door. Contractor shall submit dimensional drawing of the starter, details of the offered components wiring diagram of panel etc. Indicating lamps for three phases On OFF and TRIP shall be provided on the front. Special terminal boxes for incoming and outgoing shall be suitably designed and provided to facilitate easy entry of power cables.

The starter panel shall be tested in the manufacturers work for functional requirements H.V. tests etc. by the competent authorities of the department.

Approved makes of Contactors

L&T / Siemens / Bharatiya Cultter Hammer Adrew yele/Crompton.

ii) Relays L&T Crompton A.B.B.E.E., Siemens

iii) Timer – L&T, Siemens.

iv) Ammeter and Voltmeter A.E. IMP RISHABH

v) Auto Transformer approved standards make.

L.T. Panel

General

L.T. panel comprising 415-Volt switch gear and control gears shall be suitably designed for the functions as under

a) Reception of power from Transformer

b) Distribution of power for pump motors, lighting etc.

1.1.1.2.1 Panel Construction

The 415-grade switch gears shall be housed in a totally enclosed sheet metal clad dust and vermin proof of cubicle suitable for floor mounting and are of equal height. The panel shall incorporate the following

i) 3 ½ pole 400A Aluminum bus bars in enclosed compartment in horizontal formation C.

ii) Enclosed vertical bus bar serving the motors

iii) No of identical separate compartments for motor feeders, instruments bus bars, C.T., P.T. cable termination as required.

iv) Internal panel barriers in the bus bar Chamber shall be epoxy.

The panel shall be fabricated from 2 mm thick M.S. sheets. Hinged doors shall be provided at the front and rear with car type handles. Mechanical interlocks shall be provided to prevent the opening of front door in ON position or alternately Arrangements shall be made to trip the supply in event on opening or front door. Suitable stopper shall be provided to restrict the opening of the doors to working requirements and to prevent the rubbing of the door and scratching of paint with adjoining panel structure. Cable entries and exits shall be from the bottom only. Indicating and opening devices shall preferably be at uniform levels and shall not be above 1600 mm from the floor.

The panel framework shall have minimum ISMC 75 channel for base. Angle framework shall be 40 x 40 x 5 mm size M.S. angles.

2. BUS BARS

The bus bars shall be aluminum sections to carry 400 A rated current (minimum) continuously. The bus bar shall be covered with shear resistant P.V.C. sleeves with color code and joints shall be epoxy shrouded. The bus bars shall be supported on durable non-hygroscopic supports rigidly fixed to the framework.

Adequate clearance shall be kept between the bus bars as per relevant IS codes.

3. PANEL CABLING AND TERMINATIONS

Power cabling shall be done entirely with P.V.C. insulated 1.1kV grade cables of size designed in confirming with relevant I.S. and shall not be less than 2.5Sq.mm. control cables shall be 650 V grade insulated copper cable not less than 1.5 sq. mm. however the cable for current transformer shall be 2.5 sq. mm or above. Cost of power and control cables in the panel shall deem to be included in cost of panel.

The terminal blocks shall be one piece moulded and screwed type. At least one spare terminal block shall be provided in each panel. Control cable shall neatly run over P.V.C. cable trays and shall be terminated in compression type terminal blocks. Identification codes as approved by the engineers shall be used for cable terminations. Ferrules shall be used for multi core cables.

Current transformers

The current transformer's for metering shall be wound/bar type and shall be rated for 21 KA fault level.

4. PAINTING

The panel shall be painted as under primer coat – one coat of red oxide. Intermediate Coat – Enamel paint of shade approved Final coat – Enamel paint as above.

5. LABELS AND DANGER MARKS

Scheme of labeling shall be as under

a) Each compartment door shall have title label. The component/ control on each compartment shall have function label.

b) Each internal component and fuse shall have identification label with fuse current capacity where applicable.

All external labels shall be clear painted black in English all internal labels with crome plated nuts and bolts. Size of label shall be 50 mm x 25 mm with height of letter 5 mm.

Compartments not interlocked to an insulator shall have an external danger mark as under

“DANGER, LIVE TERMINAL” with flash mark and voltages in red letter on white background.

6. CAPACITOR

All the pump motors shall be provided with suitable capacitor banks for improving power factor to 0.95 lagging at normal duty conditions. However KVAR selected shall not exceed 90% of the magnetising KVAR of the motor even if corrected P.F. is less than 0.95 lagging but not less than 90% in any case. The capacitor shall be suitable for operation at rated voltage [415 volts +- 10%] and shall be connected in respective power circuit of the motor with isolating switch tube units.

Capacitor bank shall be complete with structure, earth wire, discharge resisters etc. The capacitor shall be low loss mixed dielectric construction of polypropylene and craft paper insulated aluminum foiled type impregnated with non PCB non toxic non hazardous non flammable synthetic di-electroral oil and fitted with internal element fuse conforming to IS 2834/1981 revised and shall be with ISI mark separate panel shall be fabricated for housing these capacitors.

7. TESTING

The capacitor shall be tested for routine test as specified in IS 2834 and test reports shall be furnished.

Contractor shall Arrange thermal stability test on the unit in the presence of the Engineer In charge.

Cables

Power cable used in 415 Volts system shall be 1.1KV grade 3 ½ core as applicable aluminum conductor P.V.C. insulated P.V.C. sheathed flat steel armored type confirming to IS 1534.

Cable shall be of sizes rated to carry full load current at 0.85 P.F. or to withstand short circuit current 20 KA for duration at least to opening of associated breaker whichever is greater but shall not be less than the size specified in subsequent clause.

Approved make for power cables/cables schedule – Tropodour /Finolex/Asian/ Gloster / Incab / universal / poly cab Nico

8. CABLING METHODS

Cables shall be laid in ground ducts and on trays in and out of pump house through R.C.C. trenches etc. with clearance not less than 600 mm below the water mains. Every cable shall be neatly run vertically, horizontally or parallels to adjacent wall, beam or column. At both ends of terminations the cable shall be approached from a common direction and are individually terminated in all orderly and symmetrical fashion.

The cables shall be terminated in mechanical glands that shall be suitable to provide adequate support by locking on the armour and additional earth continuity. Suitable compression type copper cable lugs shall be used for cable terminations.

The point of entry, exit of cables from the building shall be sealed from out side with an approved asbestos compound followed by 40 mm thick bituminous compound with sealing.

Cable route markers of approved design shall be installed at following positions

a) Entry and exit points of underground duct/trench

b) Exit from building

At every 5 meters distance of straight run

Any other position to trace the route.

A metallic plastic tag bearings cable reference number indicated in cable schedule at every 4 run to part thereof and at both ends shall be provided for case of identification and route tracing. The schedule shall be prepared by the contractor and submitted for approval.

The cable routes shall be such that sharp bench and kinks shall be avoided. The radius at bends for PVC insulated cables shall not be less than twice/thrice the overall diameter of the cable. Laying and termination of 1.1 Kv grade cable shall be as per manufacturers instruction as per practices specified code electrical manual. The cable underground shall be laid as per respective IS and practice in force and as directed by the Engineer In charge.

Loop/extra lengths shall be provided in each cable run located suitably. The loop/extra lengths shall be adequate for two straight through joints as and when needed.

Earthing

Effective earthing shall be provided to all electrical equipments and components. This shall be carried out with G.I. pipe electrode. Buried 2500 mm below ground including excavation of pit in all types of strata with charcoal salt and necessary alum etc. Strip, funnel Arrangements for watering and brick masonry chamber with C.I. frame and cover etc complete as per IS3043 and as per E.I. rules amended up to date.

The electric motors, L.T. panel starter, capacity etc shall be provided using double earthing with G.I. strip of size 25 mm x 3 mm with two independent earth pits. The pipe earth electrodes of 40 mm dia 2.5 m depth shall be used.

Earth pits shall be filled with charcoal salt and alum. They shall be provided with non hole frame and cover at top and water connection for watering the pit at intervals.

The earthing shall be carried out as per IS 3040 of 1966 and amended up to date and I.E. act 1948 amended up to date.

Ground bus or section 25 x 3 mm G.I. strip shall run through out the L.T. panel and shall be bolted to the framework.

All equipment shall be provided with two independent earthing connections and connected to earth strip.

Earth G.I. wire 6 S.W.G. shall run along with the cable from L.T. panel of pure water pumps to incoming of panel for ensuring safety and provide independent earthing to cable. This wire should be connected to armor or cable and cable end boxes at starting and end points.

Illumination to the pump house.

Necessary illumination shall be provided in and out at pump house as per specification given below.

9. EXTERNAL ILLUMINATION

i) This shall be as per direction of Engineer in charge.

10. INTERNAL ILLUMINATION

Internal illumination in pump house and attendant room should be done as per direction of Engineer in charge.

Internal wiring shall be carried out with suitable size copper conductors P.V.C. insulated in appropriate size; M.S. conduit wooden block shall be provided wherever required. Separate wooden board tick wood polished shall be provided mountains the switches etc. Four power plug points with separate switches shall be provided.

8. TEST TRIAL AND OPERATION

The plant shall be on trial operation for six months after testing during which period all necessary adjustments shall be made while operating over the full load range enabling the plant to be made ready for performance and guarantee test.

The duration of trial operation of the complete equipment shall be at least three months, out of which at least 72 hours shall be of continuous operation with full load or any other duration as may be agreed to between the Engineer in charge and the Contractor. The trial operation shall be considered successful, provided that each item of the equipment can operate continuously at the specified characteristics for the period of trial operation. Minor interruptions not exceeding four hours at a time, caused during the continuous operation shall not affect the total duration of trial operation. However, if in longer, the trial operation shall be prolonged for the period of interruption.

A trial operation report comprising observations and recordings of various parameters to be measured in respect of the above trial operation shall be prepared by the contractor. This report, besides recording details of the various observations during trials run shall also include the dates of start and finish of the trial operations and shall be signed by the representatives of both the parties. The reports shall have sheets, recording all the details of interruptions occurred, adjustments made and any major repairs done during the trial operation. Based on the observations, necessary modifications/ repairs to the plant shall be carried out by the contractor to the full satisfaction of the Engineer In charge to enable the latter to accord permission to carry out performance and guarantee test on the plant. However, minor defects which do not endanger the safe operation of the equipment shall not be considered as reasons for withholding the aforesaid permission.

11. COMMISSIONING AND OPERATION

After commissioning and testing, there will be six months trial run and thereafter five years for operation and maintenance of the plant.

During trial run and O & M period, the contractor shall depute his personnel full time to operate, maintain and repair the equipment. The personnel so deputed shall maintain log books and other records as directed by the Engineer In charge. During this period the owner's personnel shall continuously work with Contractor's personnel to take full responsibility of operating, maintaining, repairing, etc. of the equipment plant.

Civil works:

Following civil works are required to be carried out for installation transformer pole structure, fencing gates etc.

The general specifications are given below. However the general Arrangements and the layout or the substation shall be as per drawing approved by the statutory authority.

a) **Transformer platforms**- Suitable size of platform shall be provided for the transformer in 1:2:4 cement concrete as shown in the layout. The height of the transformer shall be such that the live terminal of the transformer shall be at a distance of 4m above the ground level of the transformer ground or as stipulated in I.E. rules amended up to date. The concrete work shall be carried out as per regular civil Engineering practice with excellent finished work. Necessary recess shall be provided to accommodate the outgoing cables --- for L.T. side of two transformers.

Two numbers of M.S. channels shall be embedded on the top of the each plinth for resting the wheels of the transformer.

b) Foundations for poles: These shall be provided to each pole which will be used to receive the power supply, mounting the A.B. switches, lightening arresters, D.O. fuses etc. The size of foundation shall 60 mm x 60 mm and 180 cm deep in 1:3:6 cement concrete & 45 cm x 45 cm plinth duly plastered with necessary curing etc. in a neat manner.

Cable Trenches

Necessary cable trenches shall be constructed from each transformer to the pump house.

The trench shall be at least .7m deep and of suitable with depending upon the no of cables to be used through and layer of .2m shall be provided at the bottom on trench and bricks shall be placed on both side of the cable.

Suitably designed markers shall be provided and fixed at every 3-4 meters showing the cable path. The earth in trench shall be filled with crown form at the top.

First aid kit shall be kept in the near by room immediate half to the injured person in case of accident.

9. RISING AND DISTRIBUTION MAINS

Centrifugally cast iron or ductile iron spun pipe shall be used for laying Rising and Distribution Mains as shown in drawing. Centrifugally cast iron spun pipe (LA-Class) conforming to IS 5382-1969 and ductile iron (class K-7/K-9) confirming IS 8329:2000 shall be used requisite number of CI Sluice valves and Scour valves will be provided on the mains. Necessary chambers for valves as per type design shall be constructed. Necessary CI Specials conforming to ISS:- 1538-1969 or DI specials confirming to IS 9523:2000; pig lead conforming to ISS:- 782-1978,yarn conforming to ISS:- 6587-1972 will be supplied and fixed by the contractor and making lead caulked joints or push on joints with rubber gasket as per IS Specification and direction. Thrust blocks will also be provided at places like bends and wherever directed. **The successful tenderer will have to get pipes, pumps, motor, transformers etc inspected by DGSD/SGS/RITS/BIS before dispatch to site at their own cost and will submit inspection report to consignee accordingly**. The materials will be accepted by the consignee after proper verification at the consignee end

The pipes shall be tyton jointed. Rubber gaskets conforming to IS 5382-1969 shall be used for tyton joints.

Laying of CI/DI pipes shall be as per IS 12288:1987. The width of trench at top and bottom, between faces of sheeting shall be such as to provide minimum 30 cms clearance on either side of the pipe for pipe diameters less than 600 mm and 45 cms for pipe diameters 600 mm and above.

Before laying of pipe the bottom of trench shall be trimmed off to present a plain surface and all irregularities shall be leveled. Where large stone or boulders or rock is met in excavation, murum or sand bedding of 10 cms thick shall be provided below pipe. All care should be taken to protect the pipe and the coating.

10. EXCAVATION IN AVERAGE SOIL, SOFT AND HARD MURUM, CONCRETE BOULDERS ETC.

a) General: The trench shall be so dug that the pipe may be laid to the required alignment, at the required grade and depth

b) As per direction of the Engineer in charge. The depth of the trench should be sufficient to have a minimum cover of 100 cms. In cases where this is not feasible a decision in this regard shall be taken as directed by Engineer in charge. The trench shall be excavated only so far in advance of pipe laying as per the orders of the Engineer in charge. The trench shall be so braced and drained that the workmen may work there in safely and there shall be no danger to the nearby structures. If any stems and roots of trees are encountered in the excavation of trenches these will have to be cut and destroyed under the supervision and direction of Engineer in charge. If water lines, drainage lines, Electric or Telephone cables

are encountered in the excavation of trenches, the work of excavation or laying of line etc. will have to be carried out without damaging the lines and cables and under the supervision of the concerned staff. Appropriate clearances shall be kept from the existing utilities as directed by Engineer in charge. Extra claim for dewatering will not be entertained.

c) Barricades, guards and safety provisions: To protect from injury and to avoid damage to property, adequate barricades, construction signs, torches, red lanterns and guards as required shall be placed and maintained during the progress of the work and until it is safe for traffic to use the road ways. All material, pipe equipment and pipes which may serve as obstructions to traffic shall be enclosed by fences or barricades and shall be protected by proper lights when visibility is poor.

d) Maintenance of traffic and closing streets: The work shall be carried in such a manner which will cause the least interruption to traffic, and the road street may be closed in such a manner that it causes the least interruption to the traffic. Where it is necessary for traffic to cross open trenches, suitable bridges shall be provided. Suitable signs indicating that the work is under progress or a street is closed etc. shall be placed and necessary detour signs for the proper maintenance of traffic shall be provided.

e) Structure Protection: Temporary support, adequate protection and maintenance of all underground and surface structure drains, sewers cables and other obstructions encountered in the progress of the work shall be furnished under the direction of Engineer in charge.

Refilling of Trenches.

a) General: The refilling of trenches shall be carried out immediately after the Flow test is over. Refilling shall be done for 25 cms above the ground level and then it shall be thoroughly wetted and properly compacted with a mechanical earth rammer so that mud etc. shall not be formed.

i) Clearing up the site: All surplus material and all tools and temporary structures shall be removed from the site as directed by Engineer in charge. All dirt, rubbish and excess earth from the excavation shall be hauled to a dump and the work site left clean to the satisfaction of the Engineer in charge. The item includes bailing out water manually or by dewatering pump sets. The pumped water shall be carefully disposed off in nearby nalla etc. without causing any damage or inconvenience to neighboring existing structures and property holders.

1. Excavation in soft rock, dewatering, refilling etc. as above.

2. Excavation in hard rock by chiseling, refilling etc. as above. Specifications are the same as above except that the excavation will have to be carried out in hard rock. The excavation in hard rock is to be carried out by chiseling or any other method (This includes excavation done by poclain, Splitter or any other mechanical means) to the required width and depth. Other specifications are the same as above. Blasting will not be allowed in the work. Extra claim for dewatering will not be entertained.

GENERAL

Soil testing reports of the recognized institute must be submitted by the tenderer before start of the work at own cost. The design must be on the basis of soil testing report. The design shall be in accordance with various relevant I.S. specifications (I.S. 456-2000, I.S. 875-1987, I.S. 3370-1965, I.S.432 part-1, I.S. 1786, I.S. 1139)

The design shall satisfy the stipulations as per I.S. 1893-1984 and I.S. 13920-1995 for seismic forces and I.S. 11682-1985 for RCC staging of overhead water tank.

Plain round M.S. bar grade-I conforming to I.S. 432 part –1 or high yield strength deformed bars I.S. 1786 of 1139 shall be used. Grade II M.S. bars shall not be used.

Entire structure shall be as per latest IS specifications.

19 cm thick cement plaster (1:3) with 5% water proofing compound of approved quality shall be provided over the bottom floor and inside surface of tank wall. 12 mm thick cement plaster (1:4) shall be provided over the exposed surface of columns, beams, bracings, bottom dome and tank wall outside surface etc. 12 mm thick cement plaster (1:6) shall be provided for the inside and outside surface of rooms.

Three coats of exterior painting over a coat of cement primer shall be provided in the water tower. Irrespective of the foundation proposed in the design, one set of bracing be provided at the ground level. The scope of pipe assembly work shall be up to 5 meter beyond the out side face of the wall including the cost of pipes, valves and specials including laying and jointing.

The job includes designing the structure for uplift pressure and dewatering if required during entire execution and disposal of surplus excavated stuff within a lead of 50 meter as directed by the Engineer in charge.

C.I. D/F pipe be as per relevant I.S. standard shall be used for rising, delivery, overflow and washout main of the water tower.

R.C.C roof shall be constructed at the level of first and second bracing under which rooms shall be constructed by 250 mm thick brick masonry walls for key man and operational staff or office accommodation with Toilet including W.C. Septic tank Soak pit and necessary electrification. Sufficient number of doors and windows shall be provided in the rooms.

Provision shall be made for spiral RCC stairs from outside of staging with 25 mm G.I. pipe railing on both sides for going in the tank.

Spacing between two braces should not be more than 3m C/C.

Provision shall be made for cylindrical ventilator fitted with mosquito proof net and two manholes with M.S. frame and cover with locking Arrangements of adequate size both in the roof slab as well as top dome.

Provision shall be made for lightening conductor as per I.E. rules

Provision shall be made for M.S. water level indicator with 450 mm diameter copper ball etc.

Part rate shall be payable for reinforcement concrete and plastering item of all types of water retaining structure till satisfactory hydraulic testing for water tightness test is given and till that work shall be treated as incomplete.

The Design and Drawing of the water Tower/underground service reservoir shall be vetted by NIT, Patna or any other NIT/IIT, for which no payment will be done by BRJP. The bidder has to bear the cost.

VALVES

A) Sluice Valve

The valves shall be as per IS and of standard required size

The manufacturers test certificate for the material shall be provided at the time of the testing. Required supports to the valves in C.C. shall be provided.

The dimensional drawing shall be submitted by the contractor prior to manufacture showing all the construction details etc. of valve for approval. The valves shall be painted after testing as directed by the Engineer in charge.

Kinetic Air Valve

These shall be as per IS and of standard required size. The air valve shall be designed to operate satisfactorily at normal working pressure of 10 kgf/cm2 Kinetic air valve body shall be tested for 10 kg/cm2. Air valve shall be provided with isolating sluice valve, which shall generally comply IS applicable to sluice valve.

C) VALVE CHAMBERS

The valve chambers should be constructed for protection of valves from traffic load to avoid damage by people. The valves should be constructed as per the type design drawings. The construction of the chamber should be in R.C.C and should be able to withstand the superimposed load due to vehicular traffic. The top of the chamber should be covered by RCC pre cast slabs. All the civil work should be as per the general specification mentioned earlier and as per applicable I.S. standards.

VOLUME - III

SECTION 6
TECHNICAL SPECIFICATION

TECHNICAL SPECIFICATIONS FOR CIVIL, MS PIPELINE, HYDRO-MECHANICAL AND ELECTRO-MECHANICAL WORKS

I N D E X

PART – A

CIVIL WORKS

1.0 INTRODUCTION AND SCOPE OF WORK

1.1INTENT OF TECHNICAL SPECIFICATIONS

1.1.1 The General Technical Specification (hereinafter called GTS) broadly cover the information about site conditions, transport requirements, excavation, execution of works like masonry, concrete, steel, etc., construction materials and general requirements. The GTS also covers the broad specifications and regulations for all major civil works included in the contract documents as well as the conditions for measurements and payments.

1.1.2 The items of works are based on Employer's preliminary designs as indicated in Bid Document. These specifications shall be part of the requirements for various items related to the work, which are to be provided according to the stipulations of the contract. The items of works may be modified /altered to meet the requirements of Bidder's Design and Engineering of the permanent civil works. Accordingly, the technical specifications may require additions/alterations to conform to Bidder's Design and Engineering mutually agreed to with the Employer. However, the technical specifications shall be in general as per Bureau of Indian Standards or corresponding International Standards as mutually agreed by the Employer and the Contractor during preparation of detail design and drawings and approval thereof.

1.1.3 These specifications shall be read in conjunction with the Conditions of Contract, the drawings and the preliminary Schedule of Works. While quoting the price the Contractor shall comply with all provisions contained within the bidding documents and instructions of the Engineer-in-Charge.

1.1.4 All works shall be executed according to the drawings approved by the Engineer-in-Charge for construction, in a professional and diligent manner and all supplies and works shall comply with the quality requirements defined in the relevant sections of these specifications and other bidding documents. The Contractor shall endeavour to provide all such necessary efforts in order to comply with the intent of these specifications to the satisfaction of the Engineer-in-Charge.

1.1.5 Addenda to these specifications may be issued, as required, during bidding that will form part of these specifications.

1.2 SCOPE OF WORK

The scope of work includes Design, Engineering, Construction, Erection, Supply, Installation, Testing and Commissioning of Storm Water Drainage Pumping Stations at Patna, Bihar.

The scope of work includes Construction Civil Works, Electro-Mechanical Works, Hydro-Mechanical works pertaining to the Pumping Stations and Final Disposal Pipeline.

1.2.1**Pumping Station:**

It is proposed to excavate the Pumping Station with a required bottom size to a required suitable bottom level as per design. The proposal consists of Inlet Chanel, Trashracks, Gates and Sump cum Pumping Station. EOT crane along with necessary support system of suitable capacity is to be erected.

1.2.2**Pressure Mains:**

It is proposed to take up suitable diameter of MS pressure mains for lifting the suitable discharge from the sump cum pumping station to outfall for a suitable length as per design.

1.2.3 The successful bidder has to submit the detailed designs to the employer for approval before executing the works.

1.3 **EXECUTION OF WORKS:**

The successful bidder, after approval of the design and drawings by the employer has to execute the works as per the specifications given in the subsequent sections of this volume.

1.4. **MEASUREMENT & PAYMENT:**

The quantum of work of different items will be measured periodically by the concerned Engineer-in – Charge or the contractor has to bill the quantities of work done periodically and produce to the Engineer-in – Charge to Asses the quantum of the work done. The payment will be made proportionate to the value of work done as per the conditions stipulated in this document.

2.0 TRANSPORTATION

2.1 The Contractor should make his own assessment about the accessibility to work site, quarry areas or otherwise and also the mode and means of transportation as would be required for execution of requisite works.

2.2 The Contractor shall be responsible to select proper routes to meet his needs and shall bear all costs of transportation including loading and unloading as deemed fit by the Contractor.

2.3 The costs, if any, for adjusting, modifying roads and bridges shall be borne by the Contractor. The Contractor shall submit for approval of the Engineer the method of transportation and routes he proposes to use.

2.4 In case any approval from the concerned authorities are required for transportation of materials through road/railway, the Contractor shall make necessary arrangements for obtaining the same, well in advance to avoid any interruption in works for want of

materials, etc.

3.0 WORKING FACILITIES

3.1 GENERAL

3.1.1Scope

The Contractor shall design, provide, erect, operate and maintain the working facilities required for the execution of the Permanent Works, within the specified time schedule, such as but not necessarily limited to:

- Camp and Facilities
- Plant and Equipment
- Electric Power Supply System
- Telephone and Communication Network
- Water Supply System
- Sewage and Waste Water System
- Fire Fighting Equipment
- Temporary Access and Construction Roads
- Testing Laboratory

Working facilities shall be subject to the Engineer-in-Charge's approval. The Contractor shall comply with all applicable laws, regulations, and ordinances relating to the construction and operation of the working facilities.

Materials for the working facilities shall be of first-class quality and if not new, in best condition. The capacity and number of equipment shall conform to the specific minimum requirements for the works they are intended for and the climatic conditions prevailing at the site. The capacity and number of equipment shall be determined taking into account of the requirement of equipment throughout the entire work.

The Contractor shall attach to his bid documents drawings, pictures and operating descriptions for his proposed working facilities and shall indicate weight, standards, capacity, manufacturing date and country of origin.

The Contractor shall, prior to dispatching any items of the Working Facilities, give written notice to the Engineer-in-Charge with clear indications about the purpose of the items, the kind, date and place of consignment (factory or the Contractor's premises). Said notice must be given in due time to allow for a possible cancellation in case the items do not comply with the requirements as stipulated. The Engineer-in-Charge will agree or disagree with the inquiry in writing within the next 15 days on arrival of the notice.

The Contractor shall provide all his equipment with sufficient spare parts, special tools for repair work and complete standby units of vital parts to guarantee a continuous operation without untimely delays. The Contractor is fully responsible for any delays due to disregard of said necessity.

Should the Engineer-in-Charge determine that the equipment furnished does not meet all requirements, the deficiencies shall be corrected by the Contractor before further use, or

the deficient equipment shall be replaced with satisfactory equipment any cost incurred in the correction or replacement shall be borne by the Contractor.

All Working Facilities shall be built in the areas indicated by the Engineer-in-Charge. The Contractor shall submit prior to the start of the Works to the Engineer-in-Charge for approval, a drawing showing the exact positions of the main Working Facilities.

3.2SUBMISSIONS

The Contractor shall submit basic plans of Working Facilities together with his bid.

3.3 CAMP AND WORKING FACILITIES

3.3.1 General

The Camp and Facilities include but are not limited to

- Staff residential quarters for the Contractor's staff
- Accommodation and canteen for the Contractor's workmen
- Miscellaneous social facilities
- Offices for the Contractor
- Miscellaneous Working Facilities
  - Warehouses and sheds for the Contractor
  - Work and repair shops

All working facilities shall be equipped with lighting arrangement, telephone, water supply with drinking water, sewage system and if necessary with air conditioning. Contractor shall make his own arrangement for electricity supply as would be necessary for all sorts of works.

3.3.2Offices for the Contractor

Offices for the Officers and staff of the Contractor shall be of sufficient size and fully furnished and equipped with sanitary facilities, telephone, etc.

3.3.3Miscellaneous Working Facilities

The Contractor shall construct and maintain warehouses, storage yard, a motor tool, repair shops, workshops, vehicle sheds, garages, fuel storages and field laboratory etc. for efficient execution of the work.

a. Warehouse(s) and Sheds

Warehouse(s) for the storage of materials, mechanical and electrical units, spare parts etc. shall be well secured, ventilated (if necessary) and waterproof and shall be installed with the necessary appliances.

b. Work and Repair Shops

All work and repair shops shall be well secured, ventilated (if necessary) and

waterproof. They shall be equipped with adequate equipment and tools necessary to carry out all works and repairs which are usually to be done at the Site.

3.4 PLANT AND EQUIPMENT

3.4.1 General

The Contractor shall provide all construction plants and equipment necessary for the efficient execution of the work described in the bid documents and the Specifications and details furnished by the Contractor in the construction plant and equipment schedule.

The Contractor shall also deploy additional equipment, if needed, at his own cost for timely completion of the Works.

The Contractor may collect and use sand and gravel within the construction area provided by the Employer if approved by the Engineer-in-Charge. The Contractor shall obtain aggregate through crushing of the excavated rock and/or from outside of the area at his own expenses and responsibility if he intends to do so.

Plants and equipment for the execution of all civil works include but are not limited to:

- Plant for aggregate and concrete production
- Processing plant for filter and selected surfacing material
- Open excavations
- Steel fabrications, bending and other equipment.

3.4.2 Plant for Aggregate and Concrete Production

3.4.2.1 Aggregate Crushing Plant

The number and capacity of crushing plants for aggregate shall be sufficient enough such that daily production shall at least meets the 2-3 days elements. The processing plant for aggregate for concrete shall be capable of producing the separate aggregate size groups with the proper grading stipulated in the Specifications.

Care shall be taken so that water which has been used to wash the aggregates does not cause turbidity of the river/stream water.

The Contractor shall submit the following data for approval before ordering equipment or initiating work on the Plant:

- flow diagrams
- size and capacity of each separate piece of equipment

3.4.2.2 Cement Transportation Equipment and Storage Facilities

Transportation of bulk cement shall be accomplished in adequately designed weather-

tight trucks or other means which will protect the cement completely from exposure to moisture.

Storage of bulk cement at the Site or in the railway yard shall be done in weather-tight and properly ventilated structures with adequate provisions for the prevention of absorption of moisture. Said structures shall be complete with all equipment for loading, unloading and weighing of cement. A weather - tight equipment shall be provided for conveying cement.

The cement storage structure on the Site shall be at least for 30-day capacity.

3.4.2.3 Concrete Batching and Mixing Plant

The concrete batching and mixing plant shall be a modern and dependable, automatically controlled interlocked batch-type mixing plant. Manual operation shall also be possible in the event of fault in the automatic system. The equipment shall be capable of combining the aggregate, cement, admixtures, and water into a uniform mixture within the time limit specified and of discharging this mixture without segregation. The equipment shall provide adequate facilities for the accurate measurement and control of each of the materials entering plant. The complete plant assembly, including provisions to facilitate the inspection of all operations at all times and the adequacy and dependability of each of its parts, shall be adequate to meet the requirements of the work.

The batching and mixing plant shall have means for readily wasting any material or concrete that is improperly batched, mixed or held in the mixers too long.

Auto-balance scale for weighing concrete materials and digital instruments shall be inspected, tested and calibrated in the presence of the Engineer-in-Charge after repair and maintenance of the equipment and at least once in every two (2) months or as directed by the Engineer-in-Charge.

3.4.2.4 Batching Equipment

Batching shall be done by individual weight batching equipment. Aggregate weight batching may be cumulative but by individual size. Weighing hoppers shall be arranged to permit the convenient addition or removal of material.

Delivery of materials from the batching equipment shall be within the following limits of accuracy:

Material	Percent by Weight
Cement	2
Water	1
Aggregate smaller than 5 mm size	2
Aggregate larger than 5 mm size	3
Admixture	1

Suitable facilities shall be provided for readily obtaining representative samples of aggregate from each of the batchers for test purposes.

3.4.2.5 Mixing equipment

The mixing plant shall consist of batch type tilting mixers or pan type forced paddle mixer and a discharge hopper arranged with suitable devices for obtaining representative samples and delivering to ground level of concrete for slump, unit weight, and uniformity tests. The operator platform shall be conveniently located so that the operator can visually observe the mixing action in at least one mixer and the discharge from all mixers. A platform for access from the control room shall be provided to permit visual inspection of the concrete in the mixers while mixing. All necessary platforms, tools, equipment shall be furnished by the Contractor.

On each mixer a consistency indicator and an acceptable device to lock the discharge mechanism until the required mixing time has elapsed shall be provided.

3.4.2.6. Digital Recorder

An accurate recorder of digital type shall be provided to make continuous visible combined record on a single chart of the separate measurement of each concrete ingredient, including all mixing water, air-entraining admixture, water-reducing and set-retarding admixture, and also mixing time of each batch after all materials are in the mixer, date and time of each batch, and the type of mix proportion.

The visible portion of the chart shall cover a period of not less than 30 minutes. All digital recorder charts shall be locked and the charts shall be submitted to the Engineer-in-Charge.

3.4.2.7 Communications

An effective telephone or two-way communication system for the exclusive use of the batch plant inspector, placement inspector and the laboratory shall be maintained. Telephones shall be provided with a suitable bell, buzzer, or light to attract attention under working conditions.

3.5 ELECTRICAL POWER SUPPLY SYSTEM

The contractor shall make his own arrangement at his own cost for power supply for construction and other uses. The Contractor shall furnish, install and maintain the electrical distribution system of required capacities to the required areas for his work.

For camp area, the Contractor shall arrange himself for a connection with the closer existing power-line.

As an alternative measure, the Contractor shall install generators of required capacity and related facilities at his own expenses in case of an excessive energy demand and/or for supply of power at the instance of power failure at the power network.

3.6 TELEPHONES & COMMUNICATION NETWORK

The temporary tele-communication system shall be established at site and the Contractor shall make necessary arrangement for the same.

The Contractor will be responsible for furnishing, installing and maintaining, the telephone and communication network to individual sites/offices and other areas like quarries etc., as needed.

The contractor shall be equipped with at least one mobile connection at site office. All the charges for telephone and communication network shall be borne by the contractor.

3.7 WATER SUPPLY SYSTEM

The Contractor shall make all necessary arrangements for the adequate supply of raw water for construction use and potable water for human consumption at the various work areas as well as at the camps. Regulating, transporting, treating and distributing the water shall be included in it.

For construction and other uses, sufficient storage of water shall be secured especially during dry seasons. The Contractor shall be fully responsible for the arrangement of necessary facilities for water supply.

Only adequately treated water which complies with the current sanitary standards will be accepted for human consumption. Installation of non potable water supply systems in the camp areas will not be permitted. Storage tanks with a reserve capacity equivalent to two (2) days of normal usage will be required for the drinking water system.

The Contractor shall take drinking water samples from time to time if so requested by the Engineer-in-Charge. The samples shall be sent for chemical and bacteriological analyses to approved laboratories at his expense and the results of the analysis shall be obtained within 7 days of the sampling.

If the sampling and testing are not properly performed, the Employer may perform the same directly and charge the Contractor for the corresponding expenses.

3.8SEWAGE AND WASTE WATER SYSTEM

The Contractor shall design, construct, equip, operate and maintain all the installation necessary to properly collect, treat and dispose of sewage from his camps and other construction facilities.

The Contractor shall not, under any circumstances, discharge sewage or contaminated water into natural streams or any open areas. The pondage system for treatment and disposal of sewage shall not be used.

Treatment and disposal of sewage shall be performed in accordance with the current related standards and laws in force in India and always subject to the Engineer-in-Charge 's approval.

The drainage systems shall be designed taking into account the rainfall rate in the area and the disposal of rainwater shall be accomplished in such a way that no stagnation of water or any erosion problem is caused which may alter the stability of the soil.

3.9 FIRE FIGHTING EQUIPMENT

The Contractor shall provide complete fire fighting equipment necessary to ensure the safety of the Work.

The Contractor shall supply and maintain an abundant length of fire hoses, fire buckets, sand buckets, approved fire extinguishers and alarm systems installed over the complete work and camp sites.

The Contractor shall have on the Site at all times a trained fire fighting and first-aid crew with the necessary mobilization means.

3.10 TEMPORARY ACCESS AND CONSTRUCTION ROADS

3.10.1 General

The Contractor shall design, construct and maintain the construction roads and related works that may be necessary, from the existing roads and tracks to the various work areas, and other areas such as camps, stores, explosive magazines, plants, disposal areas and any other areas related to the work at his own cost.

Additionally, the Contractor shall improve where necessary and maintain all the existing roads and tracks in and adjacent to the project area to the satisfaction of the Engineer-in-Charge for guaranteeing normal traffic for any kind of vehicle.

The Contractor shall be responsible for the safety of the traffic during the construction. The training for safe driving together with providing number of traffic signs are the responsibility of the Contractor. Additionally, he will be responsible for protecting against damage any part of the work and the property of others in relation to the performance of this works.

The construction roads as well as existing roads will be utilized by the Employer, and the Contractor will not be entitled for any payment for such use.

3.11 FIELD LABORATORY

The Contractor shall establish a well equipped field laboratory for testing of materials of construction and other as required at his own cost and responsibility. This laboratory shall be of the size with equipments and the with all testing facilities as per Indian or other equivalent Standards. Prior to setting up of the laboratory, Contractor should submit detail plan with exhaustive equipment-list, and list of professionals and other personnel identified for laboratory work, to the Engineer-in-Charge for approval.

The laboratory shall be established as early as possible. The Contractor shall collect the samples as specified or as directed by the Engineer-in-Charge, carryout the relevant test under the guidance of Engineer or Engineer-in-Charge's representative, prepare the complete report and submit them to the Engineer-in-Charge.

All tests shall be made according to approved standards and therefore, the equipment shall comply with the same standard. All relevant standards shall be made available in the laboratory. For any material/work in particular where the Contractor's laboratory

has no facility, tests shall be got done in an outside standard laboratory with the approval of Engineer-in-Charge at Contractor's cost.

The laboratory shall be provided with light, ventilation, water, telephone, air-conditioner, cold and hot water supply, tank for curing, heating, toilet, etc., and be spacious enough in order to store the test samples. The details and location of the laboratory are subject to the Engineer-in-Charge 's approval.

4 GEOTECHNICAL AND CONSTRUCTION MATERIAL INVESTIGATION

4.1 GENERAL

The Contractor shall conduct all necessary geotechnical and construction material investigation as specified in the various sections of the Technical Specifications of different works with the prior intimation to the Engineer.

4.2 MEASUREMENT AND PAYMENT

No work related to any geotechnical and construction material investigations will be measured for the purpose of payment. There will be no separate payment for the investigations and related auxiliary services, as the cost thereof is deemed to be included in quoted price

5.0MATERIALS FOR CONSTRUCTION

5.1SCOPE OF WORK

(i) The specifications described herein under relate to the work which includes all labour, materials, equipment, transportation and services required to arrange materials for construction of various works under this Contract.

(ii) Samples for testing of materials for the concrete shall be supplied by the Contractor to the Engineer-in-Charge at the Trial Mix Stage as set out in Section on "**Concrete Works**".

(iii) The specifications of some of the major construction materials are given here under. The specifications and other details for masonry stone is not included here, but given in details in the Section on "**Masonry**".

5.2SUBMITTALS

(i) The Contractor shall specify in his bid and subsequently also, if asked by the Engineer-in-Charge, the source(s) from which the cement, steel etc. will be obtained. In case the specified source(s) is not acceptable to the Engineer-in-Charge, the Contractor

shall be required to substitute the source by an acceptable source. Additional suppliers and change of suppliers shall be subject to the approval of the Engineer-in-Charge.

(ii) At least 30 days prior to procuring or dispatch of the materials to site, the Contractor shall submit the following to the Engineer-in-Charge:

(a) **Certified quality test reports** from manufacturers in respect of cement, steel and other materials. This will also be necessary whenever the source is changed or when the sub-standard materials are received on the site.

(b) If the materials are to be arranged from several sources, the estimated quantity to be procured from each source and the proposed schedule of supply.

(iii) The layout of the stockpiles and the method of drawing aggregates from them shall be submitted to the Engineer-in-Charge at least 30 days prior to the commencement of stockpiling of aggregates.

(iv) The details relating to the source, method of delivery and storage of water to be used during construction shall be submitted by the Contractor to the Engineer-in-Charge for approval atleast 30 days prior to the commencement of the works.
(v) The Engineer-in-Charge reserves the right to ask for any additional information deemed necessary to be included in the submitted documents.

5.3STANDARDS

(i) The specifications, production, sampling, testing and storage of constructional materials shall conform to the following latest Indian Standards or where not covered by these Standards, to the equivalent International Standards :

(a)Aggregates and Water

IS:456-2000 (Code of Practice for Plain & Reinforced Concrete)
IS:383-2000 (Specification for Coarse and Fine Aggregates for Natural Surface for Concrete)
IS:2116-1992 (Sand for masonry mortar)
IS:2386 (Part-IV)-1963 (Reaffirmed 1990) (Method of Tests for Aggregate for Concrete)
IS:516-1959 (Reaffirmed 1991) (Method of Tests for Strength of Concrete)

(b)Cement

IS:269-1989 (Specification for 33 Grade Ordinary Portland Cement)
IS:1489-1991 (Specification for Portland Pozzolona Cement)
IS:8112-1989 (Specification for 43 Grade Ordinary Portland Cement)
IS:12269-1987 (Specification for 53 Grade Ordinary Portland Cement)
IS:12330-1988 (Specification for Sulphate Resisting Portland Cement)
IS:455-1989 (Specification for Portland Slag Cement)

(c)Steel for Reinforcement

IS:432 (Part-I)-1982 (Reaffirmed 1995) (Mild Steel and Medium Tensile Steel Bar)

IS:1786-1985 (Reaffirmed 1990) (Specification for High Strength Deformed Steel Bars and Wires for Concrete Reinforcement)

(d)Structural Steel

IS:2062-1992 (steel for General structural purposes)
IS:808-1989 (Dimensions for Hot Rolled Steel Beam, Column, Channel and Angle Sections)
IS:8500-1991 (Structural Steel Medium and High Strength Qualities)
IS:800-1984 (Reaffirmed 1991) (Code of Practice for General Construction in Steel)

(e)Steel for fabrication of Pipes

IS:6286-1971 (Reaffirmed 1988) (Seamless and Welded Steel Pipes for Sub-zero Temperature Service)
IS:3589-1991 (Electrically Welded Steel Pipes for Water, Gas and Sewage)
IS:1536-1989 (Reaffirmed 1993) (Centrifugally Cast (Spun) Iron Pressure Pipes for Water, Gas and Sewage)
IS:6631-1972 (Reaffirmed 1988) (Steel Pipes for Hydraulic Purposes)

(f)Welding Electrodes

IS:814-1991 (Covered Electrodes for Metal Arc Welding of Structural Steels)
IS:816-1969 (Reaffirmed 1992) (Code of Practice for Use of Metal Arc Welding for General Construction in Mild Steel)

(ii) In case of conflict between the above Standards and the Specifications given herein, the Specifications shall take precedence.

5.4 BRICKS

5.4.1General

Bricks shall be hand moulded or machine moulded. They shall be free from nodules of free time, visible cracks, flaws warpage and organic matter, have a frog 100mm in length 400mm in width and 10mm to 20mm deep on one side of its flat sides. Each brick shall be marked in the frog with the manufacturer's identification mark. The bricks shall have smooth rectangular faces with sharp corner and shall be uniform in colour and emit clear ringing sound when struck. Bricks shall have nominal size of: 200mm x 100mm x 100mm; and shall be of class designation 10 with average compressive strength of $10N/mm^2$.

5.4.2Sampling and Tests

Sample bricks shall be subject to the following tests:

(i) Dimension tolerance
(ii) Water absorption.
(iii) Efflorescence.
(iv) Compressive strength

5.4.2.1Sampling

For carrying out compressive strength, water absorption, efflorescence and dimensional tests, the samples of bricks shall be taken at random. The sample thus taken shall be stored in a dry place until tests are made. Sampling shall be done as per CPWD norms.

5.5STONES FOR MASONRY/AGGREGATES

5.5.1General

(i) All stones used for masonry works and concrete aggregates shall be of sound, hard, durable and of tough quality approved by the Engineer-in-Charge.

(ii) The stones shall be fine or medium grained, hard, bright in colour, breaking with a clean fracture and as such make a ringing sound when struck with a hammer.

(iii) It shall be free from decay, vesicles, holes, flaws, cracks and other defects and must have, as far as possible, uniform colour and texture. Porous stone absorbing water more than 1 (one) percent of its dry weight after 24 hours immersion shall be rejected. No stones shattered or cracked by blasting operations or having any skin or earthy cover shall be used.

(iv) In case the stone is not considered to be free from dust or dirt etc. by the Engineer-in-Charge, the Contractor shall get the stone screened, washed and/or treated as directed by the Engineer-in-Charge.

(vi) Stone for masonry shall be roughly cubical, but not be conical in shape and stones weighing between 40 Kg to 75 Kg shall not be less than 15 cm and shall not be less than 25 cm if weighed between 75 Kg to 150 Kg in any direction. Spalls between 10 cm to 20 cm size shall also be used to wedge into the thick mortar spaces. No individual stone for use in masonry shall weigh less than 40 Kg and more than 150 Kg. Generally, the stones shall have more bedding area in the natural bedding plan. The percentage of water absorption, according to tests conforming to IS-1124-1990 shall not exceed 1% to 3% of its own dry weight, after 24 hours submersion in water. Stones for masonry shall not contain crytocrystalline silica or chertmica or any other deleterious material like iron-oxide, oganic impurities, etc. If considered necessary, the stone shall be examined petrographically in accordance with IS-1123-190.

(vii) Samples of stones that the Contractor intends to use shall be submitted for the approval of the Engineer-in-Charge not later than 45 days prior to the date of use.

5.5.2 Tests for Stones

The crushing strength in unconfined compression test shall not be less then 150 kg/cm^2 when tested on any plane. Samples of stone from quarries shall be tested for compressive strength in accordance with **IS:1121 (Part-I)- 1993**. The compressive strength testing shall be conducted with the load parallel to the bedding plane and also perpendicular to the bedding plane. The stone samples shall also be tested for water absorption **(IS : 1124-1990)** and also for soundness to ensure suitability of stones for masonry.

5.6AGGREGATES

5.6.1General

(i) Use of aggregates (coarse and fine) containing excessive amount of zeolites, secondary minerals and such other components which cause alkali reactivity of the aggregates and consequent reduction in durability of the concrete is prohibited. The Engineer-in-Charge may, however, allow the use of such material either in part or in full keeping in view the extent of reactivity, the location, the nature of exposure and the structure. If the Engineer-in-Charge considers necessary, he may carry out mineralogical tests to ascertain the lack of harmful minerals in the stones.

(ii) The Contractor shall make his own arrangements for aggregate crushing plants etc. for crushing of aggregates from stones extracted from approved quarries or other works.

(iii) The quality of all aggregates used in the works, as also processing such as washing, classifying, screening, re-screening, crushing and blending necessary to meet the required specifications shall be subject to the approval of the Engineer-in-Charge.

(iv) The aggregates shall be supplied only from the sources/quarries approved by the Engineer-in-Charge. The Contractor shall supply necessary quantities of aggregates to carry out the desired tests by the Engineer-in-Charge.

(v) The aggregates shall be sampled and tested by the Engineer-in-Charge in accordance with the Indian Standards referred above.

(vi) The tests shall be made on samples that are representative of the grading that will be used in concrete and the aggregates shall be processed by the equipment proposed for the works.

(vii) The Contractor shall at all times have access to and associate with sampling and testing of aggregates and shall be entitled to discuss with the Engineer-in-Charge, the results and proposals for grading of aggregates.

(viii) Stored Fine sand shall be stacked and maintained in such a manner as to avoid the inclusion of any foreign materials in the concrete, and such that no equipment will be operated on the storage piles. The storage piles shall be constructed so as to prevent contamination. The Contractor shall remove the excess moisture in the fine sand by adequate means.

(ix) Coarse aggregate storage piles shall be built and maintained in such a manner as to avoid the inclusion of any foreign material in the concrete and to prevent segregation and excessive breakage. No equipment shall be operated on storage piles. Rock ladders of satisfactory design shall be used with conveyor systems for stockpiling aggregate larger than 40 mm in size.

(x) Sand and aggregate storage piles shall be located close to the mixing plant and shall always contain at least a **reserve for one month**

5.6.2Coarse Aggregates

(i) The term coarse aggregates applies to pieces of natural or crushed rock ranging in size from 4.75 mm to 150 mm.

(ii) The aggregates shall be composed of clean, hard, strong, durable pieces of stone, angular or rounded in shape obtained naturally or by crushing from suitable stones approved by the Engineer-in-Charge. Coarse aggregates shall not contain more than 15% elongated or flat particles. An elongated particle is defined as a particle having a maximum length of more than 5 times its maximum width. A flat particle is defined as a particle in which its maximum width or length is more than 5 times its maximum thickness.

(iii) Coarse aggregates delivered to the batching plant shall have a uniform and stable moisture content.

(iv) The coarse aggregates shall be free from objectionable materials such as wood or other deleterious substances, the percentage of which in any size of coarse aggregate shall conform to the relevant standards except that the coarse aggregate shall contain not more than 0.30 percent by weight of deleterious (reactive) iron sulphides. The sum of the percentage of all deleterious substances in any size shall not exceed 3 percentage by weight. Coarse aggregates having a specific gravity (saturated surface-dry basis) less than 2.60 shall be rejected.

(v) The aggregates shall be resistant to deleterious, chemical or physical changes such as cracking, swelling, softening, leaching or chemical alterations after its incorporation in concrete.

(vi) For concrete exposed to the flowing water at high velocities, the coarse aggregates having high abrasion resistance shall be used.

(vii) When subject to soundness test with a solution of Sodium Sulphate coarse aggregates shall not suffer more than 12 percent loss of weight after five cycles.

(viii) The aggregates shall be crushed in approved type of stone crushers and different sizes of the coarse aggregate shall be separated into nominal sizes by screening over vibrating screens as under :

Designation of SizeNominal size range

20 mm aggregate 4.75 mm to 20 mm
40 mm aggregate 20 mm to 40 mm
80 mm aggregate 40 mm to 80 mm
150 mm aggregate 80 mm to 150 mm

(ix) The grain-size distribution of the coarse aggregate for the various maximum sizes of aggregates shall be as set out in the relevant standards.

(x) These may be altered by the Engineer-in-Charge from time to time, if necessary, on the basis of actual tests carried out regularly in the laboratory so as to get the best possible coarse aggregate grading.

(xi) The percentage of weight of all the significant under-sizes shall be less than 5 percent when tested on the designated test screens having opening 5/6 times the normal minimum size of the material. No over size (i.e. material that would be retained on the

designated test screens having opening 6/7 times the normal sizes of the material) shall be permitted.

5.5.3Fine Aggregates (Sand)

(i) General

(a) Sand or fine aggregates shall be used for mortar in stone masonry and as fine aggregates in concrete work. It shall be either natural river sand or manufactured sand crushed from rock/stones or mixture of both in specified proportions. The sand shall be composed of hard, clean and gritty pieces of stone and of a quality approved by the Engineer-in-Charge. It shall be free from injurious amount of clay, soft and flaky particles, vegetable or organic matter, loam, mica and other deleterious substances and shall not contain any salts.

(b) The fine aggregates shall conform to the requirements of IS:383-1970 (Reaffirmed 1990). Varying amount of moisture in fine aggregates contributes to lack of uniformity in concrete consistency. The fine aggregates shall therefore have uniform and stable moisture contents. Dry sand shall be preferred. Hence sand stockpiles shall be protected from rainfall.

(c) The percentage of deleterious substances in the fine aggregates shall conform to relevant standards except that the fine aggregates shall contain not more than 0.10 percent by weight of deleterious (reactive) ferrous sulphides. The total percentage of deleterious substances must not exceed 5 percent of the weight.

(d) Fine aggregate having a specific gravity of less than 2.60 are liable to be rejected. Fine aggregates when subjected to a soundness test with a solution of sodium sulphate, after 5 cycles of tests, shall not suffer a loss of weight in excess of 10 percent.

(e) The sand shall be well graded and, when tested by standard sieves, shall conform to the prescribed limits of gradation. The best gradation shall be determined after experiments and tests and the Contractor shall follow the same on approval of the Engineer-in-charge.

(f) The sand, as delivered to the batching plant shall have a fineness modulus of 2.6 to 3. The grading of fine aggregates shall be so controlled that the fineness moduli of at least 9 out of 10 samples of fine aggregates delivered to the batching plant shall not vary more than 0.20 from the average of 10 samples tested. All classifying, batching or other operations on the fine aggregates shall be done by the Contractor.

(ii) Natural Sand

(a) Natural sand shall be obtained from an approved source. No sand affected by salty water shall be used. The sand shall be screened and thoroughly washed, preferably in flowing water so as to remove all earthy impurities and very small fines unless otherwise permitted by the Engineer-in-Charge.

(b) Natural sand shall be free from softer grains and all sources of sand showing appreciable percentage of these impurities shall be rejected.

(c) The presence of mica in the fine aggregate has been found to reduce considerably the compressive strength of concrete. It is advisable, therefore, to investigate the mica content of the fine aggregates and make suitable allowances for possible reduction in strength of concrete or mortar. The decision of the Engineer-in-Charge whether to use such sand and if so, what allowances to be made, shall be final and binding on the Contractor.

(d) The contents of the organic matter shall conform to relevant standards.

(a)

5.6.4. Storage of Aggregates

(i) The Contractor shall, at all times, maintain storage of all grades of aggregates for atleast one month requirement.

(ii) Adequate drainage of stockpiles shall be provided.

(iii) The stockpiling of the processed aggregate and drawl therefrom shall be such as to ensure that the variation in the free moisture in the aggregate, during any one shift of working, does not exceed 1 percent.

(iv) The coarse aggregate shall, as far as possible, be stored in shade or covered storage and arrangement made for sprinkling of water to ensure wetting of the aggregates.

(v) Care shall be taken in screening and stocking of the coarse aggregates so as to avoid intermixture of different gouge materials and inclusion of any foreign materials.

(vi) The stockpile shall be built up in horizontal or gently sloping layers.

(vii) Trucks and bulldozers shall be kept off the piles to prevent breakage and impairing the cleanliness of aggregate.

(viii) A hard base shall be provided to prevent contamination from underlying materials in storage areas in continuous use.

(ix) Overlap of different sizes of materials shall be prevented with suitable walls or by ample distance between storage piles.

(x) Arrangements shall be made to store natural and manufactured sand in a way that shall protect it from being contaminated with dust, organic matter or other deleterious substances.

5.7WATER

(i) A reliable water supply for construction purposes shall be installed and maintained by the Contractor.

(ii) Adequate water storage facilities shall be provided by the Contractor at the batching and mixing plant and other work sites so that various operations of works do not suffer due to temporary breakdown in the main supply system.

(iii) The Contractor shall supply water samples from the intended sources to the Engineer-in-Charge for testing and approval.

(iv) The Engineer-in-Charge shall establish the suitability of water to be used for construction purposes.

(v) Water for washing of aggregates, mixing mortar, concrete or grout and/or other construction activities shall be clean and free from earth, vegetable or organic matter, injurious amount of oils, acids, sugar, salt and alkaline substances in solution or in suspension and shall conform to relevant standards. The maximum allowable contents of sulphates (SO_4) shall be 250 parts per million (ppm) and those of chlorides (Cl) shall be 2000 mg per liter for plain concrete / mortar works and 1000 mg per liter for reinforced concrete works. Turbidity shall be within 2000 ppm (or 0.2 percent by weight) and preferably as low as possible.

(vi) Water used for curing shall be clean and free from contamination and from excess amounts of acids or alkalis or other matter combining chemically with and thus disfiguring the concrete / masonry surface. Water shall not contain organic matter causing stink.

(vii) Average 28 days compressive strength of at least three 15 cm concrete cubes prepared with water proposed to be used shall not be less than 90 percent of the average of strength of three similar concrete cubes prepared with distilled water. The cubes shall be prepared, cured and tested in accordance with the requirements set out in Section on Concrete Works.

(viii) The Contractor shall bring to the notice of the Engineer-in-charge, of the occurrence of hot water found in existence during excavation. He shall supply samples of such water to the Engineer-in-Charge for testing. Suitable measures shall be taken in case such testing reveals deleterious effect on concrete.

5.8CEMENT

5.8.1General

(i) The Contractor shall procure the cement of the specified quality from the cement sources/plants approved by Employer/Employer. For this purpose Employer/Employer will approve atleast two sources/plants out of those intimated by the Contractor so that one is a standby for taking care of any eventualities.

(ii) Cement to be used for various works shall be of different types such as Ordinary Portland Cement or Portland Pozzolana Cement or Portland Slag Cement as approved by the Engineer-in-Charge and shall conform to the relevant Standards at the time of its use.

(iii) The Contractor shall deliver with each supply of 1000 tonnes of cement a certificate from the manufactures/suppliers by which the cement is guaranteed to comply with the requirement of the specifications. **The Employer/Employer shall have the right to check or test the cement at any stage of its manufacture or delivery and the Employer/Employer's test reports shall supersede the test report given in the manufacturer's certificate.**

(iv) Aggregate which has alkaline reactive tendency shall be avoided for use in concrete. In case, such aggregate has to be used, prior approval of the Engineer-in-Charge shall be obtained. In that case, the cement with alkali contents (i.e. Na_2O and K_2O expressed in equivalent weight of Na_2O) not exceeding 0.6 percent by weight of cement shall be used.

(v) The cement will be sampled and tested by the Engineer-in-Charge for strength and physical properties and chemical analysis will be carried out as set out in relevant standards.

(vi) The cement samples for testing at the source/plant shall be obtained by the Contractor as the bins are being filled. Tests for false set shall be made on samples taken at the latest time prior to shipment.

(vii) Ordinary port land cement conforming to latest revision of IS shall be procured from the reputed manufacturers only and will be accompanied by test certificate of manufacturers. Quality shall be checked regularly and Employer reserve the right to reject/approve cement quality after getting the same tested in approved Government Laboratories.

5.8.2Transportation

(i) Cement shall be delivered on site in bulk/bags in bulk containers/trucks approved by the Engineer-in-Charge.

(ii) All bulk containers/carriers shall be clean and dry prior to filling/loading with cement and equipped with weather proof closures on all openings

5.8.3Storage

(i) Sufficient storage facilities shall be provided at the batching plant to enable each new shipment of cement to be stored separately from the cement stored from earlier shipments.

(ii) Cement shall be stored above ground, adequately protected against rain, sun and moisture. Bulk storage bins and silos shall be emptied completely and cleaned of all cement accumulation **after every 3 months**.

(iii) Arrangements shall be made such that stock of approved cement are adequate to meet the programme of work at all times. The programme shall allow time for testing and approval of each shipment before such cement is incorporated in the works.

(iv) Cement shall be used in the order in which it is received on site. Cement of different brands, if received on site, shall not be combined in the same mix and structure. Such cement shall be used in different structures as approved by the Engineer-in-Charge.

(v) Handling and storage facilities shall be such that no cement is stored before use for **more than 120 days.** Should any cement be unavoidably kept in storage longer than

120 days, it shall be tested and if found defective, shall condemned for use on the project.

5.9STEEL FOR REINFORCEMENT

5.9.1General

(i) The Contractor shall procure the steel reinforcement of the specified quality from **the sources/plants approved by the Employer/Employer**. Sources of steel shall preferably be SAIL and TISCO.

(ii) Steel reinforcement shall conform to relevant Indian Standards or equivalent.

(iii) Steel shall be free from loose mill scale, rust, oil, grease, dirt, paint or other deleterious matter, when examined immediately before concrete is being placed.

(iv) Wire for tying reinforcement steel shall be black annealed iron wire or acceptable equivalent with a suitable diameter and shall have an ultimate strength of 5.68 tonne/sq.cm. and yield strength of not less than 8.8 tonne/sq.cm.

5.9.2Transportation and Storage

(i) Transportation shall be undertaken in such a manner that no damage is done to the steel.

(ii) Reinforcement steel shall be stored off the ground in separate groups according to size and length. Reinforcement steel, which has been cut and bent according to the schedules approved by the Engineer-in-Charge, shall be marked with bar number, as shown in the schedule, by using same form of weather proof tag or by placing marked bins, and shall be stored in such a manner as to be readily accessible when required and to facilitate inspection.

5.10STRUCTURAL STEEL

5.10.1General

(i) The Contractor shall procure structural steel of the specified quality from **the sources/plants approved by the Employer/Employer**. Sources of steel shall be limited to SAIL and TISCO.

(ii) All structural steel shall be of new/unused stock, clean and straight, free from rust or scale and without any sharp kinks, bends or other objectionable defects.

(iii) All structural steel including steel plates, shall conform to relevant standards.

(iv) The material used in splices shall conform to the specifications of the material being spliced.

5.10.2Transportation and Storage

Structural steel shall be transported, handled and stored in such a manner that no damage is done to the material or the structure.

6.0 EXCAVATION WORKS

6.1SCOPE OF WORK

(i) The specifications described hereunder, relate to the work of excavation and shall include all labour, tools, construction plant and services, necessary to carry out the excavation of different materials, transportation and stockpiling / disposal of all excavated materials into stockpiles / dumping areas as approved by the Engineer-in-Charge.

(ii) Excavation shall be made to the lines, grades and dimensions shown on the drawings approved for construction or as otherwise agreed with the Engineer-in-Charge.

(iii) The Contractor shall maintain the excavated slopes, drainage and trenches and prepare foundations as shown on the drawings or as agreed with the Engineer-in-Charge.

(iv) The area of open excavation shall, where, in the opinion of the Engineer-in-Charge clearing is necessary, be cleared of all trees, bushes, rubbish and other objectionable matter and the materials, so removed, shall be disposed off suitably or as directed by the Engineer-in-Charge.

(v) When additional excavation outside the lines and grades shown on the drawings is required by the Contractor for his own convenience, such additional excavation shall be required to be backfilled with acceptable material and compacted by the Contractor in a manner satisfactory to the Engineer-in-Charge. The Contractor shall submit his plans for such proposed work in writing for Engineer-in-Charge's acceptance prior to the commencement of the work.

(vi) The removal of mud and slush resulting from heavy rains or flooding of the sites, when necessary to ensure the safe and effective performance of the work, shall be performed by the Contractor.

(vii) At all times during construction, the Contractor shall adopt excavation procedures such that at no time shall the stability of any slope be impaired.

(viii) The approval given by the Engineer-in-Charge to the Contractor's methods and equipment shall not relieve the Contractor of his full responsibility for a proper and safe execution of excavations, or of liability for injuries to, or death of person(s), or any obligations under this Contract.

(ix) The Contractor shall comply with all safety procedures and requirements as stipulated in this document.

6.2SUBMITTALS

(i) At least **30 days prior** to the commencement of excavation, the Contractor shall submit his programme of excavation with details of his excavating methods and sequences for all open excavation works including the equipment.

(ii) At least **30 days prior** to dumping or stockpiling of any material, the Contractor shall submit the layout of the spoil and stockpile areas, which shall be within the identified areas. All pertinent data of working methods and provisions for the security, stability and temporary and permanent drainage of the areas shall be included along with details of volumes, material types, heights and grades provided.

(iii) To enable the Engineer-in-Charge to verify all necessary setting out and elevations carried out by the Contractor, the later shall notify the Engineer-in-Charge in writing, giving **at least 7 days notice** of his intentions to start excavation.

(iv) The Engineer-in-Charge reserves the right to ask for any additional information deemed necessary to be included in the submitted documents.

6.3SETTING OUT

(i) The Contractor shall establish, at suitable points, to the satisfaction of the Engineer-in-Charge, permanent reference marks on the centerlines, as may be necessary and directed. The permanent marks shall be inscribed on bronze pegs, set in concrete blocks where they will be free from any likelihood of the disturbance. Suitable number of benchmarks with corresponding co-ordinates shall be established with reference to SOI benchmark and grid within the project area. The reference drawing indicating all benchmarks vis-à-vis project components shall be prepared and submitted to the Engineer-in-Charge for approval.

(ii) As the work progresses, centre line marks shall be made on pegs, inserted at the convenient intervals to the satisfaction of the Engineer-in-Charge, for checking alignment, grades, levels etc. The Contractor shall at all times, remain responsible for the sufficiency and accuracy of all such benchmarks and reference points.

6.4 ACCURACY OF ALIGNMENT, GRADES AND LEVELS ETC.

(i) Bench marks and fixed reference points with the value of the levels and the coordinates, will be fixed by the Engineer-in-Charge in the work areas. The plans showing the position, co-ordinates and the levels of the salient points as available will be supplied to the Contractor. The Contractor shall fix his permanent points and benchmarks in relation to these.

(ii) The Contractor shall take all precautions to ensure that the points fixed by the Engineer-in-Charge are not disturbed by his work and shall make good the damage, if any.

(iii) The Contractor shall provide all facilities like labour, instruments, etc. and all co-operation to the Engineer-in-Charge to check the alignments, grades, levels etc. whenever and every time they are asked for.

(iv) Any discrepancy or error detected during the course of excavations and / or at the end of work shall be set right by the Contractor, in the manner satisfactory to the Engineer-in-Charge.

6.5 Earth Work Excavation

All excavation operations manually or by mechanical means shall include excavation and 'getting out' the excavated materials. In case of excavation for trenches, basements, water tanks etc. 'getting out' shall include throwing the excavated materials at a distance of at least one meter or half the depth of excavation, whichever is more, clear off the edge of excavation. In all other cases 'getting out' shall include depositing the excavated materials as specified. The subsequent disposal of the excavated material shall be either stated as a separate item or included with the items of excavation stating lead. During the excavation the natural drainage of the area shall be maintained. Excavation shall be done from top to bottom. Undermining or undercutting shall not be done.

In firm soils, the sides of the trenches shall be kept vertical up to a depth of 2 meters from the bottom. For greater depths, the excavation profiles shall be widened by allowing steps of 50 cms on either side after every 2.0 m from the bottom. Alternatively, the excavation can be done so as to give slope of 1:4 (1 horizontal: 4 vertical). Where the soil is soft, loose or slushy, the width of steps shall be suitably increased or sides sloped or the soil shored up as directed by the Engineer-in- Charge. It shall be the responsibility of the contractor to take complete instructions in writing from the Engineer-in-Charge regarding the stepping, sloping or shoring to be done for excavation deeper than 2 meter.

The excavation shall be done true to levels, slope, shape and pattern indicated by the Engineer-in-Charge. Only the excavation shown on the drawings with additional allowances for centering and shuttering or as required by the Engineer-in-Charge.

In case of excavation for foundation in trenches or over areas, the bed of excavation shall be to the correct level or slope and consolidated by watering and ramming. If the excavation for foundation is done to a depth greater than that shown in the drawings or as required by the Engineer-in-Charge, the excess depth shall be made good by the contractor at his own cost with the concrete of the mix used for leveling/ bed concrete for foundations. Soft/defective spots at the bed of the foundations shall be dug out and filled with concrete (to be paid separately) as directed by the Engineer-in-Charge.

In all other cases where the excavation is taken deeper by the contractor, it shall be brought to the required level by the contractor at his own cost by filling in with earth duly watered, consolidated and rammed.

In case the excavation is done wider than that shown on the drawings or as required by the Engineer-in-Charge, additional filling wherever required on the account shall be done by the contractor at his own cost.

The excavation shall be done manually or by mechanical means as directed by Engineer-in-charge considering feasibility, urgency of work, availability of labour /mechanical equipments and other factors involved. Contractor shall ensure every safety measures for the workers. Neither any deduction will be made nor will any extra payment be made on this account.

6.6 Planking and Strutting:

When the depth of trench in soft/loose soil exceeds 2 meters, stepping, sloping and/ or planking and strutting of sides shall be done. In case of loose and slushy soils, the depths at which these precautions are to be taken shall be determined by the Engineer-in-Charge according to the nature of soil.

Planking and strutting shall be 'close' or 'open' depending on the nature of soil and the depth of trench. The type of planking and strutting shall be determined by the Engineer-in-Charge. It shall be the responsibility of the contractor to take all necessary steps to prevent the sides of trenches from collapse. Engineer-in-Charge should take guidance from IS: 3764 for designing the shoring and strutting arrangements and specifying the profile of excavation Close planking and strutting shall be done by completely covering the sides of the trench generally with short upright, members called 'poling boards'. These shall be 250x38 mm in section or as directed by the Engineer-in-Charge.

The boards shall generally be placed in position vertically in pairs. One boards on either side of cutting. These shall be kept apart by horizontal walling of strong wood at a maximum spacing of 1.2 metres cross strutted with ballies, or as directed by Engineer-in-Charge. The length and diameter of the ballies strut shall depend upon the width of the trench. Where the soil is very soft and loose, the boards shall be placed horizontally against the sides of the excavation and supported by vertical 'wallings' which shall be strutted to similar timber pieces on the opposite face of the trench. The lowest boards supporting the si
des shall be taken in the ground for a minimum depth of 75 mm. No portion of the vertical side of the trench shall remain exposed. The withdrawal of the timber members shall be done very carefully to prevent collapse of the trench. It shall be started at one end and proceeded systematically to the other end. Concrete or masonry shall not be damaged while removing the planks. No claim shall be entertained for any timber which cannot be withdrawn and is lost or buried, unless required by the Engineer-in-Charge to be left permanently in position.

Open Planking and Strutting: In case of open planking and strutting, the entire surface of the side of the trench is not required to be covered. The vertical boards 250 mm wide & 38 mm thick shall be spaced sufficiency apart to leave unsupported strips of 50 cm average width. The detailed arrangement, sizes of the timber and the distance apart shall be subject to the approval of the Engineer-in-Charge. In all other respect, specifications for close planking and strutting shall apply to open planking and strutting.

During excavation and trenching work etc. the contractors shall ensure compliance to the guidelines in such matter laid down by the authority to ensure that there is minimum hazard to the operating personnel and user, minimum inconvenience to users, minimized damage to the underground plant / services of other utilities in a coordinated way in the interest of public inconvenience and overall safety of the adjoining structures etc.

6.7 Filling

6.7.1 Earth: Normally excavated earth from same area shall be used for filling. Earth used for filling shall be free from shrubs, rank, vegetation, grass, brushwood,

stone shingle and boulders (larger than 75mm in any direction), organic or any other foreign matter. Earth containing deleterious materials, salt peter earth etc. shall not be used for filling. All clods and lumps of earth exceeding 8 cm in any direction shall be broken or removed before the earth is used for filling.

6.7.2 **Earth Filling**: The space around the foundations and drains in trenches shall be cleared of all debris, brick bats etc. The filling shall be done in layers not exceeding 20 cm in depth. Each layer shall be atered, rammed and consolidated. Ramming shall be done with iron rammers where possible and with blunt end of crow bars where rammers cannot be used. Special care shall be taken to ensure that no damage is caused to the pipes, drains, masonry or concrete in the trenches. In case of filling under floor, the finished level of filling shall be kept to the slope intended to be given to the floor.

6.7.3 **Filling Side of Foundations:** The cubical contents of bed concrete leveling course and masonry/ concrete in foundations up to the ground level shall be worked out and the same deducted from the cubical contents of earthwork in excavation for foundations already measured under the respective item of earth work to arrive at the quantity for filling sides of foundation. The quantity shall be calculated correct to two places of decimal.

6.7.4 **Filling in Plinth and under Floors*:*** Depth of filling shall be the consolidated depth. The dimensions of filling shall be on the basis of pre-measurement correct to the nearest cm and cubical content worked out in cubic meters correct to two places of **decimal.**

6.7.5 **Compaction Quality:** Compaction of earth and sand filling in areas where foundation & floors are located, the degree of compaction achieved shall be minimum 95% of maximum dry density. As obtained by proctor compaction as per IS: 2720 (Part-IIV). In road and other areas the degree of compaction shall be 90%.

6.7.6 **Testing of Filling Layer:** After the compaction of each layer, samples shall be taken from compacted layer and tested for dry density as per IS practice. The next layer of filling shall not be permitted until the engineer in charge is satisfied that pervious layer has achieved required compaction. If any particular layer fails to meet the required compaction, it shall be recompacted as directed by the engineer in charge and fresh samples shall be taken to ascertain the compaction density. Such re-compaction shall be continued till the desired compaction is achieved. The thickness of each compacted layer shall not exceed 200mm.

6.8FORM WORK (CENTERING & SHUTTERING)

6.8.1 **Form Work:** Form work shall include all temporary or permanent forms or moulds required for forming the concrete which is cast-in-situ, together with all temporary construction required for their support.

6.8.2 **General Requirement:** It shall be strong enough to withstand the dead and live loads and forces caused by ramming and vibrations of concrete and other incidental loads, imposed upon it during and after casting of concrete. It shall be made sufficiently rigid by using adequate number of ties and braces, screw jacks or hard board wedges where required shall be provided to make up any settlement in the form work either before or during the placing of concrete. Form

shall be so constructed as to be removable in sections in the desired sequence, without damaging the surface of concrete or disturbing other sections, care shall be taken to see that no piece is keyed into the concrete.

6.8.3Material for Form Work:

6.8.3.1Centering/Staging:

(a) Propping and Centering: All propping and centering should be either of steel tubes with extension pieces or built up sections of rolled steel. Staging should be as designed with required extension pieces as approved by Engineer-in-Charge to ensure proper slopes, as per design for slabs/ beams etc. and as per levels as shown in drawing. All the staging to be either of Tubular steel structure with adequate bracings as approved or made of built up structural sections made from rolled structural steel sections.

(b) In case of structures with two or more floors, the weight of concrete, centering and shuttering of any upper floor being cast shall be suitably supported on one floor below the top most floor already cast.

(c) Form work and concreting of upper floor shall not be done until concrete of lower floor has set at least for 14 days.

Shuttering: Shuttering used shall be of sufficient stiffness to avoid excessive deflection and joints shall be tightly butted to avoid leakage of slurry. If required, rubberized lining of material as approved by the Engineer-in-Charge shall be provided in the joints. Steel shuttering used or concreting should be sufficiently stiffened.

Camber: Suitable camber shall be provided in horizontal members of structure, especially in cantilever spans to counteract the effect of deflection. The form work shall be so assembled as to provide for camber. The camber for beams and slabs shall be 4 mm per meter (1 to 250) or as directed by the Engineer-in-Charge, so as to offset the subsequent deflection, for cantilevers the camber at free end shall be 1/50th of the projected length or as directed by the Engineer-in-Charge.

Removal of Form work (Stripping Time): In normal circumstance and where various types of cements are used, forms may generally be removed after the expiry of the following periods:

Type of Form work	**Minimum period Before Striking Form work for OPC 43 grade**
(a) Vertical form work to wWalls, columns, or as directed by EIC Walls, beams	16-24 hr
(b) Soffit form work to slabs (Props to be fixed immediately after removal of formwork)	3 days
(c) Soffit form work to beams (Props to be re-fixed immediately after Removal of formwork	7 days
d) Props to slabs: (1) Spanning up to 4.5m (2) Spanning over 4.5m	7 days 14 days

(e) Props to beams and arches: (1) Spanning up to 6m (2) Spanning over 6m	14 days 21 days

(b)

Note 1: For other types of cement, the stripping time recommended for ordinary Portland cement may be suitably modified. Generally, If Portland pozzolana or low heat cement or OPC with direct addition of fly ash has been used for concrete; the stripping time will be 10/7 of the period stated for OPC with 43 grade cement above.

Note 2: The number of props left under, their sizes and disposition shall be such as to be able to safely carry the full dead load of the slabs, beam or arch as the case may be together with any live load likely to occur during curing or further construction.

Surface Treatment

Oiling the Surface: Shuttering **surfaces** of form work are coated with suitable mould oil which acts both as a parting agent and also gives surface protections.

Inspection of Form Work: The completed form work shall be inspected and approved by the **Engineer** in-charge before the reinforcement bars are placed in position.

6.90DISPOSAL OF EXCAVATED MATERIALS

(i) The excavated materials suitable for construction shall be stockpiled in areas where permanent works are not located.

(ii) Excavated materials which are not suitable for construction and those in excess of the requirement for construction shall be disposed off in the waste disposal areas as proposed by the Contractor and subsequently approved by the Engineer-in-Charge. Surfaces of material so disposed off shall be trimmed to regular lines and grades satisfactory to the Engineer-in-Charge. Disposal of all materials shall be such that it will not interfere with natural drainage and is as per the regulations for environmental protection; drains will be constructed to prevent the undesirable accumulation of water in or around the disposal area. If additional areas are required, the Contractor shall propose such areas for approval of the Engineer-in-Charge.

(iii) The Contractor shall ensure that no excavated materials are disposed off in the streams or at locations, where in the opinion of the Engineer-in-Charge, these are liable to be washed away by the floods.

(iv) All other specifications/stipulations in this regard laid in this document shall also apply.

6.11DRAINAGE/DEWATERING

Seepage water from springs or rain water shall be suitably collected and drained away by gravity, wherever it is possible to do so. Where, however, drainage by gravity is not feasible, pumping could be resorted.

The Contractor shall make all arrangements deemed necessary for keeping the excavation and work areas dry for execution of works as per specification.

6.12BACKFILL

(i) Backfill shall consist of materials as approved by the Engineer-in-Charge and shall be placed in locations as shown on the approved drawings or as directed by the Engineer-in-Charge.

(ii) Earthfill, which on account of its nature or a location requiring no compaction, shall be classified as backfill.

(iii) Backfill which shall be compacted by means of roller, mechanical or manual tampers is classified as compacted backfill.

(iv) At locations, where areas to be backfilled are too small or confined, compaction may be done manually with tampers etc.

(v) Only suitable materials obtained from excavation, if practicable, shall be used for backfill and construction of such features as approach road, causeway etc.

(vi) Material to be used in backfill shall be free draining type.

6.13ILLUMINATION

The Contractor shall install an adequate illumination system at the work site.

6.14 MISCELLANEOUS WORKS

Besides the above, the Contractor shall also carry out, but not limited to, the following activities:

(i)Excavation for drainage trenches

(ii)Clearing of all trees, bushes, rubbish and any other objectionable materials and their removal and disposal.

(iii)Replacement of survey points fixed by the Engineer-in-Charge which are damaged by Contractor’s negligence.

(iv)Formation of berms or ramps, sump pits for installation of dewatering pumps at places which fall beyond the specified excavation lines.

(v)All dewatering and drainage works

(vi)Methods adopted for specially controlled excavation at foundation level or near the faces where plain surfaces are required.

(vii) Replacement or repair of concrete or other works damaged by blasting.

(viii) Draining, shaping and trimming of the dumped material in waste disposal areas to the lines and grades as directed or approved by the Engineer-in-Charge.

(ix)All shoring, strutting and other protective as required during excavation.

6.15Measurements and Payments

(i) Immediately after the final excavation of foundation or otherwise, inspection and approval of Engineer-in-Charge, levels at salient locations of the foundation pit/trench, etc., shall be measured jointly by the Contractor and the Engineer-in-Charge.

(ii) Interim/progressive payments will be made, in accordance with Clause 14 of the General Conditions of Contract, Volume – II (Part – A), at the appropriate unit rate entered in the Schedule of works which shall include the entire cost of all operations required for execution of the respective item.

7CONCRETE WORKS

7.1SCOPE OF WORK

(i) The specifications described hereunder cover all labour, materials, equipment, plant and services related to the concrete work to be carried out by the Contractor under the Contract.

(ii) The concrete work shall be performed to the dimensions as shown on the approved drawings.

(iii)The approval given by the Engineer-in-Charge to the Contractor's plants and equipment or their operation, or of any construction methods shall not relieve the Contractor of his full responsibility for the proper and safe execution of concrete work or any obligations under the Contract.

7.2SUBMITTALS

(i) Submittals listed herein are related to the items which require the consent of the Engineer-in-Charge and are to be made by the Contractor before the appropriate work may proceed.

(ii) Within 30 days from the date of issue of the Letter of Acceptance, but before procuring or mobilizing to the site, the equipment, the Contractor shall submit to the Engineer-in-Charge, updated and detailed plans and descriptions, consistent with those submitted with his bid and any subsequent amendments and additions agreed to by the Engineer-in-Charge and the Contractor, of the following:

(a) Aggregate Processing Plant

Description, flow diagrams and drawings in sufficient details to indicate layout, type and capacity of crushing, screening, washing, covering and other aggregate processing and handling equipment.

(b) Batching and Mixing Plants

Description, flow diagrams and drawings of the plants and details of the equipment, the Contractor intends to use to determine and control the amount of each separate concrete ingredient and mixing thereof into uniform mixture.

(c) Concrete Cooling Plant

Details of refrigeration and ice plants and other method which the contractor proposes to use to comply with concrete temperature requirements.

(d) Transport and Placing of Concrete

Full details of the equipment and method for transporting the concrete from the concrete plant to the final point of placing, including numbers, type and capacity of transport vehicles, concrete pumps, and details of standby plants to be installed.

(iii) **At least 30 days** in advance of any concrete work being carried out in the site, the Contractor shall submit to the Engineer-in-Charge, following information:

(a) Details of surface finishes, treatment of construction joints and construction techniques which the Contractor proposes to use in order to achieve the required concrete surfaces and allowable tolerances.

(iv) **At least 30 days prior** to procuring or dispatch to the site of the particular item of work to which the submittal relates, the Contractor shall submit to the Engineer-in-Charge.

(a) Details covering the properties and performance, including the certified copies of reports of all tests made by the manufactures of waterstops, expansion joint fillers and joint sealing compounds along with samples of the products.

(b) Details of curing compounds

(c) Details of epoxy mortar for concrete repair

(d) Details of the cooling system for post-cooling of mass concrete.

(v) Drawings showing the location of construction joints proposed by the Contractor which differ from those on the drawings approved by the Engineer-in-Charge, including formwork and reinforcement details, shall be submitted to the Engineer-in-Charge **at least 30 days prior** to the commencement of work on the particular structure.

(vi) During the performance of the concrete work, the Contractor shall keep a diary where he shall record the construction procedures related to concreting. This diary shall be made available to the Engineer-in-Charge upon request. The records shall contain at least the following:

(a) Commencement and termination of concreting of various parts of the structures

(b) Quantities and quality of aggregates and cement provided and the storage from which they were drawn
(c) Temperature of air, water, cement aggregates and concrete
(d) Meteorological conditions and humidity of air
(e) Personnel employed during various stages of the concreting operation and name of the responsible inspector or foreman
(f) Equipment used
(g) Directives received from the Engineer-in-Charge
(h) Any special material or procedures employed
vii) The Engineer-in-Charge reserves the right to ask for any additional information deemed necessary to be included in the submitted documents.

7.3STANDARDS

(i) The concrete material, production methods, testing and admixtures shall conform to the following Indian Standards or, where not covered by these standards, to the equivalent International Standards:

IS : 456 – 2000-
IS : 1199-1959-(Reaffirmed 1991)
IS : 457-1957-(Reaffirmed 1991)
IS : 1972-1989-
IS : 7861 (Part-I) – 1975-(Reaffirmed 1990)
IS : 7861 (Part-I) - 1981 -(Reaffirmed 1992)
IS : 2505 - 1980-(Reaffirmed 1993)

(ii) In cases of conflict between the above standards and the specification given herein, the specifications shall take precedence.

7.4QUALITY CONTROL AND TESTING

7.4.1General

Field tests for quality assurance and testing of concrete and admixtures shall be performed by the Contractor at regular intervals or as directed by the Engineer-in-Charge. Employer may also carry out the required tests and for this purpose the Contractor shall supply labour, material, equipment necessary to sample and transport materials to the field laboratory from any part of the project area.

7.4.2Test Prior to the Start of Concrete Works (Trial Mix Design)

7.4.2.1 General

(i) Immediately after the Aggregate Processing Plant and Batching and Mixing Plants are established by the Contractor but at least two months prior to the Contractor's programme to commence any concreting of permanent works, the Contractor shall start the testing of materials, conduct various trial mix design of concrete ingredients for the desired strength of different grades of concrete and propose the composition of concrete mixes and prepare trial mix of each of the proposed concrete class. The Engineer-in-Charge may also prepare the trial mixes using the cement, water, aggregates and admixtures intended for the work. Such materials shall be arranged by

the Contractor which shall conform to the requirements specified in **"Materials for Construction".**

(ii) The trial tests shall be carried out until the concrete mixes show appropriate strength, workability density, and water tightness without the use of excessive cement. The trial tests shall include determination of the following parameters:
(a) Cement properties
(b) Characteristics of aggregates
(c) Water properties
(d) Admixture properties
(e) Proportion of aggregate ranges in the mix
(f) Proportion of uncrushed to crushed aggregates
(g) Cement dosage
(h) Water-Cement ratio (W/C)
(i) Workability of concrete mixes
(j) Compressive and tensile strength
(k) Entrained air
(l) Density
(m) Water tightness

7.4.2.2 Cement, Aggregates and Water

Cement, aggregates and water will be sampled and tested by the Contractor as set out in **"Materials for Construction".**

7.4.2.3 Concrete

(i) Concrete test cubes shall be prepared and cured in accordance with IS : 456 – 2000. Six test cubes shall be made from the each mix proposed for the different classes of concrete. Compressive strength of concrete will be tested at 7,28 and 90 days.

(ii) The consistency of the proposed mixes shall be tested by means of slump test. Specimen for slump test will be taken from each batch of concrete used to make the test cubes.

(iii) Air content will be determined in accordance with IS : 9103 – 1979.

(iv) Prior to the execution of large scale concreting work at the site, test will be performed to determine the temperature development due to hydration within the concrete with various types of cement. The temperature rise will be recorded and corresponding diagrams established.

7.4.3Tests During Execution of Works by the Contractor

(i) Samples from the concrete being used for the permanent works, taken either at the batching and mixing plant or the placing point, shall be cured and tested hereafter as set out in Para 9.4.2.3.

(ii) In addition to the seven, twenty-eight days strength tests, ninety days strength tests and also at other ages shall be carried out as required by the Engineer-in-Charge.

(iii) Concrete for test specimens for compressive strengths shall be collected at random as it comes out of the mixer or at placing point once every shift or more often as the Engineer-in-Charge may require, and in quantity sufficient to prepare necessary number of test pieces from each sample. The concrete so collected shall be representative sample.

(iv) In addition to the strength tests carried out as above, it is contemplated that tests on actual cores from the concrete laid in position will be made by the Contractor, and results thereof shall be in conformity with those obtained in cube cast at the batching and mixing plant or at the placing point. For this purpose, it may be necessary to establish relationship between concrete strength versus age, as it may be possible to test control cubes and cores of the same age taken from the hardened concrete in the structure. Location and number of cores shall be decided by the Engineer-in-Charge. If the cores taken out show unreasonably low results, the work is liable to be rejected and may be required to be dismantled and re-done with all consequences to the Contractor.

(v) The contractor shall fill the test holes left by the removal of the cores with concrete of the required strength to the satisfaction of the Engineer-in-Charge.

(vi) The Engineer-in-Charge shall at all times, have access to and association with sampling, design and test of trial mixes, tests of strength corresponding to the laboratory tests.

7.5PROPORTIONING OF CONCRETE

(i) All grades of concrete shall be air entrained concrete by using an approved air entraining agent. The air to be entrained shall vary in contents from 2% to 7% as per the laboratory tests.

(ii) Based on the analysis and tests made from time to time during the progress of work on the samples of various ingredients of concrete e.g. cement, aggregates and admixtures, and the resulting concrete, the Contractor will determine and submit to Employer for approval about the quantity of each ingredient to be used in the concrete mix.

7.5.1 MINIMUM LEVEL OF THE CEMENT CONTENT FOR DESIGN MIXES

S.NO	GRADE OF CONCRETE	Cement content / Cum in Kgs for 40mm MSA	Cement content / Cum in Kgs for 20mm MSA
1	M10	220	220
2	M15	280	280
3	M20	340	350
4	M25	370	380
5	M30		420
6	M35		450

7.6HANDLING OF AGGREGATES

(i) The coarse aggregates shall be stacked in three separate stock plies, designated 80 mm to 40 mm, 40 mm to 20 mm and 20mm to 4.75 mm nominal size aggregates. A separate stockpile shall however be made for 150 mm nominal size aggregate.

(ii) If tests reveal the separation of the 10 mm and lower sizes is required, a separate stockpile, shall made for this aggregate.

(iii) The fine aggregate, having the required grading, shall ordinarily be stacked in two piles, one of which is washed and drained and other freshly washed, to minimise the variation in the moisture content.

(iv) Where crushed fine aggregate replaces a part of natural fine aggregate, the two shall be stacked in independent stockpiles.

(v) It may be necessary to have two or three piles, by sizes, in case of natural fine aggregate to get the required grading.

7.7BATCHING AND MIXING

7.7.1Batching and Mixing Equipment

(i) The Batching and Mixing Plant shall be of the requisite capacity to maintain the required progress on different items of work.

(ii) The Plant shall be capable of determining accurately, by direct weighing, the prescribed amount of the various ingredients including water, cement, admixtures and puzzolana etc. and each individual size of aggregate entering the concrete and combining them to give a uniform mix within the prescribed time and discharging the mix without segregation.

7.7.2Calibration of Measuring Devices

(i) The Contractor shall provide standard test weights and other auxiliary equipment required for checking the operating performance of each scale and other measuring device and shall make periodic tests over the ranges of measurements involved in the batching operation.

(ii) The tests shall be made in the presence of a representative of the Engineer-in-Charge and shall be adequate to prove the accuracy of the measuring devices.

(iii) The frequency of such tests will be determined by the Engineer-in-Charge. Unless otherwise directed, tests shall be made once in two weeks at random without any notice in the case of cement and water scales and once a month in the case of all other scales.

(iv) The Contractor shall make such adjustments, repairs or replacements as may be necessary to meet the specified requirements for accuracy of measurement. The devices

shall be capable of being operated to control the delivery of materials so that the combined in-accuracies in feeding and measuring do not exceed the following limits:

S. No.	Material	Percent (by weight)
1	Cement	1
2	Water	1
3	Aggregate	3
4	Admixtures	1

7.7.3Mixing

(i) All concrete shall be thoroughly mixed in the Batching and Mixing Plants/Tilting batch mixer of an approved type, size and design as to positively ensure uniform distribution of the components throughout the mass during the mixing operations.

Mixing shall be continued until there is a uniform distribution of the materials and the mass is uniform in colour and consistency. If there is segregation after unloading from the mixer, the concrete shall be remixed. Unless otherwise authorised by the Engineer-in-Charge for mixers of one cubic metre capacity or less, the mixing of each batch shall continue for 1.5 to 2 minutes after all materials, except the full amount of water, are in the mixer. For mixer of larger capacity, the minimum mixing time shall be increased by fifteen seconds for each additional 0.5 cubic metre.

(ii) The mixing time shall be increased when, in the opinion of the Engineer-in-Charge, the charging and mixing operations fail to result in the uniformity of composition and consistency within the batch to batch.

(iii) Separation of coarse aggregate from mortar shall be avoided by proper arrangement of the discharge so that the concrete falls vertically and not diagonally into whatever container is to receive it.

(iv) Should the last fraction of the batch contain an excessive amount of coarse aggregate, this portion shall be retained and mixed with the succeeding batch.

(v) Discharge pipes of all water batches shall be of such a size and so arranged that the flow into the mixer is completed within the first 25% of the mixing time and delivered well inside the mixer where it is mixed quickly with the entire batch.

(vi) Over mixing requiring additions of water to preserve the required consistency shall not be permitted.

(c)

(vii) On no account shall any addition be made to any component of a concrete batch once that batch has been mixed and discharged from the mixer, whether for the purpose of retempering or any other reason, without the prior approval of the Engineer-in-Charge.

7.8TEMPERATURE OF CONCRETE

Placing temperature of concrete for open works shall be maintained as stipulated in the BIS Codes or as directed by the Engineer-in-Charge. The measures to maintain these temperatures shall, but not, be limited to the following:

(a) Pre-cooling coarse aggregate with refrigerated water or with cold air blasts.

(b) Using cold mixing water by adding ice. Ice, if used, shall preferably be batched by weight, separately from the water. In short time mixing when aggregates are pre-cooled substantially, the ice may not completely melt in the mixer. In such a case, additional mixing time may be required or the amount of ice limited to about 30% of the mixing water.

(c) Using cement having low heat of hydration.

(d) Insulating water supply lines and tanks or at least painting exposed portions white.

(e) Insulating mixer drums or cooling them with sprays.

(f) Shading the batching, mixing and conveying equipment.

(g) Working only at night.

(h) Keeping mixing time and the time required to convey to the point of placement to a minimum.

(i) Spraying foams and reinforcement with water when they are exposed to direct sun light.

(j) Placing concrete in accordance with the procedure set out in IS : 7861 (Part-I) – 1975 (Reaffirmed 1990).

(k) Protecting all freshly placed concrete from exposure to direct sun light.

(l) Employing continuous moist curing.

7.9CONVEYING

(i) Concrete shall be conveyed from mixer to forms as rapidly as practicable by methods, which shall prevent segregation and / or loss of ingredients. In case such separation occurs, concrete shall be remixed before being laid in place.

(ii) The distance between the mixer and the place of concreting and also the mode of transport of concrete shall be subject to the prior approval of the Engineer-in-Charge.

(iii) Concrete shall be deposited in the final position as early as practicable but always **within a period of 30 minutes after mixing**. This limit may be modified by the Engineer-in-Charge to suit working or weather conditions.

(iv) Plants, such as buckets, plant conveyors and/or pumping equipment, which may be used for conveying concrete from mixing plant shall be of such size, design and condition so as to ensure an even and adequate supply of concrete at the placement area.

(v) Particular attention shall be paid to prevent segregation at the ends of chutes /hopper gates and at all other points of discharge.

(vi) Methods of conveying concrete in a thin continuously exposed flow to the forms to any part of the structure shall not be permitted except for very limited or isolated sections of the work, and only when approved in writing by the Engineer-in-Charge.

(d)

(vii) Where chutes are used, they shall be so constructed and arranged as to permit continuous flow of the concrete without separation of the ingredients. Chutes shall not have a slope steeper than 1 V : 2 H.

(viii) There shall be no vertical drop greater than 1.5 m unless warranted, but subject to the approval of Engineer-in-Charge is used to confine and control the falling concrete.

(ix) Concrete may be dropped through flexible elephant-trunk chutes, provided some method is used at the lower end to retard the speed of the falling concrete and prevent it from segregating.

(x) Buckets for transporting concrete shall be manufactured as low-slump concrete buckets.

(xi) The conveying plant shall be kept free from hardened concrete and foreign materials and shall be cleaned at frequent intervals.

(xii) During hot or cold weather, concrete shall be transported in deep containers, on account of their lower ratio of areas to mass, reduce the rate of loss of water by evaporation during hot weather and loss of heat in cold weather.

(xiii) All conveying plants shall be supported independently of the forms, except as specifically permitted by the Engineer-in-Charge.

7.10PLACING OF CONCRETE

7.10.1 General

(i) No mortar or concrete shall be placed except in the presence of the Engineer-in-Charge.

(ii) The Contractor shall provide Engineer-in-Charge with a weekly placing schedule giving the detailed location of the pours, the approximate extent of pours and the date on which the concrete shall be placed.

(iii) Concrete shall be placed only in locations where authorised and no concrete or mortar shall be placed until formwork, installation of reinforcing steel, steel ribs, piping and other embedded parts, preparation of surface and necessary clean up have been done and checked and certified by the Engineer-in-Charge as being in conformity with specifications and drawings.

(iv) Concrete placed without prior knowledge and approval of the Engineer-in-Charge shall be required to be removed and replaced.

(v) Earth foundations on which concrete is to be laid shall be firm drained soil, free from any soft mud or other objectionable material.

(vi) Whenever concrete is to be placed on earth, a layer of lean concrete of approved proportion shall first be placed before placing concrete of the specified grade. The thickness of such layer of lean concrete shall be as shown on the drawings or as directed by the Engineer-in-Charge.

(vii) No concrete shall be placed in running water. Water shall, generally, not be allowed to flow over freshly poured concrete until final set has been achieved.

(viii) Immediately, before placing concrete, all the surfaces upon which concrete is to be placed 0shall be thoroughly cleaned by the use of high velocity air and water jets or sand blasting, steel brooms, picks or other effective means, satisfactory to the Engineer-in-Charge.

(ix) All pools of water from the surface on which concrete is to be placed shall be cleaned to ensure proper bonding of fresh concrete with the rock surface. The method of disposal of water in working site shall be subject to the approval of the Engineer-in-Charge.

(x) Sufficient mixing and placing capacity shall be provided so that the work may be kept alive and free from cold joints. Formed concrete shall be placed in horizontal layers, avoiding inclined layers and construction joints.

(xi) To get a monolithic placement, it is important that each layer be shallow enough so that the previous layer is still soft and the two layers are vibrated together.

(xii) Concrete shall not be allowed or caused to flow horizontally or on slopes in the forms.

(xiii) Concrete placing on slope shall begin at the lower end of the slope and progress upward, thereby increasing compaction of concrete.

(xiv) In pneumatic placement of concrete, usual high velocity discharges shall be reduced to a point where no separation and scattering of the concrete occurs.

(xv) In order to reduce bleeding, slump shall not be more than necessary to achieve proper placement and consolidation.

(xvi) All care shall be taken to avoid separation of coarse aggregate from the concrete. Obvious groups and clusters of separated coarse aggregates shall not be permitted. They shall be removed before the concrete is placed over them, otherwise they may cause serious imperfections in the finished work. Hence particular attention shall be paid to the tendency for objectionable separation to occur at the points of discharge so that uniformity and homogeneity of concrete in placement and good workmanship is assured.

(xvii) The concrete shall drop vertically into the centre of whatever container receives it. To protect the roads, spacers, and embedded features from damage and to prevent displacement of reinforcement, concrete falling in forms shall be confined in a suitable drop chute.

7.10.2 Preparation for Placing of Concrete

(i) All surfaces on which or against which concrete is to be placed, including surface of construction joints between successive concrete placement, reinforcing steel and embedded parts, shall be thoroughly cleaned of dirt, mud, debris, grease, oil dried mortar or grout, laitance, loose particles or other deleterious matter.

(ii) Surface seepage and other water shall be so controlled, to the satisfaction of the Engineer-in-Charge, that no time during the placement or hardening of the concrete will it wash, mix with, or seep into the concrete.

7.10.3 Concrete Placement

(i) The method and equipment used for placing concrete shall be such as shall permit the delivery of concrete of the required consistency into the work without objectionable delay, segregation, porosity of loss of workability.

(ii) All surfaces of forms and metal work including reinforcement bars that have become encrusted with dried mortar or grout from concrete previously placed, shall be cleaned of all such matter or grout before the surrounding or adjacent concrete is placed.

(iii) Concrete shall be placed in lifts as shown on the drawings or as directed by the Engineer-in-Charge.

(iv) In reinforced concrete work, which have congested parts, care shall be taken to see that all the bars are properly embedded and that no voids are left. On flat, horizontal surfaces, where the congestion of steel near the forms makes placing difficult, a mortar of the same cement sand ratio as is used in the concrete shall be first deposited to cover the forms.

(v) After the surface have been prepared, all approximately horizontal surfaces or rock and construction joints shall be coated with cement slurry of water cement ratio approximately of 0.60 by weight or as directed by the Engineer-in-Charge. It shall then be covered with layers of mortar approximately 50 mm to 75 mm thick for rock surface and approximately 15 mm thick for construction joints. The mortar shall have the same proportion as that of concrete mix unless otherwise prescribed by the Engineer-in-Charge. The consistency shall be suitable for placing and working in the manner hereinafter specified. The mortar shall be spread uniformly and thoroughly with stiff brooms into all irregularities of the surfaces. Concrete shall then be immediately laid upon the fresh mortar.

(vi) No concrete shall be placed in running water or during rain, high winds, dust storms, excessive heat or cold and similar conditions without prior approval of the Engineer-in-Charge.

(vii) In all cases, concrete shall be deposited as nearly as practicable directly in its final position and shall not be caused to flow by vibrators or otherwise in a manner which shall permit or cause segregation.

(viii) The maximum time internal between placing successive layers within a lift shall not exceed 30 minutes. However, depending upon job requirements and climatic conditions, the Engineer-in-Charge can allow to increase this time interval using appropriate methods of vibration/agitation.

(ix) Concrete shall not be piled up in the forms in a manner that causes movement of the unconsolidated concrete, or permit mortar to escape from the coarse aggregate.

7.10.4 Rate of Placing of Concrete

(i) Concreting shall be done as a continuous operation until the structure or section is completed or until a satisfactory construction joint can be made. The Contractor shall make all arrangement necessary to maintain continuity of concrete placing in any particular pour during meal periods, shift changes, or any other such interruptions.

(ii) Concrete shall not be placed faster than the placing crew can compact it properly.

(iii) In placing thin members and columns, precaution shall be taken against too rapid placement which may result in movement or failure of the form due to excessive lateral pressure. An interval of at least 24 hours, unless otherwise approved or directed by the Engineer-in-Charge, shall elapse between the completion of columns and walls and the placing of slabs, beams or girders supported by them.

(iv) The rate of placing shall be such as to have no objectionable effect on placement of concrete, particularly near forms and in and around embedded equipment where the rate shall not exceed the limit placed by the Engineer-in-Charge.

7.10.5 Consolidation of Concrete

(i) Consolidation of newly placed concrete shall ordinarily be done with internal vibrators of approved design. The equipment of vibration shall have adequate power and shall be of high frequency, rugged and reliable.
(ii) Operators of vibrators shall be experienced, competent in handling these devices.
(iii) Ample stand-by-units and parts as well as systematic servicing shall be provided.

(iv) Vibrators shall not be used to cause concrete to move more than a short distance laterally, otherwise fine wet material may run ahead and separate from the coarse aggregate.

(v) Inadvertent or unintended revibration of concrete is beneficial provided the concrete becomes momentarily plastic again during revibration. Revibration shall be resorted to only after specific instructions are given by the Engineer-in-Charge.

(vi) Where Vibrator is used to full advantage for consolidation of newly placed concrete, no supplementary rodding or other working of the concrete is necessary.
(e)

(vii)Concrete shall be compacted and worked into all corners and angles of forms, obstructions, blockouts, locations with congested reinforcement and around embedded items. Special care shall be taken to attend to these places with ample, properly applied additional vibration or rodding as the case may be, without permitting the concrete materials to segregate.

(viii)Internal vibrators of approved weight and frequency 7000 to 9000 r.p.m. to secure maximum consolidation shall be used.

(ix)External from vibrators of an approved type shall be used only in inaccessible locations and where it is impracticable to use immersion type vibrators after their use has been specifically authorised by the Engineer-in-Charge. The form shall be designed to receive vibrations without losing shape and causing leakage of mortar.

(f)

(x) The immersion type mechanical vibrators, complying with **IS : 2505-1980**, electric, air driven of diesel, shall generally be inserted vertically and the vibrating head shall be allowed to penetrate under the action of its own weight. In very shallow concrete, some consolidation can be obtained by using vibrators in horizontal position.

(g)

(xi)Internal vibrators, when used, shall be inserted at regular intervals and vibration, with the vibrator fully into the layer being compacted, shall be continued till acceptable degree of compaction has been achieved taking care to avoid excessive paste and laitance.

(xii)The entire depth of new layer of concrete shall be vibrated and ordinarily the vibrators should penetrate the layer below (which has not yet become rigid) for several millimeters to ensure thorough bond between the layers.

(xiii)Under ordinary job conditions, there is little likelihood of damage from direct revibration of lower layer or by vibration transmitted by embedded steel provided the disturbed concrete still is or again becomes plastic. Vibrators shall not, however, be inserted into lower courses that have commenced final set nor shall they be directly applied to or allowed to disturb reinforcement extending into hardened or partially hardened concrete.

(xiv)Systematic spacing of points of vibrators shall be established to ensure that no portions of the concrete are missed. It shall be ensured that zones of influence overlap and the concrete is properly consolidated.

(xv)In compacting the surface of a concrete lift, the coarser particles of the aggregate in the surface shall be embedded while the concrete is being vibrated, but the surface left with the desired degree of roughness.

(xvi)Disturbance of the surface concrete at construction joints during early stage of hardening shall be on timber walkways constructed so as not to cause injury to the concrete.

(xvii)When smooth surfaces are required, for all surfaces which shall be permanently exposed to the weather and for all surfaces next to embedded metal work around which it is desired to prevent leakage, the adjacent concrete shall be properly vibrated, spaded or tamped.

(xviii)To ensure even and dense surfaces which are free from aggregate pockets, honey combing or air holes, it may be necessary to supplement internal vibration with hand spading or tamping all along the boundaries of the concrete and around embedded parts, while the concrete is plastic under vibrating action.

7.11 Concrete in R.C.C. Frames/Walls/Slabs

(i) Concrete shall be placed in lifts of heights as shown on the approved construction drawings or as directed by the Engineer-in-Charge. Within each lift, concrete shall be deposited in approximately horizontal layers about 40 cm in thickness unless otherwise directed by the Engineer-in-Charge.

(ii) At locations where lift heights are not shown on the drawings, the Contractor shall submit to the Engineer-in-Charge for approval, details of the placing procedure which he proposes. No concrete shall be placed at such locations without the prior approval of the Engineer-in-Charge.

(iii) Slabs shall be placed in one lift unless otherwise indicated or directed by the Engineer-in-Charge.

(iv) In walls, lifts shall terminate at such levels as will conform to the structural requirements.

(v) The placement of concrete shall be carried out at such rate and in such a manner that the formation of cold joints is prevented.

(vi) Where slabs and beams are placed continuously with walls and columns, the concrete in walls and columns shall have been in place for at least 2 hours or for a longer period when so directed by the Engineer-in-Charge before placing concrete in the slabs and beams.

7.11.1 Concrete for Blockouts

(i) Blockouts for gate guides, seals or tack assemblies of the like shall be provided as indicated on the drawings.

(ii) After the assemblies have been installed and adjusted, the blockout recesses shall be filled with concrete as specified on the approved construction drawings or as directed by the Engineer-in-Charge.

(iii) Before installing the components to be embedded in blockout concrete and before depositing mortar or concrete, the surfaces of the blockout shall be cleaned in the manner specified for cleaning construction joints.

(iv) Exceptional care shall be taken in placing mortar or concrete in the blockouts to ensure satisfactory bond with the concrete previously placed and to secure complete contact with all components embedded in the blockouts.

(h)

7.11.2 Concrete Deposited Under Water

(i) Concrete shall be deposited in water only with the prior approval of the Engineer-in-Charge.
(ii) Concrete placed underwater shall be deposited by a tremie or by a valved tremie.

(iii) The methods and equipment used shall be subject to the prior approval of the Engineer-in-Charge.

(iv) Concrete buckets shall not be permitted for underwater placement of concrete.

(v) The tremie seal shall be affected in a manner which will not produce undue turbulence in water around the pipe. The discharge end shall be kept submerged continuously in the concrete and the concrete pumped in without interruption until the concrete has been brought to the required height.

(vi) The tremie shall not be moved horizontally during a placing operation and a sufficient number of tremies shall be provided so that concrete does not have to flow horizontally, a distance of more than 3 metres.

7.12CHIPPING AND ROUGHENING OF CONCRETE SURFACES

(i) Surface upon or against which additional concrete is to be placed shall be chipped and roughened to a depth of not greater than 25 mm.

(ii) The roughening shall be performed by chipping, sand blasting or other satisfactory methods and in such manner as not to loosen, crack or shatter any part of the concrete beyond the roughened surface.

(iii) After being roughened, the surface of the concrete shall be cleaned thoroughly of the loose fragments, dirt and other objectionable substances and shall be sound and hard and in such condition as to assure good mechanical bond between old and new concrete.

(iv) All concrete which is not hard, dense and durable shall be removed to the depth required to secure a satisfactory surface.

(v) Prior to placement of new concrete against the old concrete surfaces and the concrete surfaces over which flood has passed shall be chipped and roughened to a depth of not greater than 25 mm or sand blasted to make them clean and free from loose materials/laitance, oil, grease, etc. so as to develop good bond between the old concrete and new concrete.

(vi) Just before placement of concrete, the rock/concrete surface shall be cleaned by high velocity water jet (about 5 kg/cm^2 at the nozzle) followed by careful blowing of high pressure air jet so as to make the surface free from dirt, mud, debris, grease, oil, laitance, grout, loose particles and other deleterious matter. Contractor shall also use picks, wire brushes, if necessary for cleaning. All pools of water shall be removed from depressions.

7.13DEFECTIVE AND DAMAGED CONCRETE

Concrete which is damaged from any cause and which is not manufactured, placed and compacted in accordance with these specifications and is found to have lower strength, density etc. than specified, as determined from test samples or core samples, shall be removed and replaced by the Contractor.

7.14 FINISHING OF CONCRETE

7.14.1 Finishing of Formed Surfaces

Except as otherwise specified or directed, all permanently exposed concrete surfaces and other waterway surfaces requiring durability under water shall be finished in the following manner:

(i) Any damage to finished concrete resulting from the action of removing formwork or from any other cause shall be repaired to the satisfaction of the Engineer-in-Charge. Immediately on removal of the form, the surface shall be examined and all porous honeycombed or defective concrete removed and repaired as specified herein.

(ii) All imperfections or ridges due to joints in the formwork, shall be removed by light chipping or grinding down if necessary, to produce a smoother surface.

(iii) When the treatment of a surface has been completed, the surface shall be cured.

(iv) All patches and mortar filled pits on exposed surfaces shall be neat and of the same colour and texture as the adjoining concrete.

(v) The finished surfaces concrete shall be true, sound, smooth and free from fins, offsets, pits, depressions, voids, blemishes and other defective concrete and surface irregularities and shall be in accordance with the requirements for the particular class of finish specified herein or as shown on the drawings.

(vi) Finishing work shall be done only by skilled workman in the presence of the Engineer-in-Charge and shall be performed within 4 weeks of placing.

(vii) Before final acceptance of the work, Contractor shall clean all exposed concrete surfaces of all encrustations of cement, mortar or grout, to the satisfaction of the Engineer-in-Charge. Concrete shall not be considered finished until all required repair work and finishing have been completed.

7.14.2 Finishing of Unformed Surfaces

Unformed surfaces shall be finished by one or more methods of screeding, floating and trowelling and working of the surfaces shall be done at the proper time, employing experienced men and shall be just sufficient to produce the desired finish.

(i)Screeding

(a) It gives the surface its approximate shape by striking off surplus concrete immediately after completion and shall be accomplished by moving a straight edge or template with a swing motion across wood or metal strips which have been established as guides.

(b) Where the surface is curved, a special screed shall be used.

(ii) Floating

Shortly after the concrete is screeded, the surfaces shall be brought true to from and grade by working it sparingly with a wooden float. If a coarse textured finish is specified or if the surface is to be steel trowelled, a second or final floating shall be performed after some stiffening has occurred and the surface moisture film or shine has disappeared.

(iii) Trowelling

(a) If a smooth dense finish is desired, floating shall be followed by steel trowelling some time after moisture film or shine has disappeared from the floated surfaces and when the concrete has hardened sufficiently to prevent fine material and water from being brought upto the surface. Excessive trowelling at an early stage as would tend to produce creaking or result in a surface that is too hard to finish properly shall be avoided.

(b) Trowelling shall, therefore, be done at the appropriate time and shall have the surface smooth, even and free of trowel marks and ripples. A fine textured surface that is not slick shall be obtained by trowelling lightly over the surface with a circular motion keeping the trowel flat on the surface of the concrete. Where a hard steel trowelled finish is required, trowelling shall be continued until it no longer produces noticeable compaction and the surface has a glossy appearance, trowelling pressure being increased gradually as the operation progresses.

(c) The use of any finishing tool in areas where water has accumulated shall be prohibited. Operation on such areas shall be delayed until the water has been absorbed or has evaporated or has been removed by draining, mopping or other means.

(d) All joints and edges on unformed surfaces, that shall be exposed to view, shall be finished with suitable moulding tools with rounded, bevelled or filleted edge, as directed by the Engineer-in-Charge. Unless the use of other slopes or level surface is indicated on the drawings as directed, narrow surfaces such as top of walls or tunnel portals shall be sloped approximately 9 mm per 300 mm of width. Broader surfaces as walls, roadways, platforms and decks shall be sloped approximately 6 mm per 300 mm.

(e) Where separate floor finish is specified or directed, the concrete shall be struck of sufficiently below grade to allow for the subsequent placing of a finished floor. The surface of such concrete shall be left rough.

(f) As soon as the condition of the base permits and before it has hardened fully, all dirt, laitance and loose aggregate shall be removed from the surface, by means of water jets

and wire brooms leaving the coarse aggregate slightly exposed and the surface made suitable for taking further concrete.

7.14.3 Tolerance for Concrete Construction

(i)General

(a) The contractor shall construct all concrete structure to the exact lines, grades and dimensions established. However, inadvertent variations for the established lines, grades and dimensions shall be permitted to the extent set forth herein, provided, that the Engineer-in-Charge reserves the right to diminish the tolerances set forth herein if such tolerances impair the structural action or operational function of the structure.

(b) Where tolerances are not stated in the specifications or on the drawings for any individual structure or features thereof, permissible deviations shall be interpreted in conformity with the provisions of this paragraph.

(ii)Tolerance for Surface Finishes

(a) Surface finishes shall generally conform to the types and tolerances indicated in the table given below, unless otherwise specified on the drawings or as required by the Engineer-in-Charge.

(b) Positive tolerance shall be measured outside and negative inside the lines and grades defining the structure on the drawings.

Type of Finish	General Area of Application and method of Forming	Tolerance (mm)
1	**2**	**3**
F1	Formed surfaces of construction joints and other surfaces which shall not be permanently exposed. The surface shall required no treatment after form removal, other than repair of defective concrete and specified curing, or treatment as specified for construction joints.	+ 10 - 10
F2	All permanently exposed formed surfaces for which type F3 finish is not specified. Form sheathing or lining shall be placed so that joint marks on the concrete surface shall be in general alignment, both horizontally and vertically and conform to a standard pattern. Immediately on the removal of forms, all unsightly ridges of fines shall be removed; all holes left by removal of ends of form roads shall be neatly filled with mortar and surfaces treated to meet the required tolerances by tooling and rubbing.	+5 -5
F3	Formed surfaces which shall be exposed to flowing water shall be hard, smooth and dense, free from offsets, pits, voids, air holes and irregularities, and shall be chipped, ground and thoroughly cleaned as necessary to conform to the required tolerances.	+5 - 5
U1	Unformed, screeded surfaces which shall be covered by fill materials, static water or concrete. Type U1 finish shall be used as the first stage of type U2 and U3 finishes. Finishing shall consist of sufficient levelling and screeded to produce an even, uniform surface meeting the required	+ 10 - 10

Type of Finish	General Area of Application and method of Forming	Tolerance (mm)
1	**2**	**3**
	tolerance.	
U2	Unformed surfaces not permanently concealed by fill or concrete or not required to receive Type U3 finish. (Type U2 finish shall be used as the second stage of Type U3 finish). Floating by means of hand or power driven equipment shall be started as soon as the screeded surface has stiffened sufficiently and shall be the minimum necessary to produce a surface that is free from screed marks and uniform in texture if type U3 finish is to be applied, floating shall be continued until a small amount of mortar without excess water is brought to the surface so as to permit effective trowelling.	+5 - 5
U3	Unformed, screed surfaces which shall be exposed to flowing water. This finish shall be applied by steel trowelling after the concrete has hardened enough to prevent excess of fine materials and water from being brought to the surface free from blemishes, ripples and trowels marks. After the surface has nearly hardened, it shall be trowelled once more until the surface is hard and glossy in appearance.	+3 - 3

7.15EMBEDMENTS IN CONCRETE

7.15.1 Embedded Parts

(i) Before placing concrete, care shall be taken to ensure that all embedded parts are firmly and accurately fastened in place as indicated on the drawings or as directed.

(ii) All embedded parts shall be thoroughly cleaned, free from all foreign matter such as scale, rust, oil, etc.

(iii) Concrete shall not be placed on embedded parts unless these are checked and approved by the Engineer-in-Charge.

(iv) Parts of gates, gate hoists, valves, operating machines and other control equipment as also the anchor bolts, structural steel plates and bearings shall be installed/embedded in concrete/rock as shown on the drawings or as directed.

(v) Embedded parts for pump and other equipments as needed will be supplied to the Contractor and the same shall be embedded in concrete as shown on the drawings or as directed by the Engineer-in-Charge.

(vi) If concrete is placed by the without correctly placing in position, the necessary embedded parts, concrete shall have to be removed and replaced to enable such embedded parts to be installed in position.

(vii) Care shall be taken not to disturb or displace embedded parts during concrete placement.

7.15.2 Water Stops

(i) Polyvinyl Chloride (PVC)/rubber water stops of width and section as shown on the drawings approved for construction shall be furnished and installed for water tight construction at various locations of concrete structures/components covered under these specifications. In order to ensure proper alignment and fixing of water-stops in correct position/place, the same shall be rigidly secured to the formwork or reinforcement steel as directed/approved by the Engineer-in-Charge. Number of joints in PVC/ water stops, when installed in place shall be the barest minimum and joints, thus made, shall be suitably vulcanised/welded by the use of best method/engineering practice satisfactory to the Engineer-in-Charge. The PVC water stop shall be properly protected from sunrays and weather.

(ii) All types of water stops shall be tested as per IS : 8543 in a recognised laboratory prior to transport to the site. Test specimens shall be furnished by the manufacturer and the tests shall be carried out at the manufacturer's place.

(iii) Water stops shall be tested as to their tensile strength, elongation, tear resistance, stiffness, water absorption, gravity, effect of alkali and impact resistance etc.

(iv) The Contractor shall submit to the engineer for approval the test result from recognised institution showing that the material supplied meets the requirements specified. The Engineer may carry out the additional tests, for which the Contractor shall supply specimens from the same material to be used in the work. Test specimens, if required, shall be of the shape and dimensions as required in the individual tests methods.

7.16EXPANSION AND CONTRACTION JOINTS

i. Expansion and contraction joints shall be constructed at such points and of such dimensions as indicated on the drawings or as required by the Engineer-in-Charge. The method and material used shall be subject to the approval of the Engineer-in-Charge.

ii. Standard bitumen sheets, impregnated with saw dust or any other filler material and sealing compounds, required to be placed in the expansion joints, shall be fixed in position as shown on the drawings or as directed by the Engineer-in-Charge.

7.17CURING AND PROTECTION OF CONCRETE

(i) Plant and materials required for curing and protection of concrete shall be available at the location of each concrete placement before concrete placement is started and the water used for curing shall meet the requirement set out in these documents.

(ii) All concrete shall be protected against injury until final acceptance.

(iii) Exposed finished surfaces of concrete shall be protected from the direct rays of the sun for at least 72 hours after placement.

(iv) Fresh exposed concrete shall also be protected from the action of the rains, flowing water and mechanical injury.

(v) No fire shall be permitted in direct contact with concrete at any time.

(vi) Concrete in which standard Portland cement is used shall be kept continuously moist for not less than 14 days for normal concrete and 21 days for concrete containing puzzolana, by covering with water saturated materials or a system of perforated pipes, mechanical sprinklers or porous hose or by any other approved method. Curing period where special cement may be used shall be as approved by the Engineer-in-Charge.

(vii) Construction joints shall be cured in the same manner as the other concrete and shall also, if practicable, be kept moist for at least 72 hours prior to the placing of additional concrete upon the joint.

(viii) Horizontal surfaces shall be cured by sprinkling water or by covering with damp sand or may be cured by the use of wet quilts or mats which will satisfactorily supply the required curing water. If damp sand or quilt is used for curing, it shall later be completely removed. The time of applying damp sand shall be specified by the Engineer-in-Charge before which curing shall be carried out by other approved methods.

(ix) The method of keeping formed concrete surface moist shall be continuous sprinkling or spraying of water as may be necessary to prevent any portion of the surface from drying during the specified period.

(x) The water and other methods of curing shall be so handled as not to stain concrete surfaces, which shall be exposed.

(xi) The actual method of curing adopted shall be subject to the approval of the Engineer-in-Charge.

(xii) The contractor shall have on hand and ready to install before actual concrete placement is started, all equipment needed for adequate curing and protection at all locations of concrete placement.

(xiii) In limited areas and for special purposes, the use of an approved and properly applied compound may be permitted at the discretion of the Engineer-in-Charge to restrict the evaporation of the mixing water. Such curing compound shall be of the surface membrane type which will thoroughly seal the surface. Curing compound shall not be used on joints where bonding is required.

(xiv) Curing compounds shall be applied according to the manufacture's recommendations to provide a continuous uniform membrane over all areas. Curing compounds shall be applied only after moist curing has been carried out for at least 24 hours.

(xv) A curing compound shall not be used on any unformed surface where, in the opinion of Engineer-in-Charge, the irregularities in that surface would prevent the membrane forming an effective seal, on any surface which has a temperature lower than manufacturer's recommended application temperature, or any surface where a bond is required for additional concrete, or where a curing compound is placed on a surface where a bond is required, it shall be removed by sand blasting or by other means satisfactory to the Engineer-in-Charge.

(xvi) Curing membranes shall be protected from damage at all times.

(xvii) Care shall be taken not to disturb the steel reinforcement projecting from any placement for at least 24 hours after the completion of such placement.

(xviii) Finished concrete surface shall be protected from stains or abrasion and surface of edges likely to be injured during the construction period shall be kept properly protected by leaving forms in place or erecting protective covering satisfactory to the Engineer-in-Charge.

(xix) In case, the curing operations are inadequate or unsatisfactory, the Engineer-in-Charge shall be entitled to take such steps as he may deem necessary to make good the deficiencies and defects.

7.18REPAIR OF CONCRETE

(i) Repair of concrete shall be performed by skilled workmen and in the presence of the Engineer-in-Charge.

(ii) No repair work shall be carried out until the Engineer-in-Charge, has inspected the location of the proposed repair and accepted the method of repair.

(iii) The Contractor shall correct all imperfections on the concrete surfaces as necessary to produce surfaces that shall conform to the required standards.

(iv) All materials, procedures and operations used in the repair of concrete shall be subject to approval by the Engineer-in-Charge.

(v) Surfaces of concrete finished against forms shall be smooth and free from projections. Immediately upon the removal of forms and within 24 hours thereof, wherever practicable, all unsightly ridges or fines shall be removed and any local bulging on exposed surfaces shall be remedied by tooling and rubbing. All holes left by the removal of fasteners from the tie rods shall, after being reamed with a toothed reamer, be neatly filled with dry pack mortar.

(vi) All honeycombed, porous, fractured or otherwise defective concrete and surface concrete in which, in the opinion of the Engineer-in-Charge, additions are required to bring it to the prescribed lines, shall be removed by chipping concrete.

(vii) The chipped openings shall be sharp edged and keyed, and shall be filled to required lines with fresh concrete or as found suitable. Where concrete is used for filling, the chipped openings shall be not less than 100 mm in depth and the fresh concrete shall be

reinforced and dowelled to the surface of the openings as directed by the Engineer-in-Charge.

(viii) Dry pack mortar shall consist of one part of cement to two parts of sand by volume and just enough water so that the mortar as used sticks together on being moulded into a ball by slight pressure of the hands and does not free water when so pressed but leaves the hands damp. The mortar shall be fresh when placed and any mortar that is not used within 30 minutes, after preparation shall be wasted with all consequences to the Contractor.

(ix) The mortar shall be placed in layers not more than 25 mm thickness after being compacted and each layer shall be thoroughly tamped to the satisfaction of the Engineer-in-Charge. Each layer except the last shall be roughened thoroughly to provide effective bond with the succeeding layers. The last or finishing layer shall be smoothened to form a surface continuous with the surrounding concrete. Dry pack mortar shall be used for filling behind reinforcement or for filling holes that extend completely through a concrete section. Shotcrete shall be used for holes too wide for dry pack mortar filling and too shallow for concrete filling and no deeper than the far side of the reinforcement that is nearest to the surfaces.

(x) All patches shall be bonded thoroughly to the surface of the chipped openings and shall be sound and free from shrinkage cracks and trummy areas.

(xi) Concrete surfaces where high velocity flows may occur and as required by the Engineer-in-Charge, repair to the surfaces having F3 and U3 finishes shall be bonded with an epoxy adhesive acceptable to the Engineer-in-Charge.

(xii) All repairs to the surface of concrete for flowing water shall be ground smooth to meet the tolerances set out in the specifications

7.19CONSTRUCTION JOINTS

(i) Concrete surfaces, which become so rigid, by reason of limitations in the rate of placing of concrete imposed by these specifications or by reason of delays in construction progress, that in the opinion of the Engineer-in-Charge, the new concrete cannot be integrally incorporated with that previously placed, shall be defined as construction joints.

(ii) Construction joints shall be located in the positions shown on the approved drawings or as directed by the Engineer-in-Charge and the Contractor shall not be permitted to make any additional joints or deviate from the joints indicated on the approved drawings without the written authorisation of the Engineer-in-Charge.

(iii) Joints at exposed surfaces of concrete shall be straight and continuous, as shown on the drawings or otherwise directed.

(iv) The concrete of the earlier pour shall be hacked to produce a rough surface or green cut with air-water jet or by sand blasting after the concrete has hardened sufficiently as directed by the Engineer-in-Charge. Before placing new concrete, the surface shall be restored to the condition existing immediately after hacking or green cutting by means of another washing with air-water jet, vigorous brushing, sand blasting etc.

(v) All the joints shall be cleaned by the Contractor, to the satisfaction of the Engineer-in-Charge. All intersections of construction joints with concrete faces, which will be exposed to view, shall be made straight, level and in plumb.

(vi) All exposed construction joints shall conform to the requirements of aesthetic and their pattern shall be subject to the approval of the Engineer-in-Charge. Surfaces of the construction joints, which have been permitted to dry by reasons of the succeeding layer not placed within the specified moist curing period, shall be kept moist for at least 72 hours prior to placing the succeeding layers.

(vii) Horizontal construction joints shall be arranged wherever possible to coincide with joints in the formwork.

(viii) To prevent feather edges, the construction joints at the tops of horizontal lifts near sloping exposed concrete surface shall be inclined near the exposed surface so that the angle between such inclined surface and the exposed concrete surface shall not be less than 50 degrees.

(ix) When the work has to be resumed on a surface which has hardened, such surfaces shall be roughened and new concrete placed after taking all measures mentioned in Para 9.10.3 hereof.

(x) The use of a retarder shall not relieve the Contractor of the responsibility of producing surfaces at construction joints as specified and to the satisfaction of the Engineer-in-Charge.

(xi) Disturbance of surface concrete at the joints shall be avoided during the early hardening period. Before placing the succeeding layer, the surface of the construction joint shall be thoroughly cleaned and loose, defective or fractured concrete shall be removed satisfactorily.

7.20 OTHER RELATED EXPRESS

Besides the above, following items including others shall be carried out by the Contractor:

(i) Collection of seepage water or water inflow from the surrounding work site and diverting it into the drainage systems to maintain working area dry during execution.

(j) Developing alternative sources of aggregates by the Contractor and the resulting additional material testing.

(k) Pumping of the Concrete and plasticizers.

(l) Replacement or repair of concrete damaged during blasting carried out by the Contractor.

(m) Making stockpiles for coarse and fine aggregate.

(n) Forming expansion and contraction joints including making drainage and other holes where such joints occur.

(o) Filling of holes left by the removal of concrete cores with the concrete of the same grade.

7.21MEASUREMENT AND PAYMENT

Measurement of concrete work shall be made for making progressive payments against the total contract price using the agreed item rates entered in the contract document.

8STEEL FOR REINFORCEMENT

8.1COPE OF WORK

The specifications described hereunder relate to the work which includes all labour, materials, equipment and services required for the supply, handling, storing, cutting, bending, cleaning, placing and fastening into position all reinforcing steel as shown on the drawings, to be carried out by the Contractor under this contract.

8.2 SUBMITTALS

(i) **Within 30 days** from the date of issue of the Letter of Acceptance, but before procuring the equipment or mobilisation to the site, the Contractor shall submit to the Engineer-in-Charge, the description and drawings showing the sufficient details of the layout and capacity of the equipment proposed for the fabrication of reinforcing steel.

(ii) **At least 30 days** in advance of the reinforced concrete works being carried out on the site, the Contractor shall submit to the Engineer-in-Charge for approval, detailed bar list and bending diagrams showing the number, size, length and bending of all bars required for various parts of the work on the basis of the reinforcement drawings approved by the Engineer-in-Charge from time to time during the progress of works.

(iii) The Engineer-in-Charge reserves the right to ask for any additional information deemed necessary to be included in the submitted documents.

8.3 STANDARDS

(i) The cutting, welding, placement and binding of reinforcing steel shall conform to following Indian Standards or, where not covered by these standards, to their equivalent International Standards.

IS : 456-2000
IS : 1786-1985(Reaffirmed 1990)
IS : 2502-1963(Reaffirmed 1990)
IS : 2751-1979(Reaffirmed 1992)
IS : 9417-1989

(ii) In case of conflict between the above standards and the specifications given herein, the specifications shall take precedence.

8.4 GENERAL

(i) Steel for reinforcement shall conform to the standards and requirements outlined in the **Section on "Materials for Construction".**

(ii) Cutting, bending, cleaning, placing and fastening in position of the reinforcement steel shall conform to the requirements of relevant Indian Standards and as shown on the drawings.

(iii) Transportation and storage of reinforcing steel shall conform to the requirements outlined.

8.5 FABRICATION

(i) All bars shall be cut and bent in accordance with the bar bending schedules approved by the Engineer-in-Charge.

(ii) Reinforcing steel bars shall be cut and bent on the site of the works.

(iii) Reinforcing steel shall not be straightened or rebent in a manner that will damage the materials. Bars with kinks or bends other than those indicated on the drawings and schedules shall not be used.

(iv) Shorter lengths of steel shall not be used in places where continuous lengths are required as per the drawings without the approval of the Engineer-in-Charge. Shorter bars, if approved for use, shall be lapped or spliced to achieve continuity in accordance with the requirements of relevant Indian Standards or as approved by the Engineer-in-Charge.

(v) Bars shall be bent cold to the shape and dimensions shown on the drawings using a bar bender operated by hand or power to attain the proper radii of bends.

(vi) A hook at the end of the M.S. bar, if used, shall have an inner diameter not less than four times the diameter of the bar and shall have length of straight part beyond the curve of at least four times the diameter of the bar. Hooks shall be used only where shown on drawings or as required by the Engineer-in-Charge. The radii of bends for stirrups and ties shall not be less than twice the diameter of the bar.

(vii) Heating of reinforcement bars to facilitate bending shall not be permitted.

(viii) The reinforcement available from rejected concrete shall not be used without prior approval of the Engineer-in-Charge.

8.6 PLACING

(i) Before being placed in position, the reinforcing steel shall be thoroughly cleaned of loose mill scale and rust, grease, paint, or other coatings that would reduce bond. All splashed concrete which has dried on reinforcing steel shall be removed.

(ii) Reinforcing steel to be incorporated in the works shall be placed accurately in position as shown on the drawings and shall be held firmly in place during the placing and setting of the concrete.

(iii) Reinforcing steel shall be placed such that there will be a clear distance of at least 50 mm between the reinforcing steel and anchor bolts or embedded metal work.

(iv) Reinforcing steel shall be maintained in position by the use of small concrete blocks, steel chairs, steel spacers, steel hangers and other steel supports and ties, acceptable to the Engineer-in-Charge at sufficiently close intervals so that they do not either sag between supports or be displaced during placing of concrete or by any operation on the work. Wood supports or spreaders shall not be used. All intersections shall be securely tied except that where the bar spacing is less than 300 mm in each direction, when only alternate intersection need to be tied.

(v) Binding wire and steel chairs shall not be carried to permanently exposed surfaces and shall be subject to the same requirements with regard to concrete cover as for the reinforcing steel.

(vi) Special care shall be exercised to prevent any disturbances of the reinforcement in concrete that has already been placed. The reinforcement after being placed in position shall be maintained in a clean condition until it is completely embedded in concrete.

(vii) The longitudinal bars shall be straight and fixed parallel to each other and to the sides of the form. The ties, links and stirrups connected to the bars shall be tightly fixed so that the bars are properly braced. The inside of their curved part shall be in actual contact with the bars around which they are fixed and their position shall be exact as shown on the drawings.

Wire for tying reinforcement shall be black annealed iron wire. The diameter of wire shall be adequate and shall have ultimate strength of 5.63 tonnes per sq.cm and yield point of not less than 3.87 tonnes per sqm.

(viii) Reinforcement for lining in special locations, as required, may be fixed in position by means of anchor rods or supporting and hanger rods as approved by the Engineer-in-Charge. In difficult locations, tack welding of bars at isolated spots may be permitted to keep these bars in position provided that diameter of the bars is not reduced adjacent to the weld.

(ix) The steel bars shall be joined by providing lap joints in accordance with the requirements of the relevant Indian Standards or as approved by the Engineer-in-Charge. “Bar-Grip” type joints may also be adopted by the Contractor for deformed bars of 25mm diameter and above, subject to the approval of the Engineer-in-Charge. Splices at points of maximum stress shall however, be avoided. Splices in adjacent bars shall be staggered as directed by the Engineer-in-Charge. Lap length of bars shall be as shown on the drawings. This length may be changed by the Engineer-in-Charge in special locations.

(x) Sufficient concrete coverage as indicated on the drawing shall be provided to protect reinforcement from corrosion. All protruding bars from which other bars are to be attached and which shall be exposed to action of the weather for long period shall be protected from rusting by thin coat of neat cement grout. Accurate record shall be kept at all the times of the number, sizes, lengths and weights of bars placed in position for different parts of the work.

(xi) Where reinforcement bars are bent aside at construction joints and afterwards bent back into their original positions, care shall be taken to ensure that at no time is the radius of the bend less than 4 times of bar diameter for plain mild steel or 6 times of bar diameter for deformed bars. Care shall also be taken when bending back bars to ensure that the concrete around the bar is not damaged.

8.7WELDING FOR REINFORCEMENT BARS

(i) Lap splices shall not be used for bars larger than 36 mm diameter, which may be welded with the approval of the Engineer-in-Charge. In case where welding is not practicable, lapping of bars larger than 36 mm may be permitted, in which case, additional spirals shall be provided around the lapped bars. Where welding is approved, the Contractor shall prepare at least three samples of butt welds as directed by the Engineer-in-Charge in recognised laboratory. If the results are satisfactory, the Engineer-in-Charge may allow welding in place of lap joints. The decision of the Engineer-in-Charge in this regard shall be final. The joint shall be butt welded by the electric-arc-method. The ends of the bars shall be cleaned of all loose scale, rust, grease, or other foreign materials and all welding shall conform to the relevant standard specifications for welding or reinforcement bars used in reinforced concrete construction or as directed by the Engineer-in-Charge.

(ii) A weld shall be considered unsatisfactory if it fails to sustain a tensile stress of at least 90% of the tensile strength of the bar in which the weld has been made.

8.8 TOLERANCE FOR PLACING REINFORCING STEEL

Unless otherwise required by the Engineer-in-Charge, reinforcement shall be placed within the following tolerances.

(a) For effective depth of 200mm or less $\pm$ 10mm
(b) For effective depth more than 200mm $\pm$15mm

The cover shall, in no case, be reduced by more than one-third of specified cover or 5 mm whichever is less.

8.9 Tests

The Contractor shall carry out tests

(a) for checking butt welds to replace lapping/ splicing of reinforcing bars.
(b) for to quality of steel reinforcement to be used as per Indian Standards or as directed by the Engineer-in-Charge.

8.10Measurements

Measurement of steel reinforcement placed will be made for making progressive payments against total contract price as per the item rate entered in the Contract document.

9FORMWORK

9.1 SCOPE OF WORK

(i) The specifications described hereunder relate to the Formwork. This work shall include all labour, plant and materials and services related to the design, fabrication, supply, erection, maintenance and removal of formwork and false work to be carried out by the contractor under this contract.

(ii) The formwork shall be fabricated and erected to the dimensions of finished surfaces of concrete / masonry as shown on the approved construction drawings or as otherwise directed by the Engineer-in-Charge.

9.2 SUBMITTALS

(i) **At least 30 days prior** to the construction of formwork for concrete and other works, the contractor shall submit, to the Engineer-in-Charge, the following:

a) Shop drawings, details and structural computations of the formwork construction.
b) Details of materials, which the contractor intends to use for the fabrication of formwork.

(ii) The Engineer-in-Charge reserves the right to ask for any additional information deemed necessary to be included in the submitted documents.

9.3 GENERAL

(i) Forms or formwork shall mean the mould into which concrete / masonry is placed.

(ii) False work or shoring shall mean the structural supports and bracing for forms used in any part of the works.

(iii) All exposed concrete surfaces having slopes of 1.5 : 1 or steeper shall be formed unless otherwise directed.

(iv) Where the character of the natural material cut in, to receive concrete is such that it can be trimmed to the prescribed lines, the use of forms shall not be required.

(v) In this specifications form work / false work has been indicated for concrete work, the same shall apply for other works also like masonry etc.

9.4 MATERIALS

(i) Forms shall be of timber, steel or other approved material except that the sheeting for all exposed surfaces, where form lining is not specified, shall be of tongue and groove timber of uniform width unless otherwise directed by the Engineer-in-Charge.

(ii) All materials used in formwork construction shall be of adequate strength and quality for their intended purpose and shall be satisfactory to the Engineer-in-Charge.

(iii) Timber shall be sound, straight, free from warp, decay and loose knots and shall be dressed smooth.

(iv) Where plywood is used, it shall be non-warping, non-wrinkling and manufactured with special water-proof glues. Plywood sheets shall be of uniform width and length.

(v) The surface of steel or steel lined forms shall be smooth. Forms with dents, buckled areas or other surface irregularities shall not be used.

(vi) Reuse of forms and form lumber shall be allowed only if they are cleaned and repaired and capable of producing the finish required for the concrete. Timber or plywood forms repaired with metal patches shall not be used unless permitted by the Engineer-in-Charge.

(vii) Damaged forms or forms which have been deteriorated through usage shall not be used.

(viii) Form oil used on surfaces of timber or plywood forms shall be a straight, paraffin base refined, pale, mineral oil. The oil used on the surface of steel forms shall be specially compounded petroleum oil and other oils of animal or vegetable origin and gums or resins which are heavier in body and frequently darker than straight petroleum oils shall be used in case of steel lining forms. The contractor may use any other material also for coating of the formwork with the approval of the Engineer-in-Charge.

(ix) Forms of like character shall be used for similar exposed surface in order to produce a uniform appearance.

(x) The type, size, shape, quality and strength of all materials from which forms are made shall be the sole responsibility of the contractor but subject to the approval of the Engineer-in-Charge.

(xi) In general, forms for permanently exposed surfaces shall consists of or shall be lined with matched or dressed edge grain timber of appropriate thickness, free from loose or cracked knots.

(xii) Metal forms or metal-lined forms shall be permitted for permanently exposed surfaces only when an entire surface is to be built completely with such forms.

9.5 DESIGN, FABRICATION, ERECTION AND MAINTENANCE OF FORMWORK

(i) Forms and false work shall be designed, fabricated, erected and removed in accordance with the applicable provisions of the Recommended Practice for Concrete formwork of IS:456-1978 and as specified herein.

(ii) All false work shall be designed to withstand safely all live and dead loads, necessary pressures, ramming and vibrations without significant deflection from the prescribed lines, which might be applied to the false work during all stages of construction, service and removal.

(iii) The Contractor shall be solely responsible for the design, construction and maintenance of all formwork and false work required in the work.

(iv) Detailed drawings of shoring and false work shall be prepared by the Contractor. The calculations and drawings shall show the size and specification of the false work, including the type and grade of all materials used in the construction, design loads on false work supports, horizontal forces imposed on the false work and used for design purpose and details of splices and connections including nails, spikes and other fasteners. If mechanical equipment such as concrete buggies, screening machines etc. are to be used, this information shall be shown on the drawings.

(v) False work shall be constructed only after the false work drawings have been approved by the Engineer-in-Charge.

(vi) The approval of Contractor's drawings by the Engineer-in-Charge shall not relieve the Contractor of his responsibility for the adequacy of form and false work or for the successful completion of the work.

(vii) The Contractor shall construct the false work strictly in accordance with the approved false work drawings, one set of which shall be kept on the site at all times and no changes shall be allowed without prior written acceptance of such changes by the Engineer-in-Charge.

(viii) Forms shall be designed to permit the concrete to be deposited, as nearly as is practicable, directly in its final position and to allow inspection, checking and clean up of the formwork and reinforcement to be completed without delay.

(ix) Formwork and false work shall be designed, constructed, erected and maintained such as to confine the concrete without loss of mortar and produce finished surface which are within the tolerances specified.

(x) Forms for concrete against which backfill is to be placed or which shall not be exposed to view may be constructed of smooth tight boards not less than 25 mm nominal thickness.

(xi) Forms for concrete exposed to flow of water or exposed to view shall be constructed of steel or plywood which is smooth and free from defects with matched and sanded joints to give a symmetrical pattern over the entire area. Chamfer strips (40 mm x 40 mm) shall be used on all exposed concerns, unless otherwise specified or required by the Engineer-in-Charge.

(xii) Forms ties, supports, anchors, braces, spreaders and other similar devices which shall be embedded in the concrete for holding the forms shall incorporate threaded metal bars to facilitate removal of forms. Wood spreaders shall not be left in the forms. Any metal remaining embedded in the concrete shall be at least 50 mm from the surface of concrete. Holes left in the concrete by removal of parts of form ties or similar devices

shall be well filled with cement mortar and neatly finished to match the adjacent concrete.

(xiii) Form inserts or similar permanently embedded items shall be accurately located and securely fastened in place. The number and location of form ties and bolts shall be such as to ensure that forms fit tightly against the concrete previously placed and remain in tight contact during operations.

(xiv) Forms shall be set and maintained within the specified tolerance limits such that the complete concrete surfaces are within these limits.

(xv) All form surfaces shall be thoroughly cleaned before erection and shall be lubricated with a non-staining mineral oil. All excess oil shall be wiped off the forms prior to placement of concrete. Oil shall not be allowed to come into contract with reinforcing steel or other embedded items. For use of timber forms, the oil shall be capable of penetrating the timber and keeping it sufficiently oily to eliminate sticking and preventing absorption of water and consequent warping.

(xvi) The oils shall be applied by brush, spray or swab and the forms shall be covered fully and evenly without excess or drip. Care shall be taken to prevent oil from getting in the surface of construction joints. Special care shall be taken to oil thoroughly the form strips for narrow groove seats, windows, doors and elsewhere so as to prevent swelling of the forms and consequent damage to concrete prior to the removal of forms.

(xvii) Immediately before concrete is placed, all forms shall be inspected to ensure that they are properly placed, sufficiently rigid, clean, tight and properly surface treated and free from encrustations of mortar, grout or other foreign materials. No concrete shall be placed until formwork has been inspected and accepted by the Engineer-in-Charge. Where forms of continuous surfaces are placed in successive units, the forms shall fit tightly over the surface so as to prevent leakage of mortar from the concrete and to maintain accurate alignment of the surface.

(xviii) The formwork for the gate groove areas shall be accurately drilled to be held with first stage anchor couplings/plates to be embedded in primary concrete. Both shall be fixed through formwork into the first anchor couplings/plates to ensure that the coupling/plates remain flush with primary concrete face and the coupling do not get plugged.

(xix) Where timber forms are used, the laying shall be in the direction which will blend architecturally into the lines of the structures as decided by Engineer-in-Charge.

(xx) Curved and special forms shall be such that these will result in smooth concrete surfaces. They shall be designed and constructed so that they will not warp or spring up during erection or placing concrete.

(xxi) When metal sheets are used for lining forms, the sheets shall be placed and maintained on the form with the minimum amount of wrinkles, humps or other imperfections. The use of sheet metal to cover imperfections in the lining of timber faced forms for surfaces that shall be permanently exposed to view shall not be permitted.

(xxii) Where plywood or hardboard is used for form lining, the joints between the sheets shall be smooth and as perfect as practicable and no patching of the plywood or hardboard shall be permitted for permanently exposed surfaces. Minor imperfections in the plywood may be corrected by the use of plastic wood secured firmly in place and sand papered smooth.

(xxiii) Wire ties shall be permitted for the forms when specially approved by the Engineer-in-Charge and shall be cut off flush with the surface of concrete, after the forms are removed. Wire ties shall not be used when permanently exposed finished surfaces are required.

(xxiv) Forms shall be so constructed that the finished concrete surfaces shall be of uniform texture in accordance with the type of finish specified for concrete surfaces in these specifications.

(xxv) The erection of formwork in position shall be rapid enough, rigid and strong to withstand concreting operations and maintain the alignment. Panels of similar shape shall be identical and inter-changeable.

(xxvi) For special section/shapes, timber/steel form shall be used as approved by the Engineer-in-Charge.

(xxvii) The contractor shall strengthen or modify the formwork whenever required by the Engineer-in-Charge.

(xxviii) Unless authorised, suitable mouldings shall be placed to level all exposed edges at construction joints and any other edges shown on the drawings or as required by the Engineer-in-Charge. The final detailed drawings shall show any formed recesses, slots, block outs and similar construction details which have to be taken into account in fixing the formwork.

(xxix) Forms shall be maintained, at all times, in good condition particularly as to size, shape, strength, rigidity, tightness and smoothness of surface.

(xxx) The Engineer-in-Charge will, at any time, have the right to reject formwork which he considers to be no longer fit for use.

9.6 REMOVAL OF FORMWORK

(i) Forms shall not be removed until the concrete has hardened and has attained a crushing strength of at least twice the stress which the concrete may be subjected to at the time of removal of forms.

(ii) Duration for which the forms shall remain in place shall be decided by the Engineer-in-Charge, with reference to weather condition, shape, position of the structure or structural members and the nature and magnitude of dead and live loads. The forms shall not be removed without the permission of the Engineer-in-Charge.

(iii) The following minimum intervals of time shall generally be allowed between completion of placing of concrete and removal of forms but the period shall be

increased in case of wet or cold weather and also at the option of the Engineer-in-Charge.

Structure	Period in days with normal Portland Cement
(a) Beam sides, walls, columns (unloaded)	3
(b) Slabs and arches (Props left under)	4
(c) Props to slabs and arches	10
(d) Beam soffits (Props left under)	8
(e) Props to beams	21
(f) Mass concrete	2

The above minimum periods are only recommendatory. The Contractor may where he so desires, extend the above to longer intervals. This shall not, however, constitute any reason for any claim for extension of time or damage to concrete etc.

(iv) If the Contractor desires to remove the forms earlier than the period stated above by addition of cement and/or suitable admixtures in the concrete, so as to gain early strength without affecting long term strengths, the matter shall be examined by the Engineer-in-Charge in each case and his decision in the matter shall be final and binding.

(v) Heavy live loads shall not be permitted until after the concrete has reached its design strength.

(vi) The forms shall be removed with great caution and without jarring the structure or throwing heavy forms upon the floor. In order to achieve this end, wedges and clamps shall be used whenever practicable instead of nails.

(vii) In order to avoid excessive stresses in concrete that might result from swelling of the forms, wood forms for wall opening shall be loosened as soon as this can be accomplished without damage to the concrete. Forms for the opening shall be constructed so as to facilitate such loosening.

(viii) The Contractor shall be solely responsible for any damage that may be caused by negligence, lack of proper precautions of hastiness etc. in the matter of removal of forms and shall make the same good to the satisfaction of the Engineer-in-Charge.

9.7Measurement

No separate measurement or payment will be made for any formwork used, as required, at any location of any works and the costs for this is deemed to be included in the contract price.

10 MASONRY

10.1General

10.1.1Scope

The scope of work covered in this section shall comprise all work, the supply of all labour, construction plant and materials of required in connection with the construction of miscellaneous masonry works for civil structures as shown in the Drawings approved by the Engineer-in-Charge.

It shall also include all appertaining materials and structural parts, scaffolding, transportation, loading, unloading, survey, inspection, test, quality control preparation of foundation surfaces, adjustment of surfaces adjacent to the walls, linings, pavement, etc., and all other operations required to complete the masonry work in all respects.

10.1.2 General Requirements

All materials and structural parts incorporated in the permanent work shall be new and unused. Regarding quality and dimensions they shall comply with these Specifications and approved standards.
All masonry shall be carried out in a workmanlike manner at the highest standard.
All materials to be used for masonry works shall be protected from rain and other deleterious conditions to the satisfaction of the Engineer-in-Charge.

10.1.3 Standards and Codes

All materials and testing shall comply with the standards and codes hereinafter:-

IS1129	Dressing of Stones
IS2250	Sand for Masonry Mortars
IS2116	Specification for Sand
IS3466	Specification for Portland Cement
IS3025	Specification for Water for Concrete Construction

10.1.4 Mortar for Masonry

10.1.4.1 General

The mortar for all masonry works shall consist of cement, admixture for preventing cracks, sand and water. The mortar for masonry work shall be proportioned as given in Table 12.1 . The quantity of water shall be as necessary to obtain a satisfactory workability regarding the use of the mortar.

Proportion of Cement Mortar is given in table below

Particulars	**Cement/Sand Mix Ratio Part by Volume**
Brick masonry work	1 : 4
Stone work	1 : 3

10.1.4.2 **Cement**

The cement shall be ordinary Portland cement complying with the standards specified and all handling shall be in accordance with the provisions set forth.

10.1.4.3 **Sand**

The sand for mortar shall comply with the requirements described in **Section "concrete works"**. The grading of sand shall be as per table 12.2.

Table12.2

Grading of sand

US Standard Sieve Square Mesh No.	Percentage by Weight Passing %
4	100
8	95 – 100
16	70 – 90
30	40 – 75
50	20 - 40
100	5 - 20
200	0 - 10

10.1.4.5 **Water**

Water shall comply with the requirements set forth under **Section "Concrete Works**".

10.1.4.6**Mixing, Transporting and Placing**

The mortar shall be mixed for a minimum of 2 minutes in a mechanically operated drum-type mixer or equivalent mixer approved by the Engineer-in-Charge and the mixer shall be rotated at the speed recommended by the manufacturer. The total quantity of material mixed in each batch shall not exceed the rated capacity of the mixer.

The water shall be added gradually to the mixer, partly before the loading of the dry material and partly immediately after loading. The drum shall be totally emptied before a new batching cycle is started. The drum shall be kept free from hardened mortar and shall be thoroughly cleaned prior to change of mix or on cessation of mixing.

Hand-mixing for small batches may be approved by the Engineer-in-Charge. However, the mortar shall be mixed up to the degree obtained with a mechanically operated mixer. Prior to adding water to the mix, the fine aggregate, cement and admixture shall be mixed dry in a tight box until the mixture has a uniform colour.

The equipment and tools used for transporting and for placing of mortar shall ensure that contamination or loss of ingredients do not take place.Mortar shall be stirred or worked at frequent intervals to prevent separation. All mortar shall be placed within thirty (30) minutes after the water has been added to the batch. Except for necessary tempering on the mortar board, re-tempering of mortar is not permitted.

10.2Brick work

10.2.1 General

10.2.1.1

All brick works shall be carried out in a workmanlike manner of the highest quality. The masonry shall be performed in horizontal courses true to line and plumb. The arrangement of headers and stretchers within the walls shall be such as to surely bond the masonry and, unless otherwise specified, the masonry shall consist of alternate headers and stretchers with staggered vertical joints in consecutive joints.

Wall ends shall have finished return ends. For masonry permanently exposed to view all bricks shall have sharp, undamaged edges and cutting of bricks to required lengths shall be done carefully. Bed joints shall measure between 8 mm and 15 mm, however, the thickness shall be uniform throughout. Vertical joints shall be 10 mm. All joints of walls to be plastered shall be raked out to a depth of approximately 15 mm. Joints of walls permanently exposed to view shall be raked out to 20 mm while the mortar is still fresh and subsequently neatly pointed at a form instructed by the Engineer-in-Charge.

At corners and intersections of walls the masonry shall be bonded by overlapping blocks at alternate courses. In exceptional cases, the Engineer-in-Charge may permit the use of wire ties thoroughly embedded within the bed joints and anchored in mortar-filled cells. The connection between concrete columns and masonry shall be performed by ties or anchors protruding the concrete. Immediately after completion of a wall or part thereof the wall or part shall be thoroughly cleaned and watered. The wall or part shall be kept wet for at least 3 days.

10.2.1.2 Setting-out

All walls shall be accurately set-out to the dimensions shown in the approved Drawings by suitable equipment and the deviation between the actually set out walls and their theoretical location shall not exceed the below mentioned tolerances, unless otherwise approved by the Engineer-in-Charge. For vertical dimensions of the masonry a site datum shall be fixed at a convenient position to represent the finished ground floor level of the building. The Contractor shall take care when setting-out the first course of a wall and the combination of stretchers, closers and headers shall be laid "dry" for the approval by the Engineer-in-Charge. Repeated dimension controls shall be made at short intervals on all lines, levels and plumb throughout all masonry work.

10.2.1.3 Permissible Tolerances

The dimensional tolerances of masonry in respect of alignments, length, height, thickness, unevenness, etc. shall comply with the following limits:

a. Masonry exposed to view

- all bed joints shall be horizontal and they shall not deviate from a straight, horizontal line by more than 5 mm on a length of 2.50 m;

- the wall surface shall be vertical and it shall at no location deviate by more than 4 mm from the plumb at a length of 2.50 m;

- horizontally the wall surface shall not deviate by more than 4 mm from a straight line on a distance of 2.50 m;

- the deviation of any dimension from the design dimension of walls, openings, recesses, piers, etc., shall not exceed the following values:

Respective Dimension	Maximum Deviation
<1.00 m	4 mm
1.00 m - <2.50 m	5 mm
2.50 m - <10.00 m	8 mm
10.00 m	10 mm

- no abrupt irregularities will be permitted.

b. Masonry to be plastered

- the wall surface shall be vertical and it shall nowhere deviate by more than 6 mm from the plumb at a length of 2.50 m;

- horizontally the wall surface shall not deviate by more than 6 mm from a straight line on a distance of 2.50 m.

- the deviation of any dimension from the design dimension of walls, openings, recesses, piers, etc., shall not exceed the following values:

Respective Dimension	Maximum Deviation
<1.00 m	6 mm
1.00 m - <2.50 m	7 mm
2.50 m - <10.00 m	10 mm
10.00 m	12 mm

- abrupt irregularities shall not exceed 3 mm.

All masonry exceeding the above stated tolerances shall be corrected or replaced by the

Contractor.

10.3 Stone Masonry

For the purpose of stone masonry, the Contractor shall stockpile sufficient amount of suitable stones from the rock excavation or from approved quarries.

Stockpiled stone shall be left in air for seasoning preferably for a period of one month prior to placement or as instructed by the Engineer-in-Charge. The moisture of stones shall be kept uniform.

Stone masonry wall shall be of Random Rubble type. Dressing of stone shall conform to IS 1229.

Stonewall shall be sufficiently wetted before laying, to prevent absorption of water from mortar. The bed which is to be received the stone shall be cleaned, wetted and fully covered with mortar. All stones shall be laid in full in wetted surface both in bed and vertical faces and carefully settled in place immediately on placement. Clean Chips and Spalls may be wedged into mortar to avoid thick beds or joints. No dry or hollow space shall be left anywhere in the masonry and stones shall have all its embedded faces completely covered with mortar.

Masonry shall be laid in courses, generally of the same height, where there is a variation in the heights of the courses, longer courses shall be placed at lower levels, with course heights decreasing towards top. Pressure relief sleeves or orifices shall be left in masonry walls as shown on the Drawings or as instructed by the Engineer-in-Charge.

All exposed faces of masonry wall shall be cleared of mortars dropping.

10.3.1 Tests and Properties

All materials applied in masonry work shall comply with the relevant standards regarding quality, dimensions, strength, etc. The Engineer-in-Charge may instruct the Contractor to carry out suitability tests on the material proposed to be applied in the Works as well as to perform quality control tests during the progress of the work as described in the relevant standards.

10.4 Measurement and Payment

Measurement and payment for brick/stone masonry shall be made on the basis of the respective volume in cubic meters of masonry including bonding mortar constructed in accordance with the approved Drawings and Specification for the purpose of making progressive payments on the basis of unit rates entered in the contract against total price of the relevant items.

11 DEWATERING AND DRAINAGE

11.1 SCOPE OF WORKS

i. The specifications described hereunder relate to the works of dewatering and drainage to be carried out by the Contractor, which shall include supply of all labour, construction plant and material and performance of all services required to remove sludge/ muddy water, service water and natural surface flow or ground water seepage from the Work areas for the construction of various structures covered under the contract.

ii. The works shall be executed in accordance with the Contractor's designs, specifications and sequences as approved by the Engineer-in-Charge.

11.2 SUBMITTALS

(i) **Within 30 days** after the date of issue of the Letter of Acceptance, the Contractor shall submit, to the Engineer-in-Charge, the detailed design of dewatering system.

(ii) This design shall be consistent with the outline description submitted by the Contractor with his bid and shall include the following :

a) Design assumptions and calculations
b) Layouts of drainage / dewatering facilities

(iii) The Engineer-in-Charge reserves the right to require any additional information deemed necessary to be included in the submitted documents.

11.3 GENERAL

The pumped water carried in pipes or channels shall be discharged at point sufficiently away from the edge of foundation excavation as directed by the Engineer-in-Charge. Care shall be taken to ensure that there is no seepage and flow of water back to the pit of the working areas.

11.4 DEWATERING OF SURFACE WATER AT CONSTRUCTION SITES

11.4.1 General

(i) The Contractor shall perform all works necessary to drain out the surface water which happen to be accumulated at work site due to rain, ground water and / or service water. The works shall include, but not be limited to the following :

a) Design and construction of drainage, ditches, pits and pump sumps
b) Design, furnishing, operation and maintenance of dewatering equipment
c) Relocation of dewatering facilities required for the performance of other works, if any.
d) All auxiliary works required for safe and continuous dewatering of the construction sites.

(ii) river/stream Dewatering of construction sites located near a river/stream shall be done upto the existing water level in the river/stream by gravity or otherwise as directed by the Engineer-in-Charge. Suitable drainage shall be made joining the course downstream of the construction site to provide required gradient to facilitate proper and efficient dewatering. Below the water level of the stream, dewatering shall be done by pumping water collected in the sumps and discharging the same into course of the downstream of the construction site.

11.4.2 Requirements and Design

(i) The Contractor shall design and install complete facilities at the surface construction sites.

(ii) The surface water dewatering systems shall be designed to accommodate, without undue disruption to the works, any rainfall event and taking into account the extent of the sites to be dewatered and the dewatering arrangements proposed.

(iii) Claims for extension of time due to delays caused by unfavourable weather conditions will not be considered.

(iv) The Contractor shall provide adequate pumps of suitable capacity, including standby units, to handle all water entering into any of surface construction sites. In addition, he shall provide sumps and pumps and or well points in the immediate vicinity of the structure foundations using such water conductors as are necessary to conduct the water away from the work site as per the requirement of works to be executed in an manner so that such operation shall be kept free from standing or running water.

(v) Power for operating the dewatering system shall be arranged by the Contractor. The Contractor shall make his own arrangements for sufficient standby power at his cost to carry on the works during any interruption of power. The standby power supply shall undergo weekly trial runs lasting at least 30 minutes.

(vi) The Contractor shall ensure that all dewatered / drainage water is disposed off without causing interference on the site and that no drainage water runs into adjacent works.

(vii) The dewatering systems shall be designed and installed in such a way that modifications and extensions to the systems are possible while they are in full operation.

(viii) All the components of the dewatering systems shall be installed and operated in accordance with the approved method and the construction time schedule or approved modification thereof.

(ix) The approval by the Engineer-in-Charge of the dewatering system shall not relieve the Contractor from being fully responsible for the design, construction, operation, maintenance, safety and removal of the facilities provided for the dewatering system and he shall be liable for any damage or delays caused by its failure.

11.4.3 Materials and Execution

(i) Drainage ditches shall be excavated along the top of excavated slopes. Such ditches shall be kept well back from excavation edges in order to prevent saturating the upper

part of the slopes. The ditches shall be regularly cleaned out of all accumulated silt and other matter so that water may flow freely at all times.

(ii) Where excavation is to be made below the ground water table, the Contractor shall lower the water table sufficiently below any working surface by means of properly screened wells and/or ditches to ensure that the foundation surface remain free of standing water and undamaged by the passage of construction traffic. All ditches shall be outside the foundation areas. The water shall be collected and removed by pumping, if no outflow by gravity is possible.

(iii) Where concrete / masonry is to be placed, the water table shall be maintained below the lowest part of the finished excavation for minimum of one day following the raising of structure above the natural ground water table and for such additional time as may be necessary to preclude damages to structure foundation.

(iv) In trenches and foundations, the dewatering shall at all times enable to carry out the excavation works in dry.

(v) Upon completion of dewatering, temporary pipes and pump sumps beneath permanent structures shall be closed off and completely filled with grout, mortar or concrete as directed by the Engineer-in-Charge.

11.5 MEASUREMENT AND PAYMENT

No measurement for payment against dewatering and drainage would be recorded as the cost for the same are deemed to be included in the contract price.

12 METAL WORK

12.1 GENERAL

12.1.1 Scope

The work to be performed under this section consists of furnishing and installing the various metal works as necessary in the execution of structures including all the auxiliary works in all structures of the Work as shown on the approved drawings or as directed by the Engineer-in-Charge.

12.1.2 Submissions

At least thirty (30) days prior to commencing the work, the Contractor shall submit to the Engineer-in-Charge the following documents for his approval.

- Detailed shop and construction drawings which shall include complete details, sections and plans of all parts, assemblies, components, connections and supports, and connections to the work of other items.

- Detailed structural analysis of the proposed metal structures, if required.

- Test certificates proving the physical properties stipulated in the Specifications.

Before purchase, samples of all materials proposed for incorporation in the works shall be submitted for approval to the Engineer-in-Charge, as and when required.

12.1.3 Standards and Codes

Unless otherwise specified the materials to be used for the works shall conform to the Indian standards or equivalent International standards with regard to quality, properties and workmanship.

The Contractor shall inform the Engineer-in-Charge of the standards he follows if no particular ones are specified hereinafter. In case the Contractor wishes to follow any other standards and codes, he shall submit sufficient copies of the same to be applied in English to the Engineer-in-Charge for his approval.

12.2 MATERIALS

All materials and structural components to be supplied, erected or installed and, therefore, ultimately incorporated in the structure shall be new and unused. They shall be suitable for their intended purpose and appropriately match each other.

Unless otherwise specified, all materials of metal work shall conform to applicable BIS Codes or the following requirements or equivalent:

- Structural steel : ASTM A6/A6M, A36
- Steel tube and pipe : ASTM A53, A500, A501
- Welding : AWS A5.1, A5.17

In the drawings and the specifications, the size of steel pipes and shaped steel are indicated in the metric system as a rule. The Contractor will be permitted to use those of inch size which are approximately same or more in size as those indicated on the drawings or the specifications.

12.3 Execution

12.3.1 General

(1) Fabrication and Installation

All works shall be executed by skilled workers in a workmanlike manner.

All members shall be cut in such a manner as not to cause deformation or distortion. Irregularity of cut surface shall be properly finished by planer.

The work shall be shop fitted and shop assembled where possible, and shall conform to the details on approved shop drawings to be provided by the Contractor.

Welding shall be made by arc welding unless otherwise directed by the Engineer-in-Charge.

Where necessary, metals shall be insulated to prevent electrolysis due to contact

between dissimilar metals and to prevent corrosion due to contact between metals and masonry or concrete. Insulation shall be by means of bituminous paint or other approved means.

All fastenings, anchors and accessories required for fabrication and erection of the work under this section shall be provided by the Contractor. Exposed fastenings shall be kept to an absolute minimum, evenly spaced and neatly set out. Wood plugs shall not be permitted.

Metal work to be embedded in concrete shall be set and fixed in position as shown on the drawings or as directed by the Engineer-in-Charge before placing concrete. If blockouts will be arranged at the locations where embedded parts are set in concrete as shown on the drawings or directed by the Engineer-in-Charge, the metal work shall be fixed in place by the second stage concrete.

The bond surfaces between the first and the second stage concrete shall be roughened. The cross-section dimensions of the second stage concrete and the locations of embedded anchor bolts shall be as shown on the drawings or as directed by the Engineer-in-Charge.

Where it is impracticable to place anchors or anchor bolts when the concrete is placed, holes will be drilled in the hardened concrete 28 days after placing concrete. And expansion bolts, adhesive anchor bolts or other approved anchors will be installed and fixed in place, and then grouted or backfilled with mortar.

(2) Painting and Galvanizing

All components of the metal works shall either be painted or galvanized against corrosion prior to assembly and/or erection. Any preliminary treatment against corrosion shall ensure a basic protection remain effective for at least six months.

All steel surface except galvanized surface and embedded parts in concrete shall be painted. Rust-resistant paint shall be applied in two coats and finishing paint shall be applied in two coats. The quality of paint and the painting works shall be performed in accordance with the provisions in the Specification. The color of paint shall be approved by the Engineer-in-Charge.

Components to be installed to the exterior shall in any case be hot dip galvanized. Galvanizing of steel shall be in accordance with ASTM A123 A153 and A386 or equivalent and the zinc coating shall be not less than 610 g/m.

(3) Auxiliary Works

The following auxiliary works and services shall be deemed to be included in the metal works.

- transport, storing and protection of all structural components on site;

- protection of the executed works from detrimental influences, theft and damages until the time of handover;

- supply of consumable stores;

- removal and making good of all contaminations (building rubbish, refuse and the like) arising from and in connection with the Contractor's works;

12.3.2 Steel Cover

Steel covers shall be installed at openings designated on the approved Drawings or as directed by the Engineer-in-Charge.

Steel covers shall be of steel plate or chequered steel plate, with lifting devices as shown on the drawings or as approved by the Engineer-in-Charge.

Frames shall be composed of shaped steel sections, angles, etc. and shall be anchored to concrete as approved by the Engineer-in-Charge. The frame shall be adjusted during installation to provide an accurate fit with the cover.

In order to ease removal and setting, all covers shall be tapered along the perimeter towards the bottom. The maximum clearance between hatch cover and outer frame shall be 5 mm around at finished floor level.

The corrosion protection shall be generally achieved by painting.

12.3.3 Steel Grating

The steel gratings will serve as covers for gutters, sump and trench, and as tread for step ladder etc.

The steel gratings are normally of a rectangular shape. Some are to be provided with openings for the passage of pipes or ducts as directed by the Engineer-in-Charge or shown on the drawings.

Sizes of steel gratings shall be such as to afford easy handling.

Minimum support width shall be the height of the grating and not less than 30 mm.

The bearing frames of steel angles or channels shall be anchored to the concrete with steel bolts or straps as shown on the drawings or as directed by the Engineer-in-Charge.

Before installation the frame shall be adjusted to allow the steel grating to have a continuous support by the frame.

Before ordering the gratings, the Contractor shall check all relevant locations, dimensions and shapes of the openings.

Steel gratings and frames shall be galvanized. Damaged finishing shall be repaired on site as specified by the manufacturer and to the approval of the Engineer-in-Charge.

12.3.4 Ladder

The Contractor shall supply and install step ladders and steel ladders to the numbers and dimensions as required. Ladders shall be installed where shown in the drawings or

where directed by the Engineer-in-Charge. The details of the ladders are referred to the approved drawings or as directed by the Engineer-in-Charge.

Step ladders shall be securely fastened at top and bottom to the wall and shall have intermediate clips and plates be riveted or welded to the side.

All steel members shall be galvanized. All bolts for fastening the ladder to the concrete wall shall be of stainless steel. Where splices are required, bolted connections have to be used.

12.3.5 Steel Stair and Cat Walk

The Contractor shall prepare his own design of steel stairs and cat walks in accordance with the layout and details shown in the approved drawings or as directed by the Engineer-in-Charge.

All landings, stairs and cat walks shall be made of standard steel sections of angle, channel and I-beam shape.

Components or portions thereof shall be pre-assembled with field points designed such as to allow fast and easy erection on site.

Treads of stairs and landings shall be of galvanized steel grating, which have slipless nosing.

The catwalk shall be covered by steel checkered plate.

All outdoor metal parts shall be hot-dip galvanized after manufacture but prior to assembly and no tooling on these parts will be permitted after galvanization.

Of indoor sections only the steel gratings and the chains of railings shall be galvanized; the entire supporting steel structure and railings shall be painted.

12.3.6 Entrance Gate

The Contractor shall design, manufacture, supply and install the entrance gates at the structures to prevent unauthorized persons from entering to the relevant structures as shown in the approved construction drawings or as directed by the Engineer-in-Charge. The gate shall be of a rigid construction. The materials shall be of hot dip galvanized steel sections unless otherwise specified.

12.3.7 Steel Handrail

The Contractor shall position the steel handrails in places as shown on the approved construction drawings or as directed by the Engineer-in-Charge. The Contractor shall be responsible for furnishing of materials, fabrication and installation of the handrails.

Steel handrails shall be fabricated and installed in the places as shown on the drawings. Steel handrails shall be properly anchored to the structures. In general blockouts shall be provided whenever possible and the blockout shall be filled with the concrete after installation.

All parts shall be rust proof painted after manufacturing but prior to installation.

12.3.8Frame for Opening and Cover

a. Frame for opening

Steel angle, z-and/or channel profiles shall be provided for all openings in the size and shape indicated in the approved drawings. These frames shall be embedded in the concrete and attached to the concrete by anchors securely welded to each side of the frame. Anchors may be replaced by anchor plates and stud bolts whenever possible and where shown in the drawings and/or instructed by the Engineer-in-Charge.

All corners of the frames shall be mitered. The surfaces of the frames shall be flush with the concrete surface and the supporting parts, if any, shall be aligned in a way to prevent riding of the covers.

b. Frame for Cover

Concrete covers such as concrete hatch cover and concrete trench cover shall be provided with steel frames as shown in the approved Drawings and/or directed by the Engineer-in-Charge. In general these frames shall be formed by channel profiles, however, the lateral vertical surface shall be slightly inclined to ease lifting of the covers.

All corners of the frame shall be mitered and continuously flush- welded. All welding seams shall be ground smooth. For the connection between the frame and the cover concrete anchors or steel bars shall be welded to the frames.

The frames shall be provided with lifting rings or other arrangements to allow lifting of the covers.

12.3.9 Other Metal Works

Any other metal shall be furnished and installed as shown on the approved drawings or as directed or approved by the Engineer-in-Charge.

12.4Measurement and Payment

Measurement and payment for metal works shall be made on the basis of the respective items in accordance with the approved Drawings and Specification for the purpose of making progressive payments on the basis of unit rates entered in the contract against total price of the relevant items.

13 STRUCTURAL STEEL

13.1 GENERAL

13.1.1 Scope of Works

This chapter shall include all work in connection with anchor bolts, structural steel works for approach bridge and other miscellaneous works the steel frame of Pumphouse etc., as shown in the approved drawings and as specified hereafter.

The work shall consist of preparation of shop drawings, supply of all materials, fabrication, transportation, storage, erection, painting, inspection, quality control including survey, loading and unloading, protection from damages and other auxiliary works as required.

13.1.2Submission

The following documents shall be submitted to the Engineer-in-Charge for approval.

(1) Schedule

The Contractor shall **submit a work schedule indicating time schedule** of all works including shop fabrication, transportation, field fabrication, erection at the site and other necessary items related to the work.

(2)Detail Design, Calculation and Shop Drawing

The Contractor shall submit complete shop drawings supported by structural computations, of all structural steel work showing sizes, type and grade of metal, method of assembly, hardware and anchorage or connection with the main structures at least one month before beginning the manufacture of the various items.

Full account shall be made in the design for all temporary loads and stresses which may occur during fabrication, assembly, transportation or erection.

(3)Erection Procedure

The Contractor **shall submit drawings or documents explaining** erection procedure including the temporary bracing method and installation equipment or machinery, at least one month before beginning the erection.

(4)List of Materials

Prior to the procurement of materials, the Contractor shall submit list of materials to be used. The name, official address and brochures showing manufacturing facilities of the manufacturer of materials shall be attached with the list.

(5)Mill Sheet and Certificates of Materials

Mill sheets or certificates of materials which are based on the tests performed in the steel maker or an approved independent laboratory shall be submitted to the Engineer-in-Charge.

13.1.3Standards and Codes

All design, material, execution of work shall comply with the applicable Indian standards and codes or where not covered by these standards to the equivalent International Standards.

13.2 MATERIAL

Except as otherwise specified, all material furnished by the Contractor under this section shall be new, free from defects and imperfections and conform to the BIS or equivalent International Standards.

13.3EXECUTION

13.3.1 Shop Fabrication

(1) Measuring Tape

Measuring tapes for shop fabrication and for erection at site shall be of steel, and deviation of each other shall be measured and informed to the Engineer-in-Charge for approval.

(2) Marking-Off on Material

The positions of bolt hole and shape, dimensions of plate shall be accurately marked on base metal using full size templets.

(3) Cutting and Forming

In cutting base metal, automatic flame-cut method shall be employed. Base metal shall be accurately cut at right angle to the axis and true to marked line and well-formed to size and shape as marked on. Roughness, burrs or any other irregularity of all edges shall be removed using a grinder or a planer.

(4) Bending

Except where inevitable, bending of structural steel shall be done cold. In case that it is necessary to employ a heating process, bending of steel shall be done while the steel is red hot with the approval of the Engineer-in-Charge.

(5) Bolt Hole

Holes shall be drilled with a bit at right angles to the surfaces, and shall not be made or enlarged by burning holes. All bolt holes shall be clean-cut without any burrs or ragged-edges resulting from drilling.

Diameters of holes provided for insertion of bolts shall be as follows:

D	Diameter of bolt hole
More than 20 mm	D + 1.5 mm
Not more than 20 mm	D + 1.0 mm

D: Nominal diameter of bolt

When loose bolt holes are employed, the shape of loose bolt holes shall be shown on the approved drawings.

(6) Welding

a. Welder

Welding shall be executed only by professional welders who are skillful with welding with all position and experienced in welding of structural steel more than 6 months and approved by the Engineer-in-Charge.

b. Edge preparation and assembling

Edge to be welded shall be made into shape in accordance with the approved edge preparation plan, and shall be free from loose scale, slag, grease, paint or other objectionable materials.

Materials to be welded shall be held firmly by an adequate method so as not to move during the welding works. Tack welding shall be performed in such a manner as to minimize residual internal stress. The Contractor shall take other proper means to prevent strain or residual internal stress from welding.

c. Handling of welding rod

The welding rod shall be stored in their original packing in a dry place, with appropriate protection against the weather. If the welding rod which seem to have suffered the effects of moisture but do not have any other damage can only be used when they have been dried in satisfactory manner.

Welding rod which have areas where the flux covering is broken or damaged shall be rejected.

(7) Permissible Variation

Permissible variation in dimensions of the steel members fabricated at the manufacturer shall be in accordance with the relevant standards stipulated before.

(8) Shop Painting

a.Base preparation and treatment

After the completion of fabrication at shop all of the surface to be painted shall be cleaned of all rust, dirt, oil, slag, scale and any other foreign substance. Cleaning of the surface shall be executed with sandblasting or shotblasting and immediately thereafter

wash-primer shall be applied to the surface.

b.Rust-resistant painting

Rust-resistant paint shall be applied in two coats prior to the shipment.

c.Contacting faces for friction grip joint

Contacting faces for friction grip joint of high strength bolt shall be cleaned with sand blasting or shot blasting. Wash-primer, or rust-resistant paint shall not be applied on those faces.

13.3.2 Transportation

The Contractor shall be responsible for all necessary notifications to the concerned office or Authority concerning to the transportation of the member and parts of structural steel. They shall be transported carefully to the site in such a manner as to prevent deformation, corrosion, or other damages.

If necessary, adequate reinforcements, bracing, stiffeners or other means shall be provided.

13.3.3 Storage

The member and parts of structural steel shall be stored under proper covers and placed on supports, so that they are not in contact with the ground or with substances which may cause oxidation and deterioration.

13.3.4Erection

(1)General

The erection work shall be executed in such a manner that the steel structure do not suffer permanent deformation, and are not subject to stress greater than those considered in the design.

During the erection work the Contractor shall adopt all measures which are necessary to prevent injuries to persons and damage to the neighboring works.

(2)Installation of Anchor Bolts

Anchor bolts shall be installed accurately to meet the positions shown on the approved drawings and the positions of anchor bolts shall be inspected before placing of concrete. When placing concrete, care shall be taken so as not to move the position of anchor bolts.

(3)Friction Grip Joint

a.Length of high strength bolt

Standard length of stem shall be obtained by adding respective length tabulated below to

the grip thickness.

D (mm)	L (mm)
16	30
20	35
22	40
24	45

Where,
D:Nominal diameter of bolt
L:Length to be added to grip thickness

The bolt set shall be stored in their original packing, and care shall be taken so that materials would be free from dirt, damage and corrosion.

b.Treatment of contacting surfaces

The surfaces to become in contact with surface of another steel plate in friction grip joint shall be free from paint, oil and other defects that would decrease friction force.

c.Tightening

Temporary tightening shall be performed using bolts not less than one third (1/3) of the total number of bolts in each completed joint but never less than two. Bolts for temporary tightening shall be distributed uniformly about the joint.

Tightening shall be done using either the impact wrench method or the "turn-off-nut" method in accordance with the instruction of the bolt manufacturer. The work shall be done by competent and experienced bolting crews.

70 percent of design bolt tension shall be given to the bolts at preliminary tightening and then 100 percent of design bolt tension shall be given to the bolt finally. Excessive tightening of the bolts shall not be permitted.

d.Calibration of impact wrench

If the bolts are tightened by impact wrench method, each impact wrench shall be calibrated prior to the commencement of the work each in the morning and the afternoon.

The impact wrenches shall be equipped with torque indicating scale or calibrating means so that the torque can be measured clearly.

(4) Erection

All steel members shall be installed accurately to meet the positions and level shown on the approved drawings and the positions and level shall be inspected before permanent fixing.

During the erection works, the steel structure shall be ensured sufficiently to withstand all loads such as its own weight, live loads, wind loads and erection loads. All

temporary bracing, guys and bolts necessary to ensure safety of the structure shall be provided.

(5)Permissible Variation

Permissible variation shall be in accordance with the relevant Indian standards.

13.3.5 Field Retouch Painting

After installation, all damaged shop coated areas and all bolting, welded and other surfaces left un-painted with rust-resistant paint shall be cleaned of all rust, dirt and any other foreign substances and shall be painted with rust-resistant paint.

13.3.6 Inspection

(1)General

All materials supplied and all work performed shall be subject to inspection by the Engineer-in-Charge at the place of manufacture, fabrication and/or erection. Unless inspection is waived by the Engineer-in-Charge, no material shall be shipped until after such inspection and acceptance of the material has been performed.

Where directed by the Engineer-in-Charge, certified mill or shop-test reports shall be furnished in lieu of inspection at the mill. Acceptance of material or waiving of inspection thereof shall in no way relieve the Contractor of the responsibility of furnishing the materials and workmanship conforming with the Specifications in all respects.

The Contractor shall submit the records of tests stating the name of test, time and place, results and name of inspector.

The judgement of results of test and inspections shall be made according to the applicable provisions of the standards stipulated before.

Tests or inspections may be waived with the approval of the Engineer-in-Charge in case mill sheets or certificates or other appropriate evidences are submitted by the Contractor.

(2)Material Test

Quality of the principal materials to be used, such as rolled steels, bolt and nuts, electrodes shall be tested.

(3) Qualification Test for Welding Operators, Welders and Welding Procedures:

Shall be performed in accordance with the applicable standards.

(4)Inspection of Edge Preparation

Shall be performed in accordance with the approved plan of edge preparation.

(5)Appearance and Measurement Inspection

The appearance inspection shall be made on welded joints, bolts holes to be bolted in the field, coated surfaces and on other items for defects.

(6)Inspection of Welded Joint

Welded joint shall be inspected by means of radiographic (X-ray) method and/or ultrasonic method.

The rate of spot inspection shall be not less than 10% of the total welded length.

13.3.7 Quality Control

The Engineer-in-Charge reserves the right to ask for independent analysis and tests on the materials by an analyst or testing laboratory selected by him, in order to check the works, analysis and tests. For this purpose the Engineer-in-Charge may take samples for analysis and have pieces cut out side by side with pieces subjected to test in the workshops. Should the comparison of the result of any independent analysis or test be unsatisfactory, the materials represented will be rejected. All incidental cost for the above shall be borne by the Contractor.

13.3.8 Auxiliary Work

Mortar grouting at the base plate, installation of embedded steel parts in concrete structure shall be included in the work. Shuttering needed for these works shall also be included in the work.

13.4MEASUREMENT

Measurement of structural steel shall be based on weight by metric ton. All materials including bolts, deck plates and other steel parts shall be measured. Measurements will be made for making the progressive payments against the total contract price for the work, on the basis of rates entered in the schedule of works

14FINISHING AND MISCLLENEOUS ITEMS

14.1 SCOPE OF WORK

This section covers specifications for miscellaneous item like providing and fixing aluminum windows/doors with glazing, rolling shutters, terrazzo tiles, vinyl asbestos tiles, improved flooring, CC flooring, M.S. grating, steel work in single section in cable duct, RCC jali, W.C. Pan, wash basin, urinal unit and aluminum pipe railings, joints and water proofing treatment in intake and pump house building, pipes, installation of embedded parts, shotcreting, brickwork, coursed rubble masonry, sausage wall, approach road, and drainage arrangement etc. The work shall include all labours, materials, equipment tools and tackles etc. required for completion of the works.

14.1.1 Application Publications

All methods and procedures shall conform to Indian Standard Specification some of which are listed below :

IS:816	**Welding**
IS:1038	Specification for steel doors and windows
IS:1081	Glazing
IS :1239	Mild steel tubes
IS:1761	Glazing
IS:3548	Glazing
IS:4351	Door Frames
IS:269	Portland Cement
IS:800	Structural Steel
IS:814	Welding Electrodes
IS:2556 (Part. II)	Water Closet
IS:2556 (Part. IV)	Wash Basin
IS:2556 (Part. VI)	Urinals
IS:774	Flushing System for W.C.
IS:781	Copper alloy bib taps
IS:775	Cast iron brackets
IS:1948	Specification for aluminum doors windows and ventilation
IS:1949	Aluminum Windows for industries building

14.2 ALUMINIUM DOORS, WINDOWS AND VENTILATORS

14.2.1General

The contractor shall submit shop drawings details of various parts, methods of anchoring and any other pertinent details for the approval of the Engineer-in-charge. Before placing orders the contractor shall submit sample of hardware to the Engineer-in-charge for approval.

14.2.2 Materials

a) Aluminum alloy used in the manufacture of extruded window sections shall correspond to IS designations HEO 9-WP of latest edition of IS : 733. Hollow aluminum alloy sections used shall conform to IS Designation HV9-WP of latest edition of IS : 1285. Dimensions and weight per metre run of the extruded sections shall conform to latest edition of IS : 1948 and IS : 1949.

b) Coupling sections – Aluminum alloy coupling sections used shall conform to IS Designation HV9-WP of latest edition of IS : 1285.

c) Glass panes – Glass panes shall weigh atleast 7.5 kg/cm^2 and shall be free from flaws, specks or buggles. All panes shall have properly squared corners and straight edges. The sizes of glass shall conform latest edition of IS : 1948.

d) Screw threads of machine screws used in the manufacture of aluminium doors and windows and ventilators shall conform to the requirements of latest edition of IS : 1362.

e) The metal thickness shall not be less than 1.6 mm for frame and 2.3mm for threshold.

14.2.3 Fabrication

Frames shall be square and flat, the corner of the frame being fabricated to a true right angle. Both the fixed and opening frames shall be constructed of sections which have been cut to length, metred and welded at the corners. Where hollow sections are used with welded joints, argon arc welding or flash butt welding shall be employed (gas welding or brazing not to be done). Subdividing bars of units shall be tenoned are riveted into the frame.All fabrication shall conform to latest edition of IS 1948, 1949 and other relevant IS wherever available. Generally side hung shutters shall be used for door and windows.

Top-hung shutters shall be used for ventilators. And Central hung shutters shall be used for doors also. For fixing aluminum alloy hinges, slot shall be cut in the fixed frame and the hinges inserted inside and may be riveted to the frame. Cast or extruded aluminum alloy hinges for doors shall conform to latest edition of IS :1949, IS :617 and IS :733. The hinge shall be of projecting type. Non projecting type of hinges may also be used. The handle for doors and windows shall conform to latest edition of IS 617 and other relevant Indian Standards wherever applicable. Suitable lock for door operable either from inside or outside shall be provided. Any steel lugs coming in contact with aluminum should be either galvanized or given one coat of bituminous paint.

14.2.4 Finish

Aluminum doors, windows and ventilators shall be supplied & be anodized. Colour anodizing to be done using approved light fast shades.
A thick layer of clear transparent lacquer based on methacrylates shall be applied to protect the surface from wet cement during installation and after installation the lacquer coating shall be removed.

14.2.5 Glazing

Glazing shall be provided on the outside of the frames.

14.2.6 Hardware

Hardware for the Aluminum doors, windows and ventilators shall comply with the requirements specified on the drawings. The contractor shall submit catalogues and samples to the Engineer-in-charge for approval prior to supplying hardware. The hardware shall comply with the following requirement :

Hinges	Conforming to latest edition of IS :1948, IS :617, IS :753, IS :1949.
Knobs	Aluminum approved quality.
Lock sets	Aluminum cylinder lock of approved make.
Flush bolts	Wall or floor mounted type with rubber bumper and holder.
Door stops	Wall or floor mounted type with rubber bumper and holder
Door closers	As per relevant IS code
Hand plates	Aluminum approved make as per IS code
Hand Balls	Aluminum approved make as per IS code

The contractor shall supply three keys for each lock fitted.

14.2.7 Glazing

14.2.7.1 Materials

Glass for glazing of windows and doors shall be sound free from specks, waves and flows and shall be conforming to latest edition of IS : 1761, IS : 1081 and IS : 3548.

14.2.7.2 Execution

Glass shall be accurately cut to size to suit the dimension of openings. Glazing to Aluminum doors, windows and ventilators shall be carried out by means as described in IS code wherever available. Glass shall be cleaned and polished on completion of building works.

14.3 STEEL ROLLING SHUTTER DOOR

Steel Rolling Shutter doors capable of both electric and manual operation shall be installed at the location shown in the approved drawings and in accordance to the relevant IS Specifications. All steel plate and angles, welding and bolting shall conform to the specifications provided in section-7. The doors shall be composed of a shutter, guide rails, rolling drum and cover case, with a motor control gear, safety switch, wiring and all other accessories.

The various components shall be as follows :

Guide rails: 2.3 mm thick roll-formed steel plates, depth 75 mm, with safety stop at a height 2.2 mm above the floor.

Cover Case: 1.6 mm thick steel plate with adequate reinforcement and inspection hole.

Motor : Electric Source A.C. 230 Volt, 3 Phase 50 Hz. Operation speed 3 to 5 m/min. Motor to be installed in the cover case, operation box to be installed in the side wall at adequate height and provided with both electric and manual operation devices with all necessary accessories including hand plate and hand bar of stainless steel. The manual operation device shall be suitably geared to allow operation by one man.

14.3.2 Measurement

Measurement for providing, fabricating and fixing for Aluminum windows, doors with glazing and steel rolling shutters shall be measured on the basic of square metre.

14.4 FINISHES FOR WALLS, CEILING AND FLOORS

14.4.1Cement Plaster

The walls and the ceilings of the intake structure and the pumphouse shall be finished smooth with cement plaster as specified below:

	Particulars	Thickness of plaster	Proportion
1.	Wall	15 mm	1 cement : 4 sand
2.	Ceiling	6 mm	1 cement : 3 sand

14.4.2 Materials

i. Cement mortar shall consist of cement and sand and shall conform to the following.

1. Cement shall be ordinary Portland cement type in accordance with latest editions of IS : 269. The supply, use, storage and testing of cement shall be in accordance with IS specification.

2. Sand shall be clean, hard and durable, of proper grading and free from dirt, organic or deleterious materials.

The grading of the sand shall be within the following limits:

Classification	Screen Designation	Percentage by weight Passing screen
Rendering Coat	5 mm	100%
	0.15 mm	10% or under
Finishing Coat	2.5 mm	100%
	0.15 mm	10% or under

ii. The quality of the mortar. If required by the Engineer-in-charge water shall be tested Water used in the mixing of mortar shall be fresh, clean water suitable for drinking. Water shall not contain salt, oil, alkali, organic matter or other deleterious substances which would impair.

iii. Waterproofing and colored admixture shall be used in the cement mortar in strict accordance with the manufacturers printed instructions.

iv. The mix proportions of the cement mortar shall be as specified in the bill of quantity of this work. Water proofing compound @ 5% by weight of cement (maximum) shall be used in strict direction of the Engineer-in-charge.

Rate of respective items of work shall include cost of admixture etc.

v. The pigment of the coloured cement mortar shall be of good quality and approved by the Engineer-in-charge. It shall be used in accordance with the manufacturer's instructions.

14.4.2.1Preparation of Surface

The joints shall be raked out properly. Dust and loose mortar shall be brushed out. Efflorescence if any shall be removed by brushing and scrapping. The surface shall then

be thoroughly washed with water, cleaned and kept wet before plastering is commenced.

In case of concrete surface if a chemical retarder has been applied to the form work, the surface shall be roughened by wire brushing and all the resulting dust and loose particles cleaned of and care shall be taken that none of the retarders is left on the surface.

14.4.3 Mortar

The mortar of the specified mix using the type of sand described in the item shall be used. For external work and under coat work, the fine aggregate shall conform to grading IV. For finishing coat work the fine aggregate conforming to grading zone V shall be used.

14.4.4 Application of Plaster

Ceiling plaster shall be completed before commencement of wall plaster. Plastering shall be started from the top and worked down towards the floor. All putlog holes shall be properly filled in advance of the plastering as the scaffolding is being taken down. To ensure even thickness and a true surface, plaster about 15 x 15 cm shall be first applied horizontally and vertically at not more than 2 metre intervals over the entire surface to serve as gauges. The surfaces of these gauged areas shall be truly in the plane of the finished plaster surface. The mortar shall be applied in a uniform surface slightly more than the specified thickness. This shall be beaten with thin strips of bamboo about one metre long to ensure thorough filling of the joints, and then brought to a true surface, by working a wooden straight edge reaching across the gauges, with small upward and sideways movements at a time. Finally the surface shall be finished off with trowel or wooden float accordingly, as a smooth or a sandy granular texture, as required. Excessive trowelling or of working the float shall be avoided. During this process, a solution of lime putty shall be applied on the surface to make the later workable.

All corners, arises, angles and junctions shall be truly vertical or horizontal as the case may be and shall be carefully finished. Rounding or chamfering corners, rises, junctions etc. where required shall be done without any extra payment. Such rounding or chamfering shall be carried out with proper templates to the sizes required.

In suspending work at the end of the day, the plaster shall be left, cut clean to line both horizontally and vertically, when recommencing the plastering the edge of the old work shall be scraped and wetted with lime putty before plaster is applied to the adjacent areas, to enable the two to properly join together. Plastering work shall be closed at the end of the day on the body of wall and not nearer than 15 cm to any corners or arises. It shall not be closed on the body of the feature such as plasters, bands cornices, nor at the corners or rises. Horizontal joints in plaster work shall not also occur on parapet tops and copings, as these invariably lead to leakage. No portion of the surface shall be left out initially to be patched up later on.

a) Beating with thin bamboo strips shall not be done on the cement plaster and

b) No lime putty solution shall be applied on the face when finishing. Further the plastering and finishing shall be completed within half an hour of adding water to the dry mortar.

14.4.5 Curing

Curing shall be started as soon as the plaster has hardened sufficiently not to be damaged when watered.

The plaster shall be kept wet for a period of not less than 7 days. During this period, it shall be suitably protected from all damages at the contractor's expense by such means as the Engineer-in-charge may approve. The dates on which the plastering is done shall be legibly marked on the various section plastered so that curing for the specified period there after can be watched.

14.4.6 Finish

The plaster shall be finished to a true and plumb surface and to the proper degree of smoothness as required. The work shall be tested frequently as the work proceeds with a true straight edge not less than 2.5 m long and with plumb bobs. All horizontal lines and surfaces shall be tested with a level and all jambs and corners with a plumb bob as the work proceeds.

14.4.7 Measurements for Payment

Length and breadth shall be measured for payment correct to a cm and its area shall be calculated in square metres correct to two places of decimals.

Thickness of the plaster shall be exclusive of the thickness of the key i.e. grooves, or open joints in brick works.

The measurements of wall plaster shall be taken between the walls or partitions (the dimensions before plastering shall be taken) for the length, and from the top of the floor or skirting to the ceiling for the height. Depth of coves or cornices if any be deducted.

Deductions in measurement, for openings, etc. will be regulated as follows :-

a) No deduction will be made for openings or ends of joints, beams, posts, girders, steps etc. upto 0.5 sq m in area, no additions shall be made either, for the jambs, soffits and sills of such openings. The above procedure will apply to both faces of wall.

b) Deduction for openings exceeding 0.50 sq. m but not exceeding 3 sq. m each shall be made for reveals, jambs, soffits, sills etc. of these openings.

i. When both face of walls are plastered with different types of plaster or if one face is plastered and other is pointed, or one face is plastered and other is unplastered, deductions shall be made from the plaster or pointing on the side of the frame for the doors, windows, etc. on which width of reveal is less than on the other side but no deductions shall be made on the other side.

ii. Where width of reveals on both faces faces of are equal, deduction of 50% of area of opening on each face shall be made from area of plaster and/or pointing as the case may be

iii. For opening having door frame equal to or projecti.ng beyond thickness of wall, full deduction for opening shall be made form each plastered face of wall.

14.5 NEAT CEMENT PUNNING

Specifications for this item of work shall be same as described in clause 17.4 except for the additional floating coat of neat cement to be carried out as below :

When the plaster has been brought to a true surface with the wooden straight edge it shall be uniformly treated over its entire area with a paste of neat cement and rubbed smooth, so that the whole surface is covered with neat cement coating. The quantity of cement applied for a floating coat shall be 1 kg sq. m smooth finishing and shall be completed with trowel immediately and in no case later than half an hour of adding water to the plaster mix. The rest of the specifications described in 17.4.4 shall apply.

14.6 NISHES OF FLOOR

14.6.1 Resilient Tiles

Resilient tile and skirting shall be approximately 250 mm x 250 mm x 3 mm and 100 mm x 100 mm x 3 mm, respectively. Colour and patterns shall be selected by the Engineer-in-charge from the standard range.

The tiles shall be set on a thoroughly dried rendered base.

The layout shall be subject to the approval of the Engineer-in-charge.

Tile and skirting shall be adequately protected during the time of setting for a subsequent period. No traffic shall be allowed on the tiles for 48 hours after setting

14.6.2 Pre-cast Terrazzo Tiles

Pre-cast terrazzo floor tiles shall be made from portland cement and coloured stone chipping and shall be pressure moulded and ground to size. The tiles shall be hard, durable and sharp, true edges. Colours and patterns and patterns shall be selected by the Engineer-in-charge from a standard range.

The size of tile shall be as follows :

Floor tiles : 300 mm x 300 mm x 20 mm thick

Floor skirting 100 mm and 200 mm high.

Tiles and skirting shall be bedded and pointed in 1:3 cement mortar. Bedding for tiles shall be of required thickness to suit finished floor levels.

14.6.3 Ceramic Glazed Wall Tiles (Internal)

The ceramic will tiles for interior use shall be made of porcelain or earthenware. Tiles shall be 100mm square x 6 mm thick. Tiles shall be hard, durable and non-absorbent of exact shape and even thickness and shall have cushioned edges. Coloured and patterns shall be selected by the Engineer-in-charge from a standard range. Tiles shall be bedded in adhesive supplied by the tile manufacturers and pointed with white cement.

14.7 FALSE CEILING

14.7.1 The entire area to be air conditioned shall be provided with false ceiling of hard board three layer flat pressed teak timber tile each of size 60 cm x 60 cm x 12 mm thick or other approved suitable material for the false ceiling and the supporting frame material which shall be supplied & installed by the contractor. The complete material for the false ceiling and the supporting frame work shall be supplied by the contractor & shall conform to the relevant Indian Standards. After installation, the false ceiling (face towards the floor of the air condition rooms), shall be given suitable coating for protection as well as better finish. The colour of the coating shall be as approved by the

Engineer-in-charge. Detailed embedment drawing showing details of necessary embedments (Aluminum) to be provided in the ceiling for supporting the false ceiling frame work and ducts etc. shall be furnished by the bidder alongwith their offer. A suitable arrangement properly utilising these plates shall be furnished for approval of the Employer. All supporting material shall be supplied by the contractor.

14.7.2 Specification

Suitable provision such as semi-transparent panels or louvered openings etc., for illumination of the room shall be made in the design of the false ceiling. Full information regarding the proposed fittings for illumination purposes shall be furnished by the Contractor to the Employer. Supply and installation of lighting equipment shall be the responsibility of Contractor.

14.7.3 False ceiling supporting frame work including the Aluminum plates shall be given suitable rust resistant coating after proper cleaning of the surfaces.

14.7.4 The supporting arrangement shall be so designed as to permit easy dismantling etc. for maintenance of air conditioning equipment's or light fittings, etc.

14.8 PAINTING

14.8.1 Materials

Paints, oils, varnishes, etc., of approved brand and manufacture shall be used. Paints shall be synthetic enamel ready mixed paints and shall be used as received from the manufacturer. If for any reason, thinning is necessary in case of ready mixed paint, the brand of thinner recommended by the manufacturer or as instructed by the Engineer-in-charge shall be used.

Approved paints, oils, or varnishes shall be brought to the site of work by the contractor in their original containers in sealed condition.

14.8.2 Execution

Painting shall not be started until the Engineer-in-charge has inspected the items of work to be painted, satisfied himself about their proper quality and given his approval to commence the painting work. Painting of external surface should not be done in adverse weather condition like hail storm and dust storm.

Painting, except the priming coat, shall generally be taken in hand after practically finishing all other builder's work.

The rooms should be thoroughly swept out and the entire building cleaned up, at least on day in advance of the paint work being started.

14.8.2.1 Preparation of Surface

The surface shall be thoroughly cleaned and free from dust. All rust, dirt, scales, smoke and grease shall be thoroughly removed before painting is started. The prepared surface shall have received the approval of the Engineer-in-charge after inspection, before painting is commenced.

14.8.2.1.1 Application

Painting/Varnishes of approved colour and quality shall be done two coats over a priming coat over steel/wood works

Before pouring into smaller containers for use, paint shall be stirred thoroughly in its containers, when applying also, the paint shall be continuously stirred in the smaller containers so that its consistency is kept uniform.

The painting shall be laid on evenly and smoothly by means of crossing and laying off, the latter in the direction of the grain of wood. The crossing and laying off consists of covering the area over with paint, brushing the surface hard for the first time over and then brushing alternately in opposite direction two or three times and then finally brushing lightly in a direction at right angles to the same. In this process, no brush marks shall be left after the laying-off is finished. The full process of crossing and laying off will constitute one coat.

Where so stipulated, the painting shall be done by spraying. Spray machine used may be (a) high pressure (small air aperture) type, or (b) a low pressure (large air gap) type, depending on the nature and location of work to be carried out. Skilled and experienced workmen shall be employed for this class of work. Paints used shall be brought to the requisite consistency by adding a suitable thinner.

Spraying should be done only when dry condition prevails. Each coat shall be allowed to dry out thoroughly and rubbed smooth before the next coat is applied. This should be facilitated by thorough ventilation. Each coat except the last coat, shall be lightly rubbed down with sand paper or fine pumice stone and cleaned off dust before the next coat is laid.

No hair marks from the brush or clogging of paint puddles in the corners of panels, angles of mouldings, etc shall be left on the work.

In painting doors and windows, the putty round the glass panes must also be painted; but care must be taken to see that no paint stains etc., left on the glass. Tops of shutters and surfaces in similar hidden locations shall not be left out in painting.

In painting steel work, special care shall be taken while painting over bolts, nuts, rivets, overlaps etc.

14.8.2.2 Brushes and containers

After work, the brushes shall be completely cleaned of paint and linseed oil by rinsing with turpentine. A brush in which paint has dried up is ruined and shall on no account be used for painting work. The containers when not in use, shall be kept closed and free from air so that paint does not thicken and also shall be kept safe from dust. When the paint has been used, the containers shall be washed with turpentine and wiped dry with soft clean cloth, so that they are clean, and can be used again.

14.8.2.2.1 Measurements

The length and breadth shall be measured for payment to a cm. The area shall be calculated in sq. metres (correct to two places of decimal), except otherwise stated.

Small articles not exceeding 10 sq. decimetre (0.1 sq. m) of painted surfaces where not in conjunction with similar painted work shall be enumerated.

Painting up to 15 cm in width or in girth and not in conjunction with similar painted work shall be given in running metres.

Components of trusses, compound girders, stanchions, lattices and similar work shall, however, be given in sq. metres irrespective of the size or girth of members.

In measuring painting, varnishing, oiling etc., of joinery and steel work etc. the coefficients as in following tables shall be used to obtain the area payable.

The following coefficients shall be applied to the areas measured flat and not girthed.

Table 1 Equivalent Plain Areas of Uneven Surfaces

Sl. No.	Description of work	How measured	Multi plying co-efficient
1	2	3	4
a)	Panelled or framed and braced doors, windows etc. .	Measured flat (not girthed) including Chowkhat or frame Edges, chocks, Cleats,etc. shall be deemed to be included in the item.	1.30 (for each side)
b)	Ledged and battened or ledged, battened and braced, doors, windows etc.		
c)	Flush doors etc.	DO	1.20 (for each side)
d)	Rolling shutters of interlocked laths	Measured flat (size of opening) all over jamp guides, bottom rails and locking arrangement etc. shall be included in the item (top cover shall be measured separately)	1.10 (for each side)
e)	Fully glazed or gauged steel doors windows	Measured flat (not girthed) including frame edges etc.	0.50 for each side)
f)	Expanded metal, hard drawn steel wire fabric of approved quality, grill works and gratings in guard Bars, balustrades, Railings, partitions And M. S. Bars in Windows frames	Measured flat overall ; no deduction shall be made for open spaces; supporting members shall not be measured separately	1 (for paint all over)
g)	Open palisade fencing	------Do---------	1 (for paint all

	and gates including standards, braces; rails stays etc,. in timber or steel	over)

Explanatory notes for table 1

1. Measurement for doors windows etc. shall be taken flat (and not girthed) over all including chowkhats or frames, where provided. Where Chowkhats or frames are not provided, the shutter measurements shall be taken.

2. Where doors, windows, etc., are of composite types other than those included in Table 1 the different portion shall be measured separately with their appropriate coefficients, the center line of the common rail being taken as the dividing line between the two portions.

3. The coefficients for doors and windows shall apply irrespective of the size of frames and shutter members.

4. In case steel frames are used the area of doors, windows shutters shall be measured flat excluding frames.

5. When the two faces of a door, windows etc., are to be treated with different specified finished, measurable under separate items, the edges of frames and shutters shall be treated with the one or the other type of finish as ordered by the Engineer-in-charge and measurement of this will be deemed to be included in the measurement of the face treated with that finish.

6. In the case where shutters are fixed on both faces of the frames. The measurement for the door frame and shutter on one face shall be taken in the manner already described, while the additional shutter on the other face will be measured for the shutter area only excluding the frame.

7. Where shutters are provided with clearance at top or/ and bottom each exceeding 15 cm height, such openings shall be deducted from the overall measurements and relevant coefficients shall be applied to obtain the area payable.

8. Measurements of painting as above shall be deemed to include painting all iron fittings in the same or different shade for which no extra will be paid.

9. The measurements of guard bars expanded metal, hard drawn steel wire fabric of approved quality grill work and gratings, when fixed in frame work, painting of which is once measured else where shall be taken exclusive of the frames. In other cases the measurements shall be taken inclusive of the frames.

   14.8.2.2.2 For painting open palisade fencing and gates etc., the height shall be measured from the bottom of the lowest rail,. if the palisades do not go below it, (or from the lower end of the palisades, if they project below the lowest rail), upto the top of rails or palisades whichever are higher, but not up to the top of standards when the latter are higher than the top rails or the palisades. Measurements of wall surfaces and wood and other work not referred to already shall be recorded as per actual.

14.8.2.2.3 Precautions

All furniture's, fixtures, glazing, floors, etc., shall be protected by covering and stains, smears, splashings, if any shall be removed and any damage done shall be made good by the contractor at his cost.

14.8.4 Painting priming coat on wood, iron or plastered surfaces.

14.8.4.1 Primer

The primer for wood work, iron work or plastered surface shall be as specified in the description of the item.

Primers for plaster/ wood work/iron & steel/ aluminum surfaces shall be as specified below :

TABLE - 2

	Surfaces	Primer to be used
1.	Wood work (hard & soft wood)	Pink conforming to latest edition of IS 3536)
2.	Resinous wood and plywood	Aluminum Primer
	Aluminum steel and galvanised Steel work	Zinc chromate primer conforming to latest edition of IS : 104
4.	Cement brick work, plaster surface, asbestos surface for oil bound distemper and paint	Cement Primer

The primer shall be ready mixed of approved brand and manufacture.

14.8.4.2 Preparation of Surface

14.8.4.2.1 Wooden Surface

The wood work to be painted shall be dry and free from moisture.
The surface shall be thoroughly cleaned. All unevenness shall be rubbed down smooth with sand paper and shall be well dusted. Knots, if any shall be covered with preparation of red lead made by grinding red lead in water and mixing with strong glue sized and used for. Appropriate filler material with same shade as paint shall be used where specified.

14.8.4.2.2 Iron & Steel Surface

All rust and scales shall be removed by scraping or by brushing with steel wire brushes. Hard skin of oxide formed on the surface of wrought iron during rolling which becomes loose by rusting, shall be removed.
All dust and dirt shall be thoroughly wiped away from the surface.
If the surface is wet, it shall be dried before priming coat is undertaken.

14.8.4.2.3 Plaster Surface

The surface shall ordinarily not be painted until it has dried completely. Trial patches of primer shall be laid at intervals and where drying is satisfactory, painting shall then be taken in hand. Before primer is applied, holes and undulations, shall be filled up with plaster of Paris and rubbed smooth.

14.9 DRY DISTEMPER

14.9.1 Materials

Dry distemper of required colour and (IS-427) of approved brand and manufacture shall be used. The shade shall be got approved from the Engineer-in-charge before application of distemper. The dry distemper colour as required shall be stirred slowly in clean water using 6 decilitres (0.6 litre) of water per kg of distemper or as specified by the manufacturer. Warm water shall preferably be used. It shall be allowed to stand for at least 30 minutes (or if practicable over night) before use.

14.9.2 Application

i. Before application of distemper is taken up, the surface shall be thoroughly brushed free from mortar dropping, other foreign matter and sand and prepared smooth. New plaster surface shall be allowed to dry for at least two months before applying distemper.

ii. After preparation of the surface A priming coat of whiting shall be applied over the prepared surface. No white washing coat shall be used as a priming coat for distemper. The treated surface shall be allowed to dry before distemper coat is given.

iii. Whiting (ground white chalk) shall be dissolved in sufficient quantity of warm water and stirred to form a thin slurry and two kg of gum and 0.4 kg of copper sulphate dissolved separately in hot water shall be added for every cum of slurry. The mixed slurry shall then be diluted with water to the consistency of milk so as to make a wash ready for use.

iv. Distemper shall be applied two or more coats over the dried surface of the primary coat till the surface shows an even colour. The entire surface shall be coated with mixture uniformly, with proper distemper brushes in horizontal strokes followed immediately by vertical ones which together shall constitute one coat. The subsequent coat shall be applied only after the previous coat has dried. The finished surface shall be even and uniform and shall show no brush mark.

14.10 PROVIDING AND FIXING ANODIZED ALUMINIUM PIPE RAILING 40 MM DIAMETER

14.10.1 General

Anodized aluminum pipe railing shall be provided as shown on the drawing or as directed by the Engineer-in-charge. The railing shall be made of 3 rows of 40 mm diameter anodized aluminum pipes conforming to IS fixed in position one above the other as shown on the drawings in 1.2 metre height with vertical supports of 100 x 50 x 5 mm J section, 1.5 meter center to center. In the construction drawing suitable adjustment in the pattern as indicated above and as required as per actual site condition and as directed by the Engineer-in-charge shall have to be carried out by the contractor.

All railing shall be so constructed as to enable removal of the parts for repair and replacement.

14.11 PIPES

14.11.1 General

The work to be done under these specifications include providing and installing mild steel black perforated pipes, G.I. pipes required for water supply system connecting drainage holes to the gallery, and internal drainage of intake and pump house building, vertical drainage pipe, rigid un-plasticized PVC pipes for potable water supplies.

14.11.2 Application Publications

All methods and procedures for installing and testing of pipes shall conform to latest edition of Indian Standard Specification listed below, unless otherwise specified.

Indian Standards:

1.	**IS:2026**	**Specification for Structural Steel (Standard Quality)**
2.	IS:554	Dimension for Pipe Thread where Pressure Tight Joints are Required in Threads.
3. i)	IS:1239 (Part – I)	Specification for Mild Steel Tubes, Tubulars and other Wrought Steel Fittings.
ii)	IS :1239 (Part – II)	Mild steel Tubulars and other wrought steel pipe fittings.
4.	IS:3589	Specification for Electrically Welded Steel Pipes of Water and Sewage.
5.	IS:4711	Methods of Sampling of Steel Pipes, Tubes and Fittings.
6.	IS:4984	Specification for high Density polythylene pipes for potable water supply.

14.11.3 Rigid (Unplasticized) PVC Pipes

14.11.3.1 The pipes shall be reasonably round and shall be supplied in straight lengths with socketed end. The internal and external surface of pipes shall be smooth and clean, free from grooving and other defects. The pipe shall be designated by external diameter and shall conform to latest edition of IS 4985.

14.11.3.2 Fittings :- Fittings used shall be of the same make as that of PVC pipes, injection moulded or made in cast iron and shall conform to relevant Indian Standard.

14.11.3 JOINTING

17.11.3.1 G. I. Pipes

The pipes shall be cleaned and cleared of all foreign matter before being laid. In jointing the pipes, the inside of the socket and the screwed end of the pipes shall be oiled and rubbed over with white lead and a few turns of spun yarn wrapped round the screwed end of the pipe. The end shall then be screwed in the socket, tee etc., with the pipe wrench also as not to damage the pipe care shall also be taken that all pipes and fittings

are properly jointed so as to made the joints completely water tight and pipes are kept at all times free from dust and dirt during fixing.

14.11.3.2 PVC Pipes

Solvent cement joints/ flanged joint/rubber ring joints shall be provided and shall conform to relevant Indian Standards.

14.11.3.3 Cast Iron Detachable Joints

The joints shall consist of a central collar, two rubber rings two flanges of cast iron and the required number of bolts and nuts. One flange and rubber ring shall be placed one end of the pipe already laid and the other flange, rings and central collar shall be slipped on the pipe to be assembled. The rubber ring shall be kept positioned at half the collar width less 2.5 mm from the end of the pipe already laid. A site gauge may be used for convenience. The other pipe shall be brought nearer leaving a gap of 5 mm between the two pipe ends. This gap will facilitate maneuvering of deflection at joints after assembly and will take care of an expansion in the pipe line. The collar shall be slided to sit square around the rubber ring on pipe to sit around collar. The flange shall be moved on both ends to enclose rubber rings. The fastenings bolts shall be inserted through the holes of the flanges and the bolts shall be tightened alternately and evenly for proper sitting of the joint.

14.11.3.3 Cast iron fittings and accessories

Cast iron fittings are jointed by cast iron detachable joints only. Cast iron specials having flanges jointed in the pipe with the cast iron flange adapters having one end flanged and the other plain ended. When there will be tendency for the pipe ends or specials ends to slipout of the joints anchorage shall be provided against the direction of thrust.

14.12 WATER SUPPLY, SANITARY AND DRAINAGE FITTINGS

14.12.1 PROVIDING AND FIXING WATER CLOSET

White vitreous china water closet squatting pan (Indian type) shall be provided and shall conform to latest edition of IS : 2556 Pt.II. The pan shall have following accessories :

a) ‘P’ or ‘S’ trap
b) Foot rest pair in white vitreous china (size 25 x 13 x 3 cm.)
c) Low level flushing cistern of 12.5 litre capacity of white vitreous china including 15 mm dia inlet, float valve, C.P. brass heavy stop cock and handle etc.

The squatting pan shall be fitted flush with floor level. Brick lime coba shall be filled under the pan after fixing it to the correct position.

In fixing the pan if holes are made in the floors or wall the same should be repaired with 1:3 cement mortar, complete.

Flushing cistern to the wall shall be with CI bracket and repair of wall with 1:3 cement mortar.

14.12.3 Providing and Fixing in Position White Vitreous Flat Back Lipped Urinal

White vitreous flat back lipped urinals shall conform to IS : 2556 (Pt. IV). The urinal unit shall have following fittings and accessories.

a) Flushing cistern of 5 litre capacity – conforming to IS : 774 with flush pipe for back and front flush with spreader pipes with fittings.

b) Standard urinal C.I. trap 65 mm dia with vent arm and outer gratings and coupling in C.P. brass trap and unions.

c) White vitreous china tiling upto 1200 mm height on front and side walls.

The urinal shall be fitted on C.I. bracket embedded in wall. In fixing the urinal if wall is damaged the same shall be made good by repair. All fittings and C.I. bracket shall be painted with ready mixed paint of approved quality.

Payment for the item shall be made on the basis of numbers of urinal units fixed in position.

14.12.4 Providing and Fixing Wash Basin

White vitreous china wash basin shall conform to IS : 256 (Pt. IV). The wash basin of size 55 x 40 cm size shall have following accessories.

a) Rolled Steel or Cast Iron conforming to IS :775 duly painted
b) 15 mm dia C.P. brass pillar taps and C.P. brass chain rubber plug.
c) 32 mm dia brass waste coupling
d) 15 mm dia lead inlet connection of minimum 40 cm in length
e) 15 mm dia brass heavy duty stop cock
f) 32 mm C.I. trap and brass cleaning thimble upto and outside wall till gully trap
g) C.I. clips, 40 mm dia G.I. pipe sleeve.

The wash basin shall be fixed on C.I. bracket embedded in wall. In fixing the wash basin if holes are made in floor or walls the same should be repaired with 1:3 cement mortar to the original condition. All fittings and C.I. bracket shall be painted with ready mixed paint of approved quality.

14.13 MS GRATING AND STEEL WORK IN SINGLE SECTION (CABLE DUCT)

14.13.1 Description

400 mm wide M. S. grating over drain is consisting of 25 x 3 mm MS flats 50 mm c/c both ways welded to IS Angles of size 30 x 30 x 5 mm. All structural steel used for grating shall conform to latest edition of IS : 226. The welding shall conform to latest edition of IS : 816.

14.13.1.1 Steel work in single section for cable duct consists of 9 rows of angles 50 x 50 x 5 mm on both sides fixed in R.C.C. wall.

14.14 R.C.C. PRECAST COVER

The specification for providing and fixing RCC pre-cast cover of size 750 x 750 x 300 mm over drain shall conform to Section-5 concrete and reinforcement of this specifications.

14.15 JOINTS AND SEALS

14.15.1 Scope of Work

14.15.1.1

The section covers specifications for providing Polyvinyl Chloride (PVC) waterstops, asphalt seals with or without stainless steel strip. 12 gauge steel plate formed holes, joints filler and water proofing treatment over slab and corner joints at the location of joints as shown on the drawings or as directed by the Engineer-in-charge.

14.15.2Classification

The items covered under the specifications are as under :

Providing and fixing in position PVC water stop 305 mm/ 225 mm wide embedded in concrete with heat sealed joint, etc. complete as per drawings and specifications.

Providing and fixing in position PVC joints strip with 12 gauge stainless steel strip and stainless steel bolts and washer expansion anchors, etc. complete as per drawings and specifications.

Providing and laying asphalt seal in formed hole, at joints, including 12 mm diameter standard steam pipe duly fitted in 20 gauge sheet metal all along pipes including clamps, nuts, bolts, couplings, plugs and steam supply filled with an approved 'H' grade asphalt etc. Complete as per drawings and specifications.

Providing and laying joint filler of approved quality in joints as per drawings and specifications.

Providing and fixing 20 gauge stainless steel strip (175 mm x 27 mm) with 12 mm dia, 80 long hexagonal head, stainless steel bolts embedded in concrete and nuts and washer, etc complete as per drawings and specifications.

Providing formed holes of different sizes and shape varying form 50 mm to 175 mm for joints including centering, shuttering, etc. complete as per drawings and specifications.

Providing and laying 6 layer water proofing treatment including 12 gauge 200 mm wide galvanised steel plate embedded in bituminous plastic cement, including fixing the plate at both corner joints to the standard galvanised shape anchor 20 mm wide 200 mm, providing flushing reglet and fixing the plate at corner joints with the help of 35 mm long 28 gauge galvanised barbed roofing nails in nailing concrete a the corner joints including providing 100 mm thick, 600 mm wide A. 20 S-200 RCC with 8 mm dia bars both ways over the steel plate including water proofing treatment etc. complete as per drawings and specification.

14.15.3 Application Publications

14.15.3.1 All methods of tests and welding procedure shall conform to latest Indian Standard Specification and other publication listed below unless otherwise specified.

14.15.3.2Indian Standards

IS:702	Asphalt
IS:1322	**Bitumen felt**
IS:1346	Water proofing treatment 6 course.
IS:3384	Asphalt primer
IS:8004	Recommended procedure for welding of Flexible PVC (Flexible Polyvinyl Chloride)

14.15.3.3 Other Publications

American Society for Testing and Materials Designation D-638.

American Society for Testing and Materials Designation D-2240.

14.15.4 Polyvinyl Chloride (PVC) Water Stops

14.15.4.1 General

The dimension of Polyvinyl Chloride (PVC) waterstops, shall normally be as shown in approved drawings. The Contractor, however, will be permitted to use waterstops of any alternative manufacturer, such as waterstops with diamond shape and bulb, provided they conform with the specifications and the functional and construction requirement. For this purpose, the Contractor shall submit to the Engineer-in-charge for approval four sets of drawings, showing details of the waterstops, including shapes and details of intersections and splices between water stops of the same sizes and of different sizes. Fabrication and procurement of materials shall be made only after approval of the drawings by the Engineer-in-charge. Any fabrication or procurement of materials done prior to approval of the drawings shall be at the Contractor's expense. The Engineer-in-charge shall have the right to require the Contractor to make any changes in the drawings which may be necessary to make the finished installations conform to the requirements and intent of these specifications, without additional cost to the Employer. Approval by the Engineer-in-charge to the Contractor's drawings shall not be held to relieve the Contractor of any part of this obligations to meet all of the requirement of these specifications or of the responsibility for the correctness of his drawings.

One set of the above drawings will be returned to the Contractor, either approved, disapproved, or conditionally approved. All drawings that are disapproved shall be revised and resubmitted for approval, as directed.

The waterstops shall be dense, homogeneous and free from holes and other imperfections. The waterstops shall meet the material and test requirements given in concrete specifications. The cross-section of the waterstops shall be uniform along its length and thickness shall be symmetrical transversely. Tolerance from the dimensions

given above shall be plus 5 mm in width, plus 2 mm in thickness and plus 1 mm for the rest.

Certified copies of laboratory test reports on the physical properties of the PVC waterstops and a certificate stating the PVC waterstops as furnished meet all other requirements of these specifications, shall be obtained by the Contractor from the manufacturer of the PVC waterstops and submitted to the Engineer-in-charge for approval. Three 1.5 m long samples of the PVC water stops shall be obtained by the contractors from the suppliers and submitted to the Engineer-in-charge. These samples shall be furnished atleast 60 days prior to embedding of any waterstops in the structures.

The contractor shall arrange to obtain the waterstops from the suppliers in rolls securely packed, containing a single length of not less than 12 linear metres and having inside diameter of not less 0.3 meter.

14.15.4.2 Installation

The location and embedding of the PVC waterstops shall be as shown on the drawings, with approximately one half of the width of the waterstops embedded in the concrete on each side of the joint. In order to eliminate faulty installation that may result in leakage, particular care shall be taken that the waterstops are correctly positioned and secured during installation. Where the bottom end of PVC waterstops contact rock at the base shall be embedded at a minimum depth of 30 cm into sound rock, All waterstops shall be so installed as to form a continuous water tight diaphragm in the joint unless otherwise shown. Adequate provision shall be made to completely protect the waterstops during the progress of the work.

Additional vibration, over and above that used of adjacent concrete placement, shall be employed near the waterstops to assure complete embedding of the waterstops in the concrete. Larger pieces of aggregates near the waterstops shall be removed by hand during embedding to assure complete contact between the waterstops and the surrounding concrete.

Splices of waterstops shall be fabricated only by workmen who have demonstrated to the satisfaction of the Engineer-in-charge that they are sufficiently skilled to fabricate the required splices. Splices in the continuity of or at the intersection of runs of PVC waterstops shall be performed by heat sealing the adjacent surfaces in accordance with the manufacturer's recommendations. A thermostatically controlled electric heat source shall be used to make all splices. The correct temperature at which splices should be sufficient to melt but not char the PVC material. All splices shall be neat with the ends of the joined waterstops in the true alignment. A meter box guide and portable saw shall be provide and used to cut the ends to be joined to ensure good alignment and contact between the surface joint. After splicing, a remoulding iron with ribs and corrugations to match the pattern of the waterstop, shall be used to reform the ribs at the splice. The continuity of the characteristic members of the waterstop design (ribs, tubular central axis, protrusions and the like) shall be maintained across the splice.

Where splices are required between waterstops of different sizes the splices shall be made as recommended by the manufacturer of the waterstops and drawings showing the details of the splices shall be submitted to the Engineer-in-charge.

Prior to embedding, the edges of the waterstop shall be secured to looped wire in the end bulbs to improve the concrete bond as shown on the drawings. The bars shall conform to the provision of Section-9 "Concrete works". The manner in which the waterstop is secured to the reinforcing bars shall be subject to approval of the Engineer-in-charge.

14.15.4.3 Asphalt Seal

14.15.4.3.1General

The contractor shall construct asphalt seals in contraction joints of dam intake and pump house and intake structure as shown on the drawings or as directed by the Engineer-in-charge.

14.15.4.4 Material

Asphalt fill hole shall be filled with 'H' grade asphalt or blow bitumen asphalt R 85/25. 11mm diameter heating pipes and fittings shall be provided in the formed hole for asphalt fill as shown in the drawing.

14.15.4.5 PVC Joints Strip

14.15.4.6 PVC joint strips : PVC joint strips with or without stainless steel metal strips shall be installed in the places shown on the drawings and elsewhere as directed. The Contractor shall furnish the PVC joint strips, metal strip, expansion anchors, bolts and washers. The joint strips shall be furnished in not less than 3.5 m length. All PVC joint strips shall be stored in as cool place as practicable, preferable at 70^0 F or less, and in no case shall the rubber be stored in the open or exposed to the direct rays of the sun. PVC material for the joint shall have the physical characteristics as per para 17.15.4.1 of this section.

All PVC joint strips shall be extruded and cured in such a manner that any cross section will be dense, homogeneous, and free from porosity and other imperfection. Surface defects such as surface peel, flow lines, blisters, nonfills and air traps shall be minimum. Any defects which is not acceptable shall be repaired to the satisfaction of Engineer-in-charge or shall be removed from the finished product by cutting out a length of joint strip containing such defect.

The Contractor shall also furnish to the Engineer-in-charge with three 300mm samples of the PVC joints strips for testing for tensile strength and elongation by the Employer. The samples shall be cut from the finished product in the presence of the Engineer-in-charge. The contractor shall furnish samples at no extra cost to the Employer.

PVC joint strips shall not be installed until at curing of the adjacent concrete has been complete. The joint strips shall be installed as shown by close fitting butt joints and the location of all such joints shall be submitted to the approval of the Engineer-in-charge. The metal strips for the PVC joint strips shall be fastened to the concrete with, bolts as shown on the drawings. Where required, the metal strips shall be bent to conform to the angles formed by abutting surface.

14.15.4.6 Joint filler

The joint filler shall normally be as shown on drawing. The Contractor however, will be permitted to use, joint filler of the approved quality as per relevant Indian Standard, or any alternative manufacturer of joint filler, provided they conform to the specification and the functional and construction requirement The Contractor shall submit to the Engineer-in-charge for approval the proposal 30 days before for using such joint filler along with relevant certificate from manufacturer of joint filler.

The joints in the joint filler shall be scarfed, made tight and filled with suitable material so that mortar from the concrete will not seep through the opposite surface. The joint filler shall be racked out after the concrete has set.

14.15.5 **Water Proofing arrangement at the corners and joints in slab**.

The water proofing arrangements shall be provided on the roof at the junction of roof and the wall. The arrangement including providing fixing and laying 12 gauge G.I. plate embedded in 100 mm thick 600 mm wide RCC, including 28 gauge roofing nails of 30 mm long fixed in nailing concrete in the corner and providing and fixing flashing reglet and standard galvanized anchor strap of 200 mm long 20 mm wide, 6 layer of water proofing membrane, caulking compound etc. complete as per drawing and specification.

14.16 MISCELLANEOUS WORKS FOR CIVIL STRUCTURES

14.16.1 ROADWAY

The approaches to pump houses of Gouravelly reservoir shall be black-topped metallic road and shall consist of stone metal mechanically interlocked by rolling and bonded together screening and binding material, where necessary and water laid on a prepared subgrade. The road will be finished in accordance with the requirements of these specifications, description of item of work and in conformity with the lines, grades and cross-sections shown on the drawings or otherwise directed by the Engineer-in-charge.

14.16.1.1MATERIALS

a) Coarse aggregates

Coarse aggregates shall be stone aggregate with impact value conforming to IS : 2386 and IS : 5640. The grading of aggregates shall be as under :

Size range	Sieve designation	Percent by weight passing the sieve
63 mm to 40 mm (For Stone metal)	80 mm	100
	63 mm	90-100
	50 mm	35-70
	40 mm	0-15
	20 mm	0-5

b) Crushed or Broken Stone

Crushed or broken stone shall be free of flat, elongated, soft and disintegrated particles and should not contain any excess of dirt or other objectionable materials.

i) Screening

Screening to fill voids in the coarse aggregate shall generally consist of the same material as the coarse aggregate. However, where permitted, predominantly non-plastic material such as moorum or gravel (other than rounded river-borne material) may be used for this purpose provided liquid limit and plasticity index of such material is below 20 and 6 respectively and fraction passing 75 micron sieve does not exceed 10 percent.

As far as possible, screening shall conform to the following gradings :

Size of Screening designation	Sieve	Percent by weight passing the sieve
10 mm	10 mm	100
	4.75 mm	85-100
	150 micron	10-30

ii) Binding Material

Binding material to be used for water-bound macadam construction shall comprise a suitable material approved by the Engineer-in-charge having plasticity index value of less than 6 as determined in accordance with IS : 2720 (Part V).

Application of binding material may not be necessary, when the screenings used are of crushable type such as moorum or gravel.

14.16.1.2 CONSTRUCTION OPERATIONS

a)Preparation of Subgrade

The subgrade to receive the water-bound macadam course shall be prepared to the specified grade and camber and made free of dust and other extraneous material. Any ruts or soft yielding places shall be corrected in an approved manner and rolled until firm.

b) Spreading Coarse Aggregate

The coarse aggregates (stone metal) shall be spread uniformly upon the prepared subgrade in two layers in such quantities so that the compacted thickness of each layer is 100 mm. Each layer is to be rolled separately but no binding material will be used in the first layer.

The spreading shall be done from stockpiles along the side of the roadway or directly from vehicles. In no case shall the aggregate be dumped in heaps directly on the surface

prepared to receive the aggregate nor shall hauling over uncompacted or partially compacted base be permitted.

The surface of the aggregates spread shall be carefully checked with templates and all high or low spots remedied by removing or adding aggregate as required. No segregation of large or fine particles shall be allowed and the coarse aggregate as spread shall be of uniform gradation with no pockets of fine material.

The coarse aggregate shall not normally be spread more than 3 days in advance of the subsequent construction operations.

c) Rolling

Immediately following the spreading of the coarse aggregate, rolling shall be started with three-wheeled power rollers of 8 to 10 tonne capacity or tandem or vibratory rollers of approved type. The weight of the roller shall depend upon the type of the aggregate and be indicated by the Engineer-in-charge. Except on super-elevated portions where the rolling shall proceed from inner edge to the outer, rolling shall begin from the edges gradually progressing towards the centre. First the edge/edges shall be compacted with roller running forward and backward. The roller shall then move inwards parallel to the centre line of road, in successive passes uniformly lapping preceding tracks by at least one half width.

Rolling shall be discontinued when the aggregates are partially compacted with sufficient void space in them to permit application of screenings. However, in the case of first layer, where screenings are not to be applied, compaction shall be continued until the aggregates are thoroughly keyed. During rolling slight sprinkling of water may be done, if necessary. Rolling shall not be done when the ubgrade is soft or yielding or when it causes a wave-like motion in the sub-grade or sub-base course.

The rolled surface shall be checked transversely and longitudinally with templates and irregularities corrected by loosening the surface, adding or removing necessary amounts of aggregate and re-rolling until the entire surface conforms to desired camber and grade. In no case shall the use of screening be permitted to make up depressions.

d)Application of Screenings

After the coarse aggregate has been rolled, screenings to completely fill the inter-stices shall be applied gradually over the surface. These shall not be damp or wet at the time of application. Dry rolling shall be done while the screening are being spread so that vibrations of the roller cause them to settle into the voids of the coarse aggregate. The screenings shall not be dumped in piles but be spread uniformly in successive thin layers either by the spreading motion of hand shovels or by mechanical spreaders, or directly from trucks. Trucks operating for spreading the screenings shall be so driven as not to disturb the coarse aggregate.

The screening shall be applied at a slow and uniform rate (in three or more applications) so as to ensure filling of all voids. This shall be accompanied by dry rolling and brooming with mechanical brooms, hand-brooms or both. In no case shall the screenings be applied so fast and thick as to form cakes or ridges on the surface in such

a manner as would prevent filling of voids or prevent the direct bearing of the roller on the coarse aggregate. These operations shall continue until no more screenings can be forced into the voids of the coarse aggregate.

The spreading, rolling and brooming of screenings shall be carried out in only such lengths of the road which could be completed within one day's operation.

e) Sprinkling and Grouting

After the screenings have been applied, the surface shall be copiously sprinkled with water, swept and rolled. Hand brooms shall be used to sweep the wet screenings into voids and to distribute them evenly. The sprinkling, sweeping and rolling operations shall be continued, with additional screenings applied as necessary, well-bonded and firmly set in its full depth and a grout has been formed of screenings. Care shall be taken to see that the base or subgrade does not get damaged due to the addition of excessive quantities of water during construction.

f) Application of Binding Material

After the application of screenings, binding material where it is required to be used shall be applied successively in two or more thin layers at a slow and uniform rate. After each application, the surface shall be copiously sprinkled with water, the resulting slurry swept in with hand brooms, or mechanical brooms to fill the voids properly, and rolled, during which water shall be applied to the wheels of the rollers if necessary to wash down the binding material sticking to them. These operations shall continue until the resulting slurry after filling voids, forms a wave ahead of the wheels of moving roller.

g) Setting and Drying

After the final compaction of water-bound macadam course, the road shall be allowed to dry overnight. Next morning deficient spots shall be filled with screenings of binding material as directed, lightly sprinkled with water if necessary and rolled. No traffic shall be allowed on the road until the macadam has set. The Engineer-in-charge shall have the discretion to stop hauling traffic from using the completed water-bound macadam course if in his opinion it would cause excessive damage to the surface.

14.16.2 Specifications for the work of preparation of road base, laying and compaction of road base, providing water-bound macadam base course and asphalt wearing course/carpet shall be done as per IRC/IS specifications applicable from time to time.

14.17 RAILING

14.17.1 R.C.C. Railing

Railing shall not be cast until the centering or form-work for the span has been removed, and the span is self-supporting. The type of railing to be constructed shall be as shown on the drawings. The railing shall be carefully erected, true to line and grade. Posts shall be vertical within a tolerance not to exceed 6 mm in 3 metres.

Forms shall either be of single width boards or shall be lined with suitable material duly approved by the Engineer-in-charge. Form joints in plane surface will not be permitted.

All mouldings, panel work and level strips shall be constructed according to the details shown on the drawings. All corners in the finished work shall be sheared and clean-cut and shall be free from cracks, spalls or other defects. Payment for railing will be made at the rate per running metres. The rate shall include cost of labour, material, tools, and plant required for doing the work complete in all respects as per specifications.

14.17.2 G.I. Railings

All pipes and all steel elements used for railing, terminal sections, posts, bolts, nuts, hardware and other steel fittings shall be galvanized.

All elements of the railing shall be free from abrasions, rough or sharp edges, and shall not be kinked, twisted or bent. If straightening is necessary, it shall be done by methods approved by the Engineer-in-charge.

The railing shall be carefully adjusted prior to fixing in place to ensure proper matching at abutting joints and correct alignment and camber throughout their length. Holes for field connections shall be drilled with the railing in place in the structure at proper grade and alignment. Welding may be substituted for riveting in field connections only with the approval of the Engineer-in-charge. The payment for G.I. Railing will be made at the rate per running metre. The rate shall include cost of all labour, material, tools and plant required for doing the work complete in all respect as per specifications.

14.18Guard Rail

the Contractor shall furnish and install guard rails at the location as shown on the drawings or as directed by the Engineer.

Prior to the work the Contractor shall submit to the Engineer for his approval shop drawings and installation method of guard rails.

The rails and posts shall be structured conforming to international standard and formed to the dimensions as shown on the Drawings or as directed by the Engineer.

Required bolts, nuts and washers shall be galvanized. The post shall be set to the required depth and be held firmly in place by concrete foundation.

After the guard rails are installed in place, painting shall be executed in accordance with the relevant provisions of the Specifications.

Reflector strip shall be attached to the guard rail wherever instructed by the Engineer and at maximum distance of 30 m along straight stretch.

Measurement for payment of guard rail shall be made at actual length in meter installed in service roads and accepted by the Engineer.

The unit prices for guard rail in service roads shall include all the cost for furnishing, installing and painting of guard rails and any other incidental works.

Guard rials installed in other construction roads including existing roads shall not be paid for separately, and the cost for which shall be included in the lump sum price of construction road in the Bill of Quantities.

14.19 Laying of Concrete Block

(1) General

The concrete block work shall be provided as indicated on the Drawings

Concrete block may be pre-cast / cast-in-situ and the volume of which should not be less than 0.3 m^3. Concrete mix should be of 1:2:4 with 20 mm nominal size of aggregate. In case pre-cast blocks proper arrangement for placement of the same without damage and according to the line and levels shall be made.

In case of cast-in-situ blocks casting is to be done over the bed itself. Alternate blocks are to be taken up for casting at one time. Placement of pre-cast block/cast-in-situ block should be done in such a manner as there should not be any continuous joints.

Measurement for concrete block shall be made as per gross volume of each block in cubic metres.

Rate for concrete block shall include:

i) Cost of find and coarse aggregate / cement etc.
ii) Mixing, placing, compaction
iii) Shuttering and curing
iv) Placement of block over prepared bed.

15 FOREBAY BED LINING

15.1 GENERAL: These specifications apply to:

(a) Clearing site, preparation of sub grade in soils and rock, providing under drainage, pressure relief arrangements, anti salt treatment, placing model sections, laying plain cement concrete with machine crushed hard broken graded quartzite/ granite/ other than granite metal of 40 mm/ 20 mm. maximum nominal size and using cement level of not less than 310 Kgs. per cubic meter of concrete to yield a 28 days characteristic compressive strength specified based on laboratory tests for bed and sides respectively using conventional placement of concrete lining.

(b) If during construction, it is found necessary to alter the canal sections and side slopes without alterning the thickness of lining, the contractors shall be informed in writing of such changes.

(c) The scope of work also includes the following :

(i) Dewatering the canal section for preparing the base for lining and for laying concrete lining.

(ii) Providing necessary, under drainage arrangements consisting of longitudinal and transverse drains, pressure relief valves as per drawings.

(iii) Providing filter materials of approved quality as per designs.

(iv) Bed and side lining of the cement concrete with machine crushed hard broken graded Quartzite/granite/ other than granite metal of 40 mm./ 20 mm. nominal size and using cement of not less than 310 Kgs/cum. of concrete to yield a characteristic compressive strength specified based on laboratory tests respectively.

(v) Providing grooves for joints by cutting the concrete to the required depth and width as per drawings.

(vi) Curing.

(vii) Filling joints:

(viii)

15.2 APPLICABLE PUBLICATIONS:

All concrete, its constituents, methods and procedures of manufacture shall conform to Indian Standard Specifications and other publications listed below unless otherwise specified.

Indian Standards

1. IS : 456 -1978 Code of practice for plain and reinforced concrete (Second Revision) (Amendment No. 1).
2. IS : 3873-1978 Code of practice for laying in-situ cement concrete lining first Revision of canals (First Revision)
3. IS : 2505-1980General requirements for concrete vibrators immersion type.
4. IS: 2506- 1985General requirements for screed board concrete vibrators.
5. IS :3366-1965 Specification for pan vibrators.
6. IS : 3558-1983 Code of practice for use of immersion vibrators for consolidating concrete.
7. IS : 4558-1983Code of practice for under drainage of lined canals.(First Revision)
8. IS : 5256-1968 Code of practice for sealing joints in concrete lining on canals
9. IS : 3085-1965 Methods of test for permeability of cement mortar and concrete..
10. IS : 1199-1959Method if sampling and analysis of concrete.
11. IS : 516 -1959 Method of tests for strength of concrete (Amendment No.1)
12. IS : 5529-1985Code of practice for insitu-permeability test.(part I&II)
13. IS: 9103-1979Specifications for admixtures for concrete.
14. IS : 2720-1980Methods of test for soils Determination of water (Part– 7) content –dry density relation using light compaction (second revision)
15. IS : 9451-1985Guidelines for placing lining for Canals in expansive soils. In addition to the above I.S. codes, the specifications of A.P.S.S. and manual for quality control and inspection shall also be complied with.

15.3PREPARATION OF SUBGRADE:

15.3.1Scope :

Preparation of sub grade (Back filling) to canal side and bed lining with CNS soils of approved quality, obtained from available canal spoil including cost and conveyance of soils, Clearing the site, dewatering if necessary, treatment of the soil laying moistening compacting to 98% proctor's density with suitable compacting equipment, trimming, all water leads, material leads, lifts, delifts, and all the operations necessary to complete the finished item of work to specifications, as per drawings or as directed by the Engineer-in-charge.

15.3.2 CLEARING SITE:

The area proposed for lining the canal as a whole shall be cleared of all objectionable material. Any waste material contained from such site clearance shall be disposed off in a manner directed by the Engineer-in-charge. The cost of this operation shall be deemed to have been covered under the rates quoted for canal lining.

15.3.3 GENERAL :

The provisions of this para shall apply to the preparation of all sub-grade up on which concrete lining is to be laid. The work of trimming canal section upto the under side of concrete lining and preparing sub-grade for concrete placement includes removal of proud section. Proud equivalent to thickness of lining on sides and in bed on the underside of lining should be left un-excavated and the removal of this proud should be done prior to laying of lining but in no case, should the time interval exceed 3 days in normal weather and two days in adverse weather conditions. It shall be ensured that the subgrade is made thoroughly moist with fine water spray, through deployment of proper nozzles, to a depth of about 15 cms to prevent it from absorbing water from the freshly laid concrete.
Soil in all reaches should be tested for salt content before lining is started. Where the salt content is over one percent or sodium sulphate is over 0.36 percent, the sub grade should first be covered with about 2 mm. thick layer of bitumen, if ordered by the Engineer-in-charge It shall be treated in accordance with para 4.3 I.S. of 3873-1978.

Preparation of sub grade for concrete lining shall conform to clause 4.1 to 4.5 of IS:3873-1978.

Wherever rock is over excavated it shall be filled as specified under subsequent paras.
At the end panels of existing lining against which lining is to be placed under these specifications, all these materials shall be removed and all voids beneath the existing lining shall be refilled and thoroughly compacted.

15.3.4 SUB -GRADE :

i) Preparation of sub grade consisting of earth.

a) The sub grade shall be prepared, dressed and rolled true to level and according to the required cross- section of the canal to form a firm compacted bed for the lining.

b) The contractor shall place selected bedding material, test profile true to the cross section of the canal at times and places designated by the Engineer to show the adequacy of his construction procedures for laying bedding materials. The test sections shall conform to clause 4.5.2.of I.S. 3873. - 1978. The cost of this operation shall be deemed to have covered in the rates quoted for side and bed lining.

c) In other than predominantly sandy reaches where the dry density of the natural soil is not less than 1.8 gm. per cubic centimeter, initial excavation shall be done up to about 300mm**.** above the final section and the cutting to final shape shall be done immediately before lining. The compaction shall conform to Clause 4.5.6. of IS 3873-1978.

d) If at any point material of prepared sub grade has been excavated beyond the neat lines required to receive lining, the excess excavation shall be filled in horizontal layers with suitable semi pervious soil material compatible with the sub grade material moistened and thoroughly compacted in accordance with Clause 4.5.5. and 4.5.6of I.S. 3873-1978. Where placing and compacting bedding materials is on slopping foundation, the layers may be placed parallel to the surface of the foundation. If at any point, the foundation. material is disturbed or loosened during the excavation process or other wise, it shall be moistened if required, and thoroughly compacted by tamping, rolling or other approved methods to form firm foundation for placing the concrete lining**.** Slope compactors may also be used for effective compaction of subgrade.

e) In bed, where the dry density of the natural soil is less than 1.8 gm**.** per cubic centimeter and sub soil water is near the sub grade, the consolidation shall be done by under cutting the bed by 7.5cm and then ploughing upto 15.0cm**.** below the subgrade level. Theloosened soil shall then be recompacted with suitable devices. All along the canal alignment the raincuts on the banks shall be filled up with approved soil and shall be compacted adequately to required lines, dimensions and levels.

f) In bed where the sub soil water is low, requiring no dewatering and the dry density of the natural soil is less than 1.8 gm**.** per cubic centimeter, the consolidation shall be done by digging the canal up to sub grade level and after loosening the earth below subqrade up to 15.0cm**.** by disc harrows, or ploughing and compacting the same to a layer of 11.0cm. After that, the second layer of 15.cm**.** of earth shall be laid over the compacted layer by taking earth from lip cutting and compacting this to a depth of 11.00cm. The compacted layer of 7.0 cm above the subgrade level**.** shall be removed and the subgrade brought to design profile before laying the lining.

g) Consolidation on sides shall be done by suitable slope compactors to obtain a minimum dry density of not less than 90-98% of the density at optimum moisture content obtained in accordance with IS : 2720(part vii) 1965**.** Compaction by manual labour shall not be permitted.

ii) Preparation of sub grade consisting or rock.

a) The sub grade in rock shall be excavated to the required cross section. Final cutting for 450-600 mm**.** in hard rock shall be carried out by**,** wedging**,** barring controlled blasting or trimming with the help of suitable equipment. No extra payment will be made to this.

b) The bed and side slopes of the canal excavation profile over which the bedding material,. under drainage and pressure relief arrangements are to be placed and over laid with lining

shall be finished accurately to true and even surfaces and to the dimensions shown on the drawings.

c) All excavation including over breakages below the lines of the underside of lining shall be back filled as follows:

In slopes : In slopes, the selected bedding material shall be semi pervious material forming, the bulk of back fill with smaller aggregate filling the voids**,** and a layer of gravel as binding material duly compacted with rammers to form a firm backing for the lining (IS: 3873-1978).

In bed : In case of bed, the selected bedding material shall be rock spells and chips available from canal cutting duly compacted with Diesel Road Roller to form a firm backing to lining (IS: 3873-1978).

Tolerance in Excavation :- Excavated profile provides the final base for lining and tolerances should be comparable to the following :

Departure from established alignment :
(+) or (-) 2 mm**.** on straight section:
(+) or (-) 50 mm**.** of tangents, and
(+) or (-) 100 mm**.** on curves.
(+) or (-)20 mm**.** Departure from established alignment.

The above tolerances shall be negotiated gradually, through smooth transition in a length of 50 m**.** No over- run in excavation. Filling with the materials as directed by the Engineers, shall be paid to the contractor.

The selected bedding material in the cases of bed and sides of canal profile in normal soils shall be graded filter material comparable with sub grade material and thoroughly compacted.

iii) Preparation of sub grade consisting of expansive soils. (IS : 9451-1995)**.**

(a) Field and laboratory experiments shall be carried out to determine the physical**,** texture, engineering and chemical properties of the black cotton soils/expansive soils and evaluate the swelling pressures of soils in various reaches to establish the thickness of CNS**.** layer required so that the determination is within the permissible limit.

In respect of the provision of CNS layer is worked out from the consideration of swelling pressure. However, the thickness of CNS layer to be provided on slopes shall, in addition, be governed by the construction considerations viz., from rollable width consideration for achieving effective compaction. However making due allowance for field controls, variations in the properties of CNS materials in the field an optimum thickness of 600 mm**.** normal to the slope shall be used in the channels of discharge more than one cumec. The thickness shall be appropriately decreased to 300 mm**.** (150mm**.** in small section of less discharges) channels. Filling and compaction of CNS material in such channels shall be done by pad/file and cut method as specified in the drawings.

15.3.5 C.N.S. BACK-FILL:

Formation of CNS soils backing to lining for bed of the forebay including breaking clods, sectioning, watering, and consolidation with 8-10 ton power roller to 98% proctor, density at optimum moisture content including spreading of horizontal layers of not more than 100 to 150mm thick upto the top level of P.C,C . lining/ cast-in-situ lining.

The surface to receive the filling shall be first cleared free from all roots, vegetation or spoils and then wetted and rolled thoroughly. The C.N.S. soils to be used for filling shall be free from salts or organic or other deleterious mater. All clods of the soils selected shall be broken to small pieces less than 100 mm**.** size. No stones cobbles having maximum dimensions more than 100mm. size shall be placed in the fill. Filling shall be done in layers not exceeding the compacted thickness of 100 to 150mm. each layer being watered and compacted before succeeding layer is laid. If the moisture is below the optimum moisture content for the given compaction. Then the required water shall be added by sprinkling if the moisture content in the soils is more than the optimum moisture content then it shall be allowed to dry down to the optimum moisture content. The moisture content shall be uniform throughout the layer of material. Compaction shall be achieved by using appropriate power roller. The number of passes shall be determined by testing the density of the compacted soil at site after taking trial compaction for specified passes of the, roller. The roller shall be taken close to the sides of the trench. In cases where the compaction by roller. is not possible compaction shall be done as specified by the Engineer-in-charge. Care shall be taken to ensure that over compaction does not take place. The CNS material shall be filled in layers not exceeding the 225 mm compacted thickness of 100 to 150mm. up to T.B.L. and shall be consolidated with 8 to10ton power roller to the proctor's density of 98%at optimum moisture content. Serrations should be provided in expansive soil to present contact slides between CNS. materials and expansive soil .The work shall be tackled in continuous horizontal layers. On resuming work each day or after an interval of few day or when work is not done in continuity the previous layer shall be well raked and water sprinkled over it before the fresh layer is laid and compacted. Special precautions shall also be taken while rolling the spread soil near structures, conduits, sluices, etc., Quality control tests shall regularly be carried out to determine the suitability of the soil used for filling and to control moisture content to ensure that the specified density is obtained. All. tests shall be done in accordance with the relevant Indian standards. The frequency of the test shall be as determined by the Engineer-in-charge. The work shall be done to the construction profile.

The canal section including the thickness of the lining shall be excavated in CNS soils and canal sides and bed are trimmed to receive P.C.C slab lining and cast -in-situ lining respectively

The soils excavated shall be rehandled and used for forward reach as directed by the Engineer. No extra payment will be made for the excavation of CNS soil in canal section and rehandling the soils as above separately.

i) Gradation of C.N.S Soil :

1. Clay (less than 2 microns) -15 to 20%
2. Silt (0.06mm-0.002mm.) -30to 40%
3. Sand (2mm -0.06mm.) -30to 40%
4. Gravel (Greater than 2mm.)-0to10%

i. The CNS. material shall be non-swelling, with maximum swelling pressure of 10KN/m2 when tested in accordance with IS: 2720(Part-41)-1977at field moisture content oven dry condition

ii. The minimum shear parameters may range from 10.3422 Kn/m2 and 25^{o} to 27.5790 KN/m2 and 12^{o} to 14^{o}

iii. Index properties:

1. Liquid Limit. Less than 50% but greater than 30%
2. Plasticity Index Less than 30% but greater than 15%

a) If the expansive clay is in thin layers or in small pockets in an otherwise suitable sub grade shall be over excavated as determined by the Engineer-in-charge. and replaced with suitable non-expansive soil and compacted suitably.

b) After the canal prism has been shaped to a reasonably true and even surface, selected bedding materials shall be placed on thoroughly wetted surfaces in layers of 15CM.maximum thickness to bring the bedding material to a height where it can be trimmed to form a true and even surface upon which to place the concrete lining. Each layer shall be moistened and thoroughly compacted as per specification 3.2. Where the bedding material is placed and compacted on a slopping ground layers may be placed parallel to the surface of the foundation. The moisture content of the bedding material at the time of compaction shall be optimum. The compaction procedures used shall be as described below.

i) The contractor shall place demonstration or test sections of selected bedding material at time and places designated by the Engineer-in-charge to show the adequacy of his construction procedures for placing and compacting the bedding material. The test section shall conform to clause 4.5.2 of IS 3873-1978.

ii) The bedding material shall be placed to sufficient thickness in the test sections to allow practical density testing of the compacted material. The dimensions and densities of the compacted bedding materials shall be acceptable to the Engineer-in-charge. The procedures shall then be used to compact the selected bedding material on the remaining work.

iii) When placing and compacting selected bedding materials on a sloping foundation, the layers may be placed parallel to the surface of the foundation. If at any point the foundation material is disturbed or loosened during the excavation process or otherwise it shall be moistened if required and thoroughly compacted by tamping, rolling or other approved methods to form firm foundations upon which to place the concrete lining. The bottom and side slopes, including the surfaces of compacted embankment, compacted selected bedding materials and compacted back fill over which concrete lining is to be placed shall be furnished accurately to true and even surfaces to the dimensions shown on the drawings. The loading, handling, transporting and placing of the selected bedding material is subject to approval of the Engineer-in-charge and shall be such as will result in a uniform mixture of the material being placed without separation or segregation. Selected bedding materials required shall be obtained from excavation in areas where material in excess of that required to construct the adjacent embankment is available or the material approved by the Engineer-in-charge.

iv) Immediately prior to placing the first lift of bedding material, the surfaces of excavation and embankment to receive the material shall be adequately wetted to a depth of 15cm. or to impermeable material whichever is less as approved by the Engineer-in-charge.

v) Suitable materials trimmed from the canal shall be used to complete canal embankments, to construct road embankment, for selected bedding material in the forward areas. Where material suitable for selected bedding as determined by the Engineer-in-charge is encountered during trimming operations and cannot be placed in one continuous operation, such material shall be stockpiled along the right-of way where designated by the Engineer-in-charge.

15.3.6 MEASUREMENT AND PAYMENT:

All linear measurements shall be in meters corrected to 0.01M. and volume shall be worked out to nearest to 0.01 Cum. The items covered under their are ..

1) Mark out
2) Cost and conveyance of CNS. soil to the site of work.
3) Filing the C.N.S. soil in layers of not exceeding 100 to 150mm. thick and consolidation with appropriate power rollers to a proctor's density of 98% at optimum moisture content.
4) Cutting the canal section, including the thickness of lining in the compacted C.N.S soil
5) Rehandling the extra excavated CNS. soil to the forward reach.
6) Forming and removal of steps and ramps, benching battering, formation of temporary tracks for diversion of surface flows, bailing out seepage water and such other temporary arrangements unless otherwise specified.
7) Shrinkage allowance.
8) No separate payment will be made. It shall be included in the price bid quoted in the Bill of Quantities.

15.4 UNDER DRAINAGE:

15.4.1 General:

For a lined canal where the ground water level is higher or likely to be higher than the water level inside the canal so as to cause damaging differential pressure on the lining or where the subgrade is sufficiently impermeable to prevent free drainage of the under side of lining in case of rapid drawdown, pressure relief arrangements for under drainage shall be provided suitably as indicated in the drawing in accordance with IS: 455-1968.

15.4.2 FILTER DRAINS:

a) Scope : Forming longitudinal/transverse filter drains of Specified size in bed with 10 mm to 40mm machine crushed metal of specified variety and sand including cost and conveyance of all materials, labour charges for laying with leads, lifts, delifts, seigniorage charges, sampling and testing, dewatering, packing and all other incidental and operational charges necessary to complete the finished item of work as per drawings and as directed by the Engineer-in-charge.

b)Whenever necessary, longitudinal/transverse filter drains shall be laid in the concrete lining true to the canal grade as shown in the drawings or as directed by the Engineer-in-charge. The number of layers comprising the filter, thickness of each layer and the materials to be used shall be as shown in the drawings. The filter material shall be clean, round and well graded sand or coarse aggregate the requirements of grading of which will be established in the field laboratory on the basis of mechanical analysis of adjacent materials. Particles of decomposed rock debris, wood vegetable matter or other deleterious materials shall not be permitted in the filter. Before placing the filter the bed shall be prepared as explained in the above paragraphs.

c) The longitudinal drains shall be laid to the grade of the canal while the transverse drains in bed shall have a fall towards the centre of the canal bed from the edge as shown in the drawing. The sand shall be clean, round and well graded. Before placing the filter, the bed shall be prepared as specified in paragraph above.

d)No separate payment will be made. It shall be included in the price bid quoted in the Bill of Quantities.

15.4.3 Pressure relief arrangement:

a)**Scope** : Laying and fixing of porous concrete plugs/flap valves in position in filter pockets including (a) Manufacturing of plugs, using 20 mm size machine crushed/ hand broken aggregate of specified variety and Cement of specified quantity for each plug (or) Manufacturing of flap valves consisting specified internal diameter with P.V.C.Pipe, with P.V.C. flange and rubber flap with all accessories and (b) excavation of pit for laying filter pocket and filling the filter pocket with filter materials including cost and conveyance of cement and all other materials, seigniorage, charges, labour charges for Manufacturing of plugs/flap valves, excavation of filter pocket, filling of pocket with specified grade of filter material, form work ,moulds machine mixing manufacturing, curing, sampling and testing, laying and fixing in position with all leads, lifts, delifts, dewatering, all water leads, and all other incidental and operation charges necessary to complete the finished items of work as per drawings and as directed by Engineer-in-charge.

b) The porous plug/flap valve shall be installed in position in the filter drains in the bed normal to the canal slope in the local filters in the sides at the location shown in the drawings or as directed by the Executive Engineer.

c) **Flap valves:** Flap valves consisting of 40mm internal diameter polyvinyl chloride (P.V.C)pipe with P.V.C. flange and rubber flap shall be fabricated with all accessories as shown in the drawings. The flap valve shall be designed as to open automatically at a differential head of not more than 100 mm of water. The contractor shall arrange the performance tests of all the flap valves and those that do not conform to the specified functioning shall be rejected. Installation of flap valves shall not be permitted without the acceptance test of the same.

The flap valves shall be installed in position in the filter drains in the bed and normal to canal slope in the local filters in the side at the location shown in the drawings or as directed by the Engineer-in-charge.

The tendered unit price for this item of schedule 'A' shall be inclusive of the cost of manufacture, handling, testing and installation in position with excavation of pocket

and filling with filter material complete and shall be inclusive of all those operations as well as those defined in the nomenclature of the item.

d) **Porous plug**:

1) Wherever specified, the porous concrete shall be composed of one part of cement and 4parts of coarse aggregate (viz no fine concrete) by weight of not. more than 20 mm. size Only so much water shall be used in concrete as required to produce a paste which will coat the particles without filling the voids. In placing porous concrete in moulds, care shall be taken to ensure that it is not over tamped or compacted so as to reduce its porosity. The porous plugs after hardening (i.e. attains final setting) should be sprinkled and kept most for atleast 14days. The compressive strength of porous concrete at 7days age as determined by tests on 15 cm diameter, 30cm height cylinder should not be less than 70kgs/sq.cm and the porosity at 7days be such that water shall pass through slab of concrete 30cm thick at a minimum rate of 500liters/min/square meter of the flap with a constant 10cm depth of water on the slab.

2) Pre cast porous concrete plugs of 300 x 300 mm section size extending to full depth of canal lining shall be provided in bed and sides as shown in the drawings with filter materials.

3) The porous plugs shall be so inserted into the lining that their porosity is not lost or reduced when the concrete for the lining is vibrated.

15.5LAYING OF C.C. LINING:

a) **Scope** :- Laying cement concrete lining of specified thickness in M10 grade using a minimum cement of 310kg/cum. of concrete and 40mm. MSA machine crushed graded metal of specified variety including cost and conveyance of cement and all other materials of approved quality, seigniorage charges, sampling and testing preparing the base for laying concrete with weigh batching plant, machine mixing, conveyance of concrete with transit mixtures, placing of concrete in position and finishing SL 450 with paver finishing upto bed width of 2.00 M for less than 2.00 M bed width with acro gantry either by using machinery or by manual labour as specified in schedule 'A'. vibrating, finishing cutting grooves for panel joints, dewatering, curing, with water with a net work of pipeline system, hire and. operational charges of machinery, all leads, lifts, delifts, all water leads and all other incidental and operational charges necessary to complete the finished item of work of cast -in-site lining in bed/sides as per drawings and as directed by the Engineer-in-charge.

b) The work of laying in-situ cement concrete canal lining shall generally conform to IS. :3873--1978 and all concrete shall be governed by IS: 456-1978 concrete canal lining shall be done in the canal prism as shown in the drawings using well graded aggregate for 10 cm. thick lining shall be 40 mm. It shall be 20 mm. for lining thickness of 7.5 cms.

c) (i) Concrete shall be produced in a stationary weight batching and mixing plants/plants of adequate capacity installed at a suitable place by the contractor and concrete conveyed to the placement site/sites in transit mixes. The slump of concrete at placement site shall range shall from 50 mm. to 65 mm. with a water cement ratio of less than 0.6.

Alternatively : ii) Mobile self loading weigh batching mixing transporting equipment with adequate capacity of mixer drum, shall be deployed by the contractor for production of controlled concrete and transportation to the placement site/sites. Number of such equipment to be deployed shall be such as to achieve the construction schedule targets.

Alternatively., The Engineer-in-charge may allow the use of standard portable/stationary concrete mixes along with weight batching and measuring arrangement proportioning and protection of concrete and placement of concrete with conventional (manual) method.

15.6 Testing :

Concrete cubes at random shall be collected during laying concrete and shall be tested in the labs. If results are substandard, the entire work of the day on which cubes were collected shall have to be replaced by the contractor at his own cost.

15.6.1 Core Test : Securing and preparing test specimens from hardened concrete.

As specified in clause 4.1 of IS 1119-1959 (Bureau of Indian Standards Methods of sampling and analysis of concrete) cores shall be taken at random so as to ascertain the strength, permeability, thickness of concrete layer and cement content used. As the canal lining work progresses testing of output shall be on regular basis. Accordingly, to evaluate the quality of concrete lining completed, cores shall be taken as determined by the Engineer-in-charge. Broadly it could be one core each from bed lining completed and cured for 28 days in respective reaches. Frequency of drill cores shall be determined by the Engineer-in-charge. Broadly it could be one core each from bed lining per 200 Square meters (or even more at the discretion of Engineer-in charge of in -situ lining.

The cores shall be tested for compressive strength and if needed for permeability ,and cement content etc., as well. The cores shall be tested, for 28 days compressive strength.

The contractor shall allow all facilities and cooperation towards collection of cores. The testing of cores shall be carried out at the testing laboratories set up at the site or. at any other laboratory that the Engineer may so decide and the results given there by shall be considered correct and authentic by contractor. The contractor shall be given access to all operations and tests that may be carried out as aforesaid so that he may satisfy himself regarding the procedure and methods adopted . The payments shall be made only after satisfactory core test results acceptable to the Engineer-in-charge.

A standard test cylinder has a diameter one- half of its height (viz the length-L, diameter-D, ratio is 2). However, the cores taken from in situ lining shall not have these relative dimensions and consequently L/D ratio will not be 2. Accordingly the test strengths of the cores need to be corrected. The curve in Attachment- 1 may be used to correct the indicated strengths to make them comparable with those obtained from standard specimens. The contractor shall stack the cores properly in the sheds.

The criteria of acceptance of core strength shall be as outlined in IS : 456-1978.

15.6.2 Placing and compaction :

Sub-Grade well in advance for placement of lining. the sub -grade over which concrete is to be laid should be moistened adequately through very fine water spray so as to be

thoroughly moist (but not muddy) so that water cannot get withdrawn from freshly placed concrete. Spray nozzles should be used to assure an even application of moisture and to prevent local erosions.

15.6.2.1

a) Placing of concrete shall not be started until all form work, installation of parts to be embedded and preparation of surface upon which concrete is to be laid have been completed. All absorptive surfaces against which concrete is to be laid shall be moistened thoroughly so that moisture will not be withdrawn from freshly placed concrete. The surfaces, however, shall be free from standing water and mud.

b) In the placement register containing the list of various, work items in sequential order, the contractor or his representative shall write, " completed preparation of sub grade, earth work, installation of parts to be embedded as per specifications and ready for placing concrete and sign. Then the authorized representative of the Engineer-in-charge shall inspect and write in the Register against the item allowed for concreting; and sign. Then only, placing of concrete shall be commenced by the contractor. If concreting is not started within 24 hours after approval, it shall be got approved again.

c) Concrete shall be placed only in the presence of a duly authorized representative of the Engineer-in-charge.

d) Hand mixing of the concrete shall not be permitted under any circumstances.

e) Concrete shall be deposited in all cases as nearly as practicable in its final position and shall not be allowed to flow in a manner to permit segregation. Excessive separation of the coarse aggregate caused by allowing the concrete to fall freely from. too great height or at too great angle from the vertical shall not be permitted and where such separation would otherwise occur the Contractor shall provide suitable means to convey the concrete without allowing such separation.

f) Concrete shall be deposited and spread on the bed of the canal as indicated on the drawings. Concrete may be so laid as to facilitate placing, vibration, finishing and curing operations. Concrete required for keys as shown on the drawings shall be laid after placing side panels PCC. as directed by the Engineer-in-charge.

g) The design mix for lining shall to secure dense concrete of required strength for that grade.

h) The compaction shall be with suitable vibrators approved by the Engineer-in-charge. and it shall be effective so as to have durable impermeable concrete.

i) The concreting near the joints shall be done with utmost care so as to avoid segregation and collection of loose place of aggregate along form work which may result honey combing.

j) The concrete near the junction of the side concrete panels and bed concrete shall be done as shown in drawings such that both shall rest firmly against each other to resist any back kick from external hydrostatic forces.

k) When concrete placing operations are stopped for the day, interrupted because of break down or delayed by other causes of where the contractor selects to construct a joint such as would result from constructing one of the lining in one pass, the edge of the fresh concrete lining shall be bulk headed to a surface normal to the lining along transverse and longitudinal lines. Before placing operation are resumed the surface of the hardened concrete shall be prepared as construction joint. when ever a substantial break down occurs in the concrete production or concrete transportation system, a joint shall be formed as close to the face of the fresh concrete as possible.

l) The fresh concrete shall then be placed against the existing concrete with the full groove for required contraction joint formed in between them. The completed groove shall be sealed with sealing compounds as per clause 6.3 of IS : 3873-1978 and as shown in the drawings.

m) The contractor should use stationary weigh batching plant, transit mixtures, conveyer belt or any other machinery for transporting concrete and pavers for laying concrete. The quoted rates shall include hire operational charges of all the machinery, setting of machinery, dismantling of machinery and any other contingent works for the movement of machinery and making good after laying of lining.

n) **Compaction** : The concrete shall be compacted with vibrators to give a dense concrete which is durable and impermeable ensuring the desired strength. Concrete shall not be over vibrated. The vibration shall be sufficient to remove all undesirable air voids from the concrete including air voids trapped against the forms. After consolidation. the concrete shall be free from aggregate pockets and honeycomb areas and shall be classed against all surfaces of forms and embedded materials. All concrete shall be properly consolidated before initial setting and should not be subsequently disturbed.

Form vibrators shall be used in conjunction with slip form lining machines for consolidation. The Engineer-in-charge may remove samples of hardened concrete for testing and examination and the contractor shall replace at no extra cost to the department concrete from which such samples are removed.

15.6.3 Finishing :

a) The Contractor shall notify the Executive Engineer before commencing concrete finishing. Unless inspection is waived in each specific case, finishing of concrete lining shall will be performed only when a representative of the Engineer-in-charge. is present concrete surfaces will be tested by the Engineer-in-charge in accordance with para 5.6.1, where necessary to determine whether the concrete surface is within the specified tolerances. Finished concrete which is not in the specified tolerances shall be repaired as detailed below.

b) Immediately on the removal of forms, unsightly ridges or lips shall be removed and undesirable local bulging on exposed surfaces shall be remedied by tooling and rubbing. All exposed concrete surfaces shall be cleaned of impurities lumps or mortar or grout and unsightly stains.

c) Repairs to concrete surfaces and additions where required shall be made by cutting regular openings not less than 70 mm depth into the concrete and placing fresh concrete

to the required lines. The chipped openings shall be sharp. The fresh concrete shall be reinforced and chipped and troweled to the surface of the openings, the mortar shall be placed in layers not more than 20 mm. in thickness after being compacted and each layer shall be compacted thoroughly.

d) The surface of concrete finished against forms shall be even smooth and shall be free from projections, pockets, honeycombing and other objectionable defects.

e) The top portions of the side slopes of the canal lining extending 1.5 meter vertically below the top of the lining shall receive a nonskid, longitudinal brush finish as approved by the Engineer-in-charge.

f) Use of any finishing tool in areas where water has accumulated shall be prohibited and all finishing operations shall be delayed until the water has been absorbed evaporated or removed by draining, mopping or such other means.
(p)

15.6.4. Tolerances :

The permissible tolerances for the canal lining shall be as under in accordance with section 5.3 of IS : 3873-1978.

a) Departure from Established, alignment	± 20mm on straight reaches and + 50mm on partial curves or tangents.
b) Departure from Established grade	± 20mm on small canals.
c) Variation in thickness of lining.	± 10% provided average thickness is not less than specified .

15.6.5 Curing :

The bed lining shall be water -cured for 28days through provision of earth bunds of small height so that a column of water is available above the lining.

The joints of plain cement concrete slabs lining on side slopes shall be water cured through sprinkling of water at regular intervals for at least 21 days.

The Engineer -in-charge may instruct contractor to provide pipe line system and sprinklers for curing of the lining work, if the Engineer-in-charge feels that the manual curing is not sufficient. The contractor shall abide by the instructions and erect the pipe line system the quoted rate shall include for erection of pipe line system and dismantling of the pipes after curing instead of manual curing if the work involved is more in length and quantity.
If the contractor fails to do curing to the satisfaction of the Engineer, the latter shall make arrangements for curing at the risk and cost of the contractor or the lining work will be pulled down. The lining so pulled down shall be rebuilt by the contractor at his own cost.

15.6.6 Testing of Concrete and acceptance of work:

a) General : Systematic testing of the raw materials for concrete as well as the concrete shall be done both while it is fresh and after it has hardened by the quality control and inspection Division on representative samples taken at the site of laying the concrete in accordance with relevant Indian Standard Specifications.

b) Sampling Procedure and frequency :i) Sampling Procedure : A random sampling procedure shall be adopted to ensure that each concrete batch has a reasonable chance of being tested, that is the sampling should be spread over the entire period of concreting and cover all mixing units.

(ii) Frequency : The minimum frequency of sampling of concrete of each grade shall be in accordance with the following.

Quantity of concrete (cubic meter)	Number of Samples
1- 5	1
6-15	2
16-30	3
31-50	4
51 and above	4plus one additional for each additonal 50 cubic meters or part there of

NOTE : At least one sample shall be taken from each shift.

iii) **Test Specimen** : Three test specimens shall be made from each sample for testing at 28 days. Additional cubes may be required for various purpose, such as to determine the strength of concrete at 7days or at the time of striking form work, or to determine the duration of curing or to check the testing error. Additional cubes may also be required for testing by accelerated methods as described in IS: 9013-1978. The specimen shall be tested as described in IS : 516-1959.

iv) Test Strength of Samples : In all cases, the 28 days characteristic compressive strength specified based on laboratory tests shall be the criteria for acceptance or rejection of the concrete in so far as the strength of plain cement concrete lining is concerned.

The test strength of the samples shall be the average of there specimens. The test strength shall be greater than the specified strength. The over all coefficient of variation shall not be more than (+) 15 percent of the average for the three consecutive samples tested, not more than 20 percent of the specimen strength shall be less than 80% of the specified strength.

Contractor shall provide necessary skilled labour and facilities for transport, collection of samples, cores etc., and shall remain present at the time, when the samples, cores etc., are taken. Testing shall be carried out at the testing laboratory at the nearest Lab, or at any other laboratory that the Engineer may decide upon and the results given thereby shall be considered as correct and authentic and acceptable to the contractor. The contractor shall be given access to all operations and tests that may be carried out as aforesaid. All testing charges are to be borne by the contractor.

v) Core test :- The points from which cores are to be taken number of cores required shall be at the discretion of the Engineer-in-charge. In no case however shall, fewer three cores be taken and tested. Core shall be tested as described in IS : 516- 1959.

15.6.7 Acceptance Criteria:

a) The cores shall be tested for 28 days compressive strength. These shall be inspected, examined for segregation /honey combing and checking the thickness of lining. The Engineer-in-charge may also arrange to test the core for permeability and cement content, if considered necessary. Concrete in the member represented by core test shall be considered acceptable if the average equivalent cube strength of cores is equal to at least 85 percent of the cubic strength of the grade of concrete specified for the corresponding age and no individual core has a strength not less than 75 percent.

b) The density of concrete shall not be less than 85 percent of specified density of 2400kg/m3.

c) In case the concrete does not confirm to the accepted criteria for strength as specified above, the Engineer-in-charge reserves the right to reject the work or accept the same at a reduced rate derived from tendered rate and as approved by him after examining all aspects and provided structural integrity is not effected. In case, the cores taken from concrete lining panels exhibit heavy segregation or honey combing the Engineer shall reject the concerned panels and the contractor shall have to dismantle the same and have to cast new panels at his expense.

Whenever necessary for the purpose of obtaining economy , workability, density, impermeability, durability strength or on account of variation in the quality and gradation of aggregates or other materials, except cement the Executive Engineer shall based on laboratory tests make necessary changes in the proportion of mix and vibrators. Contractor shall have to affect these changes and will not be entitled to any compensation on account of such changes. Relevant para of IS : 456-1978. shall apply.

Regarding particular canal reach/reaches, though the lining be fully completed to acceptable quality levels, such reach/reaches will not qualify for acceptance and payment till the associated works necessary for safety of lining during rains, such as dowel banks, drainage are also completed along with.

d) The final payment shall be made only after satisfactory core tests acceptable to the Engineer-in-charge as per IS : 456-1978.

15.6.8 CONSTRUCTION JOINTS.

a) The concrete for sides and bed lining should be placed in alternate bays of not more than 3mts. Bays remaining in between may be filled after a gap of at least one day. The joint faces shall be treated with a primer at the rate of one litre per 4 sq.meter of joint surface area.

b) The shuttering should be clean, well oiled, smooth and firmly fixed to the sub grade and concrete near the shuttering properly placed and specially compacted.

c) Faces to be painted with sealing compound.

d) The concrete shall be laid continuously and the construction joints shall be left at the close of the day (or) 45 meters whichever is less vide clause in column 26.3 of IS. : 456/-1978.

15.6.9 MEASUREMENT AND PAYMENT :

All linear measurements shall be in meters, correct to 0.01 meter. Areas shall be computed in square meters, correct to 0.01 square, meters. The thickness of lining shall be determined in relation to final sub grade on which lining is to be laid. The thickness shall be cross checked by (i) Volume of concrete placed and area covered (ii) use of probe when concrete is given and (iii) cores if required. No separate payment will be made. It shall be included in the price Bid quoted in the Bill of Quantities.

15.7 JOINTS:

15.7.1 EXPANSION JOINTS:

a) Scope : Expansion joints of 12 mm. width shall be provided on each template where adjacent panels rest. The joints shall be filled in by 12 mm. thick asphaltic pads, when concrete lining is laid for canals in embankment or in cutting where subgrade does not get physically bonded with the joints. Where concrete lining in physical bond with subgrade such as in case of hard rock reaches, expansion joints need not be provided. The details of joint are shown in the drawings. Sealing compound in the joints shall conform to IS : 5256-1968, including cost and conveyance of all materials, labour charges, all leads, lifts and delifts complete for finished item of work to specifications as per drawings and as directed by the Engineer-in-charge.

b) Expansion joint shall not be provided except where structure intersects the canal lining.

c) In case of sandy soils it is preferable to provided felt/asphalt pad over template and in the vertical joint between the panels to prevent leakage through joint as shown in the drawings.

15.7.2 CONTRACTION JOINTS :

a) Scope : Providing contraction joints in bed, side lining including painting the grove with approved primer and filling grove with hot pour sealing compound of approved quality conforming to IS:5256-1968. including cost and conveyance of all materials, cleaning of groves, placing, dewatering, labour charges, all leads, lifts and delifts complete for finished item of work to specifications as per drawings and as directed by the Engineer-in-charge.

b) Contraction Joints shall be provided at places shown in the drawings or as directed by the Engineer-in-charge in accordance with the provisions laid down.

c) When lining is cast in panels, before laying cement concrete slabs, the top of the sleepers both in bed and side slopes shall be treated with two layers of sealing compound as prescribed in IS : 5256-1968 and as shown in drawings to reduce the leakage across the joints. Slabs shall be laid in alternate compartments with an interval of at least one day

for setting and contraction. The faces of the previously placed concrete shall be painted with sealing compound as prescribed in IS : 5256-1968. to ensure that no bonding takes place.

d) The grooves at the joints shall be of the size and shape as prescribed in (b) and filled with hot -applied sealing compound.

e) Filling of the joints with hot- applied sealing compound should be taken up after curing period is over. In the mean time the joints are liable to be filled with earth, which will be difficult to clean. It is, therefore, advisable to fill these joints with coarse sand during the curing period. The sand can be easily blown out from the joints when required.

15.7.2.1 : FILLER :

a) the grooves in canal lining shall be filled with sealing compound conforming to IS : 5256- 1968.

b) The grooves shall be clean and free from foreign substances when sealing compound is filled.

c) Grooves shall not be filled while it is raining or when there is free water in the grooves. The grooves shall be filled as soon as the concrete has become sufficiently stiff to prevent appreciable distortion of groove shape or damage to the concrete.

d) The expansion joint shall be filled with the mixture of following materials with proportion specified against each.

Maxphalt 80-100	30% by volume.
Sand	51% by volume
Cement	17% by volume
Hemp cut to into length	2% by volume
	100% by volume

15.7.2.2 MEASUREMENT AND PAYMENT:

No separate payment will be made. It shall be included in the price Bid quoted in the Bill Quantities.

PART B : MS PIPELINE

MS PIPELINES (Part -1)

The pipelines are used in this Project for Delivery Pipes, Manifolds and Pressure Mains. All pipes should be BIS marked only.

The pipeline shall be divided into sections by valves to avoid the necessity of emptying the whole pipeline in case of repair (in compliance with Clause No.6.16.14 of the CPHEEO manual). Each section being provided with an air valve and scouring facilities. The need for scour should be particularly borne in mind when layout of the pipeline and silting of the valves is finalized, as they cannot always be arranged in the best position due to likely difficulty in disposing of the discharge. They are necessary for scouring the mains and hence should be in proportion to the size of the main.

1. Manufacture and supply of M. S. Pipes :

For Delivery Pipes, Manifolds & Pressure Mains, the thickness of MS pipes shall be calculated as per the design requirements and allowances stated in IS:5822 and in AWWA (American Water Works Association) Manual M11- For steel pipes. The thickness provided shall also be subject to upward revision in surge analysis and as per site conditions requirement. No downward revision is permissible.

1.1. Applicable standards / codes

Following standards shall be referred for manufacture of M. S. pipes using **Structural Steel Sheets**. In all cases, latest revision of the standards / codes shall be referred to. If requirements of this specifications conflict with the requirements of the standards / codes, this specification shall govern.

IS 1916 :	Steel cylinder pipe with concrete lining and coating
IS 5822 :	Laying of electrically welded steel pipes for water supply
IS: 4853 :	Recommended practice for Radiographic inspection of fusion welded butt joints in steel pipes.
IS: 4260 :	Recommended practice for ultrasonic butt weld in ferric steel.
IS: 3600 : (Part-1)	Methods of testing fusion welded joints and weld mains in steel: part 1 cruciform fillet weld tensile test
IS: 4711 :	Sampling of pipe for various tests and criteria for conformity.
IS: 1894 :	Methods of tensile testing of steel tubes.
IS: 10748 :	Hot - Rolled Steel Strip for Welded Tubes and Pipes - Specifications
IS: 1730 :	Dimensions for Steel Plates, Sheets, Strips and Flats for General Engineer-in-Charge Purpose

1.2. Grade of steel

The steel used for manufacture of the pipes (HR coils) shall confirm to IS: 2062, grade-B or IS: 10748, grade - 3 or equivalent ISO. The dimension of HR coils shall conform IS: 2062.The quality of steel, chemical composition and tensile strength of the steel plates shall be as specified in IS: 3589 for steel of grade Fe 410. **tolerance as per IS: 3589 shall be allowed for plate thickness.**

1.3. Electrodes

The electrodes used for welding of steel plates shall confirm to IS: 814

1.4. Certificate for Steel Plates

Steel plates should confirmed to IS: 1730, Dimensions for Steel Plates, Sheets, Strips and Flats for General Engineer-in-Charge Purpose. The test certificate for the plates shall be issued by Plate Manufacturer.

1.5.Standard Length of pipes

The MS pipes shall be manufactured in lengths of 10 to 13m with beveled ends. Length of each pipe shall be measured at diametrically opposite four places and average of the four measured lengths shall be considered for measurements of pipe length.

1.6. Welding process

The pipes shall be manufactured by shop welding from steel plates, butt welded spirally or longitudinally by automatic submerged arc welding process using at least two runs, one of which shall be on the inner side of the pipes. Welding shall be so done that there will be through fusion and complete penetration and shall be free from cracks, oxides, and slag inclusion and gas pockets.

Longitudinally welded pipes shall have circumferential weld at not less than 1.8 m centre to centre. Longitudinal weld shall be staggered. Minimum distance between spiral welds should be 1.5 m.

1.7. Deviation in Length

Finished pipe length shall not deviate from straightness by more than 0.2 percent of the total length.

1.8. Radiographic / Ultrasonic test

Three percent of all seams of pipes, welded in the fabrication shop, shall be radio graphed at the end of pipe (as per IS: 4853) to render visible inspection of any internal defects such as blow holes, slag, inclusion of cracks. If any defects are detected, the metal at the location shall be chipped out and re-welded. In addition to the radiography of the joints, 100 percent testing by ultrasonic equipment (as per IS: 4260) shall also be done for welding tests. Any defects found out shall be rectified free of cost. Welds found deficient in quality shall be removed by chipping or melting and remade as per specifications. Chipping or cutting the weld shall not extend to the base metal.

1.9. Hydraulic Test at Works

Each pipe shall be hydraulically tested at manufacturer's works before applying any coating / lining.

1.10. Allowable tolerance

- Allowable tolerance for out side diameter shall be ± 0.75% of the specified diameter.

- Allowable tolerance for ovality shall not be more than 1% of the specified diameter.

1.11. Sampling and testing

Sampling and conformity criteria for various tests shall be as given in IS: 4711. The test samples shall be cut from pipes in the final condition of supply. Tests for tensile strength, percentage elongation, guided bend test, shall be carried out and the test values shall be in conformity with those specified in IS: 4711.

1.12. Inspection

The pipes ready in the manufacturer's work yard shall be inspected and tested before dispatch, by the employer and or inspecting agency appointed by the employer. All the tests including hydraulic test shall be carried out on specified number of samples from each lot as specified in IS: 4711, in presence of the inspecting agency. The internal painting shall be applied to the pipes only after the inspecting agency is satisfied regarding the test results, which shall be in conformity with the limits specified in IS: 4711.

2.0 Cement mortar coating (guniting) for external surface of MS pipes

2.1 General

The outside surface of the MS pipes and bends shall be provided with reinforced cement mortar coating for 25mm thickness, 1:3 proportions, applied by mechanical / pneumatic placement.

2.2 Material

Reinforcement

The reinforcement shall consist of BRC fabric of size 100 mm x 100 mm. x 3 mm. Reinforcement shall be free of oil, grease and other contaminants that may reduce the adherence between the coating and reinforcement. The BRC fabric shall be placed in the middle third of the coating. Mortar cover blocks shall be provided to place the BRC fabric properly. Splicing for fabric reinforcement, if required, shall have minimum 100 mm overlap.

2.3 Cement

Portland cement shall confirm to IS 269 / IS 8041 / IS 1489 and IS 8112.

2.4 Sand

Sand shall consist of inert materials having hard, strong, durable uncoated grains confirming to the requirements of IS 2116.

2.5 Water

The water used for guniting shall be clean, colour less, and free from injurious quantities of organic matter, alkali and salt. The maximum water cement ratio shall not exceed 0.45:1.

2.6 Cement mortar

The mortar applied by mechanical or pneumatic process shall consist 3 parts of sand and 1 part of cement by weight. The water in the mixture shall be carefully controlled

so that the mortar will not run, sag or segregate. The soluble chloride-ion (Cl) content of the cement mortar mix shall not exceed 0.15 percent, expressed as a percentage of cement weight. Rebound not exceeding one fourth of the total mix weight may be used as replacement material for fine aggregate only. Rebound not used within 1 hour shall be discarded.

2.7 Surface preparation

The outer surface shall be cleaned for oil grease etc. The dust shall be removed by compressed air or vacuum cleaner before placement of reinforcement. The BRC fabric reinforcement shall then be placed with required cover on the pipe surface.

2.8 Application

The pipe shall be supported on wooden logs at the ends to keep bottom clearance and to facilitate easy rotation while applying the coating. The mortar coating shall be applied in one or more continuous applications for achieving required thickness. If applied in more than one course, the interval between the first and last course shall not be more than 2 hours. The mortar shall be projected at high velocity against the exterior surfaces of the pipe with a pressure of 2.1 to 2.8 kg / cm^2 to produce a hard, tight adhering coating of specified thickness. The coating shall not be applied on ends of pipes for 100 mm length. Ends of coating shall be uniform and square to the longitudinal axis of the pipe. The rebound material unused shall be disposed off within a lead of 50m.

2.9 Placement temperature

The temperature of the cement mortar mix shall not be less than 4^0 C, nor shall the surface temperature of the MS pipe be greater than 35^0 C at the time of placement.

2.10 Curing

After the initial set of the cement mortar coating has taken place, the mortar coating shall be cured by the moist curing method. The coating shall be kept continuously moist by intermittent or continuous spraying of water for a period of at least 7 days.

2.11 Defective coating

If any sand pockets or porous spots occur, they shall be completely cut out and replaced by mechanical / pneumatic placement or hand application of mortar in proportion of 2 parts of sand and 1 part of cement, by weight.

2.12 Coating cracks

Care shall be taken to minimise the occurrence of cracks in the mortar coating. However, hairline cracks need not be repaired. The cracks, if developed, shall be repaired by brushing or wiping of neat cement in to the cracks, or painting of the cracks with epoxy coating or a combination of these methods shall be adopted.

3.0 Transportation of pipes for laying

Handling of the mortar coated pipes while transporting those from guniting yard, for laying and jointing purpose, shall be done very carefully to avoid any damage or development of cracks to the mortar coating. Any damaged portion shall be cutout and replaced. The pipes shall be laid in the trenches as early as possible after the curing period is over to avoid hair cracks in the coating due to temperature variations.

4.0 Coating for welded joint portion

After the welding and testing of the welded joints of MS pipeline, the BRC fabric reinforcement shall be provided over the joint. Cement mortar used for the joints shall be composed of one part of cement to not more than two parts of sand, by weight, thoroughly mixed with water to the consistency of thick cream. Sand shall be graded confirming to the requirements of ASTM C33, except that 100% shall pass a US standard sieve number 16.

5.0 Testing

5.1 Adsorption test

Water adsorption tests shall be performed on samples of cured cement mortar coating taken from each working shift. The samples shall have been cured in the same manner as the pipe. A test value shall consist of the average of a minimum of three samples taken on the same day from the same work shift. The test method shall be in accordance with ASTM C497, method A. The average adsorption value for any ten consecutive tests from a working shift shall not exceed 10% and no individual sample shall have an adsorption value exceeding 12%.

Tests for each working shift shall be performed on a daily basis until conformance to the adsorption requirements has been established by 10 consecutive test values not exceeding 10%, at which time testing may be performed on a weekly basis for each working shift. Daily testing shall be resumed for each working shift whenever an adsorption test result exceeds 10%. Daily testing shall be maintained until conformance to the adsorption requirements is reestablished by 10 consecutive test values not exceeding 10 percent.

The contractor shall maintain the record of the adsorption tests and shall submit the same to the Engineer-in-Charge weekly.

5.2 Inspection

The tests performed shall be inspected by the Engineer-in-Charge. If any sample fails to meet the requirements, the contractor shall be notified immediately. Material affected by the test r4esults shall be set aside pending final disposition

5.3 Rejection

Material and pipe that are noticed to be defective or that do not confirm to the requirements will be subject to rejection at any time prior to final acceptance of the

pipe. Rejected material and pipe shall be removed from the work site within a week after rejection without any liability to the Govt.

6.0 Internal Epoxy coating to MS pipes and specials

6.1 General

Epoxy coating is proposed for internal surface in all conditions and for external surface of the MS pipes laid above ground on pedestals and outer surface of tees, manholes, covers and eccentric reducers.

6.2 Material

The coating shall have one coat of two-part, chemically cured inhibitive Epoxy primer and two coats of a different two-part, chemically cured, solvent free, and spray applied epoxy paint. The coating system shall meet the performance requirements of relevant IS code or AWWA C-210 standard.

6.3 Surface preparation:

6.3.1 Cleaning

Prior to abrasive blast cleaning, the external surface shall be cleaned to remove oil, grease or other foreign matter. Only approved solvents that do not leave a residue shall be used for cleaning.

6.3.2 Abrasive blast cleaning

The surface shall be abrasive blast cleaned to achieve a white metal surface. Prior to blast cleaning, any sharp protuberances, surface laminations, weld spatter, etc shall be removed by through cleaning and grinding. The abrasive used should be capable of producing a minimum profile of 50-75 microns corresponding to "medium" in accordance with BS: 7079 part C4.

7.0 Application of Epoxy coating:

7.1 Atmospheric conditions

Prepared surfaces must be completely cleaned of dust and dirt by brush or vacuum cleaner and shall be thoroughly dry. Coating shall not be applied in the following atmospheric conditions.

- Relative humidity exceeding 85%
- When the surface to be coated is less than 3^0C above the due point
- The surface temperature is less than 7^0C or greater than 50^0C.

7.2 Successive coats

After application of the first coat, the next coat shall be applied within the time limits, surface conditions, and temperature recommended by the manufacturer.

7.3 Coating thickness

Final thickness of the coating shall not be less than 400 micron DFT. The coating shall be applied leaving 15 cm at the edge of pipes / specials for welding of the joint. Coating on this portion shall be applied after welding the joint.

7.4 Preheating

The temperature of mixed coating and that of the pipe at the time of application shall not be lower than 10^0C. Preheating of the coating material, the use of inline heaters to heat the coating material; or heating of the pipe, fittings or specials may be used to facilitate the application. Heating shall confirm to the recommendations of the coating material manufacturer.

7.5 Touch up and repair procedure

The finished coating shall be inspected for damage or reduced thickness. Any such areas shall be repaired by thoroughly degreasing the surface and abrading using 180 grade abrasive papers, the abraded areas shall extend from the edge of the damage for 50–75 mm on to surrounding sound coating. The prepared surface can then be re-coated.

7.6 Final curing

Sufficient curing period shall be allowed after application of the coating as per standards for the coating to gain required strength. The epoxy applied pipes; specials shall be stored for curing in accordance with the durations given in the specifications.

7.7 Electrical inspection for continuity

After curing, the coating shall be tested for holidays according to the procedures and using the voltage settings. Any holidays indicated by the detector shall be got repaired.

7.8 Coating of joints after welding

The joint portion shall be cleaned thoroughly as stated above and coated in required coats for same thickness i.e. 400 micron DFT.

8. Excavation for Pipe Line Trenches

8.1. Excavation for Pipe Line Trenches

The excavation is carried out by hand or by machine.

8.2. Site Clearance

The pipe line alignment shall be cleared of all bushes, shrubs, roots, grass, weeds and if required trees, coming in the alignment of pipe line in the trench width portion. The rates for excavation shall cover all such site clearance work and no extra payment will be allowed on this account.

8.3. Alignment marking

After the work site is cleared as above, pipe line alignment with required trench width shall be marked on the ground with apex points, curves etc, as shown on the drawings

or as directed by the Engineer-in-Charge in charge for the stretch where the work is to be started. The contractor shall provide all labour, survey instruments, and materials such as strings, pegs, nails, bamboos, stones, mortar, concrete etc. required for setting out and establishment of bench marks. The contractor shall be responsible for the maintenance of bench marks and other marks and stakes as long as they are required for the work in the opinion of the Engineer-in-Charge.

8.4. Working survey

Working survey of the pipeline alignment shall be carried out by the contractor before start of the excavation work. The contractor shall provide all the instruments such as leveling instruments, steel tape, ranging rods, strings, pegs etc. for carrying out the survey. Based on the working survey, the alignments, L-section (depth of laying), grade, and location of specials, valves and chambers shall be finalized and got approved from the competent authority. The gradient and alignment shall be such that minimum horizontal and vertical bends shall be required.

8.5 Use of Machinery:

All excavations shall be carried out by mechanical equipments / machinery unless, in the opinion of the Engineer-in-Charge, the work involved and time schedule permit manual excavation.

8.6 Trench Width and Depth:

All buried pipelines shall be minimum 1.2 meter below ground level.

The trench width for respective pipe diameters permissible as required under respective IS code for Pipeline laying and installation.

The trench width shall be constant through out the trench depth, which will provide a clearance of about 0.30 m on either side of the pipe line.

The contractor may, for the facility of work or similar other reasons, excavate and also backfill later, if so approved by the Engineer-in-Charges, at his own cost, outside the allowable trench width specified above. Should any excavation be taken below the specified trench bottom, contractor shall fill it up to required level, at his own cost, with the same material available at the trench bottom including watering and compaction.

The excavation shall be taken down to such depths as shown in drawings. Excavation for extra depth equal to the thickness of proposed pipe bedding shall be done below pipe soffit level for providing bedding below pipe line. The trench bottom shall be excavated to proper grade as shown on drawings. The contractor shall provide site rails and leveling instruments required for checking the grade during excavation, bottom bedding and pipe laying Projections in rock excavation shall be removed by chipping.

The contractor shall carryout extra excavation at the pipeline joints to be welded, as required (minimum 0.6 m deep and 0.9 m lengthwise, all around the pipe), for facilitating proper welding of the bottom joint from out side.
The work of trench excavation should be commensurate with laying and jointing of the

pipe line. It should not be dug in advance for a length greater than 500 m ahead of work of laying and jointing of pipeline unless otherwise permitted by the Engineer-in-Charge.

The minimum cover on pipe is to be maintained 1.2 meter. However the cover on pipe may be modified to suite gradients and site conditions as per direction of Engineer-in-Charge.

8.7. Barricading and Guarding:

To protect persons from injury and to avoid damage to property, adequate barricades, construction signs, red lanterns and guards as required shall be placed and maintained during the progress of work, till filling of the trenches after pipes are laid and jointed. The lighting, barricading, guarding of the trenches and the maintenance of watchman shall be done by the contractor at his cost.

All precautions shall be taken during excavation and laying operation to guard against possible damage to any existing structures, under ground cables, pipe lines of water, gas, sewage etc. Any damage done to such properties will have to be repaired / rectified by the contractor at his cost. The Contractor has to ensure the following:

- safety protections as mentioned above have to be incorporated in the work process
- hindrances to the public have to be minimized
- the trench must not be eroded before the pipes are laid
- the trench must not be filled with water when the pipes are laid
- the trench must not be refilled before laying of the pipes

The bed for the laying of the pipes has to be prepared according to the L-Section immediately before laying of the pipes.

8.8. Reuse of surface material

All surface materials, which in the opinion of the Engineer-in-Charge, are suitable for reuse in restoring the surface shall be kept separate from the general excavation material, as directed by the Engineer-in-Charge.

8.9. Stacking of excavated material

All excavated materials shall be stacked in such a manner that it does not endanger the work and avoids obstructing foot paths and roads. Hydrants under pressure, surface boxes, fire and other utility controls shall be left unobstructed and accessible until the work is completed. Gutters shall be kept clean or other necessary provisions made for street drainage and natural water courses shall not be obstructed. All the excavated material shall be the property of the Employer and shall be stacked or disposed off as directed by the Engineer-in-Charge.

8.10. Maintenance of traffic

The work of excavation and pipe laying shall be carried in such a manner that it causes the least interruption to traffic and the road / street may be closed in such a manner that it causes the least interruption to the traffic. Where it is necessary for traffic to cross

open trenches, suitable bridging arrangement shall be provided. When the street is closed for traffic, suitable signs indicating that street is closed shall be placed and necessary detour signs for proper maintenance of traffic shall be provided.

8.11. Structure protection

Temporary support, adequate protection and maintenance of all underground and surface structures, drains, sewers and other obstructions encountered in the progress of work shall be furnished under the direction of the Engineer-in-Charge. The structures which have been disturbed shall be restored upon completion of work.

8.12. Protection of property

Trees, shrubbery fences, poles and all other property shall be protected unless their removal is allowed by the Engineer-in-Charge. When it is necessary to cut roots and tree branches, such cutting shall be done under the supervision and direction of the Engineer-in-Charge.

8.13. Avoidance of existing services

As far as possible, the pipeline shall be laid below existing services, such as water and gas pipes, cables, cable ducts and drains but not below sewers. Excavation of the trenches shall be carried out to the required depth accordingly. If it is unavoidable, the pipeline shall be suitably protected and lesser trench depth in such cases can be allowed. A minimum clearance of 150 mm shall be provided between the pipeline and such other services. When thrust or auger boring is proposed for laying pipeline across roads, railway or other utilities, larger clearance as required shall be provided. Adequate arrangements shall be made to protect and support the other services during excavation and pipe laying operations. The work shall be so carried out as not to obstruct access to the other services for inspection, repair and replacement. When such utilities are met with during excavation, the authority concerned shall be intimated and arrangements made to support the utilities in consultation with them.

8.14. Bailing out of Water

During the excavation if subsoil water is met with, contractor shall provide necessary equipment and labour for dewatering the trenches. If pumping out subsoil water is found necessary, contractor shall provide sufficient number of pumps for the same. The tendered rate shall cover all costs for bailing out of water including hire charges of pumps, cost of diesel and labour etc and hence, no extra payment shall be allowed.

8.15. Disposal of loose boulders etc

All loose boulders, semi detached rocks, (along with earthy stuff which might move therewith), not directly in the excavation but close to the area to be excavated, as to be liable, in the opinion of the Engineer-in-Charge, to fall or other wise endanger the workman equipments, or the work etc, shall be stripped off and removed away form the area of the excavation. The method used shall be such as not to shatter or render unstable or unsafe the portion which was originally sound and safe.

8.16. Disposal of Excavated Material

All the excavated surplus material shall be disposed off on muck area with due consultation of Engineer in Charge.

9. Moorum / Sand Bedding below Pipeline

In case of hard rock before lowering of the MS pipes in trenches, a layer of selected moorum, shall be provided below the MS pipe line to act as bedding. The bedding shall be compacted properly including required watering and the thickness of well compacted layer shall not be less than 150 mm. The bedding shall be provided for full trench width with proper grade as shown on drawings.

10. Refilling the trenches

10.1. Use of selected excavated material

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

Selected surplus spoils from excavated material shall be used as backfill. Fill material shall be free from clods, salts, sulphate, organic or other foreign material. All clods of earth shall be broken or removed. Where excavated material is mostly rock, the boulders shall be broken into pieces not larger than 150 mm size, mixed with properly graded fine material consisting of murum or earth to fill up the voids and the mixture used for filling.

10.2. Back Filling

All excavations shall be backfilled to the level of the original ground surfaces unless otherwise shown on the drawings or ordered by the Engineer-in-Charge in Charge, and in accordance with the requirements of the specification. The material used for backfill, the amount thereof, and the manner of depositing and compacting shall be subject to the approval of the Engineer-in-Charge in Charge, but the Contractor will be held responsible for any displacement of pipe or other structures, any damage to their surfaces, or any instability of pipes and structures caused by improper depositing of backfill materials.

The back filled layers shall be wetted and compacted to a density of not less than 90 percent of the maximum dry density at optimum moisture content of the surrounding material. Any deficiency in the quantity of material for backfilling the trenches shall be supplied by the Contractor at his expense.

The Contractor shall at his own expense make good any settlement of the trench backfill occurring after backfilling and until the expiry of the defects liability period.

On completion of pressure and leakage tests exposed joints shall be covered with approved selected backfill placed above the top of the pipe and joints in accordance with the requirements of the above specifications. The Contractor shall not use backfilling for disposal as refuse or unsuitable soil.

10.3. Fillings of the trench excavated in rock

In case of excavation of trenches in rock, the filling up to a level of 30 cm above the top of the pipe shall be done with fine materials, such as soft soil, murrum etc. The filling up of the level of the centre line of the pipe shall be done by hand compaction in layers not exceeding 15 cm, whereas the filing above the centre line of the pipe shall be done by hand compaction or mechanical means in layers not exceeding 15 cm. The filling from a level of 30 cm above the top of the pipe to the top of the trench shall be done by mechanical methods with broken rock filing of size not exceeding 15 cm mixed with fine material as available to fill up the voids.

10.4. Consolidation

The consolidation of the filled material shall be done to attain not less than 90 percent of the maximum dry density. The density of the filled and compacted material shall be tested regularly and record maintained accordingly.

11. Lowering, laying and jointing of MS pipes

11.1. Standards

Except as otherwise specified in this technical specification, the Indian Standards and Codes of Practice in their latest version, National Building code, I & CAD specification of the state of Telangana and Manual of water supply of GOI shall be adhered to for the, handling, laying, installation, and site testing of all material and works.

11.2 Tools and equipment

The contractor has to provide all the tools and equipment required for the timely, efficient and professional implementation of the work as specified in the various sections of the contract and as specified by the instructions of manufacturers of the pipes and other material to be handled under this contract. On demand he shall provide to the Engineer-in-Charge a detailed list of tools and equipment available. If in the opinion of the Engineer-in-Charge the progress or the quality of the work cannot be guaranteed by the available quantity and type of tools and equipment the contractor has to provide additional ones to the satisfaction of the Engineer-in-Charge. The Contractor will always have a leveling instrument on site.

11.3 Handling, transportation of pipes and specials

The Contractor has to transport the pipes and other materials from manufacturer or site store yard / guniting yard to the site of laying as indicated by the Engineer-in-Charge in Charge. Pipes should be handled with care to avoid damage to the surface and the socket and spigot ends, deformation or bending. Pipes shall not be dragged along the ground or the loading bed of a vehicle. Pipes shall be transported on flat bed vehicles/trailers. The bed shall be smooth and free from any sharp objects. The pipes shall rest uniformly on the vehicle bed in their entire length during transportation. Pipes shall be loaded and unloaded by suitable mechanical means without causing any damage to the stacked pipes.

The transportation and handling of pipes shall be made as per IS 12288 and IS 5822. Handling instructions of the manufacturers of the pipes shall be followed. All precautions set out shall be taken to prevent damage to the protective coating, damage of the jointing surfaces or the ends of the pipes.

Whatever method and means of transportation is used, it is essential that the pipes are carefully placed and firmly secured against uncontrolled movement during transportation to the satisfaction of Engineer-in-Charge in charge.

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Cranes or chain shall be used for loading and un-loading of heavy pipes. However, for pipes up to 400 mm nominal bore, skid timbers and ropes may be used. Where using crane hooks at sockets and spigot ends, hooks shall be broad and protected by rubber or similar material, in order to avoid damage to pipe ends and lining / coating. Damage to lining / coating must be repaired before pipe laying according to the specifications mentioned elsewhere and as per instructions of the Engineer-in-Charge in charge. Pipes shall not be thrown directly on the ground.

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When using mechanical handling equipment, 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 shall be controlled by the use of guide ropes in order to prevent damage caused by pipes bumping together or against surrounding objects.

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Rolling or dragging pipes along the ground or over other pipes already stacked shall be avoided.

11.4 Stringing of pipes along the alignment

The pipes shall be laid out properly along the proposed alignment in a manner that they do not create any significant hindrance to the public and that they are not damaged. Stringing of the pipes end to end along the working width should be done in such a manner that the least interference is caused in the land crossed. Gaps should be left at intervals to permit the passing of equipment across the working area. Pipes shall be laid out that they remain safe where placed and that no damage can occur to the pipes and the coating until incorporated in the pipeline. If necessary, pipes shall be wedged to prevent accidental movement. Precautions shall be taken to prevent excessive soil, mud etc. entering the pipe.

11.5 Laying and jointing of pipes- following Specifications are detailed herein for laying and jointing

11.5.1. Laying of pipes below ground - guniting as per IS specifications

11.5.1.1. General

After the trench is made ready with bedding, and after the jointing pits are excavated at the joint position, the gunited and lined pipes shall be lowered in the trenches.

The MS pipe ends shall be cleaned with special care to ensure that they are free from dirt and unwarranted projections. The whole of the pipes shall be placed in position singly and shall be laid true to profile and direction of slope indicated on longitudinal sections. The pipes shall be laid without deflection in a straight alignment between bends and between high and low points. The alignment and levels shall be checked by the contractor with suitable equipment.

Before pipes are jointed they shall be thoroughly cleaned of all earth lumps, stones, or any other objects that may have entered the interior of the pipes.

Pipes and the related specials shall be laid according to the instructions of the manufacturers and using the tools recommended by them.

Cutting of pipes shall be reduced to a minimum required to conform to the drawings. Cutting has to be made with suitable tools and according to the recommendations of the manufacturer without damage to the external coating and internal lining. The spigot end has to be beveled again at the same angle as the original beveled end. While assembling the pipes the ends shall be brought close enough to leave a uniform gap not exceeding 3 mm. Marginal cutting shall be done if found necessary, for which no extra payment shall be admissible. There shall be no lateral displacement between pipe faces to be jointed. After the pipes are properly assembled and checked for the correct line and level, tack welding for the pipe joint shall be done. Final welding of the joint from inside and outside shall be done thereafter.

11.5.1.2. Straps

Whenever the pipe laying work proceeds from two ends and if gap remained between two faces is less than 30 cm, such gap shall be bridged by providing a strap. Strap shall also be provided during fixing of expansion joint for above ground pipeline. Such strap shall be fabricated on site by cutting a piece from the pipe. This piece shall be split longitudinally and stepped over the gap. A minimum overlap of 2 times of the thickness shall be provided on both the pipe ends to be connected. The strap shall be welded with pipe ends with required number of fillet welds from inside and outside. The gap between ends of the strap shall be butt welded longitudinally.

11.5.1.3. Distance piece

Distance piece shall be provided when the gap between pipe faces to be jointed is more than 30 cm. Distance pieces shall be cut from pipe pieces for required length either on site or in factory. Payment shall be as per the laying and jointing of pipeline item.

All specials like bends, tees etc. and appurtenances like sluice or butterfly valves etc. shall be laid in synchronization with the pipes. The Contractor has to ensure that the specials and accessories are ready in time to be installed together with the pipes.

At the end of each working day and whenever work is interrupted for any period of time, the free ends of laid pipes shall be protected against the entry of dirt or other foreign matter by means of approved plugs or end caps.

When pipe laying is not in progress, the open ends of installed pipe shall be closed by approved means to prevent entrance of trench water and dirt into the line. No pipe shall be laid in wet trench conditions that preclude proper bedding, or when, in the opinion of the Engineer-in-Charge, the trench conditions or the weather are unsuitable for proper installation. The pipe line laid should be absolutely straight unless planned otherwise. The accuracy of alignment should be tested before starting refilling with the help of stretching a string between two ends of the straight stretch of pipes to rectify possible small kinks in laying.

11.5.2. Laying of pipes above ground

11.5.2.1 General

Above ground pipe line shall have epoxy coating on inner and outer surfaces.
Laying of pipeline shall be started only after sufficient number of chairs / pedestals have been casted as per design which shelled not be less than 0.6 m in width to required level and have achieved their final strength including fixing of the bearing plates and roller bearings.

The contractor shall lay the pipeline to the exact line and level as shown on the drawings, or as directed by the Engineer-in-Charge.

11.5.2.2 Laying procedure

The pipe laying shall start from the successive fixity points towards expansion joint, if proposed in that stretch. Depending upon the distance between the successive chairs, and the length of the pipes fabricated, two pieces may be welded on site before laying so that after laying the pipe rests on next chair and overhangs for at least half the length of pipe.

Normally not more than one pipe shall be aligned, tacked and kept in position on the chairs at a time. During assembly, the pipes shall be additionally supported on adequate wooden sleepers or scaffolding as necessary, kept between the chairs / pedestals. While assembling the pipes, the ends shall be brought to leave a uniform gap not exceeding 3 mm. The ends shall be tack welded to align the pipe properly.

Full welding of the circumferential joint shall be done only after the Engineer-in-Charge has checked the correctness of the alignment and level. Further laying of pipes shall not be undertaken unless full welding of the circumferential joints of the piped laid earlier is completed. Expansion joint shall be fixed at the location shown on drawing or as directed by the Engineer-in-Charge.

11.6. Welding the joints

11.6.1. General

Before aligning, assembling and welding, the pipe faces shall be cleaned by scrapping with wire brushes or by any other approved method.

Welding of pipes in field shall confirm to IS: 816 (code of practice for use of metal arc welding for general construction in mild steel). Electrodes used for welding shall comply with IS:814. In case of variation, specifications hereunder shall have precedence.

Welders shall be qualified and well experienced and shall be approved by the Engineer-in-Charge. Contractor shall remove such of the welders from the job whose work is not satisfactory.

The contractor shall keep record of the welding for each circumferential joint. It shall contain the name of the welder, date of completion of the welding runs internal as well as external.

11.6.2. Gouging and chipping

MS pipes to be jointed are large in diameter and hence the joints shall be welded with required numbers of runs from one side and a sealing run from other side. External sealing run shall be done only after internal welding is completed. Before starting the external welding, the weld material in the joint shall be cleaned by chipping out loose scales. Gauging shall be done before rectification of any defective welding wherever necessary and as directed by Engineer-in-Charge.

Gauging and chipping shall not be paid separately and the rate for welding shall be deemed to include the cost of gauging and chipping.

11.6.3. Electrodes

Welding electrodes shall confirm to IS: 814. The contractor shall use electrodes depending on thickness of the plates to be welded and the type of joint. The contractor shall use standard current and AC voltage required for the machine as per manufacturer's directions.

11.6.4. Type of joints

The circumferential joints of the pipes shall have butt welded with required number of runs externally and internally.

All the fillet welds / lap welds shall have throat thickness not less than 0.8 times the thickness of the pipe to be welded.

11.7. Testing of welded joints

Welded joints shall be tested in accordance with the procedure laid down in IS: 3600, Method of testing fusion welded joints and weld metals in steel.

At least one test specimen shall be taken out for testing for every 50 field joints. Test pieces shall be taken out from the places pointed out by the Engineer-in-Charge. These shall be machined and tested as early as possible.

The shape of the test pieces removed for testing shall be such that it shall give the specimen of the required dimensions with the weld in the middle of the specimen. It must ensure good butt weld.

11.7.1. Tensile test

The test specimen taken perpendicularly across the weld shall be shaped in accordance with IS: 3600 (part 3). The tension test specimen shall be machined. The protruding welded portion from inside as well as outside shall be removed by machining before the specimen is tested. The specimen shall be tested in tension in accordance with IS: 1608

If the specimen shows defective machining or develops flaws not associated with welding, it shall be discarded and another specimen substituted. The welded joint shall show strength not less than the minimum tensile strength for the plate in accordance with IS: 226.

11.7.2. Bend test

Bend test specimen shall also be prepared in the same fashion as the tensile test specimen. The specimen shall be bent cold 180^0 around a pin that has a diameter equal to 4 ½ time the plate thickness, without developing cracks. For this test, face representing inside of the pipe shall be placed next to the pin.

11.7.3. Tree-panned plugs

Tree-panned plugs shall be taken out from any welded portion as pointed out by the Engineer-in-Charge. These plugs shall not show any defects in welding such as inclusion of slag, blow holes, cavities, etc. The plug shall be 12 mm in diameter and shall be taken out by means of suitable electrically operated machine. Such holes in the pipe shall either be filled back by inserting a steel stud and welding around or threading the hole and providing suitable GI plug. This test shall be done if considered necessary by the Engineer-in-Charge.

11.7.4. Non-destructive tests

Non-destructive testing of the completed weld shall be carried out on pipelines by radiographic method as specified under IS: 4853 or ultrasonic method as per IS: 4260. Non-destructive test for every 50 joints shall be carried out.

11.8. Procedure on failure of test specimen

If the test specimen fails in either tensile or bent test or in both, two additional test specimens shall be taken out from the section and shall be tested again for both the tests. If any one of them fails, extensive gouging and repairing shall be carried out for the welded joints in that section to the full satisfaction of the Engineer-in-Charge in charge. However, if both the samples give satisfactory results, the joint from which the original sample was taken and had failed, shall be repaired at contractor's cost.

Welder who has done the welding of the joint that has failed shall be solely held responsible for bad workmanship and failure. Since all other factors like electrodes, current, arc voltage, etc are already controlled; negligence on the part of the welder only is responsible for such failure. For first such failure, the welder shall be warned and if the failure is repeated, he shall be removed from the job.

11.9Anchoring of the pipeline:

Reinforced concrete thrust blocks shall be provided at each bend, tee, taper, end piece to prevent undue movements of the pipeline under pressure. They shall be constructed as per design done by ENGINEER-IN-CHARGE considering the highest pressure during operation or testing of the pipes, the safe bearing pressure of the surrounding soil and the friction coefficient of the soil.

12. Field Hydraulic testing of the pipelines

12.1 Sectional tests

After laying and jointing the pipeline shall be tested for tightness of barrels and joints, and stability of thrust blocks in sections approved by the Engineer-in-Charge in Charge. The length of the sections depends on the topographical conditions. Preferably the pipeline stretches to be tested shall be between two chambers (air valve, scour valve, bifurcation, other chamber).At the beginning, the Contractor shall test stretches for suitable lengths to suit the site requirements. The hydraulic testing shall have to be commenced immediately after laying and jointing.

The water required for testing shall be arranged by the contractor himself. The Contractor shall fill the pipe and compensate the leakage during testing. The Contractor shall provide and maintain all requisite facilities, instruments, etc. for the field testing of the pipelines. The testing of the pipelines generally consists in three phases: preparation, pre-test/saturation and test, immediately following the pre-test. Generally, the following steps are required which shall be monitored and recorded in a test protocol.

- Complete setting of the thrust blocks.
- Partial backfilling and compaction to hold the pipes in position while leaving the joints exposed for leakage control
- Opening of all intermediate valves (if any)
- Fixing the end pieces for tests and after temporarily anchoring them against the soil (not against the preceding pipe stretch)
- At the lower end with a precision pressure gauge and the connection to the reciprocating pump for establishing the test pressure
- At the higher end with a valve for air outlet
- If the pressure gauge cannot be installed at the lowest point of the pipeline, an allowance in the test pressure to be read at the position of the gauge has to be made accordingly

- Slowly filling the pipe from the lowest point(s).
- The water for this purpose shall be reasonably clear and free of solids and suspended matter
- Complete removal of air through air valves along the line.
- Closing all air valves and scour valves.
- Slowly raising the pressure to the test pressure while inspecting the thrust blocks and the temporary anchoring.
- Keeping the pipeline under pressure for the duration of the pre-test / saturation of the lining by adding make-up water to maintain the pressure at the desired test level. Make up water to be arranged by Contractor himself at his own cost.
- Start the test by maintaining the test pressure at the desired level by adding more make-up water; record the water added carefully and the pressure in intervals of 15 minutes at the beginning and 30 minutes at the end of the test period.

The pipeline stretch will pass the test if the water added during the test period is not exceeding the admissible limits. No section of the pipe work shall be accepted by the Engineer-in-Charge in Charge until all requirements of the test have been obtained.

12.2. Hydraulic test for MS pipes

12.2.1 Field test pressure

The sections of MS Storm Water Pumping mains shall be tested for the pressures as worked out in detailed designed.

12.2.2 Test requirement

The quantity of water added in order to re-establish the test pressure should not exceed 0.10 liter per mm of pipe diameter per km of pipeline per day for each 30 m head of pressure applied.

All pressure testing at site should be carried out hydrostatically. The pipes shall be accepted to have passed the pressure test satisfactorily, if the quantity of water required to restore the test pressure does not exceed the amount calculated as above.

12.3 Failure to pass the test

All pipes or joints which are proved to be in any way defective shall be replaced or remade and re-tested as often as may be necessary until a satisfactory test shall have been obtained. Any work which fails or is proved by test to be unsatisfactory in any way shall be redone by the Contractor.

12.4 Back filling

Water used for testing should not be carelessly disposed off on land which would ultimately find its way to trenches

On completion of a satisfactory test any temporary anchor blocks shall be broken out and stop ends removed. Backfilling of the pipeline shall be completed.

12.5. Flushing and disinfecting of pipelines

After testing and commissioning the contractor shall flush the pipes with a velocity not less than 1 m/s or as approved by the Engineer-in-Charge in Charge. Disinfection of drinking water pipelines should be done by Contractor.

MS PIPES (Part 2 - SUPPLY OF MS PIPES AND SPECIALS, VALVES, LAYING AND JOINTING OF PIPELINES)

1.1General

1.1.1Standards

Except as otherwise specified elsewhere in this tender document, the Indian/International Standards and Codes of Practice in their latest version_shall be adhered to for the design manufacturing, inspection, factory testing, packing, handling and transportation of product wherever applicable. Should any product be offered conforming to other standards, the equipment or products shall be equal to or superior to those specified and the documentary confirmation shall be submitted for the prior approval of the Engineer.

This specification requires a reference to the following standard specifications:

IS: 2062	Specification for steel for general structural purposes
IS: 808	Specification for dimensions for hot rolled steel beam, column, channel and angle sections
IS: 814	Specification for covered Electrodes for manual metal arc welding of carbon and carbon manganese steel.
IS: 3613	Acceptance tests for wire flux combination for submerged arc welding.
IS: 7280	Specification for bare wire electrodes for submerged arc welding of structural steel
IS: 1367	Technical supply conditions for threaded steel fasteners
IS: 2016	Specification for plain washers.
IS: 2074	Specification for ready mixed paint air drying, red oxide zinc chrome and priming
IS: 102	Ready mixed paint, brushing, red lead, non-setting, Priming.
IS: 1786	Specification for high strength deformed steel bars and wires for concrete reinforcement.
IS: 432 (Part-I)	Specification for mild steel & medium tensile steel bars and hard drawn steel wire for concrete reinforcement: Mild steel and medium tensile steel bars
IS: 432 (Part-II)	Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement: Hard drawn steel wire
IS: 269	Specification for 33 grade ordinary Portland cement
IS: 8041	Specification for rapid hardening Portland cement.
IS: 383	Specification for coarse and fine aggregates from natural sources for concrete
IS: 12330	Specification for sulphate resisting Portland cement
IS: 456	Code of practice for plain and reinforced concrete
IS: 800	Code of practice for general construction in steel
IS: 816	Code of practice for use of metal arc welding for general construction

	in mild steel
IS: 4353	Recommendation for submerged arc welding of mild steel & low allow steels
IS: 817	Code of practice for training and testing of metal arc welders.
IS: 1182	Recommended practice for radiographic examination of fusion-welded butt joints in steel plates.
IS: 2595	Code of practice for radiographic testing.
IS: 3658	Code of practice for liquid penetrant flaw detection.
IS: 5334	Code of practice for magnetic particle flaw detection of welds.
IS: 3600	Code of procedure for testing of fusion welded joints and weld metal in steel
IS: 4853	Recommended practice for radiographic examination of fusion welded circumferential joints in steel pipes.
IS: 3589	Specification for seamless or electrically welded steel pipes for water gas and sewage (168.3 to 2032mm outside diameter).
IS 5822	Laying of electrically welded steel pipes for water supply.
IS: 6631	Steel pipes for hydraulic purposes
IS: 7343	Code of practice for ultrasonic testing of ferrous welded pipes and tubular products.
IS: 2598	Safety code for industrial radiographic practice
IS: 5822	Code of practice for laying of welded steel pipes for water supply
BS EN 499	Welding Consumables. Covered Electrodes for Manual Metal Arc Welding of Non Allow and Fine Grain Steel Classification
AWS:A-5.1	Specification for Mild steel Covered Arc Welding Electrodes
AWS:A-5.17	Specification for Bare Mild Steel Electrodes and Fluxes for Submerged Arc Welding
ASTM E 94	Guide for Radiographic Testing
ASTM E 709	Guide for Magnetic Particle Examination
ASTM E 165	Test Method for Liquid Penetrant Examination
IS: 5504 & IS: 3589	Code for SW pipes
IS: 10748	Requirement for Weldable Hot Rolled Carbon Steel Strip in Coils

CPHEEO Manual on Water Supply and Treatment, II edition, Ministry of Urban Development, New Delhi – May 1999

MS PIPES (Part 3 APPURTENANCES AND MISCELLANEOUS ITEMS)

1. Double Flanged Valves

1.1. Sluice Valves

1.1.1 General

The sluice valves shall confirm to IS: 14846. Double flanged short body, Gland less (stem sealing rings) type Sluice valves with appropriate pressure rating.

The material to be supplied under this sub-section shall include, but not be limited to, the following: All necessary fittings including bolts, nuts, gaskets, backing rings, counter flanges, jointing material, strainers etc. shall be supplied as required. The entire Gland less (stem sealing rings) sluice valve shall be provided with ball thrust bearing and spur gear **arrangement.**

1.1.2 Scope

The Gland less (stem sealing rings) sluice valves shall be with non rising stem type. The valves will be used for water supply on line installations in upright positions, with double flange, and cap or hand wheel for manual operation. The valves shall be suitable for continuous use at their PN rating within the temperature range of -10^0 C to 65^0 C.

1.1.3 Nominal pressure and dimensions

The working pressure on the valves shall be appropriate to the working conditions and approved by the Employer. The flanges and their dimensions of drilling shall be in accordance with IS: 1538 (part-I to XXII).

1.1.4 Material

The makes given are acceptable makes however the material for different component parts of sluice valve shall conform to the requirements given below:

No.	Component	Material	Ref. to IS	Grade / Designation
1	Body, bonnet, dome, stool cover, wedge, stuffing box, gland, thrust plate, hand wheel and cap.	S. G. iron	1865	Gr.400/ 12
2	Stem	Stainless steel	6603	$12C_r$ 13 $04C_r$ 18Ni 10 $04C_r$ 17Ni 12 MO 2
3.	Wedge, nut, shoe	Leaded tin bronze	318	LTB-2

4	Body seat ring, wedge facing ring and bushes	Leaded tin bronze	318	LTB – 2
5	Bolt	Carbon steel	1363 (Part 1)	Class 4.6
6	Nut	Carbon steel	1363 (Part 3)	Class 4
7	Gasket	EPDM Rubber	11855	-
8	Gland packing	Stem Sealing Ring	5414	Nil
9	Gear	Spheroidal graphite iron	1865	G_r 500 / 7
10	Gear housing	S.G. iron	1865	Gr.400/12
11	Pinion and pinion shaft	Wrought carbon steel	1570 (Part 3)	C55Mn75

1.1.5. Marking, testing and inspection

The standard marking and packing of the valves shall be done as per Clause 11 and 13of IS: 14846. The direction of rotation for OPEN, CLOSE position shall be marked on the hand wheel and on the bonnet of the valve.

Hydraulic testing of each sluice valve shall be done for close end test in accordance with IS: 14846 Annex B, to the test pressure and test duration as specified in table 5 and 6 of the IS.

All the valves shall be inspected for flaw detection test in accordance with IS: 14846, clause 10.2.The design, construction material, manufacture, inspection, performance and testing shall comply with all applicable Indian Standards and Codes. Nothing in the specification will be construed to relieve the supplier of this responsibility.

1.1.6 Manufacturer's Test certificate

The manufacturer shall provide a test certificate confirming that all the valves have been tested in accordance with IS: 14846 and stating the pressures and medium used in the test.

1.1.7. Inspection

The inspection and testing of the sample valves from a lot will be carried out by the employer and or inspecting agency appointed by the employer, in the manufacture's workshop, before application of any paint. All the tests as required as per the IS: 14846 shall be carried out on samples from each lot (Number of samples from a lot shall be as

per the relevant IS for sampling and testing), in presence of the inspecting agency. The valves shall be dispatched only after issue of the test certificate by the inspecting agency for satisfactory performance of the tested valves. The inspection charges for such tests shall be paid by the contractor to the inspecting agency.

1.1.8. Acceptable makes for the valves

Acceptable makes for the sluice valves shall be as approved by Chief engineer.

1.1.9. Installation

The installation of the sluice valves shall be done at the locations shown on L-sections of the pumping main as washout valves and isolating valves for air valves. The job covers supply of the valves at work site with cost of all the required material and all types of taxes and duties, cost of packing, loading, transportation, unloading, stacking and installation at the specified location with cost of all jointing materials such as nuts and bolts, EPDM rubber gaskets etc. The job also covers field hydraulic testing of the valves after installation for the specified test pressure for the respective pipeline section

1.2. Butterfly valves

1.2.1. General

The Butterfly valves shall confirm to IS: 13095. Double flanged short body butterfly valves of required nominal diameter and pressure rating shall be supplied. The material to be supplied shall include, but not be limited to, that as shown in the table given below. All necessary fittings including bolts, nuts, gaskets, jointing material etc. shall be supplied as required.

1.2.2. Scope

The butterfly valves shall be with disc and shaft and shall be designed to withstand the maximum pressure differential across the valve in either direction of flow. The valves shall have no visible leakage past the disc in closed position under test conditions. The shaft may be of one piece design or in two pieces separately attached to the disc. The valves will be used for water supply on line installations in upright positions with manual operation. The valves shall be suitable for continuous use at their pressure rating within the temperature range of -10^0C to 65^0C.

1.2.3. Nominal pressure and dimensions

The working pressure on the valves shall be appropriate to the working conditions and approved by the Employer. The flanges and their dimensions of drilling shall be in accordance with IS: 1538 (part-I to XXII).

1.2.4. Material

The makes given are acceptable makes however the material for different component parts of butterfly valves shall conform to the requirements given below:

S. No.	Component	Material	Ref. to IS	Grade

1	Body	Sphéroïdal graphite Iron. / Ductile Iron.	1865	Gr. 400/12
2	Disc	Sphéroïdal graphite Iron. / Ductile Iron.	1865	Gr. 400/12
3	Shaft	Stainless steel	6603	-
4	Seating ring / Seal retaining ring	Integral Nicol Crominium Welding	-	-
5	Seat	EPDM Rubber	-	-
6	Shaft bearing seals	Bronze / brass bearing with 'O' rings	-	-
7	Internal fastners	Stainless steel	Manufacturer's standard	Suitable for duty
8	External bolting	Carbon steel; tensile strength 390 Mpa	-	-

1.2.5 Operation

All valves shall be capable of being operated at a differential pressure across the disc as marked on the valves. Leaver, worm gear / traveling nut type or any other suitable type of operator can be used.

Manually operated valves shall be closed by turning hand wheel or leaver in a clockwise direction when facing the hand wheel or leaver. The design of leaver when fitted shall be such that the leaver may only be assembled to the valve so that it is parallel to the direction of flow when the valve is open.

All traveling nut operators shall be provided with suitable stops to prevent movement of the shaft beyond the limit corresponding to the fully closed position of the disc.

All gear / traveling nut operators shall be self locking type. All leaver operated valves shall be capable of being locked at at-least three intermediate positions. The operating hand wheels shall be marked 'CLOSE' or 'SHUT' to indicate the direction of closure. The operator shall be provided with arrangement to indicate disc position.

1.2.6. Testing

All valves shall be hydraulically tested by the manufacturer before dispatch. The pressure shall be applied without any significant hydraulic shock. Testing shall be carried out before application of paint or other similar treatment.

1.2.6.1. Body test

The body ends shall be blanked. The valve disc shall be in slightly open position and the pressure equivalent to 1.5 times the maximum permissible working pressure shall

be applied with water. The duration of test shall be 5 minutes for 1600 mm diameter valve.

1.2.6.2. Seat test

Seat test shall be carried in accordance with clause 17.3 of IS: 13095 for 3 minute duration.

1.2.6.3. Disc strength test

The test shall be conducted with the body flanges in horizontal position. The test pressure shall be 1.5 times the maximum permissible pressure. With disc in closed position, hydro test pressure shall be applied to the lower face of the disc for duration as per table 3 of the IS: 13095. There shall be no damage to the valve disc or any part of the valve, or disc shall not be permanently deformed.

1.2.7. Manufacturer's certificate

The manufacture shall provide a test certificate confirming that all the valves have been tested in accordance with IS: 13095.

1.2.8. Inspection

The inspection and testing of the sample butterfly valves shall be carried out by the employer and or inspecting agency appointed by the employer, in the manufacture's workshop before application of any paint. All the tests as required as per the IS: 13095 shall be conducted in presence of the inspecting agency on the sample valves from the lot (Number of valves to be tested from a lot shall be as per the relevant IS for sampling and testing). The valves shall be dispatched only after issue of the test certificate by the inspecting agency for satisfactory performance of the tested valves. The inspection charges for such tests shall be paid by the contractor to the inspecting agency.

1.2.9. Marking

Marking shall be cast integral on the body or on a plate securely attached to the body. Marking shall be as specified under clause 21 of IS: 13095.

The design, construction material, manufacture, inspection, performance and testing shall comply with all applicable Indian Standards and Codes. Nothing in the specification will be construed to relieve the supplier of this responsibility.

1.2.10. Acceptable makes for the valves

Acceptable makes for the double flanged butterfly valves shall be as approved by the Chief Engineer.

1.2.11. Installation

The installation of the butterfly valves shall be done at the locations shown on L-sections of the pumping main as online valves. The job covers supply of the valves at

work site including all type of taxes and duties, cost of packing, loading, transportation, unloading, stacking and installation at the specified location with cost of all jointing materials such as nuts and bolts, EPDM rubber gaskets etc. The job covers field hydraulic testing of the valve after installation for the specified test pressure for the respective pipeline section.

1.3. Kinetic Air valves

1.3.1. General

Kinetic air valves are required with pressure rating appropriate for the working conditions and approved by the Employer, confirming to IS: 14845.

1.3.2. Scope and general design features

The air valves shall be capable of exhausting air from pipeline automatically when being filled. Air shall be released at sufficiently higher rate so that there shall be no restriction for the inflow rate. Similarly, the valves shall be capable of ventilating pipeline automatically when being emptied. The air inflow rate should be sufficiently high to avoid development of vacuum in the pipeline.

The design shall be such that, higher the rate of flow the greater the resultant down thrust, keeping the ball 'glued' to its seat until the last drop of air is expelled from the pipe system.

Each air valve shall be provided with an isolating sluice valve with flanged end connection. The possible air velocity (inflow and outflow) must be at least 10 m/s.

1.3.3. Construction features

The flow of air should be as unobstructed as possible. The low pressure orifice shall be in the same axis as the main discharge / incoming air flow and must have a diameter sufficiently large. The valve body shall be designed in such a way that the turbulent air at the time of filling of pipeline shall not circulate and cause the ball to be caught in the discharging air stream and blowing the valve shut permanently. The cone angle of the low pressure (large orifice) chamber shall be such that even at a critical velocity of air escaping at 344 m / sec the total impact force on the vulcanite covered ball is less than the suction force on the annular area between the ball and cone. The annulus around the low pressure vulcanite covered ball is to be generously proportioned for discharge of air under various differential pressures. Normal range of cone angle is 45^0 to 60^0.

The orifice shall be carefully profiled to allow the requisite flow of air under varying differential pressures. It shall be in molded synthetic rubber such that even after extended contact the, vulcanite covered ball does not stick to it, when the line pressure becomes zero.

The high pressure chamber having small orifice shall be so designed that the orifice is effectively sealed in working condition. The orifice shall be profiled in such a manner that the rubber covered ball is not damaged even after extended contact. There should be machined guide in the chamber which ensures that the ball travels vertically and

makes contact with the nipple and seals off the orifice without fail. The orifice size shall

Not be less than 2.5 mm and tapering to 10 mm suitable to release accumulated air within the pipeline. High pressure orifice may be fitted from bottom side of the cover.

1.3.4. Material

The makes given are acceptable makes however the material for different components parts of the air valve shall conform to the requirements given below:

S. No.	Component	Material	Reference to IS No.	Grade of designation
1	Body, cover, valve disc, stuffing box, valve guide, cowl,	S. G. iron / Ductile iron	1865	Gr.400/ 12
2	Low Pressure seat ring and face ring	Natural rubber	11855	
3	High pressure orifice	Leaded tin bronze	318	LTB-2
4	Bolts	Carbon steel	1363	Class 4, 6
5	Nuts	Carbon steel	1363	Class 4
6	Gasket	Rubber	638	Type B
7	Float	Stainless steel	-	-
8	Float guide	Leaded tin bronze	318	LTB-2

1.3.5. Floats

Minimum float diameters for kinetic air valves shall be as indicated in table 3 of IS 14845. The inner core of the floats shall be made from stainless steel having sufficient bearing strength and equivalent specific gravity.

1.3.6. Testing

Testing of all the air valves shall be carried out in the suppliers work shop as per IS:14845.

Following tests shall be carried for each valve.

- Function and performance test as per clause 12.4.1
- High pressure orifice test as per clause 12.4.2
- Low pressure orifice test as per clause 12.4.3
- Body test as per clause 12.4.4

The performance of the valve for the above mentioned tests shall be as specified under clause 12.1, 12.2 and 12.3 of IS 14845.

1.3.7. Manufacturer's Test certificate

The manufacturer shall provide a test certificate confirming that all the air valves have been tested in accordance with the relevant standards and performance of the test results observed.

1.3.8. Inspection

The inspection and testing of the sample air valves shall be carried out by the employer and or inspecting agency appointed by the employer, in the manufacture's workshop before application of any paint. All the tests as required as per IS 14845 shall be conducted in presence of the inspecting agency on the sample valves from the lot (Number of valves to be tested from a lot shall be as per the relevant IS for sampling and testing). The valves shall be dispatched only after issue of the test certificate by the inspecting agency for satisfactory performance of the tested valves. The inspection charges for such tests shall be paid by the contractor to the inspecting agency.

1.3.9. Marking

Each valve shall be permanently marked with a plate securely fixed to the body with the information as specified under clause 15.1 of IS 14845.

The design, construction material, manufacture, inspection, performance and testing shall comply with all applicable Indian Standards and Codes. Nothing in the specification will be construed to relieve the supplier of this responsibility.

1.3.10. Acceptable makes for the valves

Acceptable makes for the kinetic double orifice air valves shall be approved by the chief engineer.

1.3.11. Installation

The installation of the air valves shall be done with isolating sluice valve. The job covers supply of the valves at the work site including all taxes and duties, cost of packing, loading, transportation, unloading, stacking and installation at the specified location with cost of all jointing materials such as nuts and bolts, EPDM rubber

gaskets etc. The job covers field hydraulic testing of the valves after installation for the specified test pressure for the respective pipeline section

1.4 NON RETURN VALVES

1.4.1 General

Non-return valves generally conforming to IS 5312 Part I & II (Single or Multi Door Type) shall be provided. The valves shall be suitable for continuous use at their pressure rating within the temperature up to 60^0C and shall be conforming to following specifications and requirements.

1.4.2 Design

- The non-return valve shall be swing check reflux valve type with Single or multiple doors.
- The valve shall be suitable for mounting on a horizontal pipeline and flow direction shall be clearly embossed on the valve body.
- Valves shall possess inbuilt high speed closing and non-slam characteristics achieved by suitable disposition of weight on door and the hydraulic passage.
- Valves of multi-door type shall be additionally provided with a supporting foot.
- All faces and seat rings shall be riveted to the machined surface in the Casting. The door shall be integral with the hinge and shall have a flat seating face. Minimum two (2) nos. suspension lugs shall be cast integrally on the diaphragm plate and shall be of adequate strength.
- No spring loaded/ spring return action or external dampening arrangement will be acceptable. All the Non-return valves shall be from the same manufacturer.

1.4.3Material

The material for different component parts of Multi-door Non return valves shall conform to the requirements given below:

Component	Material of construction
Body / Door (& Diaphragm)	Ductile Iron GGG 40 / IS 1865 Gr. 500/7 to IS 1865 OR Cast steel grade B conforming to IS 1030
Stub pin	SS AISI 410
Seat & Face rings	Soft seated up to 300 mm. 350 mm and above: Gun metal : IS 318 Gr. LTB 2
Rivets	Soft annealed brass
Fasteners	Carbon steel

Painting	Liquid epoxy coating of DFT 300 microns with proper Blast cleaning to near white - SA 2 ½ Grade and 2 coats of epoxy based primer coating, prior to final coating.
Flange Drilling	IS 1538 Table 4 & 6/ BS En 1092 – 2

1.4.4 Nominal pressure

The working pressure on the valves shall be appropriate to the working conditions and approved by the Employer.

1.4.5 Marking

All valves shall be marked to show the following information permanently.

- Manufacturer's name or trade mark.
- PN rating
- Valve size
- Direction of flow

1.4.6 Factory Tests

The following tests shall be conducted on the valves at manufacture's works before painting. The tests shall be generally as per IS 5312 Part 2.

- **Body Test**

Body of each valve shall be hydrostatically pressure tested at 1.5 times its rated working pressure. The test fluid shall be water. Duration of test shall be 2 minutes. There shall be no leakage or permanent distortion of any component under the test.

- **Seat Test**

Each valve shall be tested for seat test by applying hydrostatic test pressure equal to its rated working pressure, on outlet side. Duration of test shall be 2 minutes. During the test, there shall be no leakage of water through the seats.

1.4.7 Manufacturer's certificate

The manufacture shall provide a test certificate confirming that all the valves have been tested in accordance with above specifications and relevant IS 5312 Part II.

1.4.8 Acceptable makes for the valves

Acceptable makes for the double flanged butterfly valves shall be as approved by the chief engineer.

1.4.9 Installation

The job covers supply of the Non-return valves at the work site including all taxes and duties, cost of packing, loading, transportation, unloading, stacking and installation at the specified location with cost of all jointing materials such as nuts and bolts, EPDM rubber gaskets etc. The job covers field hydraulic testing of the valves after installation for the specified test pressure for the respective pipeline section.

1.5 Anti Vacuum Valve:

1.5.1 Scope:

The Anti vacuum valve will be installed to prevent the formation of vacuum in large diameter (having Ø of 1000 mm. and above) water mains to prevent line collapse under such conditions of flow as may result, for example, from too rapid a closure of an upstream head gate or shut down valve, a down stream burst or ordinary emptying or recharging of a pipeline.

1.5.2 Design features:

Design of the anti – vacuum valve shall automatically allow induction of large volumes of air to prevent vacuum formation; and also provide an automatic means of ventilating a line when it is being emptied of water, and of exhausting air when it is being recharged.

It should be suitable to react automatically, sensitively, and positively even after long periods of inactivity, to changes of pressure within a pipe, and whenever necessary, permit air to flow in at a sufficiently high velocity, and at low enough induction pressure, to safeguard the line against collapse.

Cowled Inlet Type of the anti - vacuum valve should have an annular cowl shrouding the orifice, providing protection to the orifice and the seating. It should be suitable for air to flow through the ports provided around the periphery of the body assembly. Such application is confined to situations where no damage is likely to occur surrounding structures from sudden intakes of air.

1.5.3 Operation :

About Operation, the valve element should be in the form of the disk which is sensitively balanced by a counterpoising mechanism. The disk guide pin should be attached to a crosshead, to which is fitted at either end a cranked lever that should rock about an intermediate pivot pin and should be applicable to carry an adjustable counterweight on its outer arm. The parts should so arranged that by adjusting the position of the counterweights, the valve must be balanced at any desired points on its working travel.

Thus, when swinging freely the valve may be balanced at a partially opened position in which case, if it is closed by hand, it self-opens to the pre determined point of equilibrium, and vice- versa. Also attached to the crosshead should be an oil dashpot which should give free opening, in a downward direction, but offer resistance to closing, in an upward direction, and avoid all possibility of oscillation of the suspended.

In action, therefore, the valve should not remain at either extremity of its travel unless it is acted upon by some external force. During normal operation, the disk should be held shut by the water pressure in the pipe. If the pressure on the underside of the disk falls

below that of the atmosphere, the valve should immediately open to admit air and break vacuum. With very small vacuum, say 1 inch of mercury or about ½ psi below atmosphere, should open fully and offer a wide passage for free flow of air. On the cessation of air inflow, the valve must return to a position of slightly open, which is sufficient for the escape of air during refilling of the line. When the rising water makes contact with the underside of the disk, closure is completed: only a very small water pressure should be required to close the valve, consequently, the quantity of water over-flowing through the orifice during final closure will be negligible.

1.5.4 Manufacturer's Test certificate

The manufacturer shall provide a test certificate confirming that all the Anti vacuum valves have been tested in accordance with the relevant standards and performance of the test results observed.

1.5.5 Inspection

The inspection and testing of the sample Anti vacuum valves shall be carried out by the employer and or inspecting agency appointed by the employer, in the manufacture's workshop before application of any paint. The valves shall be dispatched only after issue of the test certificate by the inspecting agency for satisfactory performance of the tested valves. The inspection charges for such tests shall be paid by the contractor to the inspecting agency.

1.5.6 Marking

Each valve shall be permanently marked with a plate securely fixed to the body with the information as specified under relevant standards.

The design, construction material, manufacture, inspection, performance and testing shall comply with all applicable Indian Standards and Codes. Nothing in the specification will be construed to relieve the supplier of this responsibility.

1.5.7 Acceptable makes for the valves

Acceptable makes for the Anti vacuum valves shall be as approved by the chief engineer.

1.5.8 Installation

The job covers supply of the Anti vacuum valves at the work site including all taxes and duties, cost of packing, loading, transportation, unloading, stacking and installation at the specified location with cost of all jointing materials such as nuts and bolts, EPDM rubber gaskets etc. The job covers field hydraulic testing of the valves after installation for the specified test pressure for the respective pipeline section.

1.6 PAINTING SPECIFICATION FOR VALVES :

Final coating on internal and external surface of the Valve shall be carried out after satisfactory testing, prior to dispatch.

Before inspection : Each valve shall be cleaned and surface shall be prepared by Sand blasting to SA 2½ Grade – Near white blast cleaning, and suitably protected by applying one coat of two component high build polyamide cured re-coatable zinc phosphate epoxy primer.

After inspection : One coat of two component high build polyamide crude re-coatable epoxy coating shall be applied to achieve DFT 150 micron, followed by one coat of two component aliphatic polyurethane finish to achieve DFT 80 micron.

2 Surge Control System For Pumping Main shall be as approved after surge analysis.

2.1 Accepted Control System

2.1.1 Following types of control systems are acceptable for control of water hammer pressures in the pumping mains.

a) Zero Velocity Valves

b)Air Cushion Valves.

c) Surge anticipating valves

d) As may recommended by the surge analysis report

2.2 Surge Control System – Requirements

2.2.1. The requirements given are tentative. The contractor, after award of contract, must carry out the surge analysis based on the Longitudinal section, Pump and Motor characteristics of the selected pumps by the contractor. Surge analysis along with the selected system.

2.2.2. During detailed engineering following information must be submitted based on the Surge Control System' selected by the contractor. For design of surge control system limits will be adhered to (The surge pressures will be estimated after all working pumps at designed discharge, trip simultaneously) as may be approved after the surge analysis report from the expert.

2.3 Scour Valve /Silt Ejector

These valves are to be provided at regular interval at suitable location nearby local / natural drainage in the rising main / distribution network

2.4 Pressure sustaining valves / regulating valves.

Suitable size of pressure regulating or sustaining valves to be provided at pump house.

These valves shall be suitable to relief the excess pressure built in the pipe line in the event of some outlet chaks are closed and while pumps are in operation. Or these valves shall safeguard the pipe line by maintaining the defined operating pressure range.

These valves shall be auto regulated type by the pipe line pressures and shall be hydraulically operated by the flowing media, and the bleed of water shall be routed back to the sump / forebay.

PART - C

HYDRO – MECHANICAL WORKS

HYDRO – MECHANICAL WORKS

1.1 Scope of Work

The scope of work includes, but not limited to the following:

1. Designing, supply and manufacture, inspection, shop assembly, testing, painting, transportation etc.

2. Site storage, including insurance transportation and handling, site erection, painting, testing and commissioning including provision of labour, plant material etc. for the above.

3. Handing over to employer/supply of necessary spares of 2 years trouble free operation/ supply of installation of all incidentals not specified but is necessary for proper completion and satisfactory functioning of the system.

It is not the intention of these specifications to specify complete details of equipment. However, the Contractor shall supply the equipment which will meet in all respects, the requirements of employer in regard to performance durability and satisfactory operation. All the equipment supplied shall conform to the relevant Indian Standards. Wherever, Indian Standards are non-existent or silent, relevant International Standards (as agreed between the Employer and the Contractor) shall be followed. The sizes and numbers of units in each case are based upon employer's preliminary design and may vary to suit modified site conditions and design requirements.

1.1.1 **Gates** :

Suitable number of gates will be provided at the entrance of drain/ canal.

1.1.2 Gates at Draft Tube Tunnels

(a)Gates.
(b)Embedded parts (Primary and Secondary).
(c)Portal frame gantry crane of adequate capacity

1.2 Trash rack Frame

1.2.0 General Description of Equipment

1.2.1 Gate

Gate shall be designed with welded steel fabrication of skin plate supported by stiffener, main girder, vertical stiffener, side track, seals and guide etc. The gate shall be designed to withstand the head corresponding to minimum water level and it shall be suitable to lower under flowing condition and raising under unbalanced condition.

Each unit shall be fitted with bottom seal, side seal, track and guide roller assembly.
The Stoplog gate shall be designed as per IS: 5620.

1.2.2 Embedded Parts

Embedded parts shall be provided. Guides shall be provided up to the suitable height.

1.2.3 Hoisting Equipment

Hoist for Gates – The gates shall be operated by means of dedicated Electrical Operated hoists. The operating equipment shall consist of fixed rope drum type hoist provided on gantry. It shall have all breaking and control arrangement and overload protection devices. Hoist shall also have manual operation facility in case of power failure. Length of drum shall be such that not more than two layer of rope are winded on the drum.

1.2.4 Spare Parts

The mandatory spare for various gate hoist, and cranes shall include one set of rubber seal for all gates, one set of wheel assembly for fixed wheel gate, one set of Brake shoes for rope drum hoist etc. In addition to above mentioned spare if the bidder feel necessary additional spares may also be suggested.

1.2.5 Material

All material incorporated in the equipment shall be new, unused and of first commercial quality, free from defects and as per relevant India standard. Materials for various components of Hydro-mechanical equipment shall conform to the requirements given in Annexure.

1.2.6 Design

All gates shall be designed in accordance with the requirement of relevant India standard. For extra condition of loading such as earthquake condition, storm condition, Brake down torque condition etc. permissible design stress shall be increased by $33^{1/3}$% over the normal storm but limited to 80% of yield point. In case of fastener the increase in the storms for worst loading case shall be limited to 25% only.

The embedded parts of gate shall be designed to limit the bearing pressure on 2^{nd} stage to 25% of compressive strength of concrete.

1.2.7 Embedded Parts

All the sealing faces in the embedded form shall be of stainless steel. The wheel track and sliding track shall be of non-corrosive steel. The BHN of wheel track shall be 50 points higher than wheel rim. The entire track shall be machined after welding. Roller path, seal parts and guide track shall be provided up to height indicated below.

Guide track-Full travel of gate.
Track-Unbalanced operation – twice the gate height + 1 m
Track -Balance operation – gate height + 1 m

1.3Gate Seals

All gate units, zero shaft gate, draft tube gate shall be provided with natural rubber / Neoprene sealing elements in a sections appropriate to the functional requirements and gate type. In cases where low frictional resistance is necessary, the seals will be provided with a PTFE insert bonded during the moulding process. Thickness of bottom seal shall not be less than 20mm and this shall be of wedge type. All corner seals between lintel seals and side seals shall be of continuous moulded piece. All seals will be clamped to gate units by stainless steel fasteners. Suitable chamfer shall be provided in the base plate and clamps of seal assembly. The properties of natural rubber / Neoprene seals shall be as under:

a)Shore Adurometer hardness 65+5

b)Minimum elongation 450%

c) Ultimate tensile Strength (Minimum) 14.5 N/mm^2

d) The rubber compound shall not absorb more than 10% by weight, of water in 7 day test

e) The tensile strength of the test specimen, after being subjected to an accelerated ageing test of 48 hours in oxygen at 70^o C and 2.1 N / mm^2 pressure, shall be not less than 80% of the strength of the test specimen before ageing.

1.4Frictional Resistance

The following frictional resistance co-efficient shall be adopted in the Design of gates and associated equipment.

Sl. No.	**Item**	Static	Dynamic
1.	Rubber seal on Stainless steel	1.5	1.2
2.	Seals with PTFE inserts	0.2	0.15
3.	Roller bearing Factor	0.015	0.01
4.	Self –lubricating bearing	0.2	0.15
5.	Plain bearings	0.4	0.3
6.	Steel on steel	0.6	0.4
7.	Brass or bronze on steel	0.5	0.3

1.5Operating Equipment

The capacity of the hoist and crane for various gates and stoplog units be calculated on the basis of self weight of the gate, weight of lifting beam (where applicable) frictional forces (including static seal friction, wheel / trunnion friction, hoist friction, silt load etc.) and down pull forces. The hoist capacity thus arrived shall be increased by 20 percent to cater for reserve hoist capacity.

Similarly in the case of gates designed for closing under self weight, the downward forces closing the gate while lowering shall be at least 20% higher than the forces opposing down ward motion. However the sealing pressure shall not be less than the values mentioned in the IS code.

1.6 Gate Seal Leakage

The leakage allowance for gate as well as stoplogs and bulkheads shall not exceed the permissible limits.

1.7 Gantry Cranes and Hoists

Mono/double rail cranes and hoists for handling the various stoplogs / gates shall be designed and shall conform to requirements of applicable to Indian codes. Cranes will be classified according to its specific duty, service life and load status gear mechanism. The winding drums shall have single layer of rope, as far as practical.

Mono/double rail cranes shall be supplied complete with rails equipped with necessary anchorage to withstand wind and seismic loads transmitted from the gantry structure. Electro-mechanical hoist shall consist of wire ropes, drums, reduction gear, couplings, brakes, electric motors, limit switches. Both electro-magnetic and thruster brakes shall be provided on hoist drives where LT and CT drives shall be equipped with electro magnetic brakes. Necessary provisions for connections to remote control system shall be provided on local control panels.

1.8 Lifting Beams

The lifting beams for handling the stoplog sections will be of the automatic type, being preset to release or engage the hooks prior to lowering. Presetting is by manual positioning of a central counterweight system, and an interlock arrangement prevents premature release of the hooks during lowering. A probe rod incorporated in each stoplog unit releases the locking arrangement when the section is fully lowered, enabling the hooks to disengage.

1.9 Rope Drums and Wire Ropes

The rope drums and wire ropes shall conform to the Indian Standards in general. The ropes shall conform to IS 2266 improved plow steel and fiber core extra flexible high grade improved wire rope. The ropes shall have a factor of safety of six (6).

The drums shall be made of cost steel of fabricated from steel plates and shall be reinforced to sustain concentrated loads due to rope tensions. The drums shall have a diameter not less than 20 times the rope diameter and shall have sufficient length to adopt full length of rope of specified lift and number of falls, in one layer plus two idle turns at each fastening end and minimum one extra groove. The drums shall be checked for crushing and combined stress as per IS – 6938.

1.10 Electrical Equipment

All electrical equipment, including motors, starters, control panels, Solenoids and associated instrumentation shall be of international standard and shall be suitable for the climatic conditions prevailing at the project site and shall be provided with all necessary anti-condensation heaters and other protection against the ingress of dirt and insects.
All motors shall be induction type with water tight terminals, anti-friction bearings and built in totally enclosed fan ventilated enclosures. All motors have speed not exceeding 1500 rpm. Creep speed motors shall also be continuously rated. All hoists including

crane hoists shall be provided with at least two sets brakes working on different principles viz. Electromagnetic, thruster, eddy current braking system etc.

All motions shall be provided with limit switches at both extreme ends of travel. For hoist motion the system shall be provided with overload limit switches and slack rope limit switches. Indications and protections shall be provided on the control panel.

1.11 Inspection & Tests

All materials shall be of tested quality and all work performed shall be subject to rigid inspection and no articles or materials shall be dispatched until all tests, analysis and shop inspection have been completed or certifiedcopies of reports or results of tests and analysis have been accepted. Duplicate copies of manufacturer's test certificates including chemicals analysis and mechanical properties shall be made available for all materials. In case test certificates are not available for any of the material the same shall be got tested and only these materials which fulfill the requirements of these specifications shall be used. From any part / item, it should be possible to locate its manufacturer's batch / lot mark, which shall be achieved by transferring the batch marks before parting the materials.

All castings shall be annealed and forging shall be normalized.

1.12 Shop Assembly and Testing

During the course of manufacture, the equipment included in the scope of supply shall be subject to rigorous inspection and testing.

All components, sub-assemblies and assemblies will be dimensionally and functionally checked against the relevant drawing.

All gate units shall also be fully shop assembled (with temporary bolting where necessary), and checked for dimensional and flatness checks with all fitments such as wheels, guides, seals, bypass valves etc., attached. The correct Center of Gravity shall be established during shop assembly before final welding of lifting lugs.

Reception frames and guides shall be assembled on the shop floor for dimensional and straightness checks, also alignment of connecting members with the required tolerances.

In all cases the various connecting parts shall be match marked to facilitate site erection.

Hoisting units shall be fully assembled on the hoist platform and test run to at least 20 minutes and load tested to 1.25 times the rated capacity. All lifting beam shall be shop assembled and hooks will be similarly load tested. Automatic engaging and dis-engaging of lifting beam hooks shall also be tested in the shop. During test run all the components of the hoist shall be tested for their performance.

The gantry crane / monorail crane and hoist shall be fully shop assembled and tested to 1.25 times the rated capacity. The hoist shall be operated for 15 to 30 minutes in slowest speed to demonstrate that equipment has been designed for continuous duty. The gantry crane shall be made to travel for a distance of 30 m if so permitted or otherwise the driving wheels shall be rotated under power, by jacking of wheel carriage / crane.

Trashrack cleaning machine, shall be completely assembled and shall be tested for operation with load. The hydraulic thruster winches are to be tested for proper operation with load. Simulation load test at 125% on hoists and gear drive shall be carried out. Raking operation shall be performed above the deck level.

1.13 Site Testing and Commissioning

All embedded reception frames and support frames etc., shall be erected and checked for dimensional accuracy and alignment in accordance with the assembly drawing with the required tolerances and level limits before and after concreting

After site assembly of the gate units within their respective reception frames, all gates will be checked for roller alignment, seal compression and guide clearances.

The operating equipment will be checked for correct positioning and alignment, and undergo full functional tests over the operation range of the particular gate, checking operating speeds and performance of the hydraulic and electrical control systems.

Hydraulic systems will be pressure tested to 1.5 times the maximum rate operating pressure.

Gantry cranes and hoisting winches shall be load tested, all in accordance with standard.

1.14 Non Destructive Test

The fabricated gate / stoplog units, embedded parts, penstocks, hoist components and other load carrying members, shall be subjected to the following Non destructive tests.

1.15 Steel

i)	Butt welds	Rediography	100%
ii)	All fillet welds in the gate beam, end plate and lifting point	Magnetic particle	100%
iii)	Other fillet welds	Magnetic particle	10%
iv)	Root runs of important load bearing joints	Dye-penetrant	100%

1.16 Casting and Forging

Castings Ultrasonic Level I SA 603 ASME Sec. V Forgings Ultrasonic SA388 ASME Sec. V 2.3.20

1.17 Stress Relieving

Trunnion bearing hub casting prior to machining shall be stress relieved, if welded. Yoke girder and the anchor girders shall also be stress relieved. Elsewhere welded plates

thicker than 28 mm will also be stress relieved. The procedure for stress relieving shall be per ASME section VIII Division –1.

1.18 Surface Preparation and Painting

All exposed and under water steel works shall be sand blasted to at least Sa 2 ½ quality of Swedish Standards. SIS 055900. The bidder shall clearly indicate the painting system proposed by them for under water as well as exposed surfaces of steel works including liners indicating the type of primers, protective coatings, No. of coats proposed and their dry film thickness. However, the dry film thickness should be around 70-80 microns for primer protections and 400 microns (in two coats) for final paintings.

1.19 General

The bidder shall include necessary ladders, platforms, handrails in and around gate installations in order to provide approach for inspection and maintenance. Removable steel covers shall also be provided on gate openings at deck level wherever required.

Necessary cabling (within this scope of work) for various hoist installations including remote control system shall be provided by the bidder without additional cost to the Employer.

The bidder shall prepare detailed technical specifications, design calculations, general arrangement, assembly, subassembly and detailed fabrication drawings and inspection drawings for various components of works and submit the same for the approval of the employer. Fabrication shall be taken up only after approval of the above by the employer. All schematic wiring diagrams, control circuit, drawings, hydraulic piping and installation drawings and hydraulic circuit diagrams along with detailed write up shall also be submitted for approval.

The meter, kilogram, second (MKS) System shall be used for this contract where manufacturer's products are produced in imperial sizes, substitutions shall be made to nearest metric size. All drawings, calculations, design data and instructions manuals shall be in MKS units. For manufacturer's convenience imperial measurements may be placed in brackets after the MKS units.

Bidder shall indicate the approximate weight of the various components of each gates and its hoists.

a. Weight of gates / stoplogs / bulkhead
b. Weight of embedded parts
c. Weight of hoists / cranes and its capacity
d. Weight of hoist supporting structure
e. Weight of lifting beams

1.20 LIST OF I.S. CODES REQUIRED IN GENERAL

Sl. No.	Description	IS Number
1	Recommendation of structural design of fixed wheel gates	IS 4622
2	Recommendations for structural design criteria for low head slide gates	IS 5620
3	Recommendations for structural design of medium & high head slide gates	IS 9349
4	Code of practice for design of rope drum and chain hoists for hydraulic gates	IS 6938
5	Code of practice for electric overhead Traveling cranes other than steel works cranes	IS 3177
6	Code of practice for design manufacture erection & testing of cranes & hoists.	IS 807
7	Code of practice for use of structural steel in general building construction	IS 800
8	Design criteria for hydraulic hoists for gates	IS 10210
9	Recommendation for inspection testing & maintenance of fixed wheel & slide gates	IS 7718 (Part – I)
10	Recommendation for inspection testing & maintenance of fixed wheel & slide gates	(Part – II)
11	Recommendation for inspection testing & maintenance of fixed wheel & slide gates	(Part – III)
12	Recommendation for Inspection, testing & maintenance of Radial gates & their hoists	IS 10096 (Part – I)
13	Recommendation for Inspection, testing & maintenance of Radial gates & their hoists	(Part – II)
14	Recommendation for Inspection, testing & maintenance of Radial gates & their hoists	(Part – III)
15	Approval test for welding procedures (Part – I)	IS 7307 (Part – I)
16	Approval testing of welders working to welding procedures	IS 7310 (Part – I)
17	Approval tests for welders when welding procedures approval is Not required	IS 7318
18	Code of practice for liquid penetrant flow detector	IS 3658
19	Code of practice for Ultrasonic tube echo testing by contact and immersion methods	IS 3664
20	Code of practice for magnetic flow detector	IS 3703
21	Code for unfired pressure vessels	IS 2825
22	Code of practice for radiographic testing	IS 2595
23	Code of practice for structural safety of buildings : Loading Std.	IS 875
24	Code of practice for plain & reinforced concrete	IS 456
25	Criteria for Earthquake resistant design of structures	IS 1893
26	Steel wire ropes for General Engg. Purposes	IS 2266

1.21 TRASHRACKS

The structural steel for trashrack bearing plates including anchor plates and bolts shall be assembled as shown in the approved drawings. All structural steel for trashrack will be shop fabricated in convenient sizes for transport, accurate positioning and alignment of the bearing, guides will be required to ensure that the rack sections will properly site / slide. The trashrack section will be furnished completely fabricated and will require only setting in position as directed or shown in the drawings. Rack shall be cleaned, painted and installed as shown in the drawing or as directed.

Each trashrack panel shall be so nearly rectangular that the diagonal dimensions will not vary more than 12 mm. Each trashrack shall be properly supported on the supported structures consisting of R.S.J's, channel, angle as specified in the approved drawings. Line level and centers of the supported structure shall be properly checked before final placement of trashrack.

1.22 Measurements for hydro-mechanical works will be made for making the progressive payments against the total contract price for the work.

ANNEXURE A

SPECIFICATION OF MATERIAL

Materials for various components of Hydro-mechanical equipment shall conform to the requirements given below. The successful bidder should submit the exact specification of material proposed by them in this Annexure before execution of work

Sl. No.	Component	Material Conform to
1	Gate, Embedded parts, groove-liner, bonnets etc.	
	a) Steel Plate	Mild steel weldable quality
	b) Rolled section	Mild Steel Weldable quality
2	Main rollers, Guide roller,	
		Cast steel
		Forged Steel
3	Self-lubricating bearings and washers	"Lubrite" or approved equal
4	Main and guide roller axles	Corrosion-resistant Steel
5	Side Guides	
	a) Steel plate	Mild steel weldable quality
	b) Rolled Sections	Mild steel-weldable quality
6	Main Roller track	Corrosion – resistant steel
7	Side and back roller track	Carbon steel
8	Sealing surfaces	Corrosion-resistant steel
9	Seal fasteners	Corrosion-resistant steel
10	Structural members of hoist platforms, columns etc.	
	a) Steel plate	Mild steel- weldable quality
	b) Rolled sections	Mild steel- weldable quality
11	Hoist drums and achieve	Steel platge - weldable quality, cast steel
12	Gears	Cast steel
13	Pinions	Forged steel
14	Pins, shafts, sheave, axles, less than 75 mm dia above 75 mm dia	Cold rolled steel corrosion resistant steel, carbon steel, Forged steel, Corrosion resistant steel
15	Wire rope	6 x 37 construction
16	Bearing Pedestal	Cast steel
17	Bronze bush other than specified above	Plain bronze
18	Lifting pins	Carbon steel Corrosion resistant steel
19	Bolts for connecting flange plates of Hydraulic Hoist	Corrosion – resistant Steel
20	Spherical / roller bearings	SKF, FAG or approved equal
21	Machine bolts and nuts	Carbon steel
22	Steel plate for penstocks	Pressure vessel quality plate

PART D
ELECRTO MECHANICAL WORKS

PUMPS

2.1.1. SCOPE:

I. The scope of this section covers design, manufacture, testing at manufacturer's works before dispatch, supply, delivery at site, erection, testing and commissioning of VT pumps each along with valves (H.O.P.D and E.O.P.D) in delivery line and with all associated auxiliary and ancillary equipment including OPU system for MDV and all other auxiliary equipment like compressed air, electrically operated valve with all associated equipment, dewatering and drainage, lubrication systems, water and air piping with necessary instrumentation, control and safety devices etc. complete with all accessories, mandatory spares, special tools and plant as detailed in the specification The scope of supply shall also include all parts, accessories, and spaares etc., which are required for construction, operation and maintenance of Pump –Motors, even though these are not specifically stated or enumerated. The corresponding parts of all the Pump -Motors, associated equipment and spares shall be of same material dimensions, workmanship and finish and shall be interchangeable.

II. The scope of supply shall also include all parts, accessories, and spares etc., which are required for construction, operation and maintenance of Pump –Motors, even though these are not specifically stated or enumerated. The corresponding parts of all the Pump -Motors, associated equipment and spares shall be of same material dimensions, workmanship and finish and shall be interchangeable

1.2 Tentative Parameters of DPSs:

S. No.	DPS Name	Discharge	Working Pumps	Standby Pumps (50% standby)	Discharge of each pump	Head Total	Required Capacity of each pump
		Cum/sec	No's	No's	Cum/sec	m	HP
1.	Gammon India	3.44	2	1	1.72	11.5	415
2.	Digha Bailey road Junction	3.12	2	1	1.56	10	470

- Pump manufacturer should be an ISO 9001, ISO 14001, ISO 45001 & ISO 50001 Certified organization.

- Pumps manufacture must have at least 5 years manufacturing experience. Bidder must have submit documentary proof after award of contract that same required capacity of storm water drainage pump has been supplied by pump manufacturer in each year.

PUMP -MOTOR:

Type and rating.

I. The pump shall be of vertical shaft, single stage **suitable for direct** coupling to motor of **suitable** capacity with 10% over load rating. The direction of rotation shall be anti-clockwise when viewed from top. Each pump shall be so designed and constructed that all removable parts including runner, shaft, guide bearing, shaft seal, guide apparatus etc., can be easily removed. It shall be possible to repair/replace pump shaft seal without de-watering the Draft tube, for which purpose additional repair seal shall be provided. .

II. The pump shall be capable of giving rated discharge **(approximate)** with maximum of **rated suitable power input** to the motor, at rated voltage and frequency. The bidder shall evaluate the losses in the water conductor system to arrive the dynamic head and shall design pump-motors accordingly. The net head and Gate opening at which the machine gives the best efficiency shall be indicated, while delivering the rated discharge. The pump shall be designed and constructed to operate satisfactorily with complete safety and without objectionable vibrations, noise and cavitation at all heads within the range of head variation indicated above.

III. The maximum discharge and the corresponding gate opening at minimum and maximum net head, best efficiency head shall be stated in the offer. Capability of pump for giving higher output shall also be stated in the offer. Graphical data regarding the gate opening, discharge, efficiency, shall be furnished along with the bid. The pump shall operate satisfactorily for a variation in capacity up to 125% of the rated capacity at a head of indicated above at higher frequencies (50.5 Hz). The bidder shall indicate clearly the suitability of the pump for operation at heads higher than the designed net head

CHECKING GUARANTEES FROM MODEL TEST RESULTS:

Field test as per IEC form the final basis to establish the fulfillment of guarantees. The purchaser shall have option of carrying out the field test by the manufacturer. Such tests shall be to the bidders account

Penalty on account of fall in weighted Average Efficiency and output:

For any shortfall in the tested values of rated output and weighted Average Efficiencies (as determined by the following basis) from the guaranteed values, a penalty shall be applicable at the rate of Rs.2,50,000(Rupees two lakhs fifty thousand only) per pump for each 0.01**% (one hundredth percent)** by which the test figure is less than the corresponding guaranteed figures. The penalties on account of the output and efficiencies shall be computed separately and the total amount of penalty shall be the sum of these two. No tolerance limit shall be permissible over the test figures of rated output. Tolerance on measurement of efficiencies shall be allowed in accordance with the IEC test code or any other equivalent standard for Field tests of pumps

Rejection Limit:

The purchaser has right to reject the equipment if the test values of either weighted average efficiency (as determined on following basis) or the rated output falls below 3 % of the corresponding guaranteed figures as per IEC standards.

Computation Of Weighted Average Efficiency:

The weighted average efficiency of the prototype machine shall be determined from the guaranteed and field test values of the efficiencies at the rated Static head in accordance with, for the purpose of penalty and rejection limits of efficiencies guaranteed.

RECTIFICATION TO MEET GUARANTEES:

The bidder shall make good and meet the guarantees again within a period of 4 (Four) months from the date of witnessing the original tests, should the original test be unsuccessful in meeting the guarantees. However, no delay in the original delivery schedule shall be allowed due to this reason

The penalty or rejection shall be applied if the second attempt is also unsuccessful in meeting the guarantees.

CAVITATION GUARANTEE:

I. The Bidder shall guarantee the runner, discharge ring and other hydraulic passage against excessive pitting caused by cavitation for 60 months from date of commissioning or 12,000 hrs. of actual operation, whichever is earlier.

II. Excessive pitting shall be defined as the removal of metal from runner and other passages exceeding a weight of $W = 0.1D^2$ per 1,000 hrs of operation during the guarantee periods defined above, where W is weight in kg. and D is the throat diameter of runner in meters. The bidder shall indicate the method which he proposes to use for measuring the amount if the metal removed on account of cavitations, which shall be subject to the approval of purchaser.

III. If the 60 months guarantee period expires prior to the completion of 12000 hrs. of actual operation, the bidder shall guarantee, that the weighted loss shall not exceed the value proportional to the number of hours actually operated.

IV. In case of excessive cavitations being present, the Bidder at his cost shall correct the condition and rectify and/or replace the part thus affected. The pump after such modifications and repairs and/or replacements of part or parts shall be subject to the same cavitations guarantee as for the original equipment.

V. In determining whether or not excessive pitting has occurred, metal removed by erosion, corrosion by the presence of injurious foreign element in water or by chipping and grinding preparatory to repairing the pitted area, shall be excluded. The manufacturer shall adopt necessary improvements modifications in the designs, manufacturing to minimize the cavitations pitting within the permissible limit.

CRITICAL SIGMA:

Values of critical sigma as calculated by IEC code or any other equivalent standard on the basis of model test for pump shall be given in the form of curves efficiency versus sigma for different heads of operation. Plant sigma curves shall also be plotted on it to clearly show the safety margin available. Cavitations model tests shall also be given.

SPEED REGULATION:

The limits on speed rise shall not exceed the values given in the schedule of guaranteed technical particulars of this section.

RUNAWAY SPEED AND NOISE GUARANTEES:

The maximum runaway speed of the pump under any combination of cistern water and surge pool water conditions shall be stated. The pump shall be capable of running safely at the maximum runaway speed, without damage to its parts for not less than 15 minutes, on every such occurrence. The duration for which the pump can run at runaway speed safely shall be stated in the offer.

Maximum noise level of operation shall be 120 decibels, and the guaranteed value shall not exceed 120 decibels in the machine hall. The bidder shall supply necessary instruments for recording & analyzing vibration levels & shall include these in the bid.

MODEL TESTS

I. Model test shall be performed by the bidder (before commencement of manufacture of the prototype) in the presence of the Purchaser's representative to demonstrate the efficiency and other guarantees as well as requirement of specification for the performance of pump shall be met. Model tests shall be carried out as per IEC test codes or any other equivalent standards which is more stringent.

II. The hydraulic parts of the model shall be completely homologous with the corresponding parts of the prototype units as per relevant IEC recommendations or any other equivalent standard.

III. Hydraulic performance Tests shall be made to determine machine characteristics. Values of unit torque and unit discharge shall be plotted against unit speed. These tests shall include determinations of capacity, efficiency, cavitations limits, hydraulic thrust, runaway speed etc., and shall be in accordance with relevant IEC or other equivalent test codes.

IV. In deriving prototype step-up efficiencies from model tests data formula given in relevant IEC test or any other equivalent standards shall be used. Similarly, head-discharge relationship shall be stepped up from the model by the affinity law with an additional correction to the discharge as per relevant IEC code or any other equivalent standards recommendations. Cavitations limits of critical sigma shall be determined from the model test.

V. Other model tests as considered desirable to check guarantees or determine operating characteristics under unusual conditions shall be carried out as agreed jointly between the purchaser and the bidder.

VI. Copies of model test reports giving performance of pump operation shall be furnished after completion of model tests to Engineer-in-charge.

VII. The manufacture of prototype pump shall be commenced on approval of model test results by the purchaser.

VIII. Detailed graphs regarding plant sigma and machine sigma shall be finalised at the time of model test.

IX. Photographs and sketches of cavitations phenomena shall be furnished.

2.1.2. GENERAL ARRANGEMENT OF PUMP:

The pump shall be so constructed that all removable parts including runner, shaft, guide and thrust bearings and supports, gate-operating mechanism etc., can easily be removed. The design of pump shall permit a vertical movement of the runner shaft by an amount sufficient for adjustment of the thrust bearing and for clearing the joints at the coupling of the pump and motor shaft.

The bearing arrangement of the pump/motor shall be so designed as to ensure trouble free operation of the unit and permit repair/replacement of parts without disturbing the adjacent components.

All equipments shall be readily accessible for operation and maintenance. All necessary walkways ladders, hand rails, chequered plates required for the equipment covered under the specification shall be provided.

Pumps shall be vertical and shaft-driven by vertical-shaft motors. Impellers shall be of the mixed or axial-flow multi-stage type, driven at a maximum speed of 960 rpm unless otherwise specified.

Operation of pumps shall be automatic with working and standby pumps operated in rotation such that no pump shall be operated short duration.

The minimum clearance between adjacent pumps and between pump and wall shall be as per Hydraulic Institute Standards.

For all the pumps the selected model shall be such that the operating point shall lie nearest to best maximum efficiency point but towards the left of the maximum efficiency point.

The impeller diameter selected shall be such that there shall be a minimum of one diameter higher and one diameter lower size impeller is available for all the pumps.

The pump installation shall include SS 316 suction strainer, suction bell mouth, suitable length column pipe, discharge head, motor stool, lower stool, all the accessories, etc. complete.

The total suspension length shall be from suction point at bell mouth up to delivery point at common header as per design. The vertical column shall be suitably supported and anchored to prevent vibrations / movement.

The pumps shall confirm to IS: 1710 and IS: 5120. The pumps shall be capable of handling raw water from a reservoir with expected turbidity up to 1000 PPM.

Vertical-shaft driving motors shall be mounted on the discharge head above the discharge bend. Unless otherwise specified or approved, they shall be of the hollow shaft type, fitted with an axially-adjustable thrust bearing designed to carry the combined weight of pump and motor rotating parts, the drive shaft with couplings, and hydraulic loadings.

Support bearings shall be provided between each impeller stage. The impeller shaft shall be corrosion-resistive low-alloy steel, designed for low stress and long life.

The drive-shaft couplings shall be designed to preserve true shaft alignment in all operating conditions and shall be close to bearings. Coupling design shall provide for accurate assembly and re-assembly within the limits of the permissible end-float of the shaft.

The drive shaft and couplings shall be designed to withstand the maximum accelerating torque of the motor, with a factor of safety of at least two. When required, the Agency shall provide his design calculations to demonstrate that the shaft size chosen meets the requirement for safety factor.

Unless otherwise specified or approved, the drive arrangement shall incorporate an approved ratchet arrangement to ensure that Pump not rotating reverse direction, if the pumps are driven in reverse for any reason, the motor is uncoupled from the pump. Unless otherwise specified, the discharge pipe work shall include an automatic air inlet/release valve, designed to vent the pipe work on pump start and to allow air ingress when the pump stops. The valve shall be sized to ensure that accumulated air shall not be passed to the delivery pipe work on starting. If draining the column pipe on pump stopping could result in reverse rotation of the pump, means shall be incorporated to ensure that the pump cannot be restarted before reverse rotation stops.

2.1.3. CODES AND STANDARDS

The design, manufacture and performance of the pumps shall comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment will be installed. The equipment shall also conform to the latest applicable Indian or equivalent international standard. Some of the relevant standards are:

IS 1710	:	Vertical Turbine Pump for clear cold fresh water
IS 5120	:	Technical requirement for rotodynamic special purpose pumps

2.1.4. FEATURES OF CONSTRUCTION

The hydraulic design of the pump shall meet the requirements of high efficiency at least 85%, low submergence, high reliability, optimum system design.

The shut off head shall be at least 110% of the total head and maximum of 130 % of total head.

The first critical speed for the pump rotor shall be at least 30% above the operating speed.

Pumps shall run smooth without undue noise and vibrations. The velocity of vibrations and the noise level shall be as per latest IS code. To detect excessive vibrations exceeding design limits as per standards, three axis vibration monitors shall be installed on the motor at top. The motor shall stop automatically when the vibration exceeds the limits.

The power rating of the pump motor shall be higher of the following:

115% of the power input to the pump at duty point at a speed corresponding to given frequency.

Maximum power input while operating single pump corresponding to the speed of 50 Hz.

Pump impeller shall be both statically and dynamically balanced.

The pumps of a particular category shall be identical. Components of identical pumps shall be interchangeable.

Pump shall be provided with non-reversible ratchet to prevent reverse rotation.

All pumps shall be provided with suitable protections including protection against overload, bearing failure, increase in bearing temperature etc.

All accessories required for proper and safe operation shall be furnished with the pumps.

Pump and motor shall be selected for VFD operation in variable frequency.

2.1.5. REVERSE ROTATION

Non-reverse ratchet arrangement shall be provided to prevent reverse rotation. However, the unit shall be designed to operate safely at the maximum speed attainable in the reverse direction of rotation due to water returning through the pump at times when the power supply to the motor is interrupted and the valve fails to disallow reverse flow and non-reverse ratchet arrangement fails.

2.1.6. NOISE AND VIBRATION LEVEL

Pumps shall run smooth without undue noise and vibration and noise level shall be limited to

a) Sound: 85db at a distance of 1.5 m.

b) Vibration : 4.5mm/s velocity. (Measured vertical, Horizontal and axial)

2.1.7. COLUMN PIPE

i. Column pipe shall be steel Manufactured from tubes confirming to either IS 1978:1982 or Gr A of IS 2062: 1984 for depths greater than 80m, the column pipe shall be manufactured from tubes confirming to IS 4270:1983.
ii. The Standard lengths of column pipes shall be 1.5, 2.5 or 3m.
iii. The column pipe may be threaded, flanged or provided with other methods of connection.

2.1.8. GASKET, SEAL AND PACKING'S

Gaskets, seals and packings used for clear, cold water pumps shall confirm with those specified in IS: 5120:1977.

2.1.9. IMPELLER:

i. The impeller shall be ASTM A 743 CF8M may be of the enclosed or semi-open type impeller shall be fastened securely to the impeller shaft with keys, taper bushings, lock nuts or split thrust rings.

ii. They shall be adjustable vertically by means of a nut in the driver or an adjustable coupling between the pump and the driver.

iii. Impeller shall be properly balanced dynamic balancing is recommended. Closed impellers may have a renewable sealing/wear ring fitted on to the front shroud or in the bowl or both.

2.1.10. BOWL

i. The Bowl shall be Cast Iron conforming IS 210:1978 and casings of bowl shall be free of blow holes, sand holes and other detrimental defects, the bowls shall be capable of withstanding a hydrostatic pressure equal one and a half times maximum discharge pressure (this included shut off head).

ii. The bowls may be equipped with replaceable seal rings on suction side of enclosed impellers. Water passages shall be smooth and the bowls may contain bushes to serve as bearings for the impeller shaft.

2.1.11. IMPELLER SEAL RING:

The Wearing shall be ASTM A 743 CF8M wearing ring providing seal to enclosed impeller. It may be either on the impeller or in the bowl or on both.

2.1.12. TRANSMISSION BEARING RING:

The Bowl-bearing/top bowl bearing shall be rubber; bronze conforming IS 318:1981 and bearing used for impeller shafts in each bowl.

2.1.13. IMPELLER/LINE/HEAD SHAFT:

Impeller Shaft shall be stainless steel conforming IS 1570 (Part 5):1895 and it holds the rotating impellers and coupled to the line shaft.

2.1.14. MATERIAL OF CONSTRUCTION

The material of construction for various components shall be as under:

Casing & Suction bell: Cast Iron IS: 210, Grade FG 260

Bowl: Cast Iron IS: 210, Grade FG 260

Impeller: ASTM A 743 CF8M

Impeller Shaft: AISI 410

Head Shaft: AISI 410

Line Shaft: AISI 410

Discharge Head : MS IS 2062 Fe 410WA

Column pipe: MS Fabricated

Transmission Bearing : Rubber backed Bronze

Wearing Ring: ASTM A 743 CF8M

Suction strainer : SS 316

All fasteners including anchors bolts, foundation bolts, washers, nuts etc. in both in wet and dry areas Stainless Steel SS 316

2.1.15. DISCHARGE HEAD AND MOUNTING PLATE

The discharge head shall be a composite fabrication or casting. The supporting-plate assembly shall consist of a steel base plate, strong enough to carry the weight of the complete pumping unit without significant deflection. The assembly shall provide the motor mounting arrangement and support the pump. If required, the supporting plate shall be supplied with a flanged sleeve to facilitate mounting, with a puddle flange for building in.

The following shall be included:

- •supporting plate with holding down bolts or studs;
- •Bedplate ring with leveling screws and plates;
- •Lifting lugs
- •Fixings for motor and coupling;
- •Provision for insertion of cables and level-recording equipment if required;
- •Provision for access to service the shaft seal.

The discharge-head shaft seal shall be selected for long life with minimum maintenance and may be of the mechanical. The pressure limit of mechanical seals shall be at least 50% greater than the pump closed-valve delivery pressure. Provision shall be made to return to the pump well any water leaking past the head seal.

2.1.16. WATER-LUBRICATED LINE-SHAFT BEARINGS

Bearings shall be spaced at the intervals needed to ensure vibration less running at all possible pump operating speeds, with a maximum distance of 2.5 m apart. Guide bearings shall be of resilient synthetic rubber, mounted in spider bearing-retaining assemblies.

The arrangements for supplying filtered water shall ensure:

a) That filters used are duplex type so that one filter can be cleaned while the second remains in service;

b) That if required by the bearing design, a filtered water supply is provided to each bearing before the shaft begins to rotate.

c) That if the installed arrangement makes any reverse rotation possible on pump stopping, if required by the bearing design a filtered water supply is provided to each bearing until reverse rotation stops.

2.1.17. REJECTION

If the shop testing at factory premises, the guaranteed efficiency considering the zero percent negative tolerance, is not met, the pump shall stand rejected.

2.1.18. TECHNICAL DATA SHEET

The bidder shall submit detailed technical data sheet pump with their technical proposal during bidding covering all the details of pumps.

2.1.19. NAME PLATE

All Pumps shall have a stainless-steel nameplate on the body. Project name shall be printed by original manufacture.

EOPD & HOPD VALVE

2.1.20. EOPD VALVES:

Butterfly valves shall be of flanged construction and shall be complete with actuating mechanism, matching counter flanging, bolts, nuts, gaskets, lifting lugs, sole plate for supporting feet in the valve body etc.

2.1.21. DESIGN / CONSTRUCTION / MATERIALS PARTICULARS

The valves shall be designed for the design pressure / temperature as specified and in accordance with IS13095/BS5155.

i. The vales shall be suitable for installation in any position (horizontal / vertical etc.).
ii. All valve components and accessories of the same type shall be perfectly identical in size and material so as to guarantee interchangeability of the parts.
iii. This specification is valid also for the spare parts.
iv. The actuator-operated valves shall be designed on the basis of the following prescriptions.

- The internal parts shall be suitable to support the stresses due to the actuator, the valve-actuator unit shall be suitably stiff so as not to cause vibrations, misalignments, etc.
- All flanged ends shall comply with the standard specified.
- The valve flanges shall be flat faced.
- The Contractor shall furnish the coefficient of capacity of each valve (CV in metric units) and the characteristic curves.
- Necessary shaft seal shall be provided and adequately designed to ensure no leakage across the seal. This seal shall be designed so that they will allow replacement without removal of the valve shaft.
- The operating mechanism shall be mounted directly on or supported from the valve body.
- The Sealing ring on the disk shall be continuous type and easily replaceable.
- Rubber seal shall be fitted on the periphery of the disc by clamping between the disc and clamping ring. The seal design shall be T type and shall be held in machined grooves on the disc and clamping ring. Seal design with clamping bolts passing through seal shall not be acceptable.
- The shaft shall be solid type and shall pivot on bushings. Bushings/sleeve type bearings shall be contained in the hub of valve body.

The material of bearing shall be self-lubricated type with low coefficient of friction that does not have any harmful effect on water and on valve components. Bearing shall be provided beyond the shaft seal. The housing for this bearing shall be rigidly attached to the valve body.

The minimum length of the disk hubs shall be at least 1.5 the diameter of the shaft or of the stems.
The shaft shall be connected to the disk through keys or taper pins or screws of stainless steel. The connections shall be designed so as to avoid looseness during the operation; moreover, they shall be provided with suitable disassembling systems. The design of the shaft shall be such that it will safely sustain maximum differential pressure across the closed valve. The shaft and any key (taper pin or other) for transmitting the torque between shaft and disk shall be capable of with standing the maximum torque required to operate the vale.

The disc shall rotate from the full open to the tight shut position. The disc shall be contoured to ensure the least possible resistance to flow and shall be suitable for throttling operation. While the disc is in the throttled position, valve shall not create any noise or vibration.

All butterfly valves shall have permanent arrow inscription on the valve body indicating direction of flow. All valves shall be complete with:-graduated position indicator (located in a visible place for the operation).Adjustable mechanical stop limiting devices to prevent over travel of valve disk in open and closed position.

Valves shall have integrally cast supporting feet.

2.1.22. ACTUATORS OPERATED VALVES

Actuators will be with Limit and Torque switches for either end of travel for control and interlocking purpose.
The characteristics of the actuators to be located on the valves are indicated in the actuators specification.
Should the actuator be located on the control column, all connecting accessories shall be supplied (extensions, joints, articulations, etc.). The valves 350Nb and above shall also be provided with hand wheel drive arrangement suitable for manual operation. Manual operation of valve shall be through worm and gear arrangement having totally enclosed gearing with hand wheel diameter and gear ratio designed to meet the required operating torque. It shall be designed to hold the valve disk in intermediate position between full open and full closed position without creeping or fluttering. Adjustable stops shall be provided to prevent over travel in either direction.

Limit and torque switches shall be enclosed in water tight enclosures along with suitable space heaters.

MATERIALS / DESIGN DETAIL

Materials, design and other specific requirements of various categories of BF valves shall be as indicated below.

Sl. No.	Description	Requirement.
a)	Design	As per IS 13095/ BS 5155
b)	Type	Double flanged
c)	Material	
	i) Body and Disc	Cast steel grade ASTM-A 276 74 d Gr.WCB or SG Iron as per IS 1865 gr.

		500/7
	iii) Shaft	Stainless steel AISI: 431
	iv) Body Seat	Monel 60 integral
	v) Disc Seat	EPDM
	vi) Bearing	PTFE LINED ST.ST.
	vii) Testing	AWWA-C-504/ IS
	viii) Other Requirement	Tight shut off

SPECIFIC PERFORMANCE GUARANTEE

For the rubber seated valves, the Contractor shall guarantee that in the closed position and with a disc differential pressure as specified the valves shall be water tight.

The Contractor shall guarantee that the operating mechanism shall open and close the valve under the specified maximum differential pressure within the time specified.

The valve shall be suitable for frequent operation during initial commissioning operation after a long period of inactivity.

MARKING

The mark stated by the Employer in the Material Request shall be printed on the body of all valves and relevant accessories (control columns and relevant connecting elements to the valve, counter flanges, valves for the auxiliary control if separately supplied, etc.).

The face of each hand wheel shall be clearly marked "Open" and "Shut" with arrows indicating the direction of rotation to which they refer. Each handwheel shall also be fitted with a circular name plate indicating the service for which the valve is intended and valve tag number. The name plates shall be engraved in black lettering.
Each spare part shall be individually marked with metal plates suitably punched for an easy identification.

TESTING AND INSPECTION

All valves shall be checked for correctness in respect of flange details as specified. The valves shall be tested as per the requirement of AWWA C-504 (latest version)/IS.Proof of design-tested valve shall not be supplied for the project.

For cast construction : Body and Disc shall be subjected to MPI/LPI and shaft shall be subjected to UT and LPI.

For Fabricated Construction: All Butt welds having thickness 20mm and above shall be subjected to Radiography and stress relieving. Only qualified welders shall be used for the purpose of carrying out welding. Shaft shall be subjected to UT and LPI.

Site Test

The valves shall be tested at site for opening and closing time, valve operation etc. The valve should operate without any flutter, noise, and vibration.

2.1.23. ACTUATORS FOR BUTTERFLY VALVES

DESIGN REQUIREMENTS:

- Electric actuators shall essentially consist of electric motors, limit switches, hand wheel and gear trains, mechanical position indicators, internal wiring and terminal block.
- The electrical actuator assembly inclusive of drive motor and unit switches compartment shall conform to IP 55 degree of protection.
- Actuators shall be sized so as to open / close the valve at the rated speed against the design differential pressure at 90% of the nominal voltage.
- Lost motion hammer blow feature shall be provided for seating / unseating the valve when the operating torque exceeds 11 kg/m.
- Operators shall be designed to be self locking (i.e. maintains the stem position) upon loss of electric power supply.
- Motors shall be installed on the operator prior to shipment to the valve manufacturer.
- Actuators shall be provided with lifting lugs for handling it along with the bonnet. Actuator assembly shall have all metal gear trains.
- Operators shall be flange mounted on the valve bonnet. Welding of operators onto bonnets is not permitted.

OPERATING SPEED:

All actuators shall have operating speeds as per the manufacturer's standard. However, this shall meet operating requirement of the system. Actuator operating times (opening and closing) shall be furnished with actuator details.

SERVICE CONDITIONS

i. The actuator shall be suitable for operation in a hot, humid and tropical atmosphere.

ii. Unless otherwise stated in the equipment specification, the ambient air temperature shall be taken as 50 dg. C, relative humidity 100% and mean sea level less than 1000 meters.

RATING

The actuator shall be designed for operation on a 415 V + 10%, 3-Phase 50 Hz + 5% solidly grounded system. The combined voltage & frequency variation shall be +/- 10%. The control circuit voltage shall be 240/110 V A.C. or 220V D.C.

The actuator shall be rated for three successive open-close operation of the valve or 15 minutes, whichever is longer.

The normal torque rating of each drive unit shall have adequate margin and at least equal to theoretical brake torque required to drive the equipment under full load, including all losses in speed reducers and power transmission.

The drive shall take into account valve operating speeds and differential and static pressures required for the service. The Contractor shall select operating speeds and design pressure to satisfy requirements of the equipment furnished and acceptable to the Employer. Motor actuator assemblies shall have all metal gear trains. Fibre gears are not acceptable.

PERFORMANCE

- The actuator shall open and close the valve completely and make lead-tight valve close, without jamming.
- The actuator shall attain full speed operation before valve load is encountered and impart an unseating blow to start the valve in motion (hammer blow effect).
- The actuator shall operate the valve stem at standard stem speed and shall function against design differential pressure across the valve seat.
- The motor reduction gearing shall be sufficient to lock the shaft when the motor is de energized and prevent drift from torque switch spring pressure.
- The entire mechanism shall withstand any shock resulting from closing with improper setting of limit switches or from lodging of foreign matter under the valve seat.

2.1.24. SPECIFIC REQUIREMENT

Construction

The actuator shall essentially comprise of the drive motor, torque/limit switches, gear train, clutch, hand wheel, position indicator / transmitter, space heater and internal wiring. The actuator enclosure shall be totally enclosed, dust tight, whether proof suitable for outdoor use without necessity of any canopy. All electrical equipment, accessories and wiring shall be provided with tropical finish to prevent fungus growth. The actuator shall be designed for mounting in any position without any lubricant leakage or operating difficult.

Motor Drive

The drive motor shall conform to sub-section E2 of this specification.
The drive motor shall be three phase, 415V, squirrel cage, induction machine with class B insulation and IPW-55 enclosure, totally enclosed and self ventilated and designed for high torque low inertia and reversing service suitable for operation at 50 deg. C ambient temperature. The motor shall be designed for full voltage direct on-line start, with starting current limited to 6 times full-load current.
All motors shall have TEFC enclosures with space heaters to maintain the internal temperature above dew point when the motor is idle. Space heaters shall be rated for 240V AC. The motors shall be capable of operating the valve against the maximum load on the valve disc. with drive bearings in dry and dirty condition. Each motor shall be provided with two direct temperature-sensing thermostats to prevent thermal overload. All motors shall have O-ring seals to provide complete environmental protection when the motor is idle. Earthing terminals shall be provided on either side of the motor. Double shielded grease pre-lubricated, regreasble, antifriction bearings having a minimum life rating of 1,00,000 hours shall be furnished.

Limit switch

Position Limit Switches:

Each actuator shall have rotary drum position limit switches, two (2) for open and two (2) for close position, each with adjustable setting between fully open and fully close positions. Each rotary drum position limit switch shall have two normally closed (NC) and two normally open (NO) independent contacts. The adjusting mechanism for the limit switches shall be easily accessible.

Torque limit switches:

Each actuator shall have two torque limit switches with suitable arrangement to limit the opening / closing thrust. The torque switch, actuated by the torque clutch when the valve is restricted during opening / closing shall stop the motor thereby protecting the motor from

overloading torque. The torque switches shall be set as near as possible to the pull out torque of the motor without damaging the valve of the operation. Each torque switch shall have two normally open (NO) and two normally close (NC) independent contacts. The torque limit switch adjusting mechanism shall be easily accessible. Limit switches along with all necessary electrical wiring shall be housed in a weather proof NEMA-3 enclosure and shall have gasketted cover and space heater to maintain the temperature above dew point. Each torque / position limit switch shall have 2 No + 2 NC potential free contacts. Contacts shall be rated to make and carry continuously 10 A at 110 V AC and 0.5A (inductive) 220 V DC.
Manual operation: All actuators shall have mechanically independent manual drive arrangement with hand wheel and motor declutching mechanism. The manual drive shall be provided with clutch and gearing as required to limit hand wheel effort to 25 kgt maximum along with suitable latch and locking arrangement to keep the hand wheel in engaged position using manual operation. The hand wheel shall disengage automatically during motor operation.

Position indicator/Transmitter: All actuators shall have one (1) built-in local position indicator for 0-100 % travel. All actuators shall be provided with mechanical 3-point dial position indicators. Rising steam valve shall additionally have visual position indication through plastic stem covers. Where required, valves shall be provided with continuous remote position indicators of the potentiometric type. The available voltage sources for the potentiometric position transducers are 220V DC and 240 V AC. The tranducer shall be suitable for stablished 4-20 mA current signal. The associated wiring for the transducers shall be housed in the limit switch compartment.

Space Heater: A space heater shall be included in the limit switch compartment suitable for 240 V AC, 50 Hz supply 220 V DC.

Wiring: All electrical devices shall be wired up to and terminated in a terminal box. The internal wiring shall be of sufficient size for the power rating involved but no case less than 1.5mm copper. All wiring shall be identified at both ends with ferrules. Internal wiring diagram shall be neatly pasted on the rear side of the terminal box cover. Motor power, heater and all control wiring shall be wired at shop to suitably rated master terminal blocks located within the limit switch compartment. All internal wiring shall be of 650/1100 V grade flexible standard copper conductor cables with tropical fungicidal treatment and the insulation shall be flame resistant. The limit switch terminals should be capable of terminating two nos. 2.5 mm copper cable. Terminal boxes shall be provided with removable undrilled gland plates to terminate following sizes of cable.
. I) 1 no. - 14 core 2.5^2 (Cu)
ii) 1 no. -10 cores - do -
iii) 1 no. - 2 pair
iv) 1 no. - 10 pair
v) 1 no. - Power cable

Terminal Box
Actuator terminal box shall be suitable to receive and terminate the following cables:
a) 1 No. power cable details of this shall be intimated later.
b) 3 Nos. 19 C x 2.5 copper conductor PVC insulated unarmoured control cable.

Actuator terminal box shall be provided with a removable front cover plate, and an undrilled detachable gland plate.

Data to be furnished: Motor data sheet for each type of actuator shall be furnished along with internal wiring diagram, suggested control schematic and torque / limit switch contact development.

2.1.25. HYDRAULIC OPERATED VALVE (DISCHARGE VALVE) FOR FULLY CLOSING AND OPENING FUNCTIONS DURING STOPPING AND RUNNING OF PUMP

Type and description

Each pump shall be provided with oil pressure operated butter fly valve or through flow type valve, and oil pressure operated needle valve or sluice valve as by pass use. The valve shall have maximum capacity to allow maximum flow of pump discharge. The valve shall be designed to withstand the maximum transient pressure and shall be free from vibration and abnormality under the whole operating range of pump including any transient conditions of operations. The inside diameter of the valve shall be recommended by the bidder. The valve shall be so designed as to be capable of closing from fully opened position under the condition of maximum flow at every head with minimum oil pressure supplied to servomotor.

The opening and closing time of the valve shall not be more than 60 seconds including the operating time of bypass valve with normal operating pressure.

Amount of leakage passing through the gaps shall not exceed 5 litres/min. under a static head of 9.00 M including leakage through the bypass valve.

Valve Body

Valve body shall be fabricated of rolled steel plate welded structure or made of steel casting, and shall be sectionalized if required to suit transportation limitations if any. Each section shall be jointed at site by flange and bolts with sufficient strength to with stand the maximum hydraulic pressure of 100m. as well as to withstand the maximum static head without any distortion or deformation. Both ends of the valve body shall be provided with grooves for grease lubrication.

The bearings shall be provided with necessary packing glands to prevent inflow of sand or other foreign material contained in the water.

The valve shaft shall be horizontal type and the bearings shall support the full weight of the valve disc and shaft, and assure smooth opening and closing operations. The bearings shall be suitable for lubricating with grease from the grease supply device. All bearings shall be so constructed that the replacement of the liner and packing can easily be carried out.

The joint between the valve and the spiral case shall be made by flanges packing and shall be free from any leakage. The contractor shall furnish all the bolts, nuts, packing and other necessary material and bolts for making perfect tightness of the joint. Necessary connecting pipes, flanges, bolts, nuts, packing and other required parts shall be furnished by contractor. The valve body shall be provided with a set to mount the bypass valve.

Valve Disc

The valve disc shall be made of carbon steel casting or fabricated of rolled steel plates. The disc shall be designed with sufficient strength not to cause any distortion or deformation nor to cause any abnormal vibration when the valve is in open position or during operation. The disc shall be supported by forged steel turnions through the disc. on the peripheral surface of the disc a rubber ring shall be provided to seal off leakage together with a stainless steel seat provided on the valve body inner surface. The rubber ring shall be firmly fixed to the valve disc by metal fitting. The fitting bolts shall be made of stainless steel. The design shall fabricate easy renewal of the rubber ring on the spiral case side with the valve in its position. And also a maintenance seal shall be provided so that the seal replacement can be carried out without emptying the delivery line in case the regular seal is not effective.

Bypass Valve

Bypass valve shall be designed to assure the least amount of corrosion due to cavitation and cause the least noise or vibration during operation.

Metal sealing shall be provided to obtain a leak-proof seal when the valve is closed. The operation shall be provided to obtain a leak-proof seal when the valve is closed. The operation of the bypass valve shall be carried out by oil pressure commonly used for discharge valve. One end of the bypass valve shall be connected to the seat provided on the discharge valve body and a manual gate valve shall be provided on upstream of the hydraulic operated bypass valve. The valve shall be of such construction to permit easy manipulation by one man. The other end shall be connected to the seat provided. The valve shall be made of stainless steel.

Connection to Pipe to Delivery Line

In order to facilitate erection of the discharge valve, connecting pipe between the discharge valve (H.O.P.D / E.O.P.D) and the delivery line shall be furnished. The connection pipe shall be fabricated with rolled steel connection between delivery line and connecting pipe at a suitable distance away from the pump center line shall be done by welding at site. Specifications of material for connecting pipe shall be determined during detailed engineering stage. Particulars of the connection shall be decided after award of contract. The connecting pipe shall be provided with pipe seats and taps for delivery line drain, pressure gauge pipe etc. The location and inside diameter of those pipe seats and taps shall be decided during detailed engineering stage.

Discharge Valve Operating Mechanism

Discharge valve operating mechanism shall consists of servomotor, rod, link and lever. The cylinder and head of servomotor shall be made of carbon steel casting or rolled steel for welded structure. The servomotor piston shall be made of carbon steel casting or cast iron. The operating mechanism, including that for the bypass valve shall be provided with manual locking devices which can lock both the inlet and bypass valve when they are closed. When the valve is locked, both opening and closing operation by oil pressure shall be blocked.

Operation of the valve shall be such that ,in opening, the bypass valve is opened first and the discharge valve shall be opened after the delivery line is filled with water and in closing, the discharge valve is closed first and the bypass valve is closed after the discharge valve is closed.

The bypass valve shall be provided with a hydraulic oil distribution valve to establish a condition to open or close the discharge valve in conjunction with the operating.

Two limit switches shall be provided for the discharge valve. Each limit switch shall be provided with two normally open auxiliary contacts and two normally closed auxiliary contacts.

A scale plate and a needle shall be provided to indicate the discharge valve position in percentage of 100 , when the valve is fully open.

OPU system for discharge valve shall be complete in shape and quantity and shall cover oil Pressure oil pumps valves.

Oil Pressure Unit System for Main Discharge Valve

A) **Oil Pressure Vessel**

i)The oil pressure tank shall be designed and tested in accordance with the ASME code (Section-VIII), for unfired pressure vessels or any other approved equivalent code considering the maximum working pressure of the system. The interior surface of the pressure tank shall be coated with oil resistant paint or other suitable coating to prevent deterioration of the metal. It shall also be ensured that oil characteristics in regard to its functions are not affected chemically or otherwise.

ii)The capacity of the oil pressure vessel shall be sufficient to meet all the pressure oil requirements of the servomotor and even below pump shut down oil level. It shall have an oil volume capable of performing three full operations that is close-open-close, with the oil pumps being out of operation.

iii)Means shall also be provided to prevent entry of air into the oil piping system under conditions of lowest oil level in the sump tank or receiver.
iv) The oil pressure vessel shall be provided with the following safety / control / operation switches:
a) Pressure switches for automatic starting of oil in flow into the OPU receiver when oil pressure in the vessel falls below a predetermined value and for automatic stopping of oil inflow when pressure rises above a predetermined value, and for alarm and trip under low pressure or abnormally high pressure conditions. Necessary unloader valves shall be included in scope of supply.
b)Level switches, differential pressure switches for giving alarm and shutting down the pumps when oil level falls below predetermined value.
c) Level switch / differential pressure switches for giving alarm when oil level rises above the predetermined value.
v)The oil pressure vessel shall be equipped with a float type dial gauge for indicating oil level in the tank.
vi)The oil pressure vessel shall be complete with compressed air inlet, auto air replenishing system, air relief valve (safety valve), pressure gauges, piping, oil drain connections with valve, manhole, etc.

Oil Sump-Tank and Pumps

i)Two nos. screw type oil pumps shall be provided and located on the tank top itself, one serving as main and other as standby, with a manual selector switch to changeover their functions. The standby pump shall automatically start on failure of the main pump in service.

ii) The pumps shall be of continuously running type with adequate capacity during unit running time, with pressure switch control and shall continue to run intermittently with pressure switch control, when the unit is shutdown. A set of smoothly operating unloader valve, non-return valve and safety valve shall be provided to regulate the oil level.

iii) The pump motors shall be of continuous rated and shall be provided with 415V, 3 Phase, 50 Hz. squirrel cage induction motors.

iv)Oil sump tank shall be provided with float type dial level indicator, oil contamination detector, level switches for low/high oil level alarms, oil filter, air vent and filter, oil inlet/ outlet connection and drain valves etc. The interior surface of the sump tank shall be coated with oil resistant paint or other suitable coating to prevent deterioration of the metal. It shall also be ensured that oil characteristics in regard to its functions are not affected chemically or otherwise.

v)The sump tank provided shall have a sufficient capacity with not less than 50% margin to hold all the oil in the system.

vi)The sump tank shall be provided with a manhole for access to interior of the tank and shall have suitable connections for oil purifier.

vii)The sump tank shall be provided with oil level gauge and oil level switches for indication of oil level low/ high and alarms.

LEAKAGE OIL TANK AND PUMPS

Oil leakage tank with screw type pumps and necessary piping and valves shall be provided and located at suitable location. The tank shall be provided with suitable float type dial level indicator level switches for automatic start/stop of the pumps. The pump motors shall be suitable for 415 V, 3 phases, 50 Hz, AC supply. An alarm shall also be provided to indicate high & low oil level in the tank.

DISCHARGE VALVE OIL PIPING AND VALVES

Oil piping and valves complete with flanges, bolting materials, gaskets; packing etc. required for inter-connections between the various equipment shall be included in the offer. All piping shall be steel, suitable for maximum oil working pressure. All valves shall be cast or forged steel valves having flanged ends.

EOPD:
EOPD Shall be electrically operated gate valve and shall be provided and limit switches end limit switches, torque switches along motors of suitably rated with terminal block arrangements. The cable sizes shall be as detailed above.

INSTRUMENTATION AND CONTROLS FOR PUMP AND PUMP CONTROLLER.

Instrumentation, alarms, safety devices and controls necessary for automatic control, monitoring and efficient operation of the pump with its associated equipment shall be supplied by the manufacturer so as to constitute a complementary part of the complete and coordinated set of such instruments, gauges, controls and safety devices required for supervision and controls of the unit during normal running and in emergencies.

Tentative requirements of the instrumentation etc. are given in the schedule of requirement. The Bidder shall however, offer any additional instruments and safety devices which the bidder considers, necessary for the unit and the bidder shall guarantee the sufficiency and adequacy of the provisions in this regard. The Pump-motor is normally started from the SCADA system in the control room and brought to synchronous speed and then synchronized with the grid and pumping of water is done. In general the instrumentation and control scheme shall be such as to provide for manual mechanical control, manual local electrical control and automatic remote control and emergency shut down. The local electrical control and emergency shut down from unit control panel(Local control panel) and the remote electrical control from unit control board / MMI panel to be mounted in the control room shall be provided.

All necessary indicating instruments, gauges and controls etc. for the pump and controller shall be mounted on the unit control board and wherever necessary on unit control panel. All temperature indicating/recording instruments, associated relays, certain electrical instruments on the unit control board shall be provided by the manufacturer.

For remote control of the units from the main control room, all necessary items of the controller and also alarm/safety devices shall be provided on the main control panels in control room. The controller controls and indicating instruments shall be provided. The control which are provided both on the unit control board/Machine control panel and the controller cabinet (Main control Board) shall be so interlocked electrically as to eliminate the possibility of simultaneous operation of any control from both the boards.

One set of apparatus for measurement and recording of the pump discharge shall be supplied with each pump. The apparatus shall be complete with all necessary instruments, peizometers, tapings, interconnecting tubing etc. and shall be calibrated at the time of efficiency and out-put tests on the pump.

One set of pressure transducer type water level transmitter and indicator/recording instrument shall be provided for cistern. The signal for the head variation should be transmitted to the gate opening limiter of the controller. This device shall be able to prevent operation of pump at non-rated duties restricting extra gate openings at higher heads.

SPECIAL TOOLS, SLINGS, CONSUMABLES ETC.

All special tools, slings, lifting devices, jacks, turn-buckles, foundation plates, bolting materials etc. required for assembly, erection, dismantling of the pump, controller and other equipment of bidder's supply shall be included by the bidder. A list of the special tools and equipment required for assembly/erection and maintenance of pump components as listed in "Schedule of Requirement", item-4 shall be supplied. First filling of the controller and lubrication oil with 10% spare capacity, for pump shall be supplied by the manufacturer and the brand and grade of the oil shall be specified.

SPARES

Spare parts for the pump, controller equipment and instrumentation as listed in item 2 schedule of spares of this section shall be supplied along with the main equipment. All spare parts supplied shall be interchangeable with and shall be of the same material and workmanship as the corresponding parts of the equipment. The spares shall be supplied along with the first unit. The bidder shall also indicate additional spares considered essential by him for five (5) years normal operation and maintenance.

TESTING DEVICES AND INSTRUMENTS FOR TESTING DURING ASSEMBLY, ERECTION AT SITE AND FOR FIELD ACCEPTANCE TESTS

Testing tools and equipment required for testing during assembly/erection at site and all instruments and devices required for field acceptance tests for fulfillment of efficiency and output guarantees, shall be supplied.

SHOP ASSEMBLIES AND TESTS

The first pump shall be completely assembled in shop and properly match-marked and dowelled to ensure correct assembly and alignment in the field except that where necessary suitable dowels shall be furnished for insertion after field assembly and drilling.

In the case of subsequent pumps, part assemblies to the required extent shall be done and match marked to avoid any problem of matching during erection at site.

The equipment such as pressure tank, gate, servomotors, piping, coolers etc., which shall be subjected to oil (or water) pressure shall be shop tested as a pressure equal to 150 percent of the maximum operating oil (or water) pressure inclusive of maximum water hammer in such equipment.

The bidder shall give a list with details of the shop assembly tests to be performed on the components of the pump such as runner, guide bearing etc. including controller and other accessories etc. These shall be subject to the approval of the purchaser.

The purchaser or his authorized representative shall have access to the manufacturer's works for all purpose of witnessing the manufacture, Inspection of various assemblies and for testing of all components. The equipment shall be assembled and shop tested in the presence of the purchaser or his authorized representative, prior to dispatch. Any work found defective or unsatisfactory shall be rejected.

The bidder shall conduct non-destructive tests on components of pump.

FIELD ACCEPTANCE AND OTHER SITE TESTS

Hydraulic pressure tests, leakage tests and operation tests where applicable shall also be performed on components such as the pump components, pressure tanks, controller , sump tank, pumps, motors etc.

The manufacturer shall furnish a list of all the field tests to be performed during site assembly and erection of the pump prior to commissioning.

Field Acceptance tests shall be performed on the fully erected pump-motor units to determine the actual performance of the unit vis-à-vis the guaranteed performance. The field acceptance test shall be performed as per IEC test code for Hydraulic pumps or any other equivalent standard.

The pump shall be given a over speed test for a period of 15 (fifteen) minutes to demonstrate their ability to withstand successfully the mechanical stresses and hydraulic performance incident to maximum runaway speed at an effective maximum head with wicket gates fully open. The cost for any component replacement/rectification that may be required shall be to the account of manufacturer.

DRAWINGS, DATA, MANUALS ETC., AND DOCUMENTATION TO BE FURNISHED BY THE BIDDER

The bidder shall furnish all drawings, data, manuals and other necessary literature in six copies. The Bidder shall, in addition, supply the documentation for the design and manufacture of the pumps as given below:

I. Supply of complete information on Scheme design including basic data on Scheme information, model test report, characteristic curves etc. for operation.
II. Supply of detailed design drawings and calculations, strain gauging results, computer programmes, plate development data for draft tube assembly, dimensional tolerances particulars
III. Complete specifications of materials. Copies of specifications relating to inspection and testing of material and finished components
IV. Detailed manufacturing drawings for various pump components and information.
V. Tooling information.
VI. Recommended list of suppliers for supply of components.
VII. All information necessary for co-ordination of station and control equipments.
VIII. Drawings clearly showing the various components/ assemblies of the pump, governing equipment draft tube etc. in plan and elevation.
IX. Layout drawings of the pump house both in section and plan showing the overall dimensions and layout of the pumps, auxiliaries, general run off pipes etc. clearly indicating unit spacing dimensions of draft tube etc. and all important elevations.
X. Comprehensive operation, maintenance and installation instructions along with O&M manuals of all bought out items.
XI. Supply of dimensional drawing of all the vital hydraulic passages. No load to full load pump performance curves, efficiency and cavitation characteristic curves. Plant and machine sigma curves for pump operation.
XII. A complete list of equipments, Auxiliaries etc. covered in the offer.
XIII. Schematic drawings for electrical controls, instrumentation and Hydraulic controls.
XIV. Physical and schematic drawings and descriptive literature on the Pump controller and control mechanism.
XV. The bidders shall furnish all the data, especially guaranteed and other technical particulars called for in the schedules and also include their experience in the manufacture, erection, testing and commissioning of pump giving details of their technical particulars. Any offer lacking complete information in this respect is likely to be rejected.

(t)

TRAINING OF EMPLOYER'S ENGINEERS

The bidder shall arrange training for 6 engineers of the purchaser for a period as mutually agreed upon during the design and manufacture of the pump at the manufacturer's design and drawing office and manufacturing shops to familiarise with all aspects of design and manufacture of , associated auxiliaries, control systems etc. All expenses including to fro, lodging and boarding charges for training the engineers of the purchaser shall be borne by the bidder.

COMPLETENESS OF EQUIPMENT

All the fittings and accessories of the pump and associated auxiliary and ancillary equipment though may not have been specifically mentioned in the specification but are usually necessary for completeness of the above equipment shall be deemed to be covered by the specification and shall be indicated and furnished by the bidder with out any extra cost to the purchaser.

DEVIATIONS FROM SPECIFICATIONS

The deviations from the specification shall be listed in the Annexure A, absence of which it shall be presumed that the provisions of specifications are completed with by the bidder.

SCHEDULE OF REQUIREMENTS

Item No.1. pump

I. suitable type pumps each for discharging not less than of water and each pump comprising with the following.

II. One runner of stainless steel and cast steel boss complete.

III. One shaft of forged electric furnace steel properly heat-treated and forged with connecting flanges at both ends, keys coupling bolts, nuts, covers etc. for connecting to the runner and to the auxiliary shaft and motor rotor.

IV. One Set of guide bearing of oil-lubricated type with bearing housing and with temperature detector, temperature detection relay, oil piping, pressure gauges, cooling water piping, water flow indicators differential pressure relay and other accessories.

V. One Stuffing box with sealing water piping, differential pressure relay, and water flow indicators, for alarm annunciation in U.C.B. and local indication.

VI. One Draft tube of steel plate suitably sectionalized and equipment for assembly of sections access door with hinged cover and provision for connecting to discharge ring.

VII. One Set of embedded piping including leakage water drain piping, pump sets and other miscellaneous piping.

VIII. One Discharge ring with a provision for connecting to the draft tube on one side and to the guide vane supporting cover on the other side with necessary connecting bolts etc. A manhole with bolted cover for access shall be provided in the discharge ring.

IX. One Stay ring of cast steel or welded plate steel, which shall be embedded in the concrete.

X. One Inner stay vane welded with stay column and one outer stay vane with drain piping, peizometer tapings.

XI. One controller (controller) equipment comprising motor drive, gate control arrangement etc. with a complete set of instrumentation, controls, and automatic safety devices, mounted on the actuator and at the Unit Control Board and equipment for necessary remote control and indication at the main control board.

XII. One Discharge valve with oil pressure system for control, comprising oil pressure pumps, driving motors complete with starting equipment, instrumentation and automatic controls, oil piping, necessary stop valves, check valves, blow off valves, by pass valves, unloading valves, safety valves, fittings etc. and arrangement for replenishment of air in the oil pressure receiver including compressor plant etc. valves (H.O.P.D and E.O.P.D)

XIII. One Speed indicator motor.

XIV. One complete system of equipment, piping, connecting pipes, valves, bends, drains etc. for cooling water, oil and High-pressure compressed air systems for pump and controller equipment.

XV. One complete system of draft tube, drainage and dewatering system.

XVI. One Set of water level indicator for indication of cistern water levels which are common to all the three units with instruments/transmitters, sensing element, piping, valves, complete system for monitoring the reservoir level. The wells for water level sensors and wiring materials between each equipment shall be supplied.

XVII. Two Sets of erection tools common to all the three units.

XVIII. One Set of special tools, slings and consumables etc.

XIX. One Set of tools and plant for maintenance of the plant to be provided immediately after commissioning of pump-I for operation & maintenance.

EXPANSION JOINT / DISMANTLING JOINT

2.1.26. GENERAL

Expansion Joint will be provided in the discharge piping as shown in the G.A. drawings enclosed with this tender.

2.1.27. CODES AND STANDARDS

The design, manufacture and performance of metallic expansion joints shall be as FSA, USA or equivalent standard and comply with or all currently applicable statues, regulations and safety codes in locality where the equipment will be installed. The equipment shall also conform to the latest editions of fluid sealing association.

2.1.28. OPERATING CONDITIONS AND DESIGN REQUIREMENTS:

For operating conditions and design requirements refer to design data sheet enclosed.

2.1.29. CONSTRUCTIONAL FEATURES

All parts of expansion joints shall be amply proportioned for all stresses that may occur during continuous operation and for any additional stresses that may occur during installation and also during transient conditions.

The expansion joints shall be single bellow metalic expansion joints. The arches of the expansion joints shall be filled with soft metalic.

The design shall be suitable for the pressures and type of fluid i.e. raw river water.

The tube (i.e. inner cover) and the cover (outer) shall be made of natural or synthetic metallic of adequate hardness. The shore hardness shall be less than 50 deg. A for outer and 50 deg. A for inner cover.

The carcass between the tube and the cover shall be made of high quality cotton duck, preferably, square woven to provide equal strength in both directions of the wave. The fabric plies shall be impregnated with age resistant metallic or synthetic compound and laminated into a unit. Reinforcement, consisting of solid metal rings embedded in carcass, shall be provided.
Expansion joints shall be complete with stretcher bolt assembly to absorb piping movements and accommodate mismatch between pipelines.

Main Body

The expansion joints shall be of heavy-duty construction made of high-grade abrasion resistant natural or synthetic metalic compound. The basic fabric for the "duck" shall be either a superior quality braided cotton or synthetic fiber having maximum flexibility and non-set characteristic
Note: Slip type metallic joint should be provided with relevant specifications instead of metallic expansion joint.

Reinforcement
The expansion joints shall be adequately reinforced, with solid steel rings, to meet the service conditions under which they are to operate.

Retaining Rings
All expansion joints shall be provided with stainless steel retaining rings for use on the inner face of the metalic flanges, to prevent any possibility of damage to the metalic when the bolts are tightened. These rings shall be of split and beveled type for easy installation and replacement and shall be drilled to match the drilling on the end metalic flanges and shall be in two or more pieces. The split retaining rings shall be of 10 mm thick stainless steel of tested quality. Steel washers shall be provided at the boltholes where retaining rings are split.

End Flanges
The expansion joints shall be integral fabric reinforced full-face metallic flanges. The bolt hole on one flange shall have on eccentricity in relation to the corresponding bolt hole on the flange on the other face. The end metallic flanges shall be drilled to suit the companion pipe flanges.

Outer Cover
All exposed surfaces of the expansion joints shall be given a 3 mm thick coating of neoprene. This surface shall be reasonably uniform and free from any blisters porosity and other surface defects

Control Units
Each control unit shall consist of two (2) numbers of triangular stretcher bolt plates, a stretches bolt washers, nuts and lock nuts. Each plate shall be drilled with three holes, two for fixing the plate on to the companion steel flange and the third for fixing the stretcher bolt.

Expansion joint tag no. & name plate

Each joint shall have a permanently attached brass or stainless steel metal tag indicating the tag numbers and other salient design features which will be indicated by the engineer in the expansion joint drawing submitted for his approval by the Contractor.

2.1.30. TESTING FOR METALIC EXPANSION JOINTS

Manufacturer's standard test shall be performed during manufacture and after the completing the manufacturing. Tests shop shall include but not limited to the following.

All bear bellows shall be subjected to deflection test under pressure, pressure being raised from zero to design pressure in regular steps and deflection measured at each step.

Material test shall be conducted as given below:

a) Metallic compound test slab after vulcanizing shall be tested for tensile strength, elongation and hardness.
b) Fabric strength of synthetic fibre for reinforcement shall be checked and test for metalic to fabric, metallic to metal adhesion shall be carried out. Test on metallic shall include hydraulic stability check as per ASTM D- 471.

2.1.31. VACUUM TEST

All expansion joints shall be subjected to an absolute internal pressure of 25 mm Hg. The test shall be conducted in three different positions for a minimum period of thirty (30) minutes duration in each position.

Immediately after the vacuum test, a hydraulic test, as per the relevant, standards shall be conducted on the expansion joints. The rate of pressure duration the test shall not be less than 1 bar/ second. The hydraulic tests shall be conducted on the expansion joint in three different positions for duration of 30 minutes (minimum) in each position.

Either during the hydraulic test or during the vacuum test, the expansion contraction or deformation shall not be move 1.5%. However, a cumulative error is not allowed. The purpose of conducting hydraulic test or vacuum test is to ensure the stability to withstand deflection in axial and transverse direction.

Twenty four (24) hours. After the above test, the permanent set (variation in dimensions with respect to its original dimensions) shall be measured and recorded. The permanent set shall not be more than 0.5%.

Test Results
The record of the test results to establish the tensile strength, permanent set hardness and adhesion characteristics of the metalic used in the construction of the expansion joint shall be made available to the engineer for his approval.

2.1.32. SHOP INSPECTION

The surface of the expansion joints shall be examined by the engineer and/or his representative and abnormalities, if any, noted**.** The Contractor shall arrange training on the equipment supplied for engineers of the purchaser, as mutually agreed upon during the design and manufacture of the equipment to familiarise with all aspects of design and manufacture of Pumps, associated auxiliaries etc. All expenses like living, traveling and other expenses of the trainee engineers of the purchaser shall be borne by the Contractor. The supplier shall also arrange and meet the expenses of stay of Engineers of the purchaser for witnessing the Model Tests

AC MOTORS FOR VFD

2.1.33. SCOPE

The scope covers design, manufacture, testing at manufacturer's works before dispatch, supply, erection at site, testing and commissioning of motors of **suitable** capacity each complete with associated auxiliary equipment like VFD. and other ancillary equipment, like cooling water, associated piping and valves, necessary instrumentation, controls, safety devices etc. and spares as well as special tools and plants for pumping station as described in this specification and annexed schedule of requirement. The scope of supply shall also include all parts, accessories, and spares etc., which are necessary for erection, operation and maintenance of complete motors for **five** years, even though they are not individually or specifically stated in the specification. Corresponding parts of the motors, associated equipment and spares shall be of same material, dimensions workmanship and finish and shall be interchangeable.

Class of Insulation: The ac motors for VFD application shall have windings of class `F' insulation with temperature rise limited to class B unless otherwise specified [see 'IS 1271:2012 'Electrical Insulation – Thermal evaluation and Designation']

2.1.34. RATED VOLTAGE, FREQUENCY AND PERFORMANCE VALUES

Voltage and Frequency Variation - The motors shall be capable of delivering the rated output with The terminal voltage differing from its rated value by not more than +6%, -10% in general cases but in special cases if desired by the purchaser. The frequency differing from its rated value by not more than +3 /-3% in general cases but in special cases if desired by the purchaser, frequency fluctuation of +3% / -6% shall have to be provided, or
Any combination of (i) and (ii).In the case of continuous operation at extreme voltage limits, the temperature-rise limits specified in Table-1 of IS 325:1996 shall not exceed by more than 10oC. Motors, when operated under the extreme conditions of voltage and frequency variation, may not necessarily have their performance in accordance with this standard.

The motor shall be suitable for operating in the frequency range as per requirement with corresponding voltage variation for obtaining rated torque when used for variable speed application.

The motor shall be suitable for direct-on-line starting for non-inverter application. The starting current shall be limited to max. six times the full load current.

The motor shall be suitable for operation in all respects and shall deliver the rated output over the rang of voltage and frequency variation as specified above.

Each motor shall be star connected and the main and neutral leads shall be brought out of the stator frame for insertion of current transformers for protection and metering and surge protection apparatus. The motor shall be grounded though a Resistance grounding device to limit the ground fault current to less than 10 (ten) Amps.

The moment of inertia of the motor shall be coordinated with pump parameters, to meet the requirement of pressure and speed rise as specified in Section-I. The inertia constant shall preferably be not less than 1.5. The flywheel effect shall be built into pump-motor and not added in the shape of weights.

TYPE OF ENCLOSURE : The degree of protection to be provided by the enclosure shall be IP 55 of IS 4691:1985 `Degrees of protection provided by enclosures for rotating electrical machinery (first revision)' or better as required by the purchaser.

METHOD OF COOLING : The method of cooling used shall be IC 0041(fan cooled) / IC 43(separately powered force cooled by fan) / IC411(TEFC)/IC 416(A), IC416R in accordance with IS 6362:1995 `Designation of methods of cooling of rotating electrical machines'. In case of separately cooling motor, the motor speed is to be limited to 1500 rpm (synch).

MOUNTING : The mounting shall conform to any one of the designations IMB 3 ,IMB 5, IM 1001, IM3001 specified in IS 2253:1974 `Designations for types of construction and mounting arrangement of rotating electrical machines (first revision)'. If specified, hollow shaft extension may be provided according to the drawing provided by the purchaser

2.1.35. CORRECTION FACTORS FOR TEMPERATURE

Ambient temperature deg C	**Output correction factor%**
55	80
60	75

The motors shall also be suitable for operation on direct online starting.

The motors shall be suitable for type of duty S4, S5, S6 and S7 as specified in IS 12824:1989 `Type of duty and classes of rating assigned to rotating electrical machines [withdrawn]'.

Motor shall be suitable for Total harmonic distortion of 5%.

2.1.36. EFFICIENCY AND OUTPUT GUARANTEES

EFFICIENCY GUARANTEES: The efficiency of the motor at full discharge of pump shall be above 95% percent at the rated voltage and power factor and combined efficiency shall be above 85%. The weighted average efficiency shall be stated and guaranteed. The above efficiencies shall be subject to penalty and rejection as defined in clause 1.4.5

DETERMINATION OF EFFICIENCIES: The efficiencies shall be determined by summation of losses method in accordance with the latest issue of IEC: 34-2 or IS: 4889. The static excitation equipment losses shall also be included in the motor losses. No tolerance in the quoted efficiency for guarantee purposes shall be permitted.

OUTPUT AND TEMPERATURE RISES: The motor shall be guaranteed to be capable of giving its rated output and maximum output without exceeding the temperature rises.

2.1.37. PENALTY FOR SHORT-FALL IN EFFICIENCY AND OUTPUT:

While testing each pump-motor, for any short-fall in the tested values of rated output, maximum output and weighted average efficiency from the guaranteed values, penalty shall be applied Rs.2,50,000 (Rupees two lakhs fifty thousand only) for each 0.01%(one hundredth percent) by which the test figure is less than the corresponding guaranteed figure.

The penalties on account of shortfall in output and the efficiency shall be computed separately and the total amount of the penalty shall be algebraic sum of these two.

No tolerance shall be permitted over the test figures of output. Tolerance in computation of losses for determining efficiency shall be allowed in accordance with IEC.

2.1.38. REJECTION LIMIT:

The purchaser has a right to reject the motor equipment if the test values of either of the maximum output or the weighted average efficiency is less than the corresponding guaranteed value by 3 (three) percent or more.

The motor is also liable for rejection if either of the stator or rotor winding temperature exceeds the specified limits while operating corresponding to maximum output. This guarantee shall be without bonus in case of temperature raises being less than those specified

2.1.39. DIMENSIONS

The basic dimensions of foot-mounted and flange mounted ac roller table motors and their shaft extensions shall correspond to IS 1231:1974 `Dimensions of three-phase foot-mounted induction motors (third revision)' and IS 2223:1983 `Dimension of flange-mounted ac induction motors (first revision)' respectively.

2.1.40. SPECIAL CONSTRUCTIONAL FEATURES

Material of Body - Material of the motor body shall be cast iron grade FG-260 conforming to IS 210:2009 `Specification for grey iron castings (fourth revision)', or SG iron conforming to IS 1865:1991 `Specification for iron castings with spheroidal or nodular graphite (second revision)' or fabricated steel conforming to IS 2062:2011 `Hot rolled medium & high tensile structural steel'. Non ferrous material for motor body is not acceptable.

For foot-mounted motors with cast iron / Spheroidal Graphite iron body, the feet shall be integrally cast with the body.

Separately screwed eyebolts or lifting lugs of suitable sizes shall be provided on the motor for the purpose of lifting. Eyebolts conforming to IS 4190:1984 `Specification for eyebolts with collars' shall be used.

Shaft Extension - All motors shall have a single shaft extension unless otherwise specified.
Bearings - All bearings shall have an L10 life of at least 40000 h according to IS 3824:2002 `Rolling bearings – Dynamic load ratings & rating life.' The bearings shall be selected so as to take care of the thrust to which the motors are likely to be subjected. The actual thrust value shall be indicated by the user.

Lubrication of Bearings – Re-greasing facility through a grease nipple conforming to IS 4009(Parts 1 & 2):1981 `Specification for grease nipples (first revision)', along with facility for excess grease removal shall be provided for motors of frame sizes 200 and larger.

The provisions of the terminal box shall be in accordance with clause 5 of IS 1231:1974. It shall be possible to turn the terminal box to any of the four positions at 90o intervals to permit cable entry from any of these four positions.

Interchangeability of Parts - The motors of identical rating supplied in a lot by the same supplier shall have the interchangeability in the following parts:
a) Rotors,
b) End shield,
c) Bearing capsules
d) Bearing cups
e) Self cooling fans.

2.1.41. EARTHING

Two separate earthing terminals of proper size suitable to receive galvanized iron conductor shall be provided on the bottom half of the motor body. In addition to the two outside earthing terminals, provision for one more earthing terminal inside the terminal box is to be kept. Size of earthing terminal shall conform to clause 12.2.2.2 of IS 3043: 1987 `Code of practice for earthing (first revision)'.

TEMPERATURE-RISE TEST
The temperature-rise test shall be carried out at full load in accordance with 22 of IS 325:1996 by subjecting the motor to the rated acceleration value (B). The permissible limits of temperature-rise shall not exceed the relevant values given in Table-1 of IS 325:1996.

Temperature Rise Test Under Stalled Rotor Condition – The temperature shall be measured by applying rated voltage to the motor with rotor locked. The temperature-rise shall not exceed the permissible value for the relevant insulation class.

LIMITS OF VIBRATION
Limits of vibration intensity shall be in accordance with normal class of Table 1 of IS 12075:2008 `Mechanical vibration of rotating electrical machines with shaft heights 56 mm and higher – measurement, evaluation and limits of vibration severity.'

NOTE: The manufacturer shall indicate in the test certificate that rotor has been dynamically balanced with half key.

LIMITS OF NOISE LEVEL The noise level shall not exceed the limits specified in IS 12065:1987 `Permissible limits of noise level for rotating electrical machines', if required by the user

TERMINAL MARKING Terminals shall be marked in accordance with IS/IEC 60034-8 (2002) [in supersession to IS 4728:1975]. Identical markings shall be provided both on the leads and the terminal blocks.

RATING PLATE Rating plate made of stainless steel stating the following particulars shall be fixed on the body of the motor:
a) Reference to this interplant standard, i.e. IPSS:1-03-039-14
b) Rated output in kW,
c) Name of the manufacturer and trade mark,
d) Manufacturer's serial number and frame reference,
e) Rated voltage and winding connection of the motor,
f) Rated current in Amps. at rated voltage,
g) Speed in rev/min at rated output,
h) Rated frequency,
i) Class of insulation,
j) Type of duty,
k) Bearing designation,
l) Type of enclosure,
m) Mass of motor in kg,
n) Year of manufacture.
o) Motor suitable for VFD,
NOTE: An additional name plate may be used to indicate the designation of bearings, lubrication details (type, quantity and frequency).

TESTS : The tests applicable to the motors covered by this standard shall be in accordance with Table-2. A certificate indicating the routine tests conducted on each motor including thermal withstand capability shall be supplied with the motors. The manufacturer shall supply type test certificate with each order whenever required by the user.

MOTOR INSTRUMENTATION AND CONTROLS AND SAFETY DEVICES:

The supplier shall furnish all ancillary equipment relating to the motor as outlined under schedule of requirements. This equipment together with the other motor equipment supplied, shall constitute a complete and co-coordinated set of instruments, gauges, controls and safety devices for the supervision and control for the units during normal running and in emergencies. The instrumentation and controls of the units shall be provided on machine control panels/unit control panels and the main control board. The bidder shall provide equipment in accordance with schedule of requirements for mounting on these boards and locally on the equipment of his supply. The instruments and controls shall have to be suitable and adequate for manual control, automatic sequential control. The bidder may, however, provide any additional instruments, alarm control or safety devices that are considered necessary.

The unit control panels shall be supplied by the bidder. Indicating instruments, gauges, and controls for the motor as detailed in the schedule of requirements shall be provided by the motor manufacturer and shall be mounted on the unit control panel

SPARES:

Spare parts for the motors as listed in the schedule of requirements shall be supplied along with the first motor. All spare parts supplied shall be interchangeable, and shall be of the same materials and workmanship as the corresponding parts of the equipment. The bidder shall also recommend any additional spares consider essential for 5 years of normal operation

TESTS AT WORKS:

The first motor along with the excitation system and other auxiliaries shall be completely assembled at the manufacturer's works. The following tests shall be carried out on the motor at works in accordance with IS 4722/1968 and IEEE 115 or relevant IEC:

a) Temperature rise

The test shall be carried out in accordance with Indian Standards, IEC or any other equivalent standard.

b) Insulation Resistance Test:

The above test shall be carried out on all machines, both before and after high voltage test. The insulation resistance shall be measured between open windings and between windings and frame. The test for insulation resistance shall be carried out as prescribed in the "Guide for Testing Insulation Resistance of Rotating machines" - IS 7816 - 1975 or its latest revision.

c) Dielectric tests (on all machines):

The high voltage test shall be applied between the winding and the frame with the core connected to the frame and to the windings not under test. Connections between the windings (e.g. neutral point) shall be separated before making the tests. It shall be applied to the complete machine with all its parts in place under conditions equivalent to normal working conditions and shall be carried out at the manufacturer's works after the temperature rise test of the machine. The test voltage shall be alternating and shall be as nearly a sine wave as possible. Tan-delta tests shall also be conducted on specified number of coils in accordance with relevant standard.

d) Efficiency:

The efficiency of the motor shall be determined by the summation of losses method. All the losses shall be measured in accordance with the approved standards.

f) Short Circuit Tests (in Works)

To verify the capabilities of the motor to withstand short circuit stresses without injury, short circuit tests shall be carried out.

g) Characteristics tests (In Works)

1) Direct axis transient time constants
   i)Open Circuit.
   ii)Short Circuit.
2) Direct axis transient reactance.
   i) Rated current
   ii)Rated voltage.
3) Sub transient reactance.
4) Negative phase sequences reactance.
5) Moment of Inertia of rotating parts (WR)

6) Short Circuit ratio.
7) Phase sequence tests.

TESTS AT SITE:

The following tests shall be carried out on the motors at site in accordance with IS

I. Dielectric Test: In case of motor already tested at the manufacturer's works, the dielectric test shall be carried out with 85% of the test voltage where as all other motors shall be tested at the full test voltage.
II. Determination of the resistance of armature and all field windings.
III. Phase sequence test.
IV. Temperature rise test
V. Visual inspection and wiring check.
VI. Insulation test voltage withstand test.
VII. Checking of control and relay logic.

TESTING EQUIPMENT:
Field-testing equipment required for testing of the equipment shall be supplied by the bidder.

SPECIAL TOOLS AND DRAWINGS:
All necessary special tools and devices such as lifting devices for motor. for erection and maintenance of the motor shall be supplied in accordance with the "schedule of requirements".
The following drawings and data shall be submitted by the bidder with in one month from the date of signing of contract.

I. The general drawings and overall dimensions of the motor showing position of main and neutral leads, important elevation etc.
II. Graphs showing predicted characteristics of the motor (capability Curve).
III. General layout drawings showing overall dimensions and layout and relative position of all auxiliaries, ducts spaces for cables and piping etc.
IV. Details of fire fighting protection -schematic diagram, literature, etc.
V. Start/stop sequence logic diagrams.
VI. Protection and Metering systems.

PROGRAMME OF SUPPLY OF ENGINEERING INFORMATION:
Within six weeks of the effective date of the contract the bidder shall furnish The schedule of issue of documents and drawings.

A detailed scheduled listing out all major assemblies and critical parts and dates by which the related information shall be supplied should be appended to the bid.

The supply of above information should be in the form of CDs of all drawings along with one full size print of each drawing.

Twelve copies of the comprehensive, erection, operation and maintenance instruction books for the motor and its auxiliaries equipment should also be supplied, free of cost.

The bidder shall indicate requisite capacity, span, lift etc. in respect of E.O.T. crane required for installation and maintenance of the pump -motor units. These items are also in the scope of supply.

RESPONSIBILITY FOR SCHEME CO-ORDINATION:
The motor supplier shall be completely responsible for overall Scheme co-ordination comprising of the station layout, control schematics, and machine protection.

TRAINING OF ENGINEERS:
The bidder shall arrange training for 6 engineers of the purchaser for a period as mutually agreed upon during the design and manufacture of the motor at the manufacturer's design and drawing office and manufacturing shops to familiarise with all aspects of design and manufacture of , associated auxiliaries etc. All expenses including boarding and lodging , to and fro charges for training of engineers of the purchaser shall be borne by the bidder.

The supplier shall also arrange and meet the expenses of stay of Engineers of the purchaser for witnessing the Model Tests.

SCHEDULE OF REQUIREMENTS:
Item 1 (a) motors

vertical shaft 3 Ph., 0.415 KV, 50 c/s, 0.95 pf Lagging/leading induction motors of suitable capacity each, directly coupled to pump. Each motor shall consist of the following:
One Stator & Rotor consisting of stator core, frame (part of shell of steel plates) stator windings, space heaters with control switch, cooling ducts and other necessary accessories.
One set of vibration detectors.
One set of VFD The equipment shall be complete with suitable cubicles for housing external wiring, cables, etc.
The equipment shall be complete with suitable cubicles for housing external wiring, cables etc.
Fire Extinguishing Equipment: Two sets CO2 type fire extinguishing system

Technical Specification for Compact Secondary Substation

2.1.42. CODE & STANDARDS:

All equipment and material shall be designed manufactured and tested in accordance with the latest applicable IEC standards. The 12kV Package Substation Design must be as per IEC 62271-202.

The Package Sub-station offered shall in general comply with the latest issues including amendments of the following standards.

Title	**Standards**
High Voltage Low Voltage Prefabricated	IEC:62271-202

Substation	
High Voltage Switches	IEC 60265
Metal Enclosed High Voltage Switchgear	IEC 60298/ IEC62271-200
High Voltage Switchgear	IEC 60694
Low Voltage Switchgear and Control gear	IEC 60439
Power Transformers	IEC 60076

2.1.43. DESIGN CRITERIA

Package Sub-station consisting of **11kV Non-Extensible SF_6 Ring Main Unit with VCB as protection + Transformer + Low Voltage Switchgear** with all connection accessories, fitting & auxiliary equipment in an Enclosure to supply Low-voltage energy from high-voltage system as detailed in this specification. The complete unit shall be installed on a substation plinth (base) as **Outdoor substation** located at very congested places. The Vacuum Circuit Breaker shall be used to control and isolate the 11kV/433V Distribution transformer. The transformer Low Voltage side shall be connected to Low Voltage switchgear. The connection cables to consumer shall be taken out from the Low Voltage switchgear.

The prefabricated-package substation shall be designed for a) Compactness, b) fast installation, c) maintenance free operation, d) safety for worker/operator & public.

The Switchgear and component thereof shall be capable of withstanding the mechanical and thermal stresses of short circuit listed in ratings and requirements clause without any damage or deterioration of the materials.

For continues operation at specified ratings temperature rise of the various switchgear components shall be limited to permissible values stipulated in the relevant standard and / or this specification.

S. No.	DPS Name	Required capacity of each Transformer (KVA)	Required HT side- VCB	Required LT Side-VCB
1.	Gammon India	1500	800 A	800 A
2.	Digha Bailey road Junction	1600	800 A	800 A

2.1.44. SERVICE CONDITIONS:

The Package substation shall be suitable for continuous operation under the basic service conditions indicated below

Ambient Temperature: 50 Deg C
Relative Humidityupto 95%

Altitude of Installation upto 1000m

The Enclosure of High Voltage switchgear-control gear, Low Voltage switchgear-control gear & Transformer of the package substation shall be designed to be used under **normal outdoor service condition** as mentioned. The enclosure should take minimum space for the installation including the space required for approaching various doors & equipment inside.

2.1.45. SPECIFIC REQUIREMENT

The main components of a prefabricated- package substation are Transformer, High-voltage switchgear-control gear, Low-voltage switchgear-control gear and corresponding interconnections (cable, flexible, bus bars) & auxiliary equipment. The components shall be enclosed, by either common enclosure or by an assembly of enclosure. All the components shall comply with their relevant IEC standards.

Ratings:

Description	**Unit**	**Value**
Rated Voltage / Operating Voltage	kV rms	11
Rated frequency & Number of phases	Hz & nos.	50 & 3
Rated maximum power of substation	kVA	As per Requirement
Rated Ingress protection class of Enclosure	IP:	IP-23 for Transformer Compartment and IP:54 for LT & HT Switchgear Compartment.
Rated temp Class of Transformer Compartment		K10 upto 1250kVA
HV Insulation Level		
Rated withstand voltage at power frequency of 50 Hz	kV rms	28
Rated Impulse withstand Voltage	kV peak	75
HV Network & Busbar		
Rated current	Amp	630A
Rated short time withstand current	kA rms / 3 sec	21
Making capacity for switch-disconnector & earthing switches	kA peak	50kA
Breaking capacity of Isolators (rated full load)	A	630A
LV Network		As per requirement.

2.1.46. OUTDOOR ENCLOSURE

Outdoor enclosure:

The outdoor enclosure shall be made of galvanized Sheet Steel tropicalized to local weather conditions.

The enclosure shall be of partially modular design of GI sheets fastened by riveting.

The thickness of enclosure shall be 1.5 mm for non-load bearing members & 2mm for load bearing members.

The enclosure shall be painted with Powder Coating/polyurethane paint.

The metal base shall ensure rigidity for easy transport & installation.

Substation will be used in outdoor application hence to prevent enclosure from rusting/corrosion, welding should be avoided.

The protection degree of the Enclosure shall be IP54 for LT & HT switchgear compartment & IP23 for Transformer compartment. Proper / adequate ventilation aperture shall be provided for natural ventilation by way of Louvers etc.

Considering the outdoor application of the substation the doors shall be provided with proper interlocking arrangement for safety of operator and to avoid corrosion door should have stainless steel hinges. Door should be provided with stoppers.

Interconnection between HT switchgear and transformer shall be using 1Cx3x95 sq.mm al. unarmored XLPE cable and between transformer and LT switchgear shall be using busbar.

Internal Fault: Failure within the package substation due either to a defect, an exceptional service condition or mal operation may initiate an internal arc. Such an event may lead to the risk of injury, if persons are present. It is desirable that the highest practicable degree of protection to persons shall be provided. The Design shall be tested as per IEC62271-202. **Type test report of arcing due to internal fault should submitted with offer. The Compact substation shall be tested for internal arc test –AB for 21KA for 1 sec (A-operator, B-pedestrian)**

Covers & Doors: Covers & doors are part of the enclosure. When they are closed, they shall provide the degree of protection specified for the enclosure. Ventilation openings shall be so arranged or shielded that same degree of protection as specified for enclosure is obtained. Additional wire mesh may be used with proper Danger board for safety of the operator. All covers, doors or roof shall be provided with locking facility or it shall not be possible to open or remove them before doors used for normal operation have been opened. The doors shall open outward at an angle of at least 90^0 & be equipped with a device able to maintain them in an open position. **The doors shall be lockable type with cylindrical shooting bolt and the locking arrangement shall be covered by magnetic flap.**

The roof of the transformer compartment shall be detachable type to access the transformer for maintenance purpose

Earthing: All metallic components shall be earthed to a common earthing point. It shall be terminated by an adequate terminal intended for connection to the earth system of the installation, by way of flexible jumpers/strips & Lug arrangement. The continuity of the earth system shall be ensured taking into account the thermal & mechanical stresses caused by the current it may have to carry. The components to be connected to the earth system shall include:

a) The enclosure of Package substation,
b) The enclosure of High voltage switchgear & control gear from the terminal provided for the purpose,
c) The metal screen & the high voltage cable earth conductor,
d) The transformer tank or metal frame of transformer,
e) The frame &/or enclosure of low voltage switchgear,

There shall be an arrangement for internal lighting activated by associated switch for HV , Transformer & LV compartments separately.

Labels: Labels for warning, manufacturer's operating instructions etc. shall be durable & clearly legible.

Cleaning & Painting:
The paints shall be carefully selected to withstand tropical heat and rain. The paint shall not scale off or crinkle or be removed by abrasion due to normal handling. **The enclosure shall be painted with powder Coating.**

11KV SF6 METAL ENCLOSED, INDOOR RING MAIN UNIT (RMU).

This RMU should be complete with all components necessary for its effective and trouble-free operation along with associated equipment etc. such components should be deemed to be within the scope of supplier's supply.
The RMU should be fixed type SF_6 insulated with Vacuum circuit breakers with O/C & E/F relay for the protection of the transformer. It should be maintenance free equipment, having stainless steel robotically welded IP67 enclosure.

2.1.47. STANDARDS AND REFERENCE DOCUMENTS

Codes and Standards

The **RING MAIN UNIT (RMU)** should be designed, manufactured and tested to the latest version of:

IEC 60694 Common specifications for high-voltage switchgear and control gear standards.
IEC 62271-200: A.C metal-enclosed switchgear and control gear for rated voltages above 1KV and up to and including 72KV and the IEC Codes herein referred.
IEC 60129/ IEC 62271-102: Alternating current disconnections (isolators) and earthing switches
IEC 60529: Classification of degrees of protection provided by enclosures

IEC 60265 High-voltage switches-Part 1: Switches for rated voltages above 1kV and less than 52 kV
IEC 60056: Circuit breakers
IEC 60420 High-voltage alternating current switch-fuse combinations
IEC 60185 Current transformers
IEC 60186 Voltage transformers
IEC 60255 Electrical relays
□□Any other codes recognized in the country of origin of equipment might be considered provided that they fully comply with **IEC standard**s.

The design of the switchgear should be based on safety to personnel and equipment during operation and maintenance, reliability of service, ease of maintenance, mechanical protection of equipment, interchangeability of equipment and ready addition of future loads.

2.1.48. SALIENT TECHNICAL FEATURE OF "SF6 RMU."

11KV SF6 INDOOR, NON-EXTENSIBLE, Ring Main Unit (RMU), comprising of 1No. 630 A Vacuum Circuit Breaker & 1 No Air Insulated Metering Module with (3 O/C & 1E/F) Relays.

(A) Circuit Breaker. (630A)
Circuit Breaker should have the following:
- Manually operated 630 A Vacuum circuit breaker and Earthing Switch with making capacity
- Mechanical tripped on fault indicator
- Auxiliary contacts 1NO and 1NC
- Anti-reflex operating handle
- "Live Cable" LED Indicators thru Capacitor Voltage Dividers mounted on the bushings.
- 3O/C + 1E/F self powered relay with Low and High set for Over current and Earth Fault. Relay should have facility to display the maximum loaded phase current also. Relay should have facility to trip the breaker from remote commands without shunt trip coil.
- Mechanical ON/OFF/EARTH Indication

2.1.49. INDOOR RMU

1. Modular design, panel type with front cable access.
2. RMU must be made of robotically welded Non Ferrite, Non magnetic stainless steel with thickness of 2.5 mm with all live parts inside stainless steel tank
3. Offered RMU must be Non extensible.
4. Maximum Modules can be accommodated in a single robotically welded Stainless steel Tank so as to make it more compact and reliable.
5. Cable covers must be interlocked with Earth switch to have complete safety of operating person. The cable bushings shall be bolted type design.

DIELECTRIC MEDIUM

SF6 GAS shall be used for the dielectric medium, **Arc quenching should take place in vacuum** for 11KV RMU's in accordance with IEC376. It is preferable to fit an absorption material in the tank to absorb the moisture from the SF6 gas and to regenerate the SF6 gas following arc interruption. The SF6 insulating medium shall be constantly monitored via a temperature compensating gas pressure indicator offering a simple go, no-go indication.
The RMU should have provision of Gas filling at site , in case there is some leakage of the gas.

2.1.50. GENERAL TECHNICAL REQUIREMENTS

Fixed type Vacuum breakers insulated in SF6 gas. It should be maintenance free, having stainless steel robotically welded enclosure for INDOOR RMU application.
Low gas pressure devices- 1.4 Bar pressure. RMU should have full rating with Bar gas pressure.

i. Live cable indicators- High operator safety.
ii. Fully Rated integral earthing switch for Switches and Breakers.
iii. Self powered Microprocessor Based 3O/C + 1E/F self powered relay with Low and High set for Over current and Earth Fault - Does not require any external source of power.
iv. Units fully SCADA Compatible. Retrofitting at site possible at a later date. Line switches (Load break switches) as well as T- OFF circuit Breaker can be operated by remote.
v. Cable boxes should be front access and interlocked with earth switch. No rear access required.
vi. Cable testing possible without disconnection of cables.
vii. Compact in dimension.
viii. Low pressure, sealed for life equipment,
ix. Cable earthing switch on all switching device-standard, for operator safety.
x. All live parts should be inside a hermetically sealed Stainless Steel enclosure for indoor RMU.
xi. Indoor unit should be classified as sealed pressure system with gas leak rate of less that 0.1% per year requiring no gas filling for 30+ years of functional life.

2.1.51. TECHNICAL AND GUARANTEED PARTICULARS.

The bidders shall furnish all guaranteed technical particulars as called for this specification.

DESIGN CRITERIA

Service conditions

The offered switchgear and control gear should be suitable for continuous operation under the basic service conditions indicated below. Installation should be in normal indoor conditions in accordance with IEC 60694.
Ambient temperature -1oC to +45oC
Relative humidity up to 95%
Altitude of installation up to 1000m, IEC 60120

General structural and mechanical construction

The offered RMU should be of the fully arc proof metal enclosed, free standing, floor mounting, flush fronted type, consisting of modules assembled into one or

more units. Each unit is made of a cubicle sealed-for life with SF6 and contains all high voltage components sealed off from the environment. The overall design of the switchgear should be such that front access only is required. It should be possible to erect the switchboard against a substation wall, with HV and LV cables being terminated and accessible from the front.

The units should be constructed from robotically welded NON Ferrite

Non Magnetic grade stainless steel sheets of 2.5mm thickness to ensure

very high degree of precision in sealing of SF6 tank. The design of the

units should be such that no permanent or harmful distortion occurs either

when being lifted by eyebolts or when moved into position by rollers.

The cubicle should be have a pressure relief device. In the rare case of an internal arc, the high pressure caused by the arc will release it, and the hot gases is allowed to be exhausted out at the bottom of the cubicle. A controlled direction of flow of the hot gas should be achieved.

The switchgear should have the minimum degree of protection (in accordance with IEC 60529)

- IP 67 for the tank with high voltage components
- IP 2X for the front covers of the mechanism
- IP 3X for the cable connection covers

The RMU shall be internally arc tested for 20kA for 1 sec for the gas tank & it should be internally arc tested for cable compartment. Relevant type test reports should be submitted by the manufacturer.

TECHNICAL DATA

Ring Main Unit, Electrical data

Electrical data and service conditions

No *Rated voltage* KV ***12KV***

1 Power frequency withstand voltage KV 28
2 Impuls withstand voltage KV 95
3 Rated frequency Hz 50
4 Rated current busbars A 630
5 Rated current (cable switch) A 630
6 Rated current (T-off) A 630

Breaking capacities:

7 active load A 630
8 closed loop (cable switch) A 630
9 off load cable charging (cable switch) A135
10 earth fault (cable swich) A 200
11 earth fault cable charging (cable switch)A115
12 short circuit breaking current (T-off circuit breaker) kA 21
13 Rated making capacity kA 52.5
14 Rated short time current 3 sec.kA 21

Ambient temperature:

15 Maximum value °C + 45
16 Maximum value of 24 hour mean °C + 35
17 Minimum value °C 0
18 Altitude for erection above sea level 4m ...1000
19 Relative humidity Max 95%

Ring Main Unit Technical data(11KV) INDOOR

General data, enclosure and dimensions

1 Standard to which Switchgear complies IEC
2 Type of Ring Main Unit Metal Enclosed, Panel type, Compact Module.
3 Number of phases 3
4 Whether RMU is type tested Yes
5 Whether facility is provided with pressure relief Yes
6 Insulating gas SF6
7 Nominal operating gas pressure 1.4 bar abs. 20° C
8 Gas leakage rate / annum % 0.1% per annum
9 Expected operating lifetime 30 years
10 Whether facilities provided for gas monitoring can be delivered Yes, temperature compensated manometer
11 Material used in tank construction Stainless steel sheet

No Operations, degree of protection and colours

1 Means of switch operation separate handle
2 Means circuit breaker operation separate handle and push buttons
3 Rated operating sequence of Circuit Breaker O –3min-CO-3min-CO
4 Total opening time of Circuit Breaker approx. . 40-80ms
5 Closing time of Circuit Breaker approx. . 40-70ms
6 Mechanical operations of switch CO 1000
7 Mechanical operations of CO earthing switch 1000
8 Mechanical operations of circuit breaker CO 2000
9 Principle switch / earth switch 3position combined switch

Degree of protection:

10 High Voltage live parts, SF6 tank IP 67
11 Front cover mechanism IP 2X for Indoor
12 Cable covers IP 3X for Indoor

Colours:

14 Front cover 7035
15 cable cover 7035

PANEL CB DESCRIPTION

CIRCUIT BREAKERS

Vacuum bottles should be use as interrupters of the currents. The circuit breaker main circuit should be connected in series with a three-position disconnector –ear thing switch. The operation between circuit breaker and disconnector ear thing must be interlocked.

1.VCB must self tripping and has a self powered relay
2.The RMU must be nonextensible type

OTHER MAIN FEATURES

***Bus bars**:*

Comprising the 3 single phases copper bus bars and the connections to the switch or circuit breaker. The bus bar should be integrated in the cubicle Bus bars should be rated to withstand all dynamic and thermal stresses for the full length of the switchgear.

Earthing Switch

Earthing switches should be rated equal to the switchgear rating.

Earthing switches should be quick make type capable of making Rated Fault Current. Ear thing switch should be operated from the front of the cubicle by means of a removable handle.

The mechanisms

All mechanisms should be situated in the mechanism compartment behind the front covers outside the SF6-tank. The mechanism for the switch and the earthing switch is operating both switches via one common shaft. The mechanism provide independent manual operation for closing and opening of the switch, independent closing of the

earthing switch and dependent opening of the earthing switch.

The mechanism for the T-off switch and earthing switch is operating both switches via one common shaft. The mechanism has stored spring energy and provide independent manual operation for closing and opening of the switch, independent closing of the ear thing switch and dependent opening of the ear thing switch. The mechanism for the vacuum circuit breaker (VCB) and disconnector- earthing switch is operating the VCB and the disconnector earthing switch via to separate shafts. The mechanism for the VCB has stored spring energy and provides independent manual operation for closing and opening of the VCB. The mechanism has a relay with related CT's and/or remote tripping device. The mechanism for the disconnector earthing switch provide independent manual operation for closing and opening of the disconnector, independent closing of the earthing switch and dependent opening of the earthing switch.

Front covers

The front cover contains the mimic diagram of the main circuit with the position indicators for the switching devices. The voltage indicators are situated on the front panels. Access to the cable bushings is in the lower part of each module.

Position indicators

The position indicators are visible through the front cover and are directly linked to the operating shaft of the switching devices.

Voltage indicator

The voltage indicators are situated on the front cover, one for each module, and indicate the voltage condition of each incoming cable. Identification of the phases is achieved with labels L1, L2 and L3 on the front of the voltage indicators. The voltage indicator satisfies the requirements of IEC61243.

Cable compartment

The Cables access in the RMU shall be from the front. **The cable bushings shall be easily site-replaceable type.**

It should be possible to terminate up to a 1x 3c x300sqmm core HV cables in each cable compartment. The access to the compartment will be possible by removing the cable cover, Hinged to the main frame only when earth switch is ON. Cable Compartments of Indoor RMU should be Arc Proof tested for 20kA for 1sec (the type test report for the same shall be submitted by the vender) and interlocked with respective Earth Switches.. Each module has a separate cable compartment that is segregated from each other by means of a partition wall. A partition wall should be fitted to divide the cable compartment from the rear side of the switchgear. In case of an arc inside the tank, followed by the opening of the pressure relief, the partition wall prevents the hot gases flowing out from the pressure relief to enter the cable compartments. All covers are removable.
Interconnection between HT switchgear and transformer shall be using
1Cx3x95 sq.mm Al. unarmoured XLPE Cable.

Power connection.

The cables are installed in the dedicated compartment below the mimic front cover. At the bottom of the cable compartment, an earthing bar system made of copper/GI with a minimum cross section of 120 mm^2 should be fitted. In each compartment the earthing bar should be fitted with 4 screws M10. The earthing system is connected to the tank by a copper/GI bar, which rises up to the connecting point of the tank behind the rear partition wall on the middle of the switchgear.

INTERLOCKING.

The mechanism for the cable switch should be provide a built in interlocking system to prevent operation of the switch when the earthing switch is closed, and to prevent operation of the earthing switch when the switch is in the closed position.

The mechanism for the T-off switch should be provide a built in interlocking system to prevent operation of the switch when the earthing switch is closed, and to prevent operation of the earthing switch when the switch is in the closed position. The mechanism for the VCB and the disconnector-earthing switch should be has a built in interlocking system to prevent operation of the disconnector-earthing switch when the VCB is in the closed position.

Further is should not be possible to Open the Cable doors unless the Earthing Switch is Turned ON. In case the Cable door is accidentally left open a positive interlock shall prevent operation of Load Break Switch and Isolators / Breaker from any operation.

Current Transformers

All current transformers should be complying with IEC 60185.

Current transformers should be of dry type, with ratings and ratios as required.
Cable current transformers used in circuit breaker modules should be maximum 100mm wide. Current transformers used in metering cubicles should be having dimensions according to DIN 42600, Narrow type. Current transformer shall be placed in the cable covers so that it can be easily replaced at site without removing the bushings.

Auxiliaries.

The switchgear should be prepared for options like motor operation, auxiliary contacts and short-circuit indicators. Necessary terminal blocks and wiring etc. should be placed behind the front cover of each module.

Fault Passage Indicators.

These shall facilitate quick detection of faulty section of line. The fault indication may be on the basis of monitoring fault current flow through the device. The unit should be self-contained requiring no auxiliary power supply. The FPI shall be integral part of RMU to avoid thefts. The FPI shall have clear display, automatic reset facility and shall be SCADA compatible.

TESTING AND CERTIFICATION.

TYPE TESTS.

Units should be type tested in accordance with IEC standards 60056, 60129, 60265, 60298,60420,60529 and 60694. The following type tests should perform on the HT Switchgear and report should submit with offer.

- Short time and peak withstand current test
- Temperature rise tests
- Dielectric tests
- Test of apparatus i.e. circuit breaker and earthing switch
- Arc fault test
- Measurement of resistance of main circuit.
- Mechanical endurance test.
- Duty cycle test.
- Internal arc test for HT chamber.
- Type test reports for above type shall be submitted with the offer.

ROUTINE TESTS.

Routine tests should be carried out in accordance with IEC 60298 standards. These tests should be ensure the reliability of the unit.

Below listed test should be performed as routine tests before the delivery of units;

- Withstand voltage at power frequency
- Measurement of the resistance of the main circuit
- Withstand voltage on the auxiliary circuits
- Operation of functional locks, interlocks, signalling devices and auxiliary devices
- Suitability and correct operation of protections, control instruments and electrical connections of the circuit breaker operating mechanism
- Verification of wiring
- Visual inspection
- Time travel characteristics measurement facility for Breaker should be available with the manufacturer to asses the quality of RMU.

Distribution Transformer

Oil filled Transformer :

Requirement: 11000/433 Volt Oil immersed hermetically sealed, corrugated tank and without conservator type design ONAN cooled suitable for installation at outdoor in Enclosure for ground mounting.

Voltage Ratio: No load voltage 11000/433 volts within tolerance as stipulated in IEC 76.

Rating: The transformer shall have a continuous rating as specified at any of the specified tapping position and with the maximum temperature rise specified.
Temperature Rise: The maximum temperature rise at the specified maximum continuous output shall not exceed 40°C by thermometer in the hottest portion of the oil or 45°C measured by resistance of winding above ambient temperature, not exceeding 50°C maximum.
Connections: H.V. Delta and L.V Star connected with neutral brought out on the secondary side for connection to earth; Vector group DYn11.
Tapping : Each transformer shall be provided with **sliding/rotary type tap switch** so as to provided for a voltage adjustment on H.V. from +5% to –10% of rated voltage of 11000 volts in 4 equal steps (5 position) to obtain rated voltage of 433 volts on LV side. Refer clause no:4.5.4 for details of rotary switch. The tapping shall be provided for following voltage ratios at no load.

Cleaning & Painting :

a) All steel surfaces shall be thoroughly cleaned by sand blasting or chemical agents, as required to produce a smooth surface free of scales, grease and rust.
b) The internal surfaces in contact with insulating oil shall be painted with heat resistant insulation paint which shall not react & be soluble in the insulating liquid used.
c) The external Surfaces, after cleaning, shall be given two coats of high quality epoxy based rust resisting primer followed by filler coats.
d) The transformer shall be furnished with coats of weather resisting battleship gray epoxy based enamel paint specially recommended for transformer use.
e) The paints shall be carefully selected to withstand tropical heat rain, effect of proximity to the sea etc. The paint shall not scale off or crinkle or be removed by abrasion due to normal handling.
f) Special care shall be taken by the manufacturer to ensure against rusting of nuts, bolts and fittings during operation. All bushings and current carrying parts shall be cleaned properly after final painting.

Both H.V. and L.V. bushings shall have creepage corresponding to **very heavily polluted atmosphere**.
Oil: New transformer oil used shall be according to relevant IEC standards

Phase Marking & Danger Plate: Phase markings in fluorescent paint on small non-corrodible metallic tags shall be permanently fixed for H.V. and L.V sides. Phase markings tags shall be properly fixed with proper alignment. Danger plates shall be provided on the H.V & LV sides, mentioning the Corresponding Voltages.

Core and Coil :

Core : The core shall be constructed from high grade, cold rolled, non-ageing, low loss, high permeability, grain oriented, cold-rolled grain oriented silicon steel laminations. The transformer shall be so designed as to have minimum humming noise. The percentage harmonic potentials with the maximum flux density under any conditions shall be such that capacitors connected in the system shall not be overloaded.

The core and coil assembly shall be securely fixed in position so that no shifting or deformation occurs during movement of transformer. The core and coil assembly shall

be capable of withstanding without injury, the thermal and mechanical effects of short circuit at the terminals of any winding.

Noise: The Contractor shall take special precautions to ensure that the noise and vibration level does not exceed which is obtained in good modern practice.

Impedance Volts: The Percentage impedance value at 75 Deg. C at any tap shall be as per IS/ IEC subject to tolerance as specified in relevant IEC standards. i.e. 4.5% upto 630kVA and 5% upto 1250kVA The value of the impedance volts at each tapping over the specified range shall be specified in the bid.

Regulation: The regulation at 75° C at full load at unity and 0.8 power factor subject to the usual tolerance as per IEC standards shall be specified in the bid.

Power Freq. High Voltage & Insulation Level (Impulse voltage): The distribution transformer shall be designed so that they are capable of withstanding high voltage & impulse voltages as given below:

a) Impulse Voltage for 11kV winding: 75 kV (1.2/50 Microsecond wave shape).
b) High Voltage : 28kV rms.

10.4.0 RATINGS (Summary) :

	Application	**Dist. Tfr. with Corrugated Tank**
4.4.1	Service	Outdoor application inside enclosure Step down
4.4.2	Type	Oil immersed corrugated tank
4.4.3	Cooling system	ONAN
4.4.4	No. of Phases	3
4.4.5	No. of winding per phase	2
4.4.6	Rated output (MVA) With ONAN cooling	HV / LV
4.4.7	Rated voltage in KV (Line to Line	HV-11 kV LV-0.433 kV
4.4.8	Rated frequency	50 Hz
4.4.9	Temperature rise above 50°C	
A	In winding by resistance	45°C
B	In Oil by thermometer	40°C
4.4.10	Guaranteed losses at 75°C and at normal tap position as pe IS tol.	
	Losses as per IS1180 level 2	**As per IS1180 level 2**
A	50% Loading (W)	
B	100% Loading (W)	
4.4.11	Insulation level	
A	H.V. Power Freq. KV rms	28 kV
B	H.V. (kVpeak) Impulse	75 kV
C	L.V. (kV)	-
4.4.12	Vector Group	Dyn11

4.4.13	Type of taps provided	Off Load full capacity
A	Taps provided on	H.V. winding
B	Range of taps	+5% to – 5% in steps of 2.5% (6 steps, 5 position)
C	Method of Tap Change control	Rotary /sliding Switch
D	Manual load	Yes 'Off Circuit'
4.4.14	Percentage impedance at 75 Deg. C	As per IS.
4.4.15	System earthing	
A	H.V.	Solidly earthed
B	L.V.	Solidly earthed
4.4.16	Terminal arrangement	
A	H.V.	From H.V. Bushing on Top.
B	L.V.	From L.V. Bushing on Top.
C	L.V. Neutral	From L.V. Neutral Bushing on Top.
4.4.17	Transformer-bushing voltage class a) H.V. (kV) b) L.V. (kV)	 12 kV class 1.1kV class
4.4.18	System fault level a) H.V. side b) L.V. side	 500 MVA (11 kV) -
4.4.19	Short circuit withstand capability duration	3 sec.

Fittings & Accessories For Corrugated Tank Transformer :
The following accessories shall be provided for 11 kV/0.433 kV, distribution transformer.

Two earthing terminals with copper lugs. The lugs shall be provided in such a way that they shall not obstruct the movements of rollers. The earthing continuity for all the connected equipments shall be properly done.

Two lifting lugs for complete transformer as well as enclosure.

Off circuit tapping switch shall be rotary/sliding type, 3 pole gang operated, top mounting draw out type only. Tap switch shall be suitable for operating voltage of 11kV and above and shall have rated current of 16.53A/26.54A/39.64Amps. Switch shall be provided with externally operating hand wheel handle with indicator and locking device, with direction changing facility and locking arrangement. Bidders shall submit with the bid, technical catalogue for the off load tap switch for Purchaser's approval.

Rating plate and diagram plate of durable non-corroding metal giving information as required under IEC 76. Rating plate shall also include Transformer **Actual %Z, No-Load Loss & Full-Load Loss at 75°C** along with details like Purchase Order Number, date. The name plate marking shall be done with fluorescent colour. Each equipment shall carry individual name-plate with proper instructions & affixed with screws.

Four plain rollers fitting so that the transformer can suitably moved in any direction along with roller direction changing and locking facility shall be provided.

Skid with Haulage lugs.

Instructions & affixed with screws.

Skid with Haulage lugs.

L.T. PANEL

System:-

a) **Declared voltage** :– 3 Phase,400V (±6%) 50 Hz,
b) **Neutral** :– Solidly earthed at substation.
c) **Busbar** – Aluminum

General finish:- Tropical, totally enclosed, metal-clad, weather-proof, vermin and dust proof.

Construction :

Enclosure:- Dead Front type of enclosure shall be able to provide the degree of Protection IP:2X.

Circuit Ways: As per BOQ

- Air Circuit breaker will be of 3P/4P, 36kA fixed manual microprocessor based over current, short circuit and earth fault release.
- Molded case circuit breaker will be of 3P/4P,35kA fixed manual microprocessor based
- Overload and short circuit release.
- The design of the LT panel should be type tested for the short circuit , temperature & Ingress protection test and type test report should submit with offer**.**

GENERAL CHARACTERISTICS OF ACB

Conformity with Standards

The air circuit-breakers used in low voltage installations are constructed and tested in accordance with the IEC 947/IS 947 Standards and respect the following EC directives:

– "Low voltage Directive" (LVD) No. 73/23 EEC

– "Electromagnetic compatibility Directive" (EMC) No.89/336 EEC

Functional characteristics

– The circuit-breakers must have a rated service voltage of 690 V AC and a rated insulation voltage of 1000 V.
– The circuit-breakers must have a rated impulse withstand voltage of 12 kV.
– The rated uninterrupted current must be between 800 and 6300 A with the possibility of selection of ratings from 400 A.
– Different versions shall be available with rated ultimate short circuit breaking capacity(Icu) from 50kA at 415V and shall have rated short circuit service breaking capacity(Ics) equals to Icu.

– Different versions of circuit-breakers shall be available with rated short-time withstand current (Icw -1 sec) for 50kA for 1sec in category B.
– It must be possible to supply the circuit-breakers both from the top and bottom terminals without derating their performances and without jeopardising their functionality.
– The mechanical life must be at least 12000 operations, without the need for maintenance of the contacts and arcing chambers.
– The electrical life at a voltage of 440 V AC must be and without the need for maintenance of the contacts and arcing chambers:
  – at least 9000 operations up to 2000 A
  – at least 6000 operations up to 3200 A
  these values are intended to be valid only for CAT B circuit-breakers.

Environmental characteristics

– Operating temperature: -25 °C...+70 °C (-13 °F...158 °F)
– Storage temperature: -40 °C...+70 °C (-40 °F...158 °F)
– Altitude: operation without derating up to 2000 m a.s.l. (6600 ft), and with derating up to 5000 m a.s.l. (16500 ft)
– Suitability for use in a hot-humid environment. With regard to this, the circuit-breakers must undergo a tropicalisation process which makes them suitable for use in a hot-humid environment, as established by the prescriptions of the main shipping registers and in accordance with the international IEC 60068-2-30 Standards.

Construction characteristics

– The circuit-breaker structure must be made of steel sheet.
– There must be total segregation between power and front shield, using double insulation where suitable so as to guarantee maximum operator safety.
– Total segregation between the phases must be guaranteed for safety reasons.
– The main contacts must be separate from the arcing contacts in cat. B circuit-breakers only.
– It must be possible to inspect easily the arcing chambers easily and to check main contact wear with the circuit-breaker racked-out, by removing the arcing chambers.
– All the circuit-breakers in the range have the same height and depth with the aim of standardising the supporting structures of the switchgear and the switchgear itself as far as possible.
– The circuit-breakers must indicate the precise position of the main contacts and the condition of springs charged/discharged on the front, by means of certain and reliable signals.
– The operating mechanism must be of the stored energy type with operation by means of precharged springs fitted with antipumping device. The springs are charged manually by activating the front lever, or by means of a geared motor, supplied on request.
– The whole range of air circuit-breakers must be fitted with electronic protection releases. It must be allowed the interchangeability of protection releases from skilled personnel.
- ACBs shall have minimum watt losses in order to restrict temperature rise inside the breaker.

RELEASES

1) Release (Protection functions)

– The release must not require auxiliary power supplies since the power is taken from the current transformers.
– The signals supplied by the release must not operate with power supply supplied by internal batteries.The basic version of the release must provide:
– protection against overload with trip with inverse long time delay (L)
– protection against instantaneous short-circuit (I)
– Selective short-circuit (S)
– Earth fault (G)

The setting ranges shall be:

– Protection against overload (L)
  Characteristic t=k/I2
  Trip threshold I1=(0.4...1)xIn with timing adjustable from 3 to 144 sec. (value referred to a current equal to 3xI1)
– Protection against selective short-circuit (S)
  Characteristics t=k and t=k/I2
  Trip threshold I2=(1...10) xIn with timing adjustable from 0.1 to 0.8 sec.
  (value referred to a current equal to 10xIn for curves at t=k/I2 and referred to currents >I2 for curves at t=K)
– Protection against instantaneous short-circuit (I)
  Trip threshold I3=(1,5...15) xIn
– Protection against earth fault (G)
  Characteristics t=k and t=k/I2
  Trip threshold I4=(0.2...1) xIn with timing adjustable from 0.1 to 0.8 sec. (value referred to a current equal to 4xI4)
– Neutral protection level:
  50% - 100% - 200% - excluded

All the protection functions except protection against overload must be excludable

User interface and signalling LEDs

– The release shall allow parameterisation of the trip thresholds and timing by means of dipswitches.
– alarm and trip signalling for all the protection functions by means of LEDs located on the release shall be available. No batteries or external power supplies shall be necessary for powering these indicators. The indication shall be available for not less than 48 hours after the trip, even with the circuit-breaker open
– An alarm shall indicate by means of LEDs located on the release the disconnection of opening solenoid and current transformers. A trip shall also occur, after a short time delay, when the disconnection is detected.
– It shall be possible, with the aid of external devices, to read currents, and information on last 10 trips (currents, protection tripped) occoured to the unit.

General aspects of MCCB with microprocessor based release

Standards conformity

Molded case circuit-breakers (MCCB) installed in the low voltage plant must be designed, manufactured and tested according with the international standards IEC 60947-1, IEC 60947-2, IEC 60947-3, IEC 60947-4-1, IEC 61000 or with the corresponding harmonized national standards, the CE "Low Voltage Directives" (LVD) n° 73/23 EEC and "Electromagnetic Compatibility Directive" (EMC) n° 89/336 EEC.

Molded case circuit breakers functional features

- Rated insulation voltage (Ui) for MCCB shall be 800 VAC or more.
- Rated Impulse withstand voltage (Uimp) for mccb's shall be 8kV.
- Rated service voltage(Ue) for the moulded case circuit breaker shall be standard as 690V, however performance on short circuit level shall be consider based on system operating voltage.
- Rated uninterrupted current between varying from 160 and 3200 A with trip units settings starting from 10A
- Rated short circuit breaking capacity shall be considered as per bill of material and the rated service short circuit breaking capacity (Ics) shall be in 100% of rated ultimate short circuit breaking capacity (Icu). (Ics=Icu)
- According to IEC 60947-2 (§ 4.4) starting from 400 A the circuit breakers must be category B, however other small rating category A shall be confirmed.
- MCCBs must be available with different ultimate short breaking capacities between 16kA and 200kA @ 380/415 V AC.
- Both line up and line down supplying must be possible without decreasing MCCBs performances or functionality
- MCCB shall confirms to current limiting type and this feature shall ensure less amount of let through energy at the time of opening on fault. The mccb shall have opening time less then 10msec for current rating upto 630A, and less them 15msec for current rating upto 1600Amps.
- A test bottom for the correct functionality checking (moving contacts opening) must be place in front of the breaker.

Ambient characteristics

- Operating temperature: -25 °C .. +70 °C (ambient temperature)
- Storage temperature: -40 °C .. +70 °C (ambient temperature)
- Maximum relative humidity: 98%
- Maximum altitude: 2000 m above sea level, 5000 m above sea level with derating
- Suitability for being used in hot-humid places.
- Circuit-breakers fitted with electronic trip units must comply with the prescriptions of the International Standards on electromagnetic compatibility.

Construction characteristics

- The range of moulded case circuit-breakers must cover a range of rated uninterrupted currents from 160 to 3200 A.

- By means of the double insulation technique, moulded case circuit-breakers must guarantee complete separation between the power circuits and the auxiliary circuits.

- Moulded case circuit-breakers must have an operating lever which always indicates the exact position of the circuit-breaker contacts (positive operation), by means of safe and reliable signals (I= closed, O= open, yellow-green line= open due to trip unit).

- Moulded case circuit-breakers must be suitable for isolation in compliance with § 7.2.7 of the IEC 60947-2 Standard. This indication must be clearly and indelibly marked on the circuit-breaker (in accordance with § 5.2 of IEC 60947-2) and in a position where it is visible with the circuit-breaker installed.

- Moulded case circuit-breakers with rated uninterrupted current up to 250 A shall have a 45 mm high face which makes them suitable for installation on modular panels.

- The same depth must be guaranteed from 320 A up to 1000 A, in order to standardize both switchboards and their supports.

- All the installation positions must be possible without jeopardizing the function of the apparatus. Starting from 630 A up to 1600 A the withdrawable version shall be mounted and operated horizontally.

- For the front parts of the circuit-breakers the degree of protection of at least IP20 (excluding the terminals) must be guaranteed.

Protection trip units

- From the 250 A size circuit-breakers, the trip unit must be interchangeable.

  Electronic overcurrent releases

- The electronic overcurrent trip units must be self-supplied and must be able to guarantee correct operation of the protection functions even in the presence of a single phase supplied with a current value equal to 20% of the phase current.

- They must be unaffected by electromagnetic interference in compliance with the EMC directive on the matter.

- The basic version shall be fitted with protection functions against overload (function L) and against short-circuit. The latter function can either be of the instantaneous type (function I) or, alternatively, with intentional delay (function S). The function of protection against short circuit must be excludable. A basic version shall also be provided with only the protection threshold against instantaneous short-circuit which cannot be excluded.

- The minimum performances of the protection functions of the electronic protection trip unit for distribution, where present, must be:

    1. Function **L**:adjustable trip threshold I1= (0.4...1) x In, trip curves for the basic version with times from 3 to 12 seconds – 2 different trip curves - (at 6 times the set threshold). Cannot be excluded.

    2. Function **S**: adjustable trip threshold I2= (1...10) x In, trip curves for the basic version with times from 0.1 to 0.25 seconds – 2 different trip curves – (at 8 times the rated current of the trip unit.Can be excluded.

    3. Function **I**: adjustable trip threshold I3= (1...10) x In for the basic version (instantaneous trip). Can be excluded.

- All the protection functions must be characterized by threshold and time tolerances according to the International Standards.

- The size of the current sensors must be a minimum of 10 A to a maximum of 3200 A so as to cover the widest possible current range.

Earthing:

Earthing arrangement shall be provided for earthing each cable, PVC cable gland, neutral busbar, chassis and frame work of the cubicle with separate earthing terminals at two ends. The main earthing terminals shall be suitably marked .The earthing terminals shall be of adequate size, protected against corrosion, and readily accessible. These shall be identified by means of sign marked in a legible manner on or adjacent to terminals.

Neutral bus bar strip shall be connected to Earthing terminal with help of GI strip of suitable capacity & nut-bolt arrangement.
Earthing Strip of Size 50x6mm GI is require for CSS internal Earthing.

2.1.52. TYPE / ROUTINE TEST ON PACKAGE SUBSTATION

TYPE TESTS FOR THE PACKAGE SUBSTATION:

The Package Substations offered must be type tested as per IEC 62271-202. The copy of type test summary should be submitted along with the tender. CSS manufactured at in JV consortium/system integrator/OEM shall not be accepted.

Routine Tests: The routine tests shall be made on each complete prefabricated substation.

a) Voltage tests on auxiliary circuit.
b) Functional test.
c) Verification of complete wiring.

Test Witness: Routine test shall be performed in presence of Owner's representative if so desired by the Owner. The Contractor shall give at least fifteen (15) days advance notice of the date when the tests are to be carried out.

Test Certificates:

Certified reports of all the tests carried out at the works shall be furnished in three (3) copies for approval of the Owner.

Performance Certificate to Qualify Technical Bid: Manufacturer should submit CSS performance Certificate from Any Utility/Pvt organization/Industry of similar or higher rating.

Packaged Substation Enclosure:

- Tests to verify the degree of protection.
- Arcing due to internal fault
- Test to prove enclosure class - Temperature rise of the transformer inside the enclosure.
- Short circuit test to prove the capability of the earthing circuits to be subjected to the rated peak and the rated short time withstand currents.
- Tests to verify the withstand of the enclosure of the prefabricated substation against mechanical stress.

VFD PANEL

2.1.53. SCOPE OF SUPPLY

Scope of supply shall cover design, engineering, manufacture, test at manufacturer's works, packing and transportation to site of the panel in accordance with the stipulations mentioned hereunder.

2.1.54. CODES STANDARDS

The panel shall generally comply with the relevant International Standards (IEC) Specifications and relevant codes and practices.

Panel wiring Insulation: IEC 60664.
MPCB/HRC cartridge fuses: IEC 60947-3.
Control switches, Contactors: IEC 60947-4-1.
Circuit Breakers & Relays: IEC 60898.
Degree of protection: IEC 60529.
Electrical safety & Human protection IEC 61140.

2.1.55. GENERAL CONSTRUCTIONAL FEATURES

The panel shall be completely metal clad enclosed, free standing, non draw out, sheet steel Cubicle, indoor free floor mounting, non compartmentalized, **single front,** individual vertical

compartmental type and shall be dust tight, moisture, vermin proof, highly corrosive- resistive. Under normal operation and maintenance, the modules and cable connections shall be accessible from both sides of the feeders. The panel shall be maximum height of 2100mm from floor level and depth of 500mm maximum. All feeders of panel shall be suitable for bottom cable entry only. Copper bus bars for PCC panls and Aluminum bus bars for MCC panels shall be used with adequate sizes.

The panel shall be free from undulations, dents and flaws and sufficiently reinforced to provide Level surfaces, resistance to vibration and rigidity during transportation or installation. The perimeter of all doors and removable cover plates shall be provided all around with Neoprene perimeter of all doors and removable cover plates shall be provided all around with Neoprene. Lifting hooks shall be provided. All hardware shall be Zinc plated and passivated. Mounting height of components requiring operations and observations shall not be lower than 350 mm and higher than 1800 mm.

Feeder doors shall be interlocked with isolator switches so that, the door should not open when the feeder is ON.

Base frame shall be of ISMC-100 channels with 4 Nos. Holes to suit M12 foundation bolts.

All panels' feeders shall be fully DCS compatible. It shall have sufficient potential free contacts for digital signals as per our control circuits. From SCADA It should also be possible to control various functions of panel feeders through hardware connections.

Provision shall be made for cable entry.

Space heater with thermostat and lamps for interior illumination shall be provided for each column section of panels wherever is required.

All the panels shall be Free Standing, Floor mounted, Dead Rear type, common base frame (Internal open). The entire load bearing members shall be 2.0mm thickness sheet steel and all non-load bearing members shall be 1.6 mm thickness. All the panels shall be dust and vermin proof to meet with IP42 protection.

The cable entry shall be from bottom only. Suitable removable gland plate shall be provided.

All the Busbars, whenever used shall be of copper material only. Terminations shall be ferruled and Properly numbered.

The earthing arrangements shall be as per IEC standards which shall be furnished by you at the time of approvals.

All VFD panels shall be individual floor mounted type.

PAINTING: Exterior & Interior of the panel shall be painted with RAL-7032/7035 shade with MATT finish applicable as per IEC standards Powder coated (Nine tank process). All panels shall be protected against corrosion and sea. Base frames shall be painted with black.

Tests and Inspection:- Routine tests shall be conducted as per IEC 146. Required Control & Communication cables between VFD panels to plant DCS shall be in your scope of supply only.

1) Moulded Case Circuit Breaker (MCCB).

The circuit breaker shall conform to IEC 60947-2 and having rupturing capacity as specified in specification sheet and mounted on a draw out chassis.

The circuit breaker shall be provided with spring assisted quick make break type, manually operated trip- free mechanism, mechanical "ON, OFF" position indicators, thermal tripping devices of inverse characteristics, instantaneous short circuit tripping devices and necessary auxiliary and alarm switches. The MCCB chassis shall be provided with service, test and isolated
position and automatic safety shutter.

The thermal and short circuit tripping devices shall be adjustable type.

When used for motor circuits, shunt trip device shall be provided and the let through power of controlling MCCB shall be lower than the respective contactor.

In addition, under voltage trip shall be provided, if specified in the specification sheet.

2) Switches / MPCB.

The switches/MPCB shall be motor duty type AC 23 category and Class-III (AC-3) duty type Comply with the requirements laid down in IEC 60947-3. Switches upto 63 Amps shall be rotary type and those of 100 Amps and above link type with Type-II coordination. Shall be consider MPCB's upto 30HP rating and SFU's for the above rating.
"ON and OFF" position of the switches shall be indicated on the module. Provision shall be made to Lock the switch in the "OFF" position. Switch ON/OFF feedback PF element shall be provided.

The fixed contacts shall be shrouded type. The moving contacts shall be silver-plated.

3) Fuses.

The fuses shall be of non-deteriorating HRC cartridge link type and shall conform to IEC 60947-3. They shall be suitable for the load and service required in the circuit.

4) Air Break Contactors.

The Air break contactors shall be of Class III, Category AC3, unless otherwise specified, conforming to IEC 60947-4-1 and flapper type with type-II coordination.

Each contactor shall be provided with auxiliary contacts as required. The rating of the auxiliary contacts shall be 5 Amps AC or 1 Amp DC at the specified control voltages. Spare contacts shall be wired to the terminal blocks.

5) Bimetal Thermal Overload Relays

The contactor shall be provided with three pole bimetal thermal overload relays, unless otherwise specified. The bimetal relays shall be of suitable range, ambient temperature compensated and shall be separate mounting type. They shall be adjustable through graduated scale and shall be provided with change-over contact. Thermal relays having long time / current characteristics operated through saturated CTs shall be supplied, wherever required.

Bimetal thermal relays shall conform to IEC 60898 and shall have built-in Single Phasing Preventer.

The bimetal relays shall be provided with a manual-resetting device, resistible after opening module door. Auto reset thermal relays are not acceptable.

6) Panel Wiring

Wiring shall be carried out with 650/1100-volt grade, single core, stranded copper conductor wires with PVC insulation. The minimum Size & Code of stranded copper conductor for wiring shall be as follows:

Control AC circuit - 1.5 mm² Black Flexible.
CT circuit - 2.5 mm² Black Flexible.
For R-Phase - CT-Red Sleeve
For Y-Phase - CT Yellow sleeve
For B-Phase - CT Blue Sleeve
For Neutral of CTs - Green Sleeve
Potential circuit - 1.5 mm² Red, Yellow, Blue and Black Flexible.
DC circuit - 2.5 mm² Grey Flexible.
For Positive – Red Sleeve
For Negative – Black Sleeve
Earthing circuit - 2.5 mm² Solid Green Flexible.

Panel wiring shall be securely supported, neatly installed by lacing and tying or in wiring channels. Flame retardant, plastic wiring channels / troughs with strap on wiring covers shall be used.
Terminals for A.C. supply and D.C. supply shall not be terminated on adjacent terminal blocks.

All spare contacts of breakers, switches, push buttons and relays shall be wired to terminal block.

Wiring terminations shall be made with solderless, crimping type of tinned copper lugs which firmly grip the conductor and insulation. Insulated sleeves shall be provided at the wire terminations. More than one control wire should not be crimped together. Engraved core identification plastic ferrules, marked to correspond with the panel wiring diagram shall be fitted at both ends of wire. Ferrules shall fit tightly on the wires and shall not fall off when the wire is disconnected.

7) Terminal Blocks

All the terminal blocks shall be Elmex make CATM4 type and for disconnecting type terminal blocks (CT terminal blocks) shall be CATDM4 type.

At least 20% spare terminals shall be provided and these shall be uniformly distributed on all rows of terminal blocks.

There shall be minimum clearance of 250 mm between the first row of terminal block and associated cable gland plate for easy termination of cable. The clearance between two rows of terminal block shall be minimum 150 mm.

8) **Labels**

All front mounted equipment as well as equipment mounted inside the panel shall be provided with individual labels with equipment designation engraved. The labels shall be mounted directly below the respective equipment.

Labels shall be provided at the rear / inside the panel for all front mounted equipment. It shall be mounted by the side of the respective equipment wiring. The labels shall correspond to wiring diagram and GA.

Label shall be made of non-rusting metal or 3-Ply lamicoid. Labels shall have white letters on black background. Labels shall be fastened using screws. Use of adhesive is not permitted.

9) Earthing.

The panel shall be fitted with an earth bus, securely fixed along the inside base of the panel. Earth Busbars shall be inside the panel only. Material and size of earth bus shall be as specified in the specification sheet.

All metallic cases of relays, instruments and other panel-mounted instruments shall be connected to earth bus by independent insulated copper wires as per applicable standards.

PT and CT secondary neutral or common lead shall be earthed at one place only at the terminal blocks where they enter the panel.

Insulation between the live terminal and earth prior to connection of the earth to the Purchaser's earth grid shall withstand a test voltage of 500V for one minute (or have resistance of not less than one mega Ohm of 500V).

10) PAINTING

Exterior & Interior of the panel shall be painted with light Siemens gray of shade No.631 IS 5, Powder coated (Seven tank process). All panels to be protected against corrosion. Base frames shall be painted with black.

11) Inspection & Testing

We / our client's representative will visit works during manufacturing to assess the progress of work as well as to ascertain the quality as per the approved QAP.

The following typical **TYPE TEST** reports shall be submitted along with the bid.
A. Verification of Temperature Raise limits.
B. Verification of Dielectric properties.
C. Verification of Short circuit strength.

All Routine tests shall be performed at your works as per relevant IEC 60439-1/EN 60439-1norms. All routine test certificates shall be submitted to our consultant for his approvals prior to dispatch of the equipment.

We / our client reserve the right to witness final test at the works. To enable us to depute our representative, prior notice as agreed shall be given by the vendor.

Inspection by us, however will not absolve the vendor from their responsibility for good design, material and for the satisfactory performance of the equipment and as such, they have to make good any defects noticed subsequently.

12) Quality Assurance Plan

The panel shall be manufactured as per approved supplier QAP.

VARIABLE FREQUENCY DRIVE

2.1.56. GENERAL FEATURES

This feature is to cover a complete Variable Frequency Drive (VFD) consisting of a pulse width modulated (PWM) inverter. Configuration of a variable frequency drive is as follows:

a. Automatic Voltage Regulation (AVR) function
b. Automatic PFI regulation function
c. Auto energy savings mode
d. Four line digital display with info key (for four parameters)
e. Dual rating design (Light duty & Normal duty)
f. Built-in real time clock
g. Hot plug LCD keypad offers a user-friendly operation interface. The display screen can be defined by the user with customized software & adjustable pulse frequency
h. Networking drives system
i. Built-in Automation Application
j. Design should be flexible and ease maintenance

2.1.57. PRODUCT QUALITY STANDARD

a. National Electric Manufacturers Association (NEMA)
   Or Under writers Laboratories Inc (UL)/CSA
b. CE low voltage directive EN50178 Electrical Equipment for use in power installation
   Or EMC Directive 89/336/EEC or 2004/108/EC (See also EN 5008102 and EN 50082-2).

2.1.58. MAIN CONTROL FUNCTIONS

a. Fault Reset
b. Speed Search
c. S-curve Acceleration/Deceleration control
d. Slip Compensation
e. PID control (with slip function)
f. Parameter Copy
g. Energy Saving mode
h. 3-wire Sequence
i. Torque Compensation
j. Torque limit
k. Over torque Protection
l. Auto tune (rational and stationary)
m. JOG frequency control

n. MODBUS Communication (RS-485)

Communication loss functionality to ensure uninterrupted operation. It shall be possible to set the VSD to change the control location from PLC to other external location identified by user, e.g. drive's embedded PID/loop controller and change back when communication is recovered.

o. Frequency Upper/lower limit setting

p. Momentary power loss ride through Acceleration/Deceleration. Time Switch

The VSD shall include a switching frequency control function. This reduces the switching frequency, based on actual VSD temperature and allows the highest carrier frequency without de-rating the VSD or operating at high carrier frequency only at low speeds (temperature fold-back). It shall be possible to set a minimum and a reference switching frequency.

q. Cooling Fan Auto mode

r. DC injection braking at start/stop

s. Variable Frequency Drive (VFD) Efficiency: Above 98%

t. Auto phase sequence changing mode (Forward/Reverse rotation mode)

The VFD should have IEC 60721-3-3. Class 3C2 as standard Class 3S2 (solid particles) coated boards as standard delivery.

u. The VFDs shall have in-built Dry pump protection and end of curve protection, Flow Compensation and No flow detection features.

v. The VFDs shall have in-built sleep mode and Auto tuning of the PI controllers

w. Harmonic Current suppression (DC Reactor Facility)
The drive shall be equipped with a dynamic control solution that adapts to changes in the motor load and reduces the energy needed to deliver the required torque.

x. The VFD should have the option to use up to cable length minimum 150 meters without additional output choke and above 150 meters to 450 meters with additional output choke.

2.1.59. GENERAL SPECIFICATION:

a. Input Phase : Three Phase
Frequency: 50 Hz

b. VFD Capacity : 110±3% kW (106.70 kW to 113.30 kW)

c. VFD efficiency: ≥98%

d. Input Voltage Range:
380 to 480 VAC, +10%...-15%
Power Factor (cos Φ) at nominal load 0.98

e. Output Frequency: 0 to 320 Hz

f. Frequency Resolution Digital Command: 0.01 Hz

g. Analog Command: Maximum output frequency x 0.03/60 Hz (±11 bit)

h. Carrier Frequency Range: 2 ~ 15 kHz (depends on motor output)

i. Input Frequency Tolerance: 50 ±5% Hz

j. Frequency Setting Signal: 0 ~ 10 V, 4 ~ 20 mA. Analog Signal

k. Control mode: V/F control, sensorless Vector control (SVC)

l. Acceleration/Deceleration Time: 0.01~360/0.01~360 seconds (Adjustable)

m. Communication Protocols: Built-in (RS-485, MODBUS, BAC net)

n. EMI Filter: Built-in (Standard IEC 61800-3:2004,C2)

o. Harmonics Filter:

Built-in swinging choke as standard and shall meet the requirements of IEC 61000-3-12: 2011. The chokes shall be capable of delivering 25% fewer harmonics at partial loads.

p. Restart after instantaneous power failure: Up to 15 Seconds (Auto/Manual)
q. Cooling Method: Fan Cooling
r. Short circuit current rating: ≥ 100 KA (50,000 AMP)

2.1.60. SAFETY PROTECTION:

The VSDs shall support 'Safe Torque Off' (STO) function capable for safety related applications up to SIL 3, SILCL 3 and PL e.
There shall be 3rd party statement of compliance available to confirm VSD compliance. Manufacturer's statements are not accepted to confirm compliance.

a. Motor Protection: Electronic Thermal Relay Protection
b. Over Current Protection for 150% of rated current
c. Over Voltage Protection: For 1(one) Phase (230Vac): Drive will be stopped when input voltage exceeds 20% of the rated Voltage. For 3(three) Phase (410Vac): Drive will be stopped when the input voltage exceeds 20% of the rated Voltage.
d. Overload Tolerance: Light Duty: 120% of rated current for 1 minute:
e. Normal Duty: 120% of rated current for 1 minute;
f. 160% of rated current for 3 Seconds
g. Over Temperature Protection: Built-in temperature sensor
h. Torque Limit Normal Duty: Maximum 170% torque current

2.1.61. ENVIRONMENTAL PROTECTION:

a. Ambient Temperature (Storage/Transportation: 0°C- +50°C without derating
b. Air Pressure (Operating/Storage): Atmospheric Pressure
c. Pollution Level: Class 3C2: Class 3S2 (Operation), Class 2C2:Class 2S2 (Storage)
d. Protection Level: Minimum IP 20/UL Open Type (above 45 kW)
e. Sound Level: Up to 75 db
f. Humidity: Up to 95%
g. Allowable maximum temperature rise inside the panel box: ≤ 15 °C

L. T. PANELS / P.C.C. / M.C.C.

This scope shall cover design, manufacture, check test, and supply, installation, testing (Scope to assist the Ele.Contractor for installation, all the sections of panels & Internal Control wiring should be done by panel vendor on site), testing and commissioning of various medium voltage Panel Board as described in Bills of quantities and drawings. The Panel manufacturer should have a design validated by CPRI / ERDA for breaking capacity of at least 100 KA for 1 Sec.
Panels shall be suitable for operation on 3 Phase/single phase, 415/240 volts, 50 cycles, 4 wire system, neutral grounded at transformer. All Distribution panels shall be CPRI approved and / or manufactured by an approved manufacturer.
Distribution panels shall comply with the latest Relevant Indian Standards and Electricity Rules and Regulations and shall be as per IS-13947-1993.

9.6.1 SERVICE CONDITIONS AT SITE

Ambient Temperature: Max. / Min. = 55° C. / 3° C.
Design temperature: 60 Degree C.
Relative humidity: 100%
Voltage: 415+/- 10%, TPN
Frequency: 50 Hz. + 3% to -6%
Neutral: Solidly / earthed neutral.
Fault level: 18.4KA, Symmetrical at 415V solidly earthed.

9.6.2 GENERAL SPECIFICATIONS:

All the Panels shall be metal clad, totally enclosed, rigid, floor / wall mounting, air insulated, cubicle type suitable for operation on three phase / single phase, 415 V / 230 V / 240 V, 50 Hz., neutral effectively grounded at transformer and short circuit level.
Degree of protection for following type of distribution panel enclosure shall be as per IS:13947-1993. IP 52 for indoor panels. The painting of all the metal part shall be with seven tank process followed by powder coating as per the standard. The Panels shall be designed to withstand the heaviest condition at site, with maximum expected ambient temperature of 50° c., 95% humidity.

9.6.3 STANDARDS AND CODES:

The Panels shall comply with the latest edition of relevant Indian Standards and Indian Electricity Rules and Regulations. The following Indian standards shall be complied with:

STANDARD NO.	PARTICULAR
IS: 4237	General requirements for switchgear and control gear for voltages not exceeding 1000 V a.c. or 1200 V d.c..
IS: 5578	Guide for marking of insulated conductors.
IEC 61439-1&2	Specifications to Low-voltage switchgear and control-gear assemblies
IS/IEC 60947-2: 2003	Low Voltage Switchgear & Controlgear, Circuit Breakers
IS 2147-1962	Degree of protection provided by enclosure for Low Voltage Switchgear & Control-gear
IS 3043	Earthing codes
IS: 11353	Guide for uniform system of marking and identification of conductors and apparatus Terminals.
IS: 13947	Low voltage switchgear and control gear.
IS: 8197	Terminal marking for electrical measuring instrument and their accessories.
IS: 2551	Danger notice plates
IS: 10118	Code of Practice for selection, installation and maintenance of switchgear and control gear
IS: 8623	Specification for factory built assemblies of switchgear and control gear for voltage upto and including 1000 V A.C. and 1200 V D.C.

IS: 8828	Miniature circuit breakers.
IS: 9224	HRC fuse links
IS: 2705	Current transformer
IS: 3156	Voltage transformer
IS: 3231	Electrical relay for protection
IS: 1248	Indicating instrument
IS: 722	Integrating instrument

Indian Electricity Act and Rules (as amended up to date) and approval of FIA of India.
The Panels also require approval of the consultant at various stage of their manufacture such as design, selection, construction, testing, shipping etc..

Every cabinet shall be provided with Trifoliate or engraved metal name plates. All panels shall be provided with circuit diagram engraved on PVC sheet. All live accessible connections shall be shrouded and shall be finger touch proof and minimum clearance between phase and earth shall be 20 mm and phase to phase shall be 25 mm.

2.1.62. TECHNICAL PARAMETERS

System Details

- System Voltage : 415V ± 10% 3-phase, 4 wire solidly grounded
- Frequency : 50Hz ± 3%
- Control Supply : 230 Volts AC ± 10% (tapped from phase & neutral) 110V DC ± 10%

2.1.63. STRUCTURE :

- The PCCs, MCCs & PDBs shall be metal clad enclosed and be fabricated out of high quality CRCA sheet, suitable for indoor installation, front operated and floor mounting type.
- CRCA sheet steel used in the construction of PCCs / MCCs / PDBs shall be 2 mm thick for structure, 1.6 mm thick for doors, covers shrouds and 3 mm thick for gland plate and shall be folded and braced as necessary to provide a rigid support for all components. Joints of any kind in sheet shall be seam welded, all welding slag grounded off and welding pits wiped smooth with plumber metal.
- The PCCs / MCCs / PDBs shall be totally enclosed, completely dust and vermin proof and degree of protection being no less than IP-54 confirming to IS 2147. Gaskets between all adjacent units and beneath all covers shall be provided to render the joints dust proof. All doors and covers shall be fully gasketted with neoprene gaskets and shall be lockable.
- All panels and covers shall be properly fitted and secured with the frame, and holes in the panel correctly positioned. Fixing screw shall enter into holes taped into an adequate

thickness of metal or provided with bolts and nuts. Self-threading screws shall not be used in the construction of PCCs / MCCs / PDBs.

- A base channel of 75 mm x 75 mm x 5 mm or as per the weight of the panel shall be provided at the bottom.
- PCCs / MCCs /PDBs shall be arranged in multi-tier formation. The PCCs / MCCs / PDBs shall be of adequate size to facilitate enough space for maintenance and cooling. The size of the PCCs / MCCs / PDBs shall be designed in such a way that the internal space is sufficient for hot air movement, and the electrical component does not attain temperature more than 40 degree Celsius. Openings shall provide for natural ventilation, but the said openings shall be screened with fine weld mesh.
- Knockout holes of appropriate size and number shall be provided in the PCCs / MCCs/ PDBs in conformity with number, and size of incoming and outgoing conduits / cables.
- Alternatively the PCCs / MCCs / PDBs shall provided with removable sheet plates at top and bottom to drill holes for cable / conduit entry at site.
- The PCCs / MCCs / PDBs shall be designed to facilitate easy inspection, maintenance and repair.
- The PCCs / MCCs / PDBs shall be sufficiently rugged in design and shall support the equipment without distortion under normal and short circuit condition they shall be suitable braced for short circuit duty.

2.1.64. PROTECTION CLASS:

All the indoor PCCs / MCCs / PDBs shall have protection class of IP - 54

2.1.65. POWDER COATING:

All sheet steel material shall undergo seven-tank process after all the necessary shearing and other mechanical works are completed. After the seven-tank process powder coating treatment shall be adopted using powder of reputed make. After the powder coating is complete welding in the panel or any sort of shearing, bending or cutting activity shall not be done. The colour shall be Siemens Grey 631

2.1.66. CIRCUIT COMPARTMENT:

Each circuit breaker and switch fuse units shall be housed in separate compartments and shall be enclosed an all sides. Sheet steel hinged lockable door shall be duly inter locked with the breaker / switch fuse units in ON and OFF position. Safety interlocks shall be provided for non-opening of the door when the breaker is in ON position.
The door shall not form integral part of the draw out position of the circuit breaker. All instruments and indicating lamp shall be mounted on the compartment door. Sheet steel barriers shall be provided between the tires in a vertical section.

2.1.67. INSTRUMENT COMPARTMENT :

Separate and adequate compartment shall provided for accommodating instruments, indicating lamp, control contactors, relays and control fuses etc. These components shall be accessible for

testing and maintenance without any danger of accidental contact with live parts of the circuit breaker, switch fuse units, bus bars and connections.

2.1.68. BUSBARS :

Bus bar and interconnections shall be of high conductivity electrolytic grade copper as indicated in the bill of quantities complying with requirement of IS: 5082 – 1981 and of rectangular / Square cross section suitable for carrying the rated full load current and short circuit current and shall be extendable on either side. Bus bars and interconnections shall be insulated with heat shrinkable sleeve of 1.1 KV grade and shall be colour coded.
Bus bars shall be supported on glass fiber reinforced thermosetting plastic insulated supports at regular intervals to withstand the force arising from in case of short circuit in the system. All bus bars shall be provided in a separate chamber and all connections shall be done by connected by means of bus bar connectors to avoid tapings on solid bus bars. Additional cross-sectional area to be added to the bus bar to compensate for the holes if required. All connections between bus bars and breakers shall be through solid / Flexible copper strips of proper size to carry full rated current and insulated with insulating sleeves.
The busbar shall be air insulated and made of high quality, high conductivity, high strength electrolytic grade Copper. The busbar shall be of 3 phases and neutral system with separate neutral and earth bar. The size of neutral busbar in all panels or lighting panels and feeders shall be equal to phase busbar. The busbar and interconnection between busbars and various components shall be of high conductivity Copper.
The busbar shall be of rectangular / square cross-section designed to withstand full load current for phase busbars and half rated current for neutral busbars in case of APFCR panels only and shall be extensible on either side.
The busbar size shall be as per drawing. The busbar shall have uniform cross-section throughout the length. The busbars and interconnections shall be insulated with epoxy coated bus sleeves. The busbar shall be supported on glass fiber reinforced thermosetting plastic insulated supports type at sufficiently close intervals to prevent busbars sag and shall effectively withstand electromagnetic stresses in the event of short circuit capacity of 18.4 KA RMS symmetrical for 1 sec.
The busbar shall be housed in a separate compartment. The busbar shall be isolated to avoid any accidental contact. The busbar shall be arranged such that minimum clearances between the busbars are maintained as below:
Between phases : 30 mm. minimum
Between phases and neutral : 30 mm.
Between phases and earth : 30 mm.
Between neutral and earth : 30 mm. Minimum
Busbar shall be calculated on 55 deg. C. ambient temp. and 85 deg. C. for continuous and short time rating Busbar surrounding air temperature shall be considered 70 deg. C. for busbar calculation
All joint shall have non-flammable insulation shrouds for secondary insulation purpose

2.1.69. TEMPERATURE - RISE LIMIT

Unless otherwise specified, in the case of external surface of enclosures of bus bar trunking system which shall be accessible but do not need to be touched during normal operation, an increase in the temperature rise limits of 25° C above ambient temperature shall be permissible for metal surface and of 15° C above ambient temperature for insulating surfaces as per IS

8623(Part-2) 1993. All main distribution panels and sub distribution panels shall be provided with MCCB of appropriate capacity as per Single Line Diagram. All final Distribution boards shall be provided with Miniature Circuit Breakers. Final Single-Phase Distribution boards shall be connected to the incoming supply through double pole MCB units & earth leakage circuit breakers.

All wiring for final distribution boards shall be concealed behind 5 mm thick bakelite sheet or M S sheet cover. All Distribution boards shall be completely factory wired, ready for connection. All the terminals shall be of proper current rating and sized to suit individual feeder requirements. Each circuit shall be clearly numbered from left to right to correspond with wiring diagram. All the switches and circuits shall be distinctly marked with a small description of the service installed. Continuous earth bus sized for prospective fault current shall be provided with arrangement for connecting to station earth at two points. Hinged doors/ frames shall be connected to earth through adequately sized flexible braids.

2.1.70. ELECTRICAL POWER & CONTROL WIRING CONNECTION :

Terminal for both incoming and outgoing cable shall be suitable for 1100 volts grade, aluminum/copper conductor PVC insulated and sheathed, armoured cable and shall be suitable for connections of solder less sockets for the cable size as indicated on the appended drawing for the PCCs, MCCs, PDBs.
Both control and power wiring shall be brought out in cable alley for ease of external connections, operation and maintenance.
Both control and power terminals shall be properly shrouded.
10% spare terminal shall be provided on each terminal block. Sufficient terminals shall be provided on each terminal block so that not more than one outgoing wire connected per terminal.
Terminal strip for power and control shall preferably be separated from each other by suitable barriers of enclosures.
Wiring inside the module for power, control protection and instrument etc. shall be done with use of 1100 V confirming to IS 694 and IS 8130. Power wiring inside the starter module shall be rated for full current rating of contactor, but not less than 4 sq mm cross section area. For current transformer circuits, 2.5 sq mm-copper conductor wire shall be used. Other control wiring shall be done with 1.5 sq mm copper conductor wires. Wires for connections to the door shall be flexible. All conductors shall be crimped with solder less sockets at the ends before connections are made to the terminals.
Control power for the motor starter module shall be taken from the respective module switchgear outgoing from R phase and Neutral. Control wiring shall have control fuse (HRC type).
Particular care shall be taken to ensure neat and orderly laying of the wiring. Identification ferrules shall be tagged to all the wire termination for ease of identification and to facilitate and testing.
"CUPAL" washers shall be used for all copper and aluminum connections.
Final wiring diagram of the PCC, MCC, PDB power and control circuit with ferrules number shall be submitted along with the PCC/MCC/PDB as one of the documents.

2.1.71. TERMINALS :

The outgoing terminals and neural link shall be brought out to a cable alley suitably located and accessible from the panel front. The current transformer for instrument metering shall be mounted on the disconnecting type terminal blocks. No direct connection of incoming and outgoing cables to internal components connection of the distribution board is permitted. Only one conductor may be connected in one terminal.

2.1.72. WIREWAYS :

A horizontal PVC wire way with screwed covers shall be provided at the top to take interconnecting control wiring between different vertical sections.

2.1.73. CABLE COMPARTMENT:

Cable compartment of adequate size shall be provided in the Distribution panels for easy clamping of all incoming and outgoing cables entering from the top/bottom. Adequate supports shall be provided in cable compartment to support cables. Minimum 200 mm gap should be provided in the Panel from Metal Enclosure Gland plate to Polycarbonate Cable compartment gland plate. In Polycarbonate Cable compartment minimum 150 mm gap should be provided from bottom of the cable connector. Minimum 75 mm gap Should be provided between connectors of every cable. All the cable gland plate should be detachable (on both Panel enclosure as well as Internal IP 65 Box). Provide glands at both the detachable gland plate to maintain complete IP 65. All cable terminals should be of Hensel / Spelsberg make only & Terminal size should be 2 sizes higher than required current capacity.

2.1.74. EARTHING :

Copper earth busbar of minimum 25 mm x 6 mm size shall be provided in the PCCs & MCCs for the entire length if panel. As per the rating of the main busbars the size of earthing busbar shall be decided. The framework of the PCCs & MCCsshall be connected to this earth busbar. Provisions shall be made for connection from earth busbar to the main earthing bar coming from the earth pit on both sides of the PCCs, MCCs, PDBs.

The earth continuity conductor of each incoming and outgoing feeder shall be connected to this earth bar. The armour shall be properly connected with earthing clamp and the clamp shall be ultimately bounded with the earth bar.

2.1.75. LABELS:

Engraved Aluminium sheet labels shall be provided on all incoming and outgoing feeders. Single line circuit diagram showing the arrangements of circuit inside the distribution board shall be pasted on inside of the panel door and covered with transparent laminated plastic sheet.

2.1.76. NAME PLATE :

A name plate with panel designation in bold letter shall be fixed at top of the central in panel. A separate name plate giving feeder details shall be provided for each feeder module door.

Inside the feeder compartment, the electrical component, equipments, accessories like switchgear, contactor, lamp, relays etc. shall suitably be identified by providing stickers. Engraved nameplates shall be of Aluminium strip of black colour and silver letters format.

Nameplate shall be fastened by counter sunk screws / riveted and not by adhesives.

2.1.77. DANGER NOTICE PLATE :

The danger plate shall be affixed in a permanent manner on operating side of the panel.
The danger notice plate shall indicate danger notice both in Hindi and English and with a sign of skull and bones.
The danger notice plate in general shall meet to requirements of local inspecting authorities.
Overall dimension of the danger notice plate shall be 200 mm wide and 150 mm high. The danger notice plate shall be made from minimum 1.6 mm thick mild steel sheet and after due pretreatment to the plate, the same shall be painted white with vitreous enamel paint on both front and rear surface of the plate.
The letter, the figure, the conventional skull and bones shall etc. shall be positioned on the plate as per recommendations of IS : 2551-1982.
The said letter, the figure and the sign of skull and bones be painted in single red colour as per IS: 5-1978.
The danger plate shall have rounded corners. Locations of fixing holes for the plate shall be decided to suit design of the panel.
The danger notice plate, if possible, be of ISI certification mark.

2.1.78. INTERNAL COMPONENTS:

The PCC / MCC / PDB shall be equipped complete with all type of required number of air circuit breakers, switch fuse unit, contactor, relays, fuses, meters, instruments, indicating lamps, push buttons, equipment, fittings, busbar, cable boxes, cable glands etc. and all the necessary internal connections /wiring as required and as indicated on relevant drawings. Components necessary for proper complete functioning of the PCC / MCC but not indicated on the drawings shall be supplied and installed on the PCC / MCC .
All part of the PCC / MCC carrying current including the components, connections, joints and instruments shall be capable of carrying their specified rated current continuously, without temperature rise exceeding the acceptable values of the relevant specifications at any part of the PCC / MCC .
All units of the same rating and specifications shall be fully interchangeable.

2.1.79. MINIATURE CIRCUIT BREAKER (MCB):

Miniature circuit breakers shall be quick make and break and break type conform with British standard BS: 3871 (Part-I) 1965 and IS: 8825 (1996). The housing of MCBs shall be heat resistant and having high impact strength. The fault current of MCBs shall not be less than 10000 amps, at 230 volts. The MCBs shall be flush mounted and shall be provided with trip free manual operating mechanism with mechanical "ON" and "OFF" indications.
The circuit breaker dollies shall be of trip free pattern to prevent closing the breaker on a faulty current.
The MCB contact shall be silver nickel and silver graphite alloy and tip coated with silver. Proper arc chutes shall be provided to quench the arc immediately. MCB's shall be provided with magnetic fluid plunger relay for over current and short circuit protection. The over load or short circuit devices shall have a common trip bar in the case of DP and TPN miniature circuit breakers. All the MCB's shall be tested and certified as per Indian Standard, prior to Installation.

2.1.80. MOULDED CASE CIRCUIT BREAKER:

The MCCB should be current limiting type with trip time of less than 10 msec under short circuit conditions. The MCCB should be either 3 or 4 poles as specified in BOQ. MCCB shall comply with the requirements of the relevant standards IS13947 – Part 2/IEC 60947-2 and should have test certificates for Breaking capacities from independent test authorities CPRI / ERDA or any accredited international lab.

MCCB shall comprise of Quick Make -break switching mechanism, arc extinguishing device and the tripping unit shall be contained in a compact, high strength, heat resistant, flame retardant, insulating moulded case with high withstand capability against thermal and mechanical stresses The breaking capacity of MCCB shall be as specified in the schedule of quantities. The rated service breaking capacity (Ics) should be equal to rated ultimate breaking capacities (Icu). MCCB's for motor application should be selected in line with Type-2 Co-ordination as per IEC-60947-2, 1989/IS 13947-2. The breaker as supplied with ROM should meet IP54 degree of protection.

Protection Functions

- MCCB's with ratings up to 200 A shall be equipped with Thermal-magnetic (thermal for overload and magnetic for short-circuit protection) trip units
- Microprocessor MCCB's with ratings 250A and above shall be equipped with microprocessor based trip units.
- Microprocessor and thermal-magnetic trip units shall be adjustable, and it shall be possible to fit lead seals to prevent unauthorised access to the settings
- Microprocessor trip units shall comply with appendix F of IEC 60947-2 standard (measurement of rms current values, electromagnetic compatibility, etc.)
- Protection settings shall apply to all poles of circuit breaker.
- All Microprocessor components shall withstand temperatures up to 125 °C

Testing

- Original test certificate of the MCCB as per IEC 60947-1 &2 or IS13947 shall be furnished.
- Pre-commissioning tests on the switch board panel incorporating the MCCB shall be done as per standard specifications.

Interlocking

Moulded, case circuit breakers shall be provided with the following interlocking devices for interlocking the door of a switch board.

a) Handle interlock to prevent unnecessary manipulations of the breaker.

b) Door interlock to prevent the door being opened when the breaker is in ON position.

c) Defeat-interlocking device to open the door even if the breaker is in ON position.

- The MCCB shall be current limiting type and comprise of quick make – Break switching mechanism.
- MCCB's shall be capable of defined variable overload adjustment. All MCCB's rated 200 Amps and above shall have adjustable over load & short circuit pick-up both in Thermal magnetic and Microprocessor Trip Units.

- All MCCB with microprocessor based release unit, the protection shall be adjustable Overload, Short circuit and earth fault protection with time delay.

The trip command shall override all other commands.

2.1.81. CONTACTORS:

The contactor shall meet with the requirements of IS: 2959 and BS: 775.
The contactors shall have minimum making and breaking capacity in accordance with utilization category AC 3 and shall be suitable for minimum class II intermittent duty.
If the contactor forms part of a distribution board then a separate enclosure is not required, but the installation of the contactor shall be such that it is not possible to make an accidental contact with live parts.

2.1.82. TRIVECTOMETER:

Flush mount 96 x 96 x 80 mm load manager type Enercon EM 6400 or equivalent meter of accuracy class 1 as per IS 13779 shall be provided. The meter shall be accurate on distorted waveforms; simultaneous sampling of voltage and amperes shall be done. It shall have low burden on PT and CT shall have bright display, shall view 3 parameters together shall have auto scaling from kilo to mega to giga units, shall have programmable CT, PT ratios with built in phase analyser. Auto scrolling shall be programmable as per user choice and communication with PC; PLC DCS shall be possible through RS 485 serial port. It shall be dust proof, tamper proof with data import export option and 10 years back up of integrated data.
Parameters to be monitored shall be Frequency, Line to line and average and line to neutral and average voltage, phase wise and average current, phase wise and total KVA, KW and P.F. reading and KWH monitoring.
User programmable facility for delta 2e and star 3e measurement, C.T. and P.T. ratios, sliding window auto sync. And auto scrolling of parameters shall be available.
Sensing shall be 3 phase, 4 wire measuring True RMS with voltage input range of 110 to 415 V nominal and current input of 5 amps or 1 amps as per field configuration. Current range shall be from 50 mA to 7.5 A and burden on PT or CT shall be app 0.2 VA.
Accuracy for kW / kWh shall be as per IS 1377 / CBIP88 and for all other parameters shall be +/- 0.5% of full scale + 0.5% of reading + 1 digit. Digital readout shall be of 3 rows of 4 digits each (12.5 mm size) with 7 segments bright red LED. Input frequency shall be 50Hz / 60Hz +/- 5%. Power factor range shall be 0.5 lag – unit – 0.8 lead.
Resolution for power parameters shall be for 4 digits and energy parameters shall be 8 digits. Display update shall be at every 15 seconds for demand parameters and 1 sec for other parameters. Display sequence shall be parameter followed by value.
Temperature range shall be 0-50oC and humidity <95% non-condensing.

2.1.83. CURRENT TRANSFORMER:

Where called for, CT's shall provide for current measuring. Each phase shall be provided with separate CT of class I accuracy and VA burden as shown in SLD for operation of associated metering and controls. Current transformer shall be in accordance with IS: 2705 - 1964 as amended up to date.

2.1.84. PUSH BUTTON:

The push button unit shall comprise of the contact element, a fixing holder, and push button actuator. The push button shall be momentary contact type. The contacts shall be of silver alloy and rated at 10 Amps. Continuous current rating. The actuator shall be of stranded type and colour as per its usage for ON, OFF and Trip.
The push button unit shall comprise of the contact element, a fixing holder, and push button actuator. The push button shall be momentary contact type. The contacts shall be of silver alloy and rated at 10 Amps. Continuous current rating. The actuator shall be of stranded type and colour as per its usage for ON, OFF and Trip. Push button shall be of self-glowing type with LED lamp.
Indicating Lamp shall be LED type and shall supplied complete with translucent covers to diffuse the lamp light. Indicating lamps shall be part of push buttons.
Colour shade for the indicating lamps shall be as below:
ON indicating lamp : Green
OFF indicating lamp : Red
TRIP indicating lamp : Amber
PHASE indicating lamp : Red, Yellow, and Blue.

2.1.85. TESTING

The following drawings shall be submitted before procurement for approval from the client / consultant.
1. General arrangement and Fabrication details.
2. Power wiring diagram of the panel.
3. Control wiring diagram of panel.
4. C.T. ratios with connection.
5. Material list with make, catalogue nos.

Testing and setting the relay set – point and co-ordination between relay on LT/HT fuses, breaker, setting shall be done by contractor. The downstream of the setting should be provided.
The relay should be tested by reputed agencies and test report of the relay should be submitted by the contractor.
Testing of panels shall be as per following codes:
IS: 8623 (Part -I) 1977 for factory built assemblies of switch gear for voltages upto and including 1000 VAC.
IS: 13947: 1993 Degree of protection
IS: 5578 & 11353:1985 Arrangement of bus bars.

1.1 KV & 6.35/11 KV GRADE L.T & H.T CABLES AND CABLE TERMINATION:

Technical specifications for design, engineering, manufacturing, inspection, testing at manufacturer's works, packaging and delivery by road (properly packed in nonreturnable steel drums), various sizes of aluminum, XLPE insulated, voltage upto and including 1100 Volts, extruded PVC inner sheathed, extruded FRLS PVC outer sheathed, GI round wire armoured cables, suitable for solidly grounded system. The cables shall confirm to IS 7098-Part 1 with latest amendments.

Technical specifications for design, engineering, manufacturing, inspection, testing at manufacturer's works, packaging and delivery by road (properly packed in nonreturnable steel drums), 6.35 / 11 KV (E) Voltage Grade, 3-Core, 400Sq. mm Stranded Compacted Circular Shaped Aluminum Conductor of H4 Grade, Shielded with extruded Semi-conducting compound, XLPE insulated, PVC sheathed, GI Round wire armoured Power Cables for effectively grounded system. The cable shall confirm to the latest revisions of IS: 7098 (Part – 2).

2.1.86. GENERAL TERMS & CONDITIONS

1. Climatic Condition: The site is located about 500 meters from the seacoast and the atmosphere is laden with salt spray. The climate is tropical with high humidity, heavy rainfall and prone to rust and fungus growth
2. Ambient Air Temperature:
   i. Maximum 45^0C
   ii. Maximum Daily Average 40^0C
   iii. Max. Weighted Yearly Average 32^0C
   iv. Max. Relative Humidity 90%

   The maximum temperature and relative humidity likely to occur simultaneously are 420C and 80% respectively
3. Installation Location: The cables may be laid/buried directly in ground, covered cable trenches, Cable racks/ladders in open air

2.1.87. 1.1 KV,6.35 / 11 KV (E) GRADE, ALUMINUM CONDUCTOR, POWER CABLES

This section covers the technical specifications for design, engineering, manufacturing, inspection, testing at manufacturer's works, packaging and delivery by road (properly packed in non-returnable steel drums), 1.1KV & 6.35/11 Kv grade, Multi-stranded Aluminum conductor, XLPE insulated, extruded PVC inner sheathed, GI round-wire armoured, extruded FRLS PVC ST2 outer sheathed. Power Cables for effectively grounded system, conforming to the latest revisions of IS: 7098 (Part –I), 1988 & as per the technical specifications attached herewith.

2.1.88. STANDARDS

The design, manufacture and testing of the cable shall comply with the latest editions/amendments of the following Indian Standards, unless otherwise specified. Equipment's complying with equivalent standards shall also be acceptable.

IS-7098, 1998 (Part-I):	Cross linked polyethylene insulated PVC sheathed cables for working voltages upto 1100V.
IS-7098 (Part –2):	Specification for cross linked polyethylene insulated PVC sheathed cables for working voltages from3.3 kV up to and including 33 kV
IEC-60502-2 1998:	Power Cables with extruded insulation and their accessories for rated voltages from 1 kV up to 30 kV
IS-5819:	Recommended Short circuit Current ratings for High voltage cables
IS-396:	Recommended current ratings for cables

IS 8130-1984:	Specification for conductors for insulated electric cables and flexible cords.
IS-3975, 1999:	Low Carbon galvanized steel wires, formed wires & tapes for armoring of cables
IS-4759:	Specifications for Hot dipped galvanized coating on round steel wires
IS-5831:	PVC insulation and sheath of electric cables.
IS-10418:	Drums for electric cables.
IS-10810 (Part 0 to 64):	Method of test for cables.

2.1.89. SERVICE CONDITION

The cable shall be designed with the following service conditions into consideration:

a) Cables shall be capable of satisfactory operation under a power supply system frequency variation of +3% and voltage variation of ±10%.
b) Cables shall be suitable for laying in conduits, ducts, trenches, channels, trays, racks or for direct buried in ground in both dry and wet locations with chances of flooding by water.
c) The cables shall be suitable for the following ambient condition: Ambient Air temperature: 400C
d) Ambient ground temperature: 300C
e) The current rating shall be based on maximum conductor temperature depending on the type of insulation for continuous at the rated current.
f) The one second short circuit current rating values shall be furnished and shall be subjected to the purchaser's approval.
g) The cables will have current ratings and de-rating factors as per relevant Indian Standards.

Full technical details and descriptive literature shall be furnished indicating the construction details, standard applicable for the components of the cable and current ratings of the cables in air and ground. De-rating factors to be considered for the ambient temperature, ground temperature, de-rating due to cable location in air and ground shall also be furnished. The certificates for the type tests conducted on cables similar to the cables covered herein shall be submitted along with the tender.

2.1.90. DESIGN AND CONSTRUCTION PERTICULARS

- **General**

The cables supplied under this specification shall be adequate insulated to operate continuously at the specified voltage with a high degree of safety and reliability throughout the life of the cables. The sheathing material shall be high quality PVC based compound. The construction of cable shall be as per IS: 7098 (Part I &2) – 1988. Cable shall be designed and manufactured to prevent damage during transportation, installation & operation under all climatic & operating conditions to which cable may be subjected to.

Technical parameters

- **Cable Insulation Level**

The power cables shall withstand power frequency voltage, impulse voltage and partial discharge extinction level as per IS: 7098 part – 2.

- **Cable Current Carrying capacity**

The cable shall be suitable for use where combination of ambient temperature and temperature rise due to load, results in conductor temperature not exceeding 90oC under normal operation. The cables shall have the following continuous current ratings when laid in ground 1100 mm below ground level and in air with the ground temperature being 30oC and air temperature being 40° C and assuming that thermal resistivity of soil is 150°C.cm/W and a maximum operating temperature of 90o C.

- **Cable Short Circuit withstand capacity**

The cable shall withstand the short-circuit current of 11Kv-31.5KA & 415V -25KA for 1 second, assuming the initial conductor temperature of 90° C and final temperature of 250° C.
The cables shall be suitable for Voltage grade 6.5 / 11 KV (E) & 650/1100 VOLTS, 3 phase, 50 Hz frequency, effectively grounded system and capable of continuous operation at their rated currents.

- **Cable Voltage Rating**
  - **Conductor**
    - ALUMINIUM

The Aluminium conductor used shall be of H-4 grade (Tensile strength above 150 N/mm2). High conductive aluminium, stranded (Class-II, stranded circular shaped), uniform in quality and free from scale, inequalities, spills, splits and other defects. The aluminium used shall have purity meeting the criteria for maximum resistance allowed. *Two sample conductor randomly selected from finished lot of cables, shall be tested for its purity at any 3rd party NABL accredited lab.*

- **Cable Joints:**

Joints shall be permitted in the individual wires of which the conductor is formed, but no joint shall be within 300 mm of any other joint within the same layer. The joints shall be made by resistance butt welding, fusion welding, cold pressure welding,
electric welding, gas welding, brazing or silver soldering. No joint is allowed in the conductor after stranding. A maximum of two joint shall be allowed in any strand forming complete length of the cable.

The conductors shall conform to appropriate dimensions, resistance and number of wire in the conductor (number of strands) as given in IS 8130 (Part I): 1984.

- **Conductor Screening**

The Conductor screening shall be provided over the conductor by extrusion of semiconducting compound and shall be so applied that it fits closely on the conductor and it shall be possible to remove it without damaging the conductor. Strippable screening shall be provided. The screening material shall be non-metallic semi-conducting compound.

- **Insulator**

The conductor insulation shall be of extruded layer of water tree free cross-linked polyethylene (XLPE), meeting the requirements of IS: 7098 (part–2). The method of cross-linking of polyethylene shall be indicated in the offer. Cross linking will be by Dry Gas Curing process.

The average thickness and tolerance of insulation when measured in accordance with IS shall not be less than the values specified in IS: 7098- Part -2.

- **Insulator Screening**

Insulation screening shall be by means of extruded bonded strippable semi-conducting layer followed by a semi-conduction-water swell able tape and metallic screening by means of wrapped copper tape.
The cable core shall be triple extruded and cross-linked in fully enclosed process such that the inner semiconducting screen, XLPE insulation and outer semi-conducting screen are applied simultaneously on the pre-heated cable conductor. In-line inspection mechanism shall continuously monitor the dimensional accuracy of the extruded core.
The cable will be tested for partial discharges after application of the copper tape screen as part of the Quality Control Procedure.

- **Insulation**

The insulating material for power cables shall be extruded cross-linked polyethylene (XLPE) compound as per **IS-7098(Part-I)-1988**. The minimum thickness of insulation shall not be less than the values specified in Table-2 of IS-7098 (Part-I)- 1988. No negative tolerance shall be applicable for the thickness. The insulation of the cable shall be designed and manufactured for the specified system voltage. The manufacturing process shall ensure that insulation shall be free from voids. The insulation shall withstand mechanical and thermal stress under steady state and transient operating conditions.
The cores shall be identified as per the following colour scheme:
3-Core - Red, Yellow & Blue
3 ½ or 4-Core - Red, Yellow, Blue & Black

- **Core Layout**

The core identification for the 3-core cable shall be done by using coloured strips of Red, Yellow & Blue colours respectively for each phase. The three cores shall be laid up together with a suitable right hand lay as per IS: 7098 (Part-2).
The interstices shall be filled with Non-hygroscopic material. The filler at the centre of the three cores shall be of vulcanised rubber. The filler shall be fresh material, recycled PVC material is not acceptable. The filling material shall be suitable for the operating temperature of the cable and compatible with the insulating material. The filler material should be non-hygroscopic, fire retardant and compatible with sheath.

- **Inner Sheath**

The inner sheath shall be extruded FRLS PVC, Type ST2, compatible with thermal rating of insulation conforming to IS-6380-1984. The sheath shall have adequate thickness, mechanical strength and elasticity, as specified in IS 5831. The material shall be soft thermoplastic type, applied by extrusion method. The thickness of the inner sheath shall be as per IS: 7098 (Part I & II) and the color of the inner sheath shall be Grey. The inner sheath shall be so formed that it fits closely on the laid up cores and could be easily removed without damaging insulation. One or more layer of proofed plastic tape shall be provided over the laid up core before extrusion.

- **Armouring**

The armouring arranged over the inner sheath shall consist of one layer of galvanized round steel wires for all sizes of cable. The armour round wire used on the cable shall conform to IS: 3975 for all requirements. The direction of lay of armour shall be opposite to that of the cores. The zinc coating on the galvanized steel strip shall comply with relevant standards. The joints

in armour wires/strips shall be made by brazing or welding and the surface irregularities shall be removed. A joint in any wire/strip shall be at least 300 mm away from the nearest joint in any other wire/strip in the completed cable.

- **Outer Sheath**

Extruded outer sheath shall be provided over the armouring. The material used for sheathing shall be FRLS PVC sheath, Type ST-2 base compound conforming to IS 1554/ IS 5831 for power cable. The outer sheath shall be so formed that it fits closely on the laid up armour and could be easily removed without damaging the intermediate sheath and insulation. The colour of the outer sheath shall be black. The thickness of outersheath shall be in accordance with the IS 1554 (Part-I & II)-1988. Suitable additives shall be added to prevent attack by rodents and termites. All serving must be given anti-termite treatment. The PVC compound used shall be abrasion proof, chemical resistant, provide protection against ants, termites, rodent and fungal growth.

Cables shall have suitable fillers laid up with the conductor to provide a substantially circular cross section before the sheath is applied. Fillers shall be suitable for the temperature of the cable and compatible with the insulating material. The material shall be of the best quality and workmanship. The fillers and sheath material shall be non-hygroscopic. All materials shall be new, unused and of the finest quality.

- **End Sealing, Joining and Joining Material**
  - **End Sealing Materials:**

The two ends of the cable shall be sealed by means of non-hygroscopic sealing materials preferably by Heat shrinkable end caps. Each drum shall be supplied with two numbers additional heat shrinkable end caps.

- **Jointing & Jointing Materials:**

Supplier shall indicate jointing procedures for terminal joints / straight joints of XLPE cables at motors, transformers and in switchgear. Detailed write-up shall be given along with the bid detailing the procedure for jointing along with drawings.

2.1.91. INSPECTION & TESTING

All the tests specified below shall be carried out in accordance with the Indian Standards by the manufacturer in the presence of Purchaser's representative. If the cable fails to pass the test specified, the Purchaser shall have the option to reject it. Shipping release shall be obtained from the Purchaser's representative. The Purchaser, however reserves the right to waive off the inspection.

The tests at works shall include electrical, mechanical and hydraulic tests in accordance with the appropriate clauses of Statutory Regulation, relevant codes and standards, in addition any test called for by the Purchaser or his representative to ensure that the equipment being supplied fulfils the requirement of the specification. For test not covered by any code or specifically mentioned in this specification, the test procedures are to be agreed with the Purchaser.

- **Stage Inspection**

i. The Purchaser's representative shall have access to the Supplier's works for the purpose of witnessing the tests and to ascertain that the cable being manufactured conforms to the requirements of this specification.

ii. The Purchaser's representative shall have a stage inspection during the following, important stages of production processes at manufacturer's works.

a. During Triple Extrusion process.
b. The cables will be tested for partial discharges after application of the copper tape screen as part of the stage inspection.

iii. During stage inspection the following tests shall be carried out.

a. Tensile strength
b. Elongation at break
c. Hot set test
d. Permanent set
e. Partial discharge test
f. IR before and after HV test
g. High voltage test
h. Conductor resistance test.

iv. Purchaser will witness triple extrusion process. Advance intimation shall be given to the Purchaser before starting of triple extrusion process. Ensure that online thickness monitoring unit (SIKORA) is in working condition. If online thickness monitoring unit is not working at triple extrusion point then production and as well as stage inspection shall not be carried out.

v. The customer will see the stabilizing point during triple extrusion process. Bubbles and other uneven surfaces shall not appear on the cable coming out of CCV line. If any bubbles or any other abnormality observed on the triple extruded single core cable at the end of the triple extrusion process then upto that point cable shall be cut and shall not become part of supply.

vi. After completion of water cooling of triple extruded line, residual moisture on the cable shall be removed with sufficient number of heaters. At the end of the CCV line, heaters in all the angles shall be placed to remove the residual moisture on the cable.

vii. Hot air blower shall be provided at the end of the CCV line, so that moisture on surface of the triple extruded core will get evaporated. It has to be ensured that there shall not be any water on surface of the core of the cable before winding it on to a cable drum. Sufficient delay (1 day) shall be given between end of triple extrusion process and winding of water swellable tape. & copper foil. (To avoid trapped moisture in copper foil).

- **Pre-Dispatch Inspection**

The manufacturer shall be given at least 15 days advance notice prior to the commencement of testing, so that Purchaser's representative can plan to witness the tests.

All the tests indicated in the test clause of this specification shall be carried out in the presence of Purchaser's representative by the manufacturer and shall provide all the facilities and equipment for testing.

Six copies of the Test Certificate shall be furnished to the Purchaser for approval prior to dispatch of cables from factory.

Visual check to conform the details given in this specification is to be done. In addition to the above, the general workmanship of the cable drums and cables laid in drums shall be checked.

Manufacturer shall have proper test set up for testing all the routine tests & type tests on finished cables as per IEC.

- **Type Test**

Type tests on four randomly selected cable drums will have to be conducted in the presence of the department's representative. The test samples will be taken from finished cables. This test shall be in accordance to IS: 7098, Part-1,1988.

a. Test on Conductor

· Annealing test for copper conductors
· Tensile test for aluminium conductor

· Wrapping test for aluminium conductor
· Conductor Resistance Test

b. Test on Insulation

· Physical dimension measurement
· Tensile strength and elongation at break
· Hot set test
· Shrinkage test
· Ageing in air oven
· Water absorption test

c. Test on round Armour

· Physical dimension measurement
· Tensile strength
· Elongation at break
· Torsion test for round wires
· Winding test for firmed wire
· Mass of zinc coating.
· Uniformity of zinc coating
· Resistivity measurement, Resistance test for armour

d.Test on Sheath

· Physical dimension measurement
· Tensile strength & Elongation at break test
· Ageing in air oven
· Loss of mass in air oven
· Shrinkage test
· Hot deformation test
· Heat shock test
· Thermal stability test

e. Partial discharge test

f. Dielectric power factor test

· As a function of voltage

· As a function of temperature

g. Insulation resistance (volume resistivity test)

h. Heating cycle test

i. Impulse withstand test

j. High voltage test

k. Flammability test

l. Water tightness test in longitudinal and radial direction (Manufacturer shall submit detailed procedure for this test and shall take prior approval of the engineer-in-charge).

m. Conductor purity test

One sample of aluminium shall be taken from any of the finished set of cables at random and the sample shall be tested for its purity at a NABL accredited lab.

i. *Test requirement of FRLS inner and outer sheath*

The inner and outer sheath of cables shall meet the following test requirements related to flame retardant, low smoke emission, low acid and toxic gas emission. The BIDDERs shall have proper test apparatus to

conduct all the relevant tests as per the applicable standards:

· Flame retardant test on single cable

· Oxygen Index Test

The critical oxygen index value shall be minimum 29 when tested at 27+2ºC as per ASTMD-2863

· Temperature index test

Temperature index value shall be minimum 250ºCat oxygen index of 21 when tested as per NES 715.

· Flammability test

Cables shall pass test under fire conditions as per IS-10810- Part-53. Cables shall also pass tests as per IS-10810 Part- 61 & Part-62. Flammability shall be as per IEC 332-1 and IS 694: 1990.

. Smoke Density Test

The cables shall satisfy the tests conducted to evaluate the percentage obscuration by smoke in an optical system placed in the path of the smoke. The maximum smoke density rating shall not be more than

60% when tested as per ASTM-D-2843.

· Acid Gas Generation test (halogen acid gas evolution)

The hydrochloric acid generation when tested as per IEC 754-1 shall be less than 20% by weight.

· Test for specific optical density of smoke

· Anti termite and rodent property test

The sequence of electric tests shall be as per the relevant Indian/International standards. The Bidder shall submit the sequence of tests for the approval of the purchaser before conducting the tests. A copy of the adopted standard shall also be supplied.

Routine Test (On each drum)

The following routine tests shall be carried out by the Manufacturer on each and every length of the cable in the presence of Purchaser's representative at manufacturer's works.

a. Resistance test for conductors

b. Insulation resistance (Dry) test

c. High voltage test

d. Partial discharge test.

- **Conductor purity test**

Two samples of aluminium and copper shall be taken from any of the finished set of cables at random and the sample shall be tested for its purity at a NABL accredited lab.

Qualifying Criteria:

The test results should be within limits as per IS 7098. All the routine tests as per IS 7098 / IEC shall be conducted and passed as per the limits given in the standards. All the bought-out certificates will be verified, and the test results shall be as per respective standards.

- **IDENTIFICATION**

The following details shall be marked sequentially for each meter run length of the cable by non-erasable embossing on the outer sheath:

a. Reference to Indian Standard

b. Name of the manufacturer/ Trade Name

c. Name of the project: **CWMF, BARC (K)**

d. Configuration of the cable: viz. Voltage grade, no. of Core, Sq. mm, A2XWY/2XWY/YWY / YY as applicable

e. Year of manufacturing

f. Sequential marking of running meter length

The running length of the cable shall be identified at regular intervals of one meter (Increasing order from inner end to outer end of the cable.

- **PACKAGING**

    - Each drum shall consist of single length cable ≥ 500 metres.
    - The cable shall be wound on *non-returnable steel drums* of suitable size, packed and marked.
    - Packing shall be sturdy to protect the cable from any injury during transportation, handling and storage. The cut ends of the cable shall be sealed by means of non-hygroscopic sealing material preferably Heat shrinkable end caps.
    - One end of the cable shall be brought out of the drum and suitably clamped to the drum flange with proper mechanical protection. Location of the other end may be marked on the drum.
    - The cable shall be placed on drums in such a manner that it will be protected from injury during transit. Each end of the cable shall be firmly and properly secured to the drum. No undue stress shall appear on cables when laid on drums.

- The cable drum shall carry the following information stencilled on a metallic label, securely attached to each end of the drum:
  i. Reference to the Indian standard
  ii. Manufacturer's name, brand or trade mark
  iii. Type of cable and voltage grade
  iv. No. of cores
  v. Nominal cross-sectional area of conductor
  vi. Cable code
  vii. Length of cable on drum
  viii. No. of lengths on reel, drum or coil (if more than one)
  ix. Gross weight
  x. Country of manufacture
  xi. Year of manufacture
  xii. Direction of rotation of drum (an arrow)
  xiii. ISI certification mark

- **PREFERRED MAKE**

Reputed brand possessing system certification of ISO 9001:2008, ISO14001:2004, OHSAS18001:2007 & EN 16001- 2009 and product certifications IS: 7098 (Part-I), CE, UL etc. Quotations without these certification details will not be considered for technical evaluation.
Preferred make of bought out material:
a. Aluminium for Conductor: Reputed brands
b. Copper for Conductor: Reputed brands
c. XLPE compound of Insulator: Reputed brands
d. Armour Steel: Reputed brands

- **GUARANTEE**

All the cables shall be guaranteed against faulty material, defective design & poor workmanship for a period of 18 months from the date of supply. The materials becoming defective during the guarantee period shall be replaced free of cost and the defects arising out of the works shall be rectified free of charge without delay.

TECHNICAL DATA SHEET

TECHNICAL DATA SHEETS FOR 6.35 / 11 KV (E) 3 CORE ARMOURED, SCREENED HT XLPE CABLES

S.No.	Description	cores x sq.mm	3 C x 400
1	**GENERAL**		
	Cable Type / Code	sq.mm.	A2XFY
	Voltage Grade		6.35 / 11 KV (E)
	Standards Applicable		IS:7098 (P-2) 2011, IS:5831-1984, IS:8130-1984, IS:3975
	Extrusion method	mm	Triple Extrusion
2	**CONDUCTOR**		
	Material		Stranded (Class 2) Compacted Circular Aluminium Conductor as per IS 8130
	Cross Sectional Area	mm	400
	Min No of strands	ohm - cm	53
3	**CONDUCTOR SCREEN**		
	Material		Extruded Non-Metallic Semi Conducting Compound
	Thickness (Min)		0.3
4	**INSULATION**		
	Material		Extruded, XLPE as per IS: 7098 Part-2
	Thickness (Nom.)	mm	8.8
	Volume Resistivity		
			1 x 10^14
5			1x 10^12
	at 27 deg C		90 Deg .C.
6	at 90 deg C		250 Deg. C.
7			
8	**CONDUCTOR TEMPERATURE**	mm	Extruded Non-Metallic Semi Conducting Compound
	Rated		0.3
	During short circuit	mm	
9	**INSULATION SCREEN**		0.04 mm Copper Tape
	Material		Red, Yellow & Blue Stripes Below Copper Tape
	Thickness (Nom)	ohm/km	
10	**METALLIC SHIELD**	ohm/km	
	Material & Thickness		Extruded PVC Type ST-2 as per IS:5831
	CORE IDENTIFICATION	Amps	0.7
	INNER SHEATH	Amps	Black
		µF/km	

S.No.	Description	cores x sq.mm	3 C x 400
11	Material	Ohm/km	
	Thickness (Min.)		Galvanised Steel Flat Strip as per IS:3975
	Colour		4 x 0.8
12	**ARMOUR**		
	Material		Extruded, PVC Type ST-2 as per IS: 5831
	Thickness(Nom)		3.00
	OUTER SHEATH		Black
	Material		
	Thickness (Min.)		0.0778
	Colour		0.1000
	ELECTRICAL DATA		
	Max.D.C. resistance at 20deg.c.		395
	A.C. resistance		530
	at 90 deg C		0.250
	Current rating		0.0971
	in ground at 30		
	deg C in air at 40		
	deg C		
	Approx. capacitance		
	Approx reactance at 50 Hz		
	Short circuit current rating	KA	37.60
	Impulse voltage withstand capacity		170 KV
		mm	103.0
			+/- 3mm
	CABLE DATA		CABLE ELECRTIC, Voltage Grade, CABLE SIZE, YEAR OF MFR.
13	Approximate overall dia of cable		15 x D mm
	Tolerance on overall dia		250 mtrs
	Printing / Embossing		+/- 5
	Min. Bending radius	shall be prov	+/- 5
	Drum Length (Non-returnable	one mtr	
14	wooden drum)		
	Drum Tolerance (%)		
	Overall Tolerance (%)		
15	Sequential length marking		

Cables are conforming to IS: 7098(Part - 2)2011

TECHNICAL DATA SHEET

DATA SHEETS FOR LT XLPE 3.5C ALUMINIUM ARMOURED CABLES

S No	Description	cores x sq.mm	3.5 C x 240 to 400
1	**GENERAL**		

			A2XFY
	Voltage Grade		650/1100 volts
	Standards Applicable		IS: 7098 (Part I) 1988, IS:5831-1984, IS:8130-1984, IS:3975
2	**CONDUCTOR**		
	Material		Stranded Compacted Setor shaped Aluminium conductor as per Class-2 of IS:8130-1984
	Cross Sectional Area (M/N)	sq.mm.	240/120
	Max.C.R.@ 20°c.(M/N)	ohms/km	0.125/0.253
3	**INSULATION**		
	Material		Extruded Cross-linked polyethylene (XLPE) as per IS:7098 Part-1
	Thickness (Nom.)	mm	1.7/1.2
	Volume Resistivity	ohms-cm	
	at 27 deg.c.		1 x 10^14
	at 90 deg.c.		1x 10^12
	CONDUCTOR TEMPERATURE		
	Rated		90 Deg .C.
	During short circuit		250 Deg. C.
4	**INNER SHEATH**		
	Material		Extruded PVC Type ST-2 as per IS: 5831-1984
	Thickness (Min.)	mm	0.60
	Calculate dia over laid up cores	mm	46.90
	Colour		Black
5	**ARMOUR**		
	Material		Galvanised steel Flat Strip as per IS: 3975
	Size	mm	4 x 0.80
	Calculated dia under armour	mm	48.10
6	**OUTER SHEATH**		
	Material		Extruded PVC Type ST-2 as per IS: 5831-1984
	Thickness (Min.)	mm	2.04
	Colour		Black
	Approx.overall dia of cable	mm	51.70
	Tolerance on overall dia		+/- 3mm
7	**ELECTRICAL DATA**		
	Max DC resistance at 20 deg C	Ohm /Km	0.1250
	AC Resistance at 90 deg C	Ohm/km	0.1600
	Capacitance	µF/Km	0.63
	Reactance at 50Hz	Ohm/Km	0.072
8	**Current Ratings**		
	In ground at 30 deg C	Amps	327
	In air at 40 deg C	Amps	392
	Short circuit rating for 1	KA	22.6

	second		
9	**Cable Data**		
	Drum Length (Non-Returnable Wooden Drum)	meters	500
	Drum Tolerance (%)		+/- 5
	Overall Quantity Tolerance (%)		+/- 5
	Core indentification		3.5 Cores - Red,Yellow,Blue, Black
	Printing / Embossing		CABLE ELECTRIC, Voltage Grade, Cable Size ,Year Of Mfg
	Min. Bending radius		15 x D
10	Sequential Marking		Shall be provided

Cables are conforming to IS: 7098(Part-1) 1988

2.1.92. CABLE TERMINATION:

Cable terminations shall be made with aluminium crimped type solder less lugs for all aluminium cables and stud type terminals. For copper cables copper crimped solder less lugs shall be used.
Crimping shall be done with the help of hydraulically operated crimping tool.
For joints where by cable is with aluminium conductor and bus bars are aluminium, bimetallic lugs shall be used with compound. CUPAL type of washers shall be used. Crimping tool shall be used for crimping any size of cable.

2.1.93. CABLE GLANDS:

Cable glands shall be of brass single compression type. Generally single compression type cable glands shall be used for indoor protected locations and double compression type shall be used for outdoor locations.

2.1.94. FERRULES:

Ferrules shall be of self-sticking type and shall be employed to designate the various cores of the control cable by the terminal numbers to which the cores are connected, for ease in identification and maintenance.

2.1.95. CABLE JOINTS:

Kit type joint shall be done and filled with insulating compound. The joint should be for 1.1 KV grade insulation.

2.1.96. CABLE LAYING

The scope consists of Design, manufacture, shop testing, supply at site, storage, cable trays, cable supporting angles, and accessories for trays, cable supporting angles, and accessories for cable erection such as glands, lugs, Hume pipes etc. tray covers, cable route markers for buried cable trench, including all accessories, fittings and sundry materials to make the job complete.

The scope includes supply of Perforated type cable trays for control room cables including all accessories, fittings and supports. Successful we of this contract shall be responsible for any loss or damage or additional cost for completion of control room.

This section covers laying of cables, in cable trenches cable jointing, termination at both ends and testing of the complete cable installation. The trench shall be leveled to the formation level of the yard. The cable route is shall be marked at regular intervals of 10 M by providing cable route marking pegs.

Cable schedules and drawing indicating the cable routing shall be furnished by the for approval. The cable laying shall be done strictly as per approved schedules.

Cable lugs shall be provided by the we for cables. We shall supply all other cable terminating accessories, like jointing ferrules, cable clamps, cable grips, cable compound flux, tapes, etc., as necessary and shall include supply of such accessories in the quoted rates. Dressing/bunching of all individual cores of the cables shall be done in a neat fashion. The we shall drill holes suitable for the cables in cable gland plate.

Cable lugs shall be compressed on the conductor ends by means of tools. Insulating sleeves shall be furnished and covered over the bare ends of the connections so as to prevent accidental contact with the ground or with the adjacent terminals.

The insulating sleeve shall be fire resistant, and long enough to over pass the conductor insulation and shall be of correct size of the conductor used.

Cable entering the control room from out door areas shall be sealed.

Standard cable grips and seals shall be utilized for cable pulling after pulling cable, the we shall put and attach aluminum cable markers at both ends of the cables and at the control room entry. The cable number and other data shall be punched and the cable markers are shall be securely attached to the cables.

Cable shall not be jointed and used for laying purpose. When necessary the approval of the Engineer at site should be taken before resorting at jointing.

Sharp bending cables shall be avoided. Cables shall cross control room basement wall in 4" A.C. Pipe embedded in cement concrete in basement wall. These pipes shall be supplied and installed by we.In each cable run some extra length shall be kept at a suitable point to enable one or two straight through joints shall be made.
The bidder shall put sufficient lengths of each cable to permit neat arrangement of all cables.

Cable splices shall not be permitted except where called for or where permitted by the purchaser.

At cable terminal points where the conductor and cable insulation shall be terminated, termination shall be made in a neat, workman like and approved manner by men specialized in this class of work.

Before any cable terminal connections are made, conductor's insulation shall be pulled out, at the end and identifying ferrules shall be fixed according to the wiring diagrams. Connection shall be made according to the wiring diagram

Polarity, or phasing shall be checked before connections are made and the we without additional cost shall make corrections of polarity, phasing or rotation.

Control cable terminations shall be made in accordance with wiring diagram using color codes established by the purchaser for the various control circuits, by code marked wiring diagrams furnished to the we for this purpose or any other approved means of identification. It is the intent that the we shall terminate the cable where the contractor lays.

Additional work of testing and reconnecting where leads have been brought to the terminal boards and connected, but where on further testing, reversed or other rearrangement of load turns out shall be necessary shall be performed by the we without additional cost.

Jointing of cables shall be in accordance with Indian Standard codes. The we shall arrange the manufacturers special instructions on materials and tools required for cable jointing work. Metal sheath and armour of the cable shall be connected to the Earthing system of the station by a steel strip wire. The we shall furnish two sets of marked up cable layout drawings after installation, indicating altered cable routes and location of straight joints.

Cable from equipment to trench shall run in GI conduits. Necessary conduits of adequate sizes and length shall be supplied and installed by the we. Flexible conduit should be used between fixed conduit/cable trays (perforated type) and equipment terminal boxes, where vibration is anticipated. The flexible conduit shall be as per relevant IS.

11.12 POST INSTALLATION CHECKS ON CABLE TRAYS:

The following shall be checked before laying the cables on the trays:-

1. Check for proper painting and identification numbers of cable trays.
2. Check for continuity of power and control cable trays over the entire route.
3. Check that oil, sharp washers, bars and waste material have been removed from the trays. Check for earth continuity and earth connection of cable trays.

INTERNAL WIRING

Providing fixing and layout of electrical system unit including fixtures, wiring, cabling conduting fixing & connecting to the mains panel distribution boards, power points, light points and earthing system. The work to be carried out as per electricity safety rules and practices materials used shall be ISI approved only.

2.1.97. TECHNICAL SPECIFICATIONS

- **GENERAL SCOPE OF WORK**

The electrical scope of work covers the followings:
a. Internal electrification through concealed/surface PVC conduit and provide light points and socket outlets as shown in the detailed drawings.
b. Provide telephone outlets as shown in the detailed drawings.
c. Provide Distribution panel at convenient locations to facilitate power for lights, fans, sockets,

power plugs data points through UPS supply. UPS supply shall be separate..
d. Provide Power distribution network including Panels, cabling, mains and sub-main wiring.
e. Scope of work shall include supply installation, testing and commissioning of complete electrical installation
f. Earthing of electrical installations complete in all aspects.

2.1.98. REGULATIONS AND STANDARDS

The installation shall conform in all respects to Indian Standard Code of Practice for Electrical wiring installation IS:732-1963 and IS:2274-1963. It shall also be in conformity with Indian Electricity Rules and the Regulations, National Electric Code and National Building Code. CPWD specifications and requirements of the Local Electric Supply Authority. In general, all materials, equipment and workmanship shall conform to the Indian Standards, specifications and code. Some of the applicable codes/standards are as under:

The following standards and rules shall be applicable:

IS: 1646 Code of practice for fire safety of buildings (General) Electrical installation

IS: 4648 Guide for electrical layout in residential building Indian electricity act and rules.

IS 375 – 1963 Marking and arrangements for switchgear: Bus bars, main connection and auxiliary
wiring.
IS 2675 – 1983 Specifications for enclosed distribution

IS10118-1982 Installation and maintenance of switchgear.

IS 1554 – 1988 Specifications for PVC insulated (heavy duty) electric cable Part-I for voltage up to 1100 volts.
IS 694-1990 Specifications for PVC insulated: Cables for voltage up to 1100V with Aluminium conductors.

IS 9537 – 1981 Specifications for Rigid Steel conduit for electrical wiring.

IS 3837-1976 Specifications for accessories for rigid steel conduits for electrical wiring.

IS 5133 – 1969(Part-I) Boxes for the enclosure of electrical accessories, Steel and CI boxes.

IS 1293 – 1988 3 pin plugs and socket outlets

IS 1913 – 1978 General and safety requirements for electric lighting fittings.

IS 374 – 1979 Electric ceiling fans and regulators.

IS 3043 – 1987 Code of practice for earthing

IS 1646 – 1982 electrical installation.

IS 2705 – 1992 Current transformers

IS 1248 – 1983 Direct acting electrical indicating instruments.

IS 8623 Factory built assemblies of switch gear & control gear.

IS 8828 MCB

IS 2516 MCCB

IS 13947 SFU

IS 12640 ELCB

2.1.99. INTERNAL ELECTRIFICATION OF BUILDING

SCOPE

Under this head, the bidder is to carry out the internal electrification of the auditorium as mentioned under para 1.0.

The scope covered under this head includes concealed/surface conduiting, wiring, provision of distribution boards, submains/mains and fittings.

- **GENERAL**

The electrical Installation work shall be carried out in accordance with Indian Standard Code of Practice for Electrical Wiring Installation IS: 732-1989 and IS: 2274-1963. It shall also be in conformity with the current Indian Electricity rules and regulations and requirements of the Local Electricity Supply Authority and Fire Insurance regulations, so far as these becomes applicable to the installation. Electrical work in general shall be carried out as per following CPWD Specifications with up to date amendment.

General Specifications for Electrical Works. (Part I - Internal) – 1994.
Wherever this specification calls for a higher standard of material and or workmanship than those required by any of the above mentioned regulations and specification then the specification here under shall take precedence over the said regulations and standards.

2.1.100. DISTRIBUTION BOARDS

Distribution Board shall be standard type as per the CPWD specifications. All distribution boards shall be of three phase (415 Volts) or single phase (240 volts) type with incoming isolator or MCB as in Schedule of quantities. Distribution boards shall contain plug in or bolted type miniature circuit breaker mounted on busbars. Miniature circuit breakers shall be quick

make and quick break type with trip free mechanism. MCB shall have thermal and magnetic short circuit protection. MCB shall conform with IS 8828-1978. Neutral busbars shall be provided with the same number of terminals as there are single ways on the board, in addition to the terminals for incoming mains. An earth bar of similar size as the neutral bar shall also be provided. Phase barrier shall be fitted and all live parts shall be screened from the front. Ample clearance shall be provided between all live metal and the earth case and adequate space for all incomingand outgoing cables. All distribution board enclosures shall have an etched zinc base stove painted followed by synthetic stoved enamel, colour light gray.

A circuit identification card in clear plastic cover shall be provided for each distribution board. Miniature Circuit Breakers for lighting circuits shall be of "L" series where as `G' series MCB's shall be invariably used for motor loads, halogen lamps fitting, sodium/mercury discharge lamps and for all power circuits. All miniature circuit breakers shall be of 9 KA rated rupturing capacity.

2.1.101. SURFACE CONDUIT

Conduit pipes shall be fixed by heavy gauge saddles, secured to suitable wood plugs or other approved plugs with screws in an approved manner at an interval of not more than one meter but on either side of the couplers or bends or similar fittings, saddles shall be fixed at a distance of 30cm from the center of such fittings. The saddles should not be less than 24 gauge for conduits upto 25 mm dia and not less than 20 gauge for larger diameter conduits. The corresponding widths shall be 19 mm & 25 mm. Where conduit pipes are to be laid along the trusses, steel joint etc. the same shall be secured by means of special clamps made of MS. Whereas it is not possible to drill holes in the trusses members suitable clamps with bolts and nuts shall be used.

For 25 mm diameter conduit width of clip shall be 19mm and of 20 SWG. For conduit of 32 mm and above, width of clip shall be 25mm and of 18 SWG.
Where conduit pipes are to be laid above false ceiling, either conduit pipes shall be clamp to false ceiling frame work or suspended with suitable supports from the ceiling slab. For conduit pipe run along with wall, the conduit pipe shall be clamped to wall above false ceiling in uniform pattern with special clamps if required to be approved by the Engineer-In-Charge at site.

2.1.102. RECESS/CONCEALED CONDUIT

The chase in the wall shall be neatly made and of ample dimensions to permit the conduit to be fixed in the manner desired. In the case of building under construction, conduit shall be buried in the wall before plastering and shall be finished neatly after erection of conduit. Incase of exposed brick/rubble masonry work, special care shall be taken to fix the conduit and accessories in position along with the building work. Entire work of chasing the wall, fixing the conduit in chases, and burring the conduit in mortor before plastering shall form part of point

wiring work.

The conduit pipe shall be fixed by means of staples or by means of saddles not more than 60cm apart or by any other approved means of fixing. Fixing of standard bends and elbows shall be avoided as far as practicable and all curves maintained by bending the conduit pipe itself with the long radius which shall permit easy drawing in of conductors. Suitable inspection boxes to the barest minimum requirements shall be provided to permit periodical inspection and of facilitate replacement of wires, if necessary. These shall be mounted flush with the wall. Suitable ventilating holes shall be provided in the inspection box covers. Wherever the length of conduit run is more than 10 meters, then circular junction box shall be provided.

2.1.103. OUTLET BOXES & COVERS

The switch box shall be made of metal on all sides except on the front. Boxes shall be hot dip galvanised mild steel. Upto 20 x 30 cm size M.S. box shall have wall thickness of 18 SWG and MS boxes above 20 x 30 cm size shall be of 16 SWG. The metallic boxes shall be painted with anticorrosive paint before erection. Clear depth of the box shall not be less than 60mm. All fitting shall be fitted in flush pattern. Phenolic laminated sheet of approved shade shall be used for switch box covers.
These shall be of 3 mm thick synthetic phenolic resin bonded laminated sheet as base material and conform to grade P-I of IS: 2036-1994.

2.1.104. ERECTION AND EARTHING OF CONDUITS.

The conduit if used metallic of each circuit or section shall be completed before conductors are drawn in. The entire system of conduit after erection shall be tested for mechanical and electrical continuity throughout and permanently connected to earth conforming to the requirement by means of special approved type of earthing clamp effectively fastened to conduit pipe in a workmen like manner for a perfect continuity between the earth and conduit. Gas, water pipe shall not be used as earth medium.

2.1.105. SWITCHES.

All 5 and 15 Amp switches shall be piano type of 240 volts A.C. grade. All switches shall be fixed on 3 mm thick laminated sheet cover. All 5 Amp socket shall be 5 pin type. All 15 Amp socket shall be 6 pin type suitable for 15/5 Amp. All switches, sockets, telephone outlets, etc. shall be in off white finish. The switches controlling the lights or fans shall be connected to the phase wire of the circuit. Switches shall be located at 1200 mm above finished floor level unless otherwise indicated on drawings. In dean, professor and lecturers rooms switches and socket outlets shall be modular type in modular metal box.

2.1.106. FLUSH COVER PLATE.

All switches, sockets, telephone outlets etc. shall be fixed on 3 mm thick phenolic laminated sheet cover. Flush cover plate shall be secured to the box with counter sunk brass screws & cup

washers.

2.1.107. WALL SOCKET PLATE.

All 5 and 15 Amp socket outlet shall be 5 and 6 pin respectively. Each outlet shall have a switch located beside the socket preferably on the same flush cover plate. The earth terminal of the socket shall be connected to the earth wire.

2.1.108. WIRING

All PVC insulated stranded copper conductor wires shall conform to relevant IS Codes.

All internal wiring shall be carried out with PVC insulated FRLS wires of 650/1100 volts grade. The circuit wiring for points shall be carried out in looping in system and no joint shall be allowed in the length of the conductors. Circuit wiring shall be laid in separate conduit originating from distribution board to switch board for light/fan. A light/fan switch board may have more than one circuit but shall have to be of same phase. Looping circuit wiring shall be drawn in same conduit as for point wiring. Each circuit shall have a separate neutral wire. Neutral looping shall be carried out from point to point or in light/fan switch boards.

A separate earth wire shall be provided alongwith circuit wiring for each circuit. For point wiring red colour wire shall be used for phase and black colour wire for neutral. Circuit wiring shall be carried out with red, yellow or blue colour PVC insulated wire for RYB phase wire respectively and black colour PVC insulated wire for the neutral wires. Bare copper wire shall be used as earth continuity conductor and shall be drawn alongwith other wires. No wire shall be drawn into any conduit until all work of any nature, that may cause injury to wire is completed.

Care shall be taken in pulling the wires so that no damage occurs to the insulation of the wire. Before the wires are drawn into the conduit, the conduits shall be thoroughly cleaned of moisture, dust and dirt. Drawing and jointing of copper conductor wires and cables shall be as per CPWD specifications.
Maximum number of PVC insulated 650/1100 V grade aluminium/copper conductor cable conforming to IS: 694 – 1990

- **JOINTS.**

All joints shall be made at main switches, distribution board socket and switch boxes only. No joint shall be made in conduits and junction boxes. Conductors shall be continuous from outlet to outlet.

- **MAINS AND SUBMAINS.**

Mains and sub-main cable where called for shall be of the rated capacity and approved make. Every main and sub-main shall bedrawn into an independent adequate size conduit. Adequate size draw boxes shall be provided at convenient locations to facilitate easy drawings of the sub-

Nominal Sectional area of conductor in Sq.mm.	25mm		32mm		38mm		51mm		64mm Cross-	
	S	B	S	B	S	B	S	B	S	B
1	4	5	6	7	8	9	10	11	12	13
1.5	10	8	18	12	-	-	-	-	-	-
2.5	8	6	12	10	-	-	-	-	-	-
4	6	5	10	8	-	-	-	-	-	-
6	5	4	8	7	-	-	-	-	-	-
10	4	3	6	5	8	6	-	-	-	-
16	2	2	3	3	6	5	10	7	12	8
25	-	-	3	2	5	3	8	6	9	7
35	-	-	-	-	3	2	6	5	8	6
50	5	-	-	-	-	-	-	5	3	6
70	-	-	-	-	-	-	4	3	5	4

main & main cables. Cost of junction box/drawn box is deemed to be included in the rates of sub main wiring. As independent earth wire of proper rating shall be provided for every sub-main. Single phase sub main shall have single earth wire whereas three phase sub main shall be provided with two earth wire. The earth wire of proper rating shall be fixed to conduits by means of suitable M.S. clips at not more than 1000 mm distance. Where mains and sub-mains cables are connected to the switchgear, sufficient extra lengths of sub main and mains cable shall be provided to facilitate easy connections and maintenance. For termination of cables creeping type cable socket/lugs shall be provided. Same color code as for circuit wiring shall be followed.

NOTE:

1. The above table shows the maximum capacity of conduits for a simultaneous drawing in of cables.

2. The columns headed `S' apply to runs of conduits which have distance not exceeding 4.25m between draw in boxes and which do not deflect from the straight by an angle of more than 15 degrees. The columns headed `B' apply to runs of conduit which deflect from the straight by an angle of more than 15 degrees.
3. Conduit sizes are the nominal external diameters.

- **LOAD BALANCING**

Balancing of circuits in three phase installation shall be planned before the commencement of wiring and shall be strictly adhered to.

- **COLOUR CODE FOR CIRCUIT & SUBMAIN WIRING.**

Colour code for circuit and submain wiring installation shall be Red, Yellow, Blue for three phases. Black for neutral and yellow/green or green only for earth incase of insulated earth wire.

2.1.109. CLASSIFICATION OF POINTS.

- **General**

Classification and measurement of Point wiring shall be as per CPWD specification for Electrical Works (Part-I-Internal)1994.

- **CONDUCTOR SIZE.**

Wiring shall be carried out with following sizes of PVC insulated stranded single core copper conductor wire/cable.
i. Light point. - 1.5Sq.mm
ii. Ceiling /Cabin/Exhaust Fan Point - 1.5Sq.mm
iii. Call Bell Point - 1.5Sq.mm
iv. Plug Point (5 A S.S. outlet) - 1.5Sq.mm
v. Circuit Wiring - 2.5Sq.mm
vi. General Power Point – 4Sq.mm

2.1.110. LIGHTING FIXTURE AND FANS

- **GENERAL**

a) The Contractor shall supply and install lighting fixtures including but not limited to lamps, ballasts, accessories fixing hardware necessary for installations, as shown on the Drawings, as required, and as herein specified.
b) All fixtures shall be delivered to the building complete with suspension accessories, canopies, hanging devices, sockets, holders, reflectors, ballasts, diffusing material, louvers, plaster frames, recessing boxes, etc. all wired and assembled as indicated.
c) Full size shop detail drawings of special fixture or lighting equipment, where called for in the fixtures schedule, shall be submitted to the Engineer in-charge for approval.
d) Fixtures, housing, frame or canopy, shall provide a suitable cover for fixture outlet box

or fixture opening.

e) Fixtures shall comply with all applicable requirements as herein outlined
f) Manufacturer's name and catalogue number of lighting fixtures are given for general reference only. It shall be understood that the actual fixtures supplied shall meet all the requirements of the specification, and, if necessary, the standard fixture indicated for reference, shall be modified accordingly.
g) Fixtures shall bear manufacturer's name and the factory inspection label.
h) Fixtures shall be completely wired and constructed to comply with the IEE wiring regulations requirements for lighting fixtures, unless otherwise specified.
i) Revamping the fixture shall be possible without having to remove the fixture from its place.
j) Lamps of the proper type, wattage and voltage rating shall be furnished and installed in each fixtures.

- **WIRING WITHIN THE FIXTURES**

a) Fluorescent fixtures shall be wired with not smaller than 1.5 sq. mm asbestos-covered wire. No splice or tap shall be located within an arm, stem or chain. Wire shall be continuous from splice in outlet box of the building wiring system to lamp socket or to ballast terminals.
b) Wiring within incandescent fixtures and for connection to the branch circuit wiring up to the outlet box of lighting point shall not be less than 1.5 sq. mm silicone rubber insulated wire. (150oC temperature).

- **INSTALLATION**

Fixtures shall be installed at mounting heights as detailed on the Drawings or as instructed on site by the Engineer-In-charge.

Pendent fixtures within the same room or area, shall be installed plumb and at a uniform height from the finished floor. Adjustment of height shall be made during installation.

Flush mounted recessed fixtures, shall be installed so as to completely eliminate leakage of light within the fixture and between the fixture and adjacent finish.

Fixtures mounted outlet boxes shall be rigidly secured to a fixture stud in the outlet box. Hickeys or extension pieces shall be installed where required to facilitate proper installation.

2.1.111. ENERGY EFFICIENT LED BASED LUMINAIRE UNIT FOR INDOOR & OUTDOOR LIGHTS

- **SCOPE**

The scope of work includes design, development, manufacturing, testing, supply, installation and commissioning of energy efficient luminiar complete with all accessories, LED lamps with suitable current control driver circuit including mounting arrangement for recessed type & ceiling mounting arrangements. The luminiar shall be suitable for rugged

service under the operational and environmental conditions encountered during service. The following types of luminaries are required to be provided:

1. LED Tube Light/ LED Line fitting
2. LED Bulb

Sl No	Place/Location	Type of lighting Fixture	Lighting level
1	Main control room	LED	300 lux
2	Other areas inside The pump house	-Do-	100 lux
3	Machine hall (high bay)	LED	250 lux
4	Transformer bay	LED	200 lux
5	Switch yard and other approach Roads	LED	150 lux

Each type of luminarie shall be supplied with associated driver circuit compatible with LEDs in all respect as required including complete optics.

- **SERVICE CONDITIONS:**

Indoor lights on pipe/Recess mounting type light unit complete with luminaries and mounting accessories shall be suitable for Buildings(indoor) of pump hous under the following environmental conditions: -

Environmental conditions

Maximum ambient air temperature: 45□ C

Minimum ambient air temperature: -5□ C

Max. Relative humidity 100%

Atmosphere Extremely dusty and desert weather and desert terrain in certain areas. The dust contents in air may reach as high values as 1.6 mg/m3

Coastal area: The equipment shall be designed to work in coastal area in humid, salt laden and corrosive atmosphere.

- **REFERRED STANDARDS**

IS: 513 Cold-rolled low carbon steel sheets and strips

IEC 60529 Classification of degree of protections provided by enclosures.

EN 55015, CISPR15 Limits and methods of measurement of radio disturbance characteristic of electrical lighting and similar equipment

IEC 62031 LED modules for general lighting-Safety requirements

EN 61547 Equipment for general lighting purposes – EMC imunity requirement.

EN 60929 Performance, AC supplied electronics ballast for tubular fluorescent lamps

performance requirement.

IEC 60598-2-1 Fixed general-purpose luminaries

IEC 60598-1 Luminaires - General requirement and tests

IEC 61000-3-2 Electro Magnetic compatibility (EMC) -Limits for Harmonic current emission -– (equipment input current ≤ 16 Amps. per phase.

IEC 60068-2-38 Environmental Testing: Test Z- AD: composite temperature/ humidity cyclic test

IEC 61347-2-13 Lamp control gear: particular requirements for DC or AC supplied electronic control gear for LED modules

IS 10322 Specification for the luminaries

IS 4905 Method for random sampling

LM 79 LED luminaire photometry measurement

LM 80 Lumen Maintenance

IEC 62384 DC or AC supplied electronic control gear for LED modules performance requirements

IEC/PAS 62612 Self-ballasted LED lamps for general lighting services- Performance requirements

- **CONSTRUCTION**

a. All the luminiars shall be finalized based on the performance feedback. The detailed calculation for lux level as per clause no.5.8 with uniform distribution including the lux distribution curve /graph distribution shall be submitted in support of the dimensions selected and variation thereof. Housing, if not used as a heat sink shall be made of at least 0.8 mm thick sheet Steel conforming to IS: 513 (Grade O)/CRCA polyester powder coated of at least 60 microns) and high U.V. & corrosion resistance. Heat sink used should be aluminum extrusion having high conductivity preferably to grade 6061 alloy or better having thermal conductivity of at least 170-180 W/m.K or Aluminium die cast having high conductivity preferably ADC 12 or LM 24. Efforts shall be made to keep the overall outer dimensions as minimum as possible.

All luminaires shall be provided with toughened glass of min. 0.8 mm thickness of sufficient strength and high efficiency (90%) prismatic diffuser under the LED chamber to protect the LED and luminaries. And shall not show yellowness during luminarie life time.

1.Tube Light /Line fitting
2. LED Bulb

Suitable number of LED lamps shall be used in the luminiars. LED lamps of Reputed make shall be used for the purpose. The manufacturer shall submit the proof of procurement of LEDs from above OEMs at the time of testing. Suitable reflector / lenses may also be provided to increase the illumination uniformity and distribution. Supplier will be solely responsible for testing and performance of the luminaries after installation and shall also ensure the specified and uniform illumination and comfort level on the work desk/ floor. Design of the thermal management shall be done in such a way that it shall not affect the properties of the diffuser.

High power and high lumen efficient LEDs suitable for following features shall be used:

- The efficiency of the LED lamps at 85 Deg C junction temperature shall be more than 85%.
- The working life of the lamp at junction temperature of 85 Deg C at rated current shall be more than 50,000 working hours of accumulative operation and shall be suitable for continuous operation of 24 hours per day. These features shall be supported with datasheet.
- Adequate heat sink with proper thermal management shall be provided.
- Colour temperature of the proposed white colour LED shall be 5700k (nomonal CCT) and the color variation should be 5665 +/-365K (ANSI binning)
- Minimum view angle of the LED shall not be less than 1200.
- The output of LED shall be more than 100 lumen per watt at minimal operating current and shall ensure guaranteed operation life of 50,000 burning hours with controlled junction temperature of 850C.
- Lumen maintenance report as per LM 80 guidelines shall be produced for the power LEDs
  used.

Power factor of complete fitting shall be more than 0.9 at full load 240V. Thermal management shall be in such a way that LED soldering point temperature shall not go beyond 75 degree centigrade. Input frequency range shall be between 50Hz±3%.
The LED luminaire shall be free of glare.
Color rendering index CRI >=75

LED DRIVER specification used for street light

- Input voltage Range within 180Vrms to 270Vrms
- Operating input voltage 240Vrms
- No load power consumption ≤ 500mW
- Output voltage 105VDC±3%
- Output voltage ripple should be within 3%
- Output over voltage protection 125VDC
- Power factor 0.95
- Full Load Efficiency ≥ 90%
- THD ≤8 %
- Hot swapping
- Load regulation ±5%
- Current waveform should meet EN 61000-3-2

- Led Driver shall withstand, withstand voltage of 440V for 2 hours and restore normal working
- when normal voltage is applied
- Maximum Temperature rise <= 30ºC @ 45ºC Tamb with safety margin of 10oC
- The driver should comply to CISPR 15 for limits and methods of measurement of Radio
- Disturbance characteristics
- The equipment should comly
- The controlgear should be compliant to IEC 61347-2-13, IEC 62031 and IEC 62384 as per the
- requirements
- The equipment should be compliant to IEC 60598-1, IEC 62031and IEC/PAS 62612 depending on
- the type of luminaire.

TECHNICAL REQUIREMENTS

The driver of the luminiars should have

- 2 x 2 Fixture- Shall have Short Circuit, Over Voltage, String Open protections.
- 1 x 1 Fixture- Shall have Short Circuit, Over Voltage, String Open protections.
- Tube Light – Shall have Over Circuit, Over Voltage protections.

The electronic components used shall be as follows: -

- IC (Integrated circuit) shall be of industrial grade or above.
- Metallic film / Paper/Polyester Capacitor shall be rated for a temperature of at least 105ºC.
- The resistors shall be preferably made of metal film of adequate rating. The actual loading versus rating shall be 3.
- The junction temperature of the Switching devices such as transistors and MOSFETs etc. shall not exceed 125ºC (allowing thermal margin of 25 ºC).
- The conformal coating used on PCBs must be cleared and transparent and shall not affect colour code of electronic components or the product code of the company. The LED must be mounted on MCPCB, which should be made up of Metal core (Aluminum metal core) and should have the alumina coating with aerosol spray process of manufacturing to have the better heat conduction or dissipation.
- MCPCB shall be made with OPA dielectric thickness of 0.1mm and Al 5052H34. MCPCB must comply with IPC-A-600G and IPC-6012A class 2. UL approved solder mask and silkscreen must be used.
- The heat sink compound used should be of silicon with high thermal conductivity with 3W/mk.
- The heavy components shall be properly fixed. The solder connection shall be with good finish.
- The electronics covered for this equipment shall pass all the tests called for in the specification
- The infrastructure for Quality Assurance facilities as called for in the specification shall be available for the manufacturing of this product.

The connecting wires used inside the luminiar, shall be low smoke halogen free, fire retardant PTFE

cable and fuse protection shall be provided in input side. Care shall be taken in the design that there is no water stagnation anywhere. The entire housing shall be dust and water proof having IP20 protection as per IEC 60529.
The control gear shall be designed in such a way so that temperature rise of MCPCB shall not be more than 200C with respect to ambient temperature when measured half inch away from the component. Luminiar shall be such that the glare from individual LED is restricted and shall not cause inconvenience to the people. The Diffuser should be used in the luminiar to restrict the glare of LEDs. And should have no yellowness during the entire life of the luminaire.
All the material used in the luminiar shall be halogen free and fire retardant confirming to UL94 V.0
Illumination Level: The fitting shall be so designed that the illumination level shall be evenly distributed and shall be free from glare. Illumination level of different types of luminiar shall be as below:

Sl. No.	Place to be illuminated	Vertical Distance of fittings from the floor level(Mtrs)	Average Illumination Level (Lux)	Colour Temp in oK
Indoor Light				
1	Work areas	2.743	250 at 1mtr above ground level	5500 to 7000
2	Corridors	2.743	125 on the floor	5500 to 7000

* Illuminance at center is assumed for single luminaire.

Note:
1. Variation in illumination level shall be ±2% is allowed in input voltage range from 180VAC to 270VAC.
2. The illumination shall not have infra-red and ultra-violet emission. The test certificate from the NABL approved laboratory shall be submitted

TESTS:
Tests are classified as:
Type test
Acceptance test
Routine rest.

Type Test
Type tests shall be carried out to prove confirmation with the requirement of specification and general quality/design features of the unit. In case of any change in Bill of Material or design of unit, complete type test shall be repeated. If any sample fails in any of the type tests, two fresh samples shall be taken and tested. If any sample again fails in that test, the whole lot shall be rejected.

Acceptance Tests:
These tests are carried out by an inspecting authority at the supplier’s premises on sample taken

from a lot for the purpose of acceptance of a lot. Acceptance tests shall not be carried out from particular size from the lot on which type tests have already been conducted. Recommended sampling plan is given below.

Sample size and criteria for conformity
The luminaries shall be selected from the lot at random. In order to ensure randomness of selection, procedures given in IS 4905-1968 (Reaffirmed 2001) may be followed.

Routine Tests:
These tests shall be performed by the manufacturer on each complete unit of the same type and the results shall be submitted to the inspecting agency, prior to offering the lot for acceptance test. the
firm shall maintain the records with traceability.

Method of Testing
Visual and Dimensional Check:
The unit shall be checked visually for all dimensions as per approved design and drawing. General workmanship should be good; all the components properly secured and sharp edges shall be rounded off. Check the marking and quality of the workmanship visually. Check the rating and make of electronic / electrical items.

Checking of documents of purchase of LED
Check Document of purchase of LED lamps of approved sources viz. NICHIA/ OSRAM/ SEOUL/ PHILIPS LUMILEDS / LEDNIUM/AVAGO/CREE.

Resistance to humidity test
This is carried out by suspending the painted panels in corrosion chamber maintained at 100% RH and temperature cycle of 42 to 48 deg. C for 7 days and examining it for any sign of deterioration and corrosion of metal surface.

Insulation resistance test
The insulation resistance of the unit between earth and current carrying parts shorted together shall not be less than 2 M□ when measured with 500V megger.

HV test
Immediately after insulation resistance test, an AC voltage of 1.72 KV rms (1500 + 2 x rated voltage) of sine wave form of 50 Hz shall be applied for one minute between the live parts and frame. There shall not be any kind of break down, flashover or tripping of supply.

Over voltage protection
The Luminaire shall withstand at 300V AC for two minutes.

Surge protection
It shall withstand a surge of 1.5kV „b 3% for 50 microseconds „b 20 % at the input terminals for all types. (Tests shall comply with Clause 5.4 of latest IEC 60571-1).

Reverse polarity

The Luminaire shall withstand polarity reversal. It shall be operated with reverse voltage for 5 minutes at maximum value of voltage range. At the end of this period, the supply shall be made correct polarity and Luminaire shall operate in a normal way.

Temperature rise Test:

Temperature rise Test shall be conducted at 100VAC with full load. The temperature rise shall be recorded by temperature detectors mounted at the specified reference points on the body of semiconductors, capacitors and other components as agreed between purchaser and manufacturer. The maximum-recorded temperature under worst conditions shall be corrected to 550C and compared with maximum permissible temperature (for power devices at junction). Under loading conditions as specified above, the corrected temperature of the power devices shall have a safety margin of minimum 100 C. Temperature at junction shall not exceed 100 0 C when corrected to 550 C. The Luminiar shall also be subjected for short time rating after continuous loading to ensure the temperature rise is within the permissible limit. The maximum temperature rise of the electronics devices on the PCBs shall be in limit for industrial grade components suitable for 850C environment. In case of exceeding limit, use of MIL-grade component shall be considered keeping RDSO informed.

Ra (Colour Rendering Index) measurement test

- The lumen is the unit of luminous flux, which is equal to the flux emitted in a solid angle of
- one Steradian by a uniform point source of one candela.
- The initial reading of the chromaticity co-ordinates x & y shall be within 5 SDCM (Standards
- Deviation for Colour matching) from the standardised rated value as per Annex. D of IEC
- 60081 – 1997.
- The initial reading of the general colour-rendering index (Ra) shall not be less than the rated
- value decreased by 3.
- The lumen maintenance of the lamp shall not be less than 80% of the initial lumen after
- 20000 burning hours and 70% of the initial lumen after 50000 hours . The initial lumen will be
- taken after 100 hours aging
- Photometric test shall be conducted as per Annexure B of IEC 60081-97.
- The lumen maintenance test shall be done as per Annexure C of IEC 60081-97.

Lux measurement

Lux measurement with the help of Lux meter shall be done at a distance. Value obtained shall not be less than the Lux specified in the table considering 10% Lumen is absorbed by the reflector.

Fire retardant Test
Fire Retardant test shall be conducted as per IEC 60332-1 of the wire used in the fittings.

Test for IP20 protection

This test shall be conducted as per IEC 60529.
Environmental tests
The Luminiar shall meet the following tests as prescribed in IEC – 60571.
a) Dry heat test.
b) Damp heat test
c) Test in corrosive atmosphere
d) Combined dust, humidity and heat test

Reliability Test
The reliability can only be determined in actual service. However, the following tests shall be carried out on the prototype to simulate as close as possible, the service conditions. There shall be no failure during this test.
a) The light unit shall be mounted in an oven maintained at 45°C.
b) The light will be operated at the specified maximum voltage and at 45°C for a period of 100 hours.

Life Test
The lumen maintenance & life test shall be done as per Annexure C of LM 80 Report of LEDs.

Endurance Test
The Luminiar shall be kept "ON" with input voltage of 250VAC for 200 hours. After this the Luminiar is subjected to 20,000 cycles of "ON" and "OFF", each cycle consisting of 3 seconds "ON" and 10 seconds "OFF" period. Luminiar should survive this test. Test is to be continued for 20,000 cycles, followed by performance test.

Safety:

The Luminaire shall comply with the safety requirements as per IEC 61195.

MARKING:

The following information shall be distinctly and indelibly marked on the housing:
a) Year of manufacture/Batch Number/ Serial Number
b) Name of Manufacturer
c) Rated watt and voltage
d) Input frequency

APPROVAL

The manufacturer shall also submit details like make, type, reliability grade, rating and loading of various electronic components used in the circuit. The temperature rise of the various components under the most adverse conditions shall also be declared.

- Technical specification for LED STREET LIGHT & FLOOD LIGHT of – 80 Watts

- Input voltage: 90 V to 270 V
- LED lamp efficacy: Min 95 to 130 lumens/watt
- Power factor: >0.90
- Life expecting: 50,000 hours
- No of hours usage / day: 10 to 12 hours/day
- Rated watt: 80 W (cool white)
- Luminous flux: 7500 to 10500 lumens
- LED type: High power LED (1 Watt)
- Working Humidity: 10% to 90%
- Colour Temperature: 4,500 to 7,000 K with test certificate
- Ingress protection: IP 65/IP 66 as per IS/IEC60529-2001 with test certificate.
- Total harmonic distortion (THD): <15% with test certificate
- Colour rendering index: Ra > 80
- Working Temperature: 20 deg to 50 deg C
- Average lighting/ beam angle: 120 to 160 deg
- Control Circuit: Compatible to LED
- Lamp starting time: Not more than 5 sec
- Energy consumption: Not more than 1.2 times at rated voltage
- System power efficiency: > 85 %
- Luminary Casing: Pressure die cast Aluminum with toughened glass cover and water proof fixture.

LED thermal management: LED shall be mounted on heat sink conductive aluminum with fins to dissipate the heat to ambient air

Driver board: Details shall be given for getting spare

Pole entry/ Retro fitting: Suitable for fixing in existing lighting pole (30 mm to 55 mm dia with bracket and locking bolt & nut.

Applicable Standard: IESNA LM 79 for fixture and with stand to wind velocity 150 mph with test certificate

Electrical connector: Connecting wires with minimum one-meter length

Warranty: 2 Years

2.1.112. CEILING FANS

All ceiling fans shall be provided with suspension arrangement in the concrete/slab/roof members. Contractor to ensure that provision are kept at appropriate stage at locations shown on the drawing. Fan box with MS hook shall be as per CPWD specification. Ceiling fan shall be double ball bearing type, copper wound motor complete with canopy, down rod, blades etc. and shall conform to relevant IS standards ceiling fan shall be white in color. Ceiling fan shall be provided with standard regulator. Regulator shall be suitable for 240 volts A.C supply 50 Hz and shall be of continuous duty type

2.1.113. EXHAUST FANS

Exhaust fans shall be heavy duty type with double ball bearing and conforming to IS 2312-1967. Exhaust fan shall be complete with copper wound motor, capacitor, Louver/shutter, frame and mounting bracket. Exhaust fan shall be suitable fan operation on 240 volts single phase A.C supply.

2.1.114. EARTHING/GROUNDING

Earthing

All the non-current carrying metal parts of electrical installation shall be earthed properly. All metal conduits trunking, cable amour, switchgear, distribution fuse boards, lighting fittings and all other parts made of metal shall be bonded together and connected by means of specified earthing conductors to an efficient earthing system. All earthing will be in conformity with the relevant Indian Electricity Rules 1956 and Indian Standard Specifications IS:3043-1966.

EARTHING CONDUCTOR

Earth continuity conductor alongwith submain wiring from Main/Sub Distribution boards to various distribution boards shall be of copper. Earth continuity conductor from distribution board onward upto outlet point shall also be of bare copper. Earth continuity conductor connecting Main & Sub Distribution boards to earth electrode shall be with galvanised MS strip.

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Connection of Earthing conductors

Main earthing conductor shall be taken from the earth connections at the main distribution panel to the earth electrode with which the connection is to be made. Distribution boards, earthing conductor shall run from Main Distribution Boards. Circuit earthing conductor shall run from the exposed metal of equipment and shall be connected to any point on the main earthing conductor, or its distribution boards. Cable sheathing and armouring shall be earthed at the ends adjacent to switch boards at which they originate, or otherwise at the commandment of the run by an earthing conductor in effective electrical contact with cable sheathing. Where equipment is connected by flexible cord, all exposed metal parts of equipment shall be earthed by means of and earthing conductor enclosed with the current carrying conductor within the flexible cord. Switches, accessories, lighting fittings etc. which are rigidly secured in effective electrical contact with a run of metallic conduit hall not be considered as a part of earthing

conductor for earthing purposes, even though the run of metallic conduit is earthed.

2.1.115. LIGHTING DISTRIBUTION BOARDS

The Distribution Panel and Distribution boards shall be suitable for operation on 3 phase/single phase 415/230 Volts, 50 cycles, neutral grounded at transformer and short circuit level not less than 31 MVA at 415 Volts. The Distribution Panel/Boards shall comply with the latest addition of relevant Indian Standards and Indian Electricity Rules and Regulations.

CONSTRUCTION FEATURES

The Distribution Panels/Boards shall be metal enclosed sheet steel cubical, indoor, dead front, floor mounting/wall mounting type. The Distribution board shall be totally enclosed completely dust and vermin proof. Gaskets between all adjacent units and beneath all covers shall be used to render the joints dust proof. Distribution Boards shall be preferably arranged in multitier. All MS sheet steel used in the construction of Distribution Boards shall be 2 mm thick and shall be folded and braced as necessary to provide a rigid support for all components. Joints of any kind in sheet metal shall be seam welded, all welding slag grounded off and welding pits wiped smooth with plumber metal. All the panels and covers shall be properly fitted and square with the frame, and holes in the panel correctly positioned. Fixing screws shall enter into holes tapped into an adequate thickness of metal or provided with bank nuts. Self-threading screws shall not be used in the construction of Distribution boards. A base channel of 75 mm x 75 mm x 9mm thick shall be provided at the bottom. Knockout holes of appropriate size and number shall be provided in the distribution board in conformity with the location of incoming and outgoing. Removable sheet steel plates shall be provided at top and bottom to drill holes for cables entry at site if required.

BUS BAR CONNECTIONS

The bus bars and interconnections shall be electrolytic copper and of rectangular cross sections suitable for full load current for phase bus bars and half rated current for neutral bus bar and shall be extensible on either side. The bus bars and interconnection shall be insulated with insulation tapes and color coded. The bus bars shall be supported on unbreakable non-hygroscopic insulated supports at regular intervals to withstand the forces arising from short circuit in the system. All bus bars shall be provided in a separate chamber and properly ventilated. All bus bar connections shall be done by clamping. No holes shall be drilled in the bus bars for mounting clamps. All connections between bus bars and switches and between switches and cable alley terminal shall be through solid copper strips of proper size to carry full rated current and insulated with insulating tapes.

FIXING OF MCB'S

All TPN Distribution Boards shall be provided with SP MCB's as outgoing. Separate neutral bus bars shall be provided for TPN distribution boards for each phase. MCB's shall be provided on the phase of each circuit. The individual banks of MCB's shall be detachable. There shall be ample space behind the banks of MCB's to accommodate all the wiring. All the internal wiring of distribution boards shall be concealed behind 5 mm thick Bakelite sheet. All the distribution

boards shall be completely factory wired, ready for connections. All the terminals shall have adequate current rating and size to suit individual feeder requirements. Each circuit shall be clearly numbered from left to right to correspond with wiring diagram. All the switches and circuits shall be distinctly marked with a small description of the service installed.

CABLE COMPARTMENTS

Cable Compartments of adequate size shall be provided in the distribution panel/boards for easy termination of all incoming and outgoing cables entering from bottom. Adequate supports shall be provided in cable compartments to support cables. All incoming and outgoing switches, terminals shall be brought out to terminal blocks in cable compartments.

INSTRUMENT ACCOMMODATION

Separate and adequate compartments shall be provided for accommodating instruments, indicating lamps, control contractors and control fuses etc. These shall be accessible for testing and maintenance without any danger of accidental contact with live parts of circuit breaker, bus bars and contact.

TERMINALS

The outgoing terminals of the breaker and neutral link shall be borough out to a terminal block suitably located at the rear side of the panel. Separate cable compartments shall be provided for incoming and outgoing cables.

WIRE WAYS

A horizontal wire way with screwed covers shall be provided at the top to take interconnecting control wiring between different vertical section.

SWITCH FUSE UNITS

The switch fuse units shall be 3 pole double break type (AC-23A) suitable for load duty quick make and break action. Separate neutral link shall be provided in the switch. All switch fuse units shall be provided with hinged doors duly interlocked with operating mechanism, so as to prevent opening of the door when the switch is in `On' position and also to prevent closing of the switch when the door is not properly secured. All contacts shall be silver plated and all live parts shall be shrouded. High rupturing capacity (HRC) fuse links shall be provided with switch fuse units and shall be in accordance with IS: 2208 - 1962 and having rupturing capacity of not less than 31 MVA at 415 volts. HRC fuse links shall be provided with visible indicators to show that they have operated.

FUSES

Fuses shall be high rupturing capacity (HRC) fuse links and shall be in accordance with IS:2208-1962 and having rupturing capacity of not less than 31 MVA at 415 Volts.

PAINTING

All sheet steel shall undergo a process of degreasing, picking in acid, cold rinsing, Phosphating, pasivating and then sprayed with a high corrosive resistant primer. The primer shall be baked in an oven. The finishing treatment shall be with powder coating..

LABELS

Engraved PVC labels shall be provided on all incoming and outgoing feeder switches. Circuit diagram showing the arrangement of the circuit inside the distribution board shall be pasted on inside of the panel door and covered with transparent laminated plastic sheet. All the distribution boards shall be subject to tests specified in relevant Indian Standards and test certificates shall be furnished.

METERS

All the meters shall be housed in a separate compartment and accessible from front only. Lockable doors shall be provided for the metering compartments. The distribution boards shall be provided with indicating panel comprising of 1 No.(0-500V) 90 cm x 90 mm square type voltmeter with 3 way "OFF" selector switch and CT operated ammeter with 3 way and neutral selector switch of appropriate range and scale. Wiring for motors shall be colour coded and labeled with approved plastic beads for identification.

Point Wiring (Internal & External Telephones)

The point wiring shall be carried out with Double pair telephone wire/cable, unarmoured, PVC insulated and sheath. 0.61 mm dia annealed tinned copper conductor (IS: 2532-1965)in suitable size conduit (one pair always remaining spare for one point)

Minimum Dia of Conduit for Internal/External Telephone Wiring - 20mm.

If more than one telephone point has to be provided at one point, multicore, unarmoured telephone cable shall be used (pairs required are equal to 2 No. of points) in suitable size of conduit.

The point shall commence from the main telephone tag box/sub tag box and would terminate at outlet box of point. Connection at both ends included in point wiring.

Fixing of conduit, conduit accessories draw out boxes and outlet box etc. in concealed/surface conduit works) shall be applicable for telephone wiring conduit system also.

EARTHING

(AS PER IS 3043-1987)

Earthing shall generally be carried out in accordance with the requirements of Indian Electricity Rules 2003 amended from time to time and relevant regulations under Electricity Supply Authority concerned.

In case of high and extra high voltages, the neutral points shall be earthed by not less than two separate distinct connections with earth, each having its own electrodes sub-station and will be earthed at any other point provided no interference is caused by such earthing. If necessary, the neutral may be earthed through suitable impedance. As far as possible, all earth connections should be visible for inspection. Each earthing system shall be so designed, that, the testing of individual earth electrodes is possible. It is recommended that the value of any earth system resistance shall be such as to conform to the degree of shock protection desired.

It is recommended, that a drawing showing the main earth connections and earth electrodes be

prepared for each installation and submitted to Employer. No addition to the current carrying system, either temporary or permanent, shall be made which will increase the maximum available fault current on its duration until it has been ascertained that the existing arrangement of earth electrodes, earth bus-bar etc., are capable of carrying the new value of earth fault current which may be obtained by this addition.

All materials, fittings etc., used in earthing shall conform to Indian Standard Specifications, wherever they exist.

2.1.116. GENERAL REQUIREMENTS AND PROCEDURES FOR EARTHING

The ground resistance for sub-stations should not exceed a value 2(two) ohms. The joints/connections in the earthling, system shall be welded only, except the connections, which require opening for testing/maintenance. Such connections should be bolted tightly, using spring and ring washers for proper contact pressure.

The G.S. flats to be provided for the horizontally laid earth grid should have overlap welded joints, with length of welding at least twice the width of the flat, e.g., 100 MM for 50x6 MM G.S. flats. There should not be any dirt, grease, oil, enamel, paint or any such non-conductive coatings on the surfaces being joined/ connected. Only the finished joints/connections above ground may be provided with red-oxide or any other protective coating. Underground earth electrodes and earth grid elements, when laid, should have a clean metallic surface, free from paint, enamel, grease or any such non-conductive coatings.

As far as possible, all earth connections should be accessible for visual inspection. No cut-outs, links or switches, other than linked switches arranged to operate simultaneously on the earthed or earthed neutral conductor and the live wire shall be inserted in the supply system. Earth electrodes or mate should not be installed in close proximity to metal fence to avoid possibility of fence becoming live. Separate earth electrodes, isolated from the earth grid, are to be provided for grounding the fence wires. Pipes or rods used as electrodes should be in one piece, as far as possible, with a minimum allowable length of 3 mtrs. Except where rock or hard stratum is encountered, the pipe/rod electrodes should be driven into the ground to a minimum depth of 3 mtrs. The strip electrodes, forming the horizontal gild, should be buried underground to a minimum depth of 0.5 mtrs. The path of earth wire should be out of normal reach of any person, as far as possible.

For high resistivity soils, above 100 Ohm-mtrs., attempts should be made to bring the soil resistivity in the range of 50 to 60 Ohm-mtrs. By digging and treating the soil mass around the earth grid/electrodes

with a mixture of salt and charcoal. In case of rocky top soil and sub-stratum, having very high resistivity, with no scope of improvement by other means, the procedure given below should be followed:

- At least two bores of diameter little less than 40 mm, with a minimum distance of 10

mtrs. between them, should be made in the ground at suitable locations inside the S/S yard. The boring should be done until soil sub-stratum rich in moisture and low in resistivity is encountered. G.I. pipes of 40 MM dia. should be descended in each bore, such that, the soil mass around the pipes grips them tightly, Back – filling of bores, if required, with wet soil/clay may be done to ensure this condition. The G.I. pipes in these deep bores should be interconnected with the main earthing grid of the S/S through 50x6 mm G.S. flat, with all the joints/connections and terminations being either fully welded, or clamped/bolted and welded simultaneously. The G.I. pipes in the bores should also be interconnected with each other. In extreme cases, the bores may have to be made at remote locations i.e. outside the S/S yard, with inter-connections, through 50x6 MM flats, as explained before.

- The procedures to be observed stringently for making connections and joints between various elements of the earthing system are as follows:

  G.S. flat to Structure/flat - The G.S. flat should be welded to the metallic portion (leg) of the structure after thoroughly cleaning the surfaces to be welded. The length of the welding should be at least twice the width of the G.S. flat, e.g.-minimum 100 mm for 50x6 mm G.S. flat. Exactly similar procedure is to be adopted for joints between two G.S. flats.

  G.I. wire to structure. The G.I. wire should be bolted to the structure after making an eye formation and kept tight with the help of spring and ring washer. Then, the entire arrangement should be welded.

  G.I. wire to G.S. flat- The G.I. wire should be bolted and then welded to G.S. flat, as explained above.

  G.I. rod to G.S. flat- The G.I. rod should be securely clamped to the G.S. flat with the help of bolts and washers and the entire arrangement should then be welded.

  G.I. wire to G.I. pipe – GI wire should be bolted to the G.I. pipe and then welded, keeping in view the relevant precautions, mentioned before.

  G.I. flat to G.I pipe – The GI flat should be bolted tightly to the G.I. pipe and then the connection should be welded.

Before making connections and joints, it should be ensured that, the elements to be joined have a clean metallic contact surface without any non-conductive coating.

2.1.117. EARTH GRID SYSTEM

Grid system of interconnected conductors forming a closed loop mesh is to be installed using 75x8 mm MS flat for peripheral and branch conductors. Interconnections are made by welding them. This earth grid will be laid at a depth of about 0.5 mtr. bonded to general mass of the earth by 3 mtrs. long earth electrode of solid MS rod (or pipe) of dia 25mm. The G.I. pipe 40 mm. dia 3 mtrs. long in the earthing pits, driven vertically.

It is to this earth grid that the transformer neutral, apparatus, frame work and other non-current carrying metal work associated like transformer tank, switchgear frame etc. are to be connected. All these connections should be made in such a way that reliable and good electrical connection is ensured. Aluminum/ other paint, enamel, grease and scale should be removed from the point of contact before connections are made. No part of the ground connection leads should be embedded in concrete.

Arrangement of connection of earth connection shall be as follow:

2.1.118. GI EARTHING PIPE

Earthing pipe should be made of 40 mm diameter ISI marked B class GI Pipe. 12 mm dia suitable holes on its circumference shall be made as per approved drawing. The pipe should be in one piece. No joints or welding would be allowed on its length. Clamps made of 50x6mm GI flat duly drilled with 12 mm size holes should be welded at the top end for connection of earth conductor.

Pipe used shall be 40mm NB diameter, ISI marked Galvanized Mild Steel Tubes continuously welded Electric Resistance Welded ERW/High Frequency Induction welded (HFIW)/Hot finished welded (HFW) type, conforming to IS-554-1985 with latest amendment of MEDIUM quality (Class B).

2.1.119. MANUFACTURE:

GI earth pipe (40 mm diameter & 3 metre long) shall be made of tubes which shall be made from tested quality steel manufactured by any approved process as follows:

a) Electric Resistance Welded (ERW).
b) High Frequency Induction Welded (HFIW) and
c) Hot finished Welded (HFW).

Tubes made by manual welding are not acceptable.

2.1.120. DIMENSIONS:

The dimensions and weights of tubes shall be in accordance with Table-I and Table-II of IS: 1239 (Part- I)/1990 with latest amendments, subject to tolerance permitted therein. Necessary 12 mm diameter holes across the circumference shall be provided as per approved drawing. Drawings shall be approved by the owner before start of the manufacturing work. The tube, earthing pipe shall be provided with 50x6mm GS clamps on one end, one clamp is to be welded with the pipe and another is removable to enable measurement of earth resistance of the pit. Other end of the earth pipe should be cut half in slop to make it a sharp.

2.1.121. GALVANIZING:

Tubes shall be galvanized in accordance with IS-4736-1986 with latest amendment for not dip zinc coating of Mild Steel Tubes. The minimum mass of zinc coating on the tubes shall be in accordance with clause 5.1 of IS-4736-1986 (specification for hot dip zinc) and when determined on a 100mm long test piece in accordance with IS: 6745:1972 shall be 400 g/m2. The zinc coating shall be uniform adherent reasonably smooth and free from such imperfections as flux, ash and dross inclusions, bare patches, black spots, pimples, lumpiness, rust, stains, bulky white deposits and blisters.

2.1.122. HYDRAULIC TEST:

(Before applying holes) Each tube shall withstand a test pressure of 5 M Pa maintained for at least 3 seconds without showing defects of any kind. The pressure shall be applied by approved means and maintained sufficiently long for proof and inspection. The testing apparatus shall be fitted with an accurate pressure indicator

2.1.123. TEST ON FINISHED TUBES AND SOCKETS:

The following tests shall be conducted by the manufacturer of finished tubes and sockets.

a) The tensile strength of length of strip cut from selected tubes when tested in accordance with IS-1894-1972, (Method for tensile testing of steel tubes), shall be at least 320N/mm2.

b) The elongation percentage on a gauge length of 5.65/so (where so is the original cross-sectional area of test specimen) shall not be less than 20%.

c) When tested in accordance with IS-2329-1985 (Method for Bend test on Metallic tubes) the finished tube shall be capable of withstanding the bend test without showing any sign of fracture or failure. Welded tubes shall be bent with the weld at 90 degree to the plane of bending. The tubes shall not be filled for this test.

d) Galvanized tubes shall be capable of being bent cold without cracking of the steel, through 90 degree round a former having a radius at the bottom of the groove equal to 8 times the outside diameter of tube.

e) Flattening Test on Tubes above 50 mm Nominal Bore: Rings not less than 40 mm in length cut from the ends of selected tubes shall be flattered between parallel plates with the weld, if any, at 90 degree (point of maximum bending) in accordance with IS-2328-1983. No opening should occur by fracture in the weld unless the distance between the plate is less than 75 percent of the original outside diameter of the pipe and no cracks or breaks in the metal elsewhere than in the weld shall occur, unless the distance between the plates is less than 60% of the original outside diameter. The test rings may have the inner and outer edges rounded.

f) **GALVANISING TEST:**

Weight of zinc Coating: For tubes thickness upto 6 mm the minimum weight of zinc coating, when determined on a 100 mm long test piece in accordance with IS-4736-1986 shall be 400 grm/m2.

The weight of the coating expressed in gram/m2 shall be calculated by dividing the total weight of the zinc (inside plus outside) by the total area (inside plus outside) of the coated surface.

Test specimen for this test shall be cut approximately 100 mm in length from opposite ends of the length of tubes selected for testing. Before cutting the test specimen, 50 mm from both ends of the samples shall be discarded.

g) Free Bore Test: A rod 230mm long and of appropriate diameter shall be passed through relevant nominal bore of the sample tubes to ensure a free bore.

h) Uniformity of Galvanized Coating: The galvanized coating when determined on a 100 mm long test piece [see V (a) (iii)] in accordance with IS-2633-1986 (Method for testing uniformity of coating on zinc coated articles) shall with stand 4 one minute dips.

- **WORKMANSHIP:**

The tubes shall be cleanly finished and reasonably free from injurious defects. They shall be reasonably straight, free from cracks, surface flaws, laminations, and other defects, both internally and externally. The screw tubes and sockets shall be clean and well-cut. The ends shall be cut cleanly and square with the axis of tube.

- **MARKING:**

The medium class of tubes shall be distinguished by Blue colour bands which shall be applied before the tubes leaves the manufacturers‟ works. Tubes shall be marked with the standard

mark.

BATTERY CHARGER & DC DISTRIBUTION BOARDS.

2.1.124. SCOPE OF SUPPLY:

One set of 220 V Maintenance free sealed DC Batteries of 500-Ampere Hours capacity and one set of 24V maintenance free sealed DC Batteries of 500AH, one set of battery charger for 220V and 24 V system and one set of DCDBs for each system shall be provided The battery shall be able to support the complete station load for a period of 10 hrs, without AC supply.

2.1.125. BATTERY, BATTERY CHARGER AND DCDB

GENERAL :

This section covers the salient aspects and technical particulars of design, manufacture, testing, erection and commissioning of 220V, 500AH and 24V, 500 AH capacity, high discharging performance, maintenance free sealed stationary batteries, along with battery charging equipment consisting of silicon controlled rectifier type float chargers, Silicon diode type boost charger and D.C. distribution boards along with accessories.

SCOPE OF SUPPLY :

The scope of supply against this specification covers manufacture, assembly, testing at works, packing, supply by Road, delivery at Project site, erection, testing and commissioning of 220V D.C & 24 D.C. system .

1. **a.** 220V Bank, 500AH capacity high discharging performance, maintenance free sealed batteries along with accessories, fittings etc.1 No.

   b Battery charging equipment for the above consisting of 1 No

   i) Silicon controlled rectifier type float charger. 1nos.

   ii) Silicon diode rectifier type boost charger 1nos.

   c)D.C Distribution Board (220V) 1nos.

2 (a) 24V Bank, 500AH capacity high discharging performance maintenance free sealed lead acid batteries along with necessary accessories, fittings etc. 2nos.

   (b) Battery charging equipment for the above (item 2) consisting of : 1 No

   i) Silicon controlled rectifier type float charger : 1 nos.

   ii) Silicon diode rectifier type boost charger. : 1 nos.

c) DC Distribution Board (24V): 1 No.

The batteries with associated equipment and accessories are required to provide continuous and reliable supply to respective boards of 220V and 24V DC Boards for various applications, viz control, protection, indication, annunciation, regulation panels of pump house and also for pump house emergency lighting.

SPECIFICATIONS AND STANDARDS FOR BATTERIES:

a) Stationary cells and batteries, lead acid type with tubular positive plates : I.S.1651

b) Stationary cells and batteries, lead acid type with plant positive plates : I.S.1652

c) Sealing compound for lead-acid batteries I.S.3116

d) Valve Regulated Batteries BS: 6290 Part IV

SPECIFICATIONS AND STANDARDS FOR BATTERY CHARGERS.

a) Degrees of protection provided by enclosure for low-voltage switchgear and control gear : I.S.2147

b) Air Break switches, air break disconnectors and fuse combination units for voltages not exceeding 1000 Volts AC or 1200 V DC : I.S 4064

c) Contactors for voltages not exceeding 1,000V AC or 1,200V DC : I.S.2959

SALIENT FEATURES OF 220V, 500AH BATTERY :

1. Type of battery :Maintenance free sealed lead acid high discharging performance indoor type station battery.

2.Design ambient temp : 50 deg. C.

3.Rating :

i)Ampere hour capacity :220V, 500AH at 10Hr.

ii)End cell voltage after 10 hour discharge (Electrolyte temperature 27 deg.C.) Voltage of 1.75 V

iii) Rated voltage of Battery.

a)Nominal Voltage : 220V
b)Maximum : 243 V
c)Minimum Voltage: 189V

4. Number of cells :110 (May vary depending upon the voltage of each cell at fully charged condition to maintain the nominal voltage)

5. Discharge current: and cell end voltage Amperes cell end of battery voltage.

a)1 minute load:460A1.85V

b)2 Hr.emergency load : 135A1.85V

c)10Hr.continuous load: 40A1.85V without trickle or boost charging.

6.Nominal Cell voltage :2 Volts.

7.Ampere Hour efficiency : 90% Minimum

8.Watt Hour efficiency : 82% Minimum

9.Float charge current : 40A

10. Boost charge current: 100A (will not be less than the rate of Boost charge required for batteries plus station load of 40A)

11.Time required for:8-10 Hrs. Boost charging from discharge condition.

SALIENT FEATURES OF 24V, 500AH BATTERY

1. Type of battery: Maintenance free sealed lead acid high discharging performance indoor type station battery.

2. Design ambient temp: 50 deg.C.

Rating:

i) Ampere hour capacity24V, 500AH at 10H
ii) End cell Voltage at 10 hour discharge rated (Electrolyte Voltage of 1.86V Temperature 87 deg.C) .

iii)Rated voltage of:
Battery.

a) Normal Voltage: 24 V
b) Maximum Voltage: 27 V
c) Minimum Voltage: 21 V

4.Number of cells: 12 (May vary depending upon the voltage of each cell at fully charged condition to maintain the nominal voltage).

5.Discharge current: Cell end of battery Voltage and cell end voltage Amperes

a) 1 minute load:	345A	1.85V
b) 2 Hr. emergency load :	100A	1.85V
c) 10 Hr. continuous load: without trickle or boost charging.	30A	1.85V

6.Nominal Cell voltage :2 Volts.

7.Ampere Hour efficiency:90% Minimum

8.Watt Hour efficiency :82% Minimum

9.Float charge current : 30A

10.Boost charge current :80-100A.(will not be less than the rate of boost charging required for batteries) plus station load of 30A)

11.Time required for :8-10 Hours.
Boost charging from
discharge condition.

CONSTRUCTIONAL FEATURES (COMMON FOR 220V AND 24V BATTERIES):

1.Container and cover: Flame retardant special material grade policy propylene

(v)

2.Thickness: 2-3 mm.

3.Separator Type: Highly absorbent glass mat separator.

Material: Spun glass microporous matrix.

Thickness :3 mm (approx.)

4.Electrolyte: Prepared from the battery grade sulphuric acid confirming to IS 266:1961

5. Specific gravity of: electrolyte at 27 deg. (with cells fully dis-charged) 1.1

6. Specific gravity of fully : 1.2 +/- 0.005 corrected to 27 deg.C.

7. Type of positive plates : Flat pasted plate type with MFX alloy

8. Type of negative plates : Flat pasted plate type with lead calcium alloy.

9. Rack material: Mild steel.

10. Self discharge rate of: Less than 0.5% Battery. capacity per week.

11. Life of the battery: 20 Years.

12. Terminals : Integral lead terminal with solid copper core.

13. Connectors: Heavy duty, lead plated copper connectors.

CONSTRUCTIONAL DETAILS OF BATTERY(COMMON FOR BOTH 220V AND 24V SYSTEM:

Plates: Positive plates shall be made of flat pasted type using lead cadmium patented MFX alloy.
Negative plates shall be heavy, durable flat plate using lead calcium alloy pasted box grid. Negative palates shall be designed to match the life of positive plates and combination of positive and negative plates will ensure long life, durability and trouble free operation of battery.
Separators: Separator shall be made of spun glass, micro porous matrix and shall be resistant to sulphuric acid. It shall be capable of keeping all the electrolyte absorbed in the separator with no free electrolyte. It shall be electrically insulated. Internal resistance will ensure discharge characteristics under all operating conditions. Sufficient separator overlap to edges of the plate is to be provided to prevent short circuit formation between the edges of adjacent plates.

. **Containers and lids:** The containers and lids shall be made or a flame retardant special grade copolymer polypropylene. They shall be sufficiently robust and not liable to deformation under internal operating pressures and with in the temperature range naturally encountered, leak proof, non absorbent and resistant to the acid.
Containers will have adequate space at the bottom for collecting sediments for the entire life of the batteries.
Provision for by passing any defective cell during service for replacements etc may be made.
For identification each container shall be marked in a permanent manner to indicate the following information:

a) Cell number
b) Type of plate
c)AH capacity at 10 hour rate
d) Type of container
e)Manufacturer's name
f) Month and year of manufacture.

Sealing & Venting: Vent plug shall be made of suitable plastic material, pressure regulating, explosion proof and self resealing. Venting will only occur through porous disc. The vents will release excess pressure and reseal when the pressure is low.

Electrolyte: The electrolyte shall be prepared from the battery grade H2SO4 confirming to ISS:266. The batteries shall be supplied in factory filled and charged condition.

Water: Water required for preparation of electrolyte will confirm to IS :1069

Connectors: Connectors may be supplied either as separate bars or alternately as part of the cell structure i.e. as suitably elongated group bars or terminal lugs. The connectors shall be lead coated copper of suitable size to join the cells. The connectors which shall be of suitably designed copper connectors and suitably coated to withstand corrosion due to sulphuric acid may be used where the cells are called upon to discharge at very high rates. The coating should be adequate and tenacious.

Plate connections: Lugs of plates of like polarity shall be connected by lead burning to a horizontal strap having an upstanding terminal post adopted for connection to external circuit. Strap and post shall be cast with lead antimony alloy. The positive and negative terminal posts shall be clearly marked for unmistakable identification.

Nuts and Bolts: Nuts & Bolts for connecting the cells shall be effectively lead coated to prevent corrosion.

Terminals: Terminals shall be of Integral Lead terminal with Solid Copper Core.
Supporting racks: Batteries shall be installed on MS racks to be supplied by the contractor to fit in the battery/battery charger room. Layout of batteries in the battery room shall be approved by the Board.Racks shall be so designed that cells are located within easy reach at convenient height.
Minimum number of bolts and nuts should be used primarily for anchoring and joining. Joining will ensure proper and tight fit. Racks shall be painted with 2 coats off anti corrosive paint and supplied in unassembled state. Racks will also be provided with

spray or dip coating for protection against fungus growth and other harmful effect due to tropical environment.

Charging:

Lower optimum voltage shall be maintained by chargers to maintain batteries in fully charged condition, for minimum evaporation and maximum battery life for both 220V and 24V DC systems. The tenderer will also specify life as well as boost charging cycling of the batteries is not envisaged.

Suitable means shall be provided for indicating and annunciating the fully discharged condition of the Battery of both 220V and 24V DC systems in control room.

Voltage:

The cell voltage will not exceed 2.25V with a continuous low rate of floating charge and will not be less than 1.85V at the end of emergency discharge.

Operation:

The DC battery shall be operated without an intentional ground. For indicating the incidence and degree of a ground fault on the DC control circuitry, the midpoint of the battery shall be earthed through a high resistance with an ammeter. The high resistance shall be so proportional that the current flowing under the worst earth fault will not exceed 100mA for 220V DC system and 25 mA for 24V DC system.

Ventilation:

The requirement of ventilation of the Battery room shall be finalized at the time of finalization of layout plant

Both 220V and 24VDC battery banks are proposed to be installed in the same Battery room. The layout of the battery (both for 220V and 24V) keeping in view the working space required. shall be finalized at the time of finalization of layout of plant.

CONTRUCTIONAL FEATURES OF BATTERY CHARGING EQUIPMENT:

a) BOOST CHARGER:

The boost charger shall be suitable for 3 phase, 50HZ, A.C. input supply. The charger shall be manual control type consisting of full wave silicon diode rectifier with suitable transient voltage suppression.

Suitable ripple filtering circuits shall be provided for the boost charger to limit ripple content in DC output.

The boost charger shall have dry type double wound transformer of suitable rating with adequate no. of taps on both primary and secondary sides for the change of output voltage/current control. OFF load tap changer will also be provided for boost charger transformer on primary side.

The boost charger shall have the control gear consisting of 2/4 position rotary switch for coarse and fine control of output voltage.

The boost charger shall have necessary protection to prevent the failure of diodes due to heavy currents from the boost charger when the battery is fully in discharged condition.

The boost charger shall be designed to charge a fully discharged battery without over loading or causing over voltage or without causing interruption of operation of AC or DC system. After the batteries recharged, the charger will maintain the battery at full charge.

The charger shall be provided with all necessary equipment and devices to protect the charger from short circuits, transient voltage surges, load and supply fluctuations including sudden loss of input or load.

b)FLOAT CHARGER :

The float charger shall be suitable for 3 phase, 415V, 50HZ AC input supply. The float charger shall be invariably Automatic type employing silicon controlled rectifiers with full half controlled bridge for voltage and current limit control.

The float charger will have built-in automatic voltage control and load limiting feature. The voltage regulator will automatically sense, monitor and regulate the DC voltage to within + or - 10% of the set value, from no load to full load and under supply voltage and frequency fluctuating conditions.

The float charger shall be designed to give higher output currents thus allowing a margin for future increase in load current or battery capacity.

Suitable control gear (Auto/Manual) shall be provided for smooth control of the voltage.

Suitable ripple filtering circuits shall be provided for the charger to give smoothing for DC output.

The boost charger will have dry type double wound transformer of suitable rating with adequate no. of taps on both primary and secondary side for the change of output voltage current control.

The charger shall be current limited at 125% of full load to reduce output voltage for charger circuit protection and protection of battery from over charge. The current limit shall be continuously adjustable from 80% -125%.

The float charger shall be provided with soft start feature which will make the DC output voltage to raise gradually to its rated value over a duration of 6-10 seconds whenever the charger is powered or at the time of restoration of supply.

COMMON FEATURES OF BATTERY CHARGING EQUIPMENT:

The battery charging equipment will capable of operating satisfactorily and delivering the rated DC output (220V/24VDC) with input A.C. supply voltage variation of + -5% of rated value.

The input supply for the battery chargers is 3 phase,415V, 50HZ A.C. supply for both 220V and 24VDC systems.

The ripple content of the battery charger will not exceed 3%

The battery charger equipment shall be supplied complete with all devices, bus bars, output terminals, earthing, links, cable glands for all external cables, rating plates etc.

The tenderer will also supply necessary equipment like relays for adequate protection of the charger against faults.

Bidder shall furnish schematic diagram showing the general protection features provided for the charger along with the general layout diagram.

While boost charging the battery normal load shall be fed by float charger. In the event of failure of float charger the load shall be fed from 90% tap of the battery through suitable means.

In the event of incoming AC supply failure, when the battery is being boost charged the available battery capacity shall be automatically transferred to the DC bus.

The float and boost chargers shall be housed in individual panels, separately in complete shape with all necessary accessories mounted. The panels shall be indoor, floor mounting, free standing type. They shall be totally enclosed, complete dust tight and vermin proof. The thickness of the steel sheet of the panel shall be 3.0mm. The internal power and control wiring of the charger shall be carried out with PVC insulated 1100V grade stranded copper conductor wires. The control wiring shall be carried out with 2.5 sq.mm. copper conductor cable. Power and control wiring shall be wired in separate bunches/troughs.

The terminal blocks shall be stud type terminals of ELMEX make type cat M4 suitable for connecting external cables to be provided by the purchaser. The size of all such cables shall be finalized with the successful tenderer. All external cables to be connected to the charger shall be arranged for bottom entry.

Space heaters suitable for operation on single phase 240VAC system in both the charger panels along with the ON/OFF switch shall be provided

Illumination in the charger panels shall be provided with a tube light operated on single phase 240VAC system. Suitable earthing lugs shall be provided for each of the charger panels.
Padlocks shall be provided for the panels to prevent unauthorised access or operation of any equipment.

MCCBS :

MCCBS used shall be non draw out type. They shall be quick make/ brake type and shall be provided with thermal overload magnetic short circuit releases. The operating mechanism must be trip free.

FUSES :

All fuses shall be HRC non-deteriorating type. Unless otherwise specified, the fuses shall be of class 4 (80KA breaking current) for AC circuits and class 2 (33KA DC current) for DC circuits

INSTRUMENTS :

The instruments shall be moving coil type ISS and will withstand over loads as experienced in system without injury or change in calibration. They shall be flush mounting type and dust proof.

BUS BARS :

The bus bars shall be of tinned copper having adequate current rating and shall be continuous throughout each section.

CONTACTORS :

The DC contactors shall be suitable for uninterrupted duty, making & breaking the current of the associated circuits. Each contactor will have not less than 2 No and 2 No auxiliary contacts in addition to those required for contactor operation.

ACCESSORIES :

All accessories of batteries, battery charger and DC distribution board required for installation, operation and maintenance of the both and charger shall be provided.

PROTECTION SYSTEM :

1. AC overload protection. A thermal overload relay is to be provided at AC input side which on over current trips and opens the input contactor.
2. Over voltage protection: Over voltage Protection for any failure in regulating circuit is to be provided.
3. Protection against earth fault indicating continuous earth leakage shall be provided.
4. Fully discharged condition of the battery shall be indicated on battery charger panel.
5. The equipment should restart automatically on restoration of AC supply. The DC output will raise gradually to its rated value over a duration of 8-10 seconds.

DETAILS OF COMPONENTS OF BATTERY CHARGING EQUIPMENT

The Battery charging system will consist of the following equipment.

METERS :

Float charger panel :

a) AC Input voltmeter with selector switch 500V.
b) DC Ammeter.0-50A
c) DC Voltmeter. 0-300V

Boost charger panel :

a.AC input voltmeter with selector switch0-500V
b.DC Ammeter0-60A
c.DC Voltmeter0-300V

(vi) d. Battery ammeter with centre Zero. with suitable shunt 125 -0-25A 150-0-150A

INDICATIONS :

1. Neon type indication lamps shall be provided for
a. Boost charger AC input ON (R,Y,B phases)
b. Float charger AC input ON (R,Y,B phases)

2. Long life LED indicators shall be provided for the following conditions with audio alarm for fault conditions.
a) A.C. input fuse fail
b) D.C. output fuse fail
c) Contactors ON
d) A.C. input over load
e) Charger fail
f) Charger fuse fail
g) Charger over voltage
h) Output over load
i) Filter condenser fuse fail
j) Rectifier fuse fail
k) System output over voltage
l) System output under voltage

m) 105th cell in circuit/ 12th cell circuit
n) Battery low
o) Battery discharging
p) Battery earth fault
q) D.C leakage indicator (centre zero meter with -100 MA to +100 MA scale)

POTENTIAL FREE CONTACTS:

Potential free contacts (No contacts) shall be provided for following conditions in the respective panels.

a. Float charger fail
b. Boost Charger On
c. Battery low
d. Battery discharging
e. System under voltage.

MCCBS

a) For float charger input
b) For float charger output
c) For Boost charger input
d) For Boost charger output

SWITCHES :

a) Tap changing switch on B.C (Coarse/fine)
b) Battery input ON/OFF switch
c) system output ON/OFF switch
d) Space heater power supply ON/OFF switch
e) Panel illumination power supply ON/OFF switch

PUSH BUTTONS FOR THE FOLLOWING:

A) Float charger ON and OFF
B) Boost charger ON and OFF
C) Lamp test
D) Alarm silence

CONTACTORS FOR :

a) Boost charger
b) Float charger
c) D.C. contactor to connect 220VDC/24VD bus.

PROTECTION :

a) HRC Fuses at AC Input
b) Fast acting fuses for semiconductor devices protection.
c) AC Input over load
d) DC over voltage
e) Float charger over current
f) Thermal O/C relay Boost Charger.
g) Thermal O/C relay Float charger.

TRANSFORMERS :

a) Boost charger Transformer
b) Float Charger Transformer
c) Transformer for gate pulse power supply.
d) Current Transformers to limit over load
e) Filter choke.

PROTECTION CLASS : IP 42

CONSTRUCTIONAL FEATURES OF D.C DISTRIBUTION BOARDS:

The D.C. distribution Boards shall be rated for 600VDC and 30VDC respectively distinct from charger equipment. D.C. distribution boards shall be supplied separately both for 220V and 24V D.C. Systems.

The D.C. distribution board will consist of DC MCCBS for controlling the incoming supplies and for various out going feeders along with indication lamps to indicate `ON' condition of MCCB.

The D.C. distribution Boards will comprise necessary earth leakage indication device, bus bars, all internal connectors, earthing connections wiring etc., as required.

The distribution boards to be supplied shall be made of cold rolled sheet steel and suitably dimensioned. The thickness of the steel will not be less than 3.0mm.

DETAILS OF 220V D.C. DISTRIBUTION BOARDS:

The D.C. distribution Boards offered will comprises of two sections two numbers incoming feeders (one shall be closed at a time) with 400A DC MCCB, of 220V DC shall be provided for connecting to Battery Bank which shall be common for both sections.

a)220VDC Distribution Board: Section-I
Out going feeders :

1)15 Amps DC Double pole MCCBs : 32 Nos.
(16 Nos for each unit, Total for 3 pumps)

2)Under voltage relay: 1 No.
b) 220V DC Distribution Board : Section-II

1) 30 A feeders: 2 Nos.
2) 15 A feeders: 40 Nos.
(common for all pumps and switchyard equipment)
For each feeder “ON” indication lamp or LEDs hall be provided
c)24VDC distribution Board
Incoming feeder from 24 V Battery: 1 No.
bank with 100 A DC MCCB

The 24VDC distribution shall be provided with the following outgoing feeders on the suitable MCCBs

16Amps DC double pole MCCBs: 15 Nos.
30 Amps DC double pole MCCBs: 4 Nos.

For each feeder "ON" indication lamp or LED shall be provided

.The prior approval shall be taken for the drawings before manufacturing the distribution Boards.

TESTS :

The routine and type tests on the equipment viz. battery, battery chargers, DC distribution boards shall be carried out at works. The capacity test on Battery at site shall be carried out after commissioning. Should the capacity test of battery is found lower than the specified, the supplier will rectify defects at his cost. The Purchaser reserves the right to reject the battery, if ultimately the battery is found lower than the specified rating.

BID DATA, DRAWINGS, AND INSTRUCTION BOOKS:

Layout of battery room, calculations for battery capacity, operation and maintenance instruction books shall be submitted.at the time of detailed engineering

NOISE: All apparatus will operate without excessive vibrations and with the least practicable amount of noise. Terminal Blocks.

Sealed Maintenance Free (SMF / VRLA) battery and charger with static control circuits and Thyristor bridge rectifiers with complete automatic voltage, current regulation.

Type of battery:Maintenance free sealed lead acid high discharging performance indoor type station battery.
Nominal Voltage:220 Volts
AH efficiency:90% minimum
Watt Hour efficiency:82% minimum
Time required for Boost :8-10 Hrs
charging from completely
discharged condition
Nominal life of battery :20 Years
Terminals :Integral lead terminal with solid copper core
Connectors:Heavy duty lead plated copper connectors.

The battery charger will consists of boost and float chargers. The rectified DC shall be fed into Main DCDB. From this the DC supply shall be extended to individual panels through MCBS of suitable rating ONE MCB shall be provided for each function panel independently.

1. **List of Mandatory spares for VT Pumps.**

I. Complete impeller with impeller Nut1 no for Each type of Pump
II. Impeller wear ring1 no for Each type of Pump
III. Set Shaft sleeve 1 no for Each type of Pump
IV. Set of Thrust bearings1 no for Each type of Pump
V. Set of Throdan bearings 1 no for Each type of Pump
VI. Set of wearing rings1 no for Each type of Pump
VII. Set of couplings1 no for Each type of Pump
VIII. Gland packing/mech. Seal set1 no for Each type of Pump
IX. Set of packings and gaskets1 no for Each type of Pump
X. Set of fasteners1 no for Each type of Pump

List of Mandatory Spares for EOPD/HOPD Valve:

I. Seats ring and seal ring 1 no for Each type of Valve
II. Actuator gear box` 1 no for Each type of Valve.
III. Actuator complete unit 1 no for Each type of Valve
IV. Actuator control cards 1 no for Each type of Valve
V. Actuator Power cards 1 no for Each type of Valve
VI. Limit switches for actuators 1 no for Each type of Valve.

2. **List of Mandatory Spares for Motor:**
   I. Motor Bearing set 1 no for Each Rating
      RTDs used for air circuits & bearings 20% of total quantity.
   II. Cooling Fans1 no for Each Rating.

3. **List of Mandatory Spares for VFD:**
   I. VFD 1Nos. for Each Rating
   II. Bypass contactors 1Nos. for Each Rating
   III. Multipliers Contactors1Nos. for Each Rating
   IV. Thermal Relays1Nos. for Each Rating.
   V. Timers1Nos. for Each Rating

4. **List of Mandatory Spares for Switch gear Panels**:
   I. Circuit Breaker 1Nos. for Each Rating
   II. Current transformers 1Nos. for Each Rating
   III. Potential Transformers 1Nos. for Each Rating
   IV. Spring Charge Motors 1Nos. for Each Rating
   V. Protection relays 1Nos. for Each Rating
   VI. Indicating and recording Meters 5% of total quantity
   VII. Selector switches (each type) 5% of total quantity
   VIII. Indicating Lamps 20 Nos for each type and color

5. **List of Mandatory Spares for LT Distribution Panels(SAB):**
   I. LT Contactors1 No. for Each Rating
   II. MCB/MCCB1 No. for Each Rating

III. Switch fuse Unit1 No. for Each Rating
IV. Indicating and recording Meters 5% of total quantity
V. Selector switches5% of total quantity
VI. Indicating Lamps20 Nos for each type and color

6. **List of Mandatory Spares for Battery and Battery charger:**
   I. Thyristors/SCR5% of total quantity
   II. Diodes5% of total quantity
   III. Multipliers Contactors5% of total quantity
   IV. Multipliers Contactors5% of total quantity
   V. Control cards1 No. for Each type
   VI. Control transformers1 No. for Each type
   VII. Indicating Lamps5 Nos for each type and color
   VIII. All types of PCB1 set

7. **List of Mandatory Spares for EOT Cranes:**
   I. Thrust Breaks7 Nos.
   II. Coils for Break solenoids1 Set
   III. Control contactors5% of total quantity
   IV. Brake pads/Linings5% of total quantity
   V. Fuses5% of total quantity
   VI. Limit switches2 Nos.
   VII. Bearings1 No. for Each type
   VIII. Oil seals1 No. for Each type
   IX. Carbon Brushes 1 set
   X. Fuses all ratings 1 set

List of Special Tools, Instruments and T&P.

1) Chain block (special)1 set
2) Separating bolts (Special)1 set
3) Special Spanners for Pumps1 set

List of testing instruments for electro mechanical equipment

The following testing instruments and equipment shall be supplied for testing of Pump Motor sets (units).

1) A.C. Analog / digital Voltmeter,
    a. 0-150 / 300V 1No.seach
    b. 0-75 / 150V1No.seach
2) A.C. Analog / digital Ammeter, 0-1/5A, 0-5/25A 1 No.seach
3) Analog Watt meter 3 Phase, 1/5A, 600 V 0.5 class 1 No. each
4) Frequency meter (Digital), 45-55 Hz & 1 No.
5) D.C. Analog / digital Voltmeter, 0-100m V. 0-100V/300 V2No.s
6) D.C. Analog / digital Ammeter 0-1/5A. 0-5/25 A2 No.s
7) Phase angle meter Analog, 120/240 V.
   50/60 Hz 0.5/1A. & 2.5/5A.1 No
8) Phase rotation meter, AC, 60 V-500V 1 No.
9) Wheatstone Bridge, 0.0001-10 ohms1 No.
10) VAR Meter Analog 2.5/5A, 120V, 0.5 Class1 No.
11) Earth megger500V1 No
12) Single Phase Variac, 0-250 V, 15 A2 Nos.
13) 3 Phase Variac 0 -500V, 15A1 No.
14) Testing Transformers:
    a. 1 Ph. 30 KVA, 220/30 V, 1000A1 No
    b. 3 Ph 440 V, 0 to 50 A.1 No.
15) DC High voltage testing kit, 0 to 60 KV/10 mA1 No.
16) Megger Digital, 500 V, 1000 M ohm2 Nos.
17) Megger Digital, 1000V, 2000 M ohm2 No.
18) Motor operated Megger 2.5 KV/5 KV (Digital)2 No.
19) Oscilloscope dual champed storage1 No.
20) Stop watch, 1/5 sec. (60 sec.)4 Nos.
21) Electric Hand tachometer (Digital) (0-3000 rpm)7 Nos.
22) Manometer Gauge Tester 0.05 kg/cm27 set
23) Manometer Gauge Tester 2.50 kg/cm2 7 set
24) Manometer for oil use, 0-50 kg/cm27 sets.
25) Manometer for water use7 sets.
26) Resistance box, 6 element7 No.
27) Open Angle measuring tool7 set
28) Shunt, 5A or 7.5 A/50 mV7.No.
29) Bell, 220 V DC.7 Nos.
30) Elec. Soldering iron, 230 V AC 100W (with temp. control).7 Nos.
31) Noise Meter A/B/C range 7 No.
32) Hand Operated crimping tool2 Nos
33) Hydraulic operated criping tool2 Nos
34) Vernier calipers 150mm, 300mm2 Nos.
35) Pitch gauge 2 Nos.
36) Depth micro meter0 to 50mm, 0 to 400mm 2 Nos.

37) Inside micro meters25 mm to 1 meter 2 Nos.
38) Out side micro meters 0 to 150mm, 0 to 300mm2 Nos.
39) Slip gauge up to 100mm 1 No.
40) Straight edge150mm, 300mm and 1 meter1 No.
41) Telescope gaugeup to 150mm1 set
42) Dail gauges8 Nos
43) Vibration Meter 2 No.

Range 1 to 1000 mm/sec2, Velocity 0.1 – 100 mm/sec. with recorder.

I. List of Tools and plant:

The following tools and equipment shall be supplied for regular operation & maintenance of pump units.

1) Double end ring spanners 6mm to 36mm7 sets
2) Open end type spanners 6mm to 36mm7 sets
3) Box spanners with ratchet handle and extension rod. 6mm to 36mm 7 sets
4) Feeler gauge0.01mm to 2.5mm 7 sets
5) Screw drivers with insulation 150mm to 600mm7 sets
6) Cutting player with insulation7 sets
7) Bearing Pullers varies sizes 7 sets
8) Aluminum ladders 30 feet, 50 feet,100 feet7 No.
9) Drilling machines 6mm, 13mm and 25mm 7 Nos.
10) Welding Transformer 230 V, 300 A to 600 A7 No.
11) Portable welding machine0 to 150 A7 Nos.
12) Bench grinder 150mm7 Nos.
13) Horizontal grinder 100mm7 Nos.
14) Angel grinder 180mm7 Nos.
15) Flexible shaft grinder7 Nos.
16) Vacuum cleaners heavy duty, 230 V. 7 Nos.
17) 'D' shackles 3T, 5T and 10T 7 Nos.
18) Slings (Steel) 8 mtrs. Length3T, 5T and 10T 7 Nos.
19) Portable Hot air blower 7 Nos.
20) Oxygen regulators 7 sets
21) Blow pipe set7 sets
22) Tap sets6, 8, 12, 16, 20, 24mm 7 sets
23) Hammers (Steel) 2, 6, 8 LBS7 Nos.
24) Hacksaw frame 300 mm7 Nos.
25) Sheet metal cutters300 mm7 Nos.
26) BSP taps¼ , ½, ¾ and 1inch7 sets
27) Chain block pulleys.1 T, 3 T and 5 T 7 Nos.
28) Bench vise 8 inches7 No.
29) Surface plate 400 mm7 No.
30) Pipe bending Kit.7 No
31) Align keys 7 set

All the above spares, T&P, Testing instruments to be supplied 2 sets in total.

Pre-commissioning Trials

4.1 Start up

On completion of the erection of equipment and before start up, each item of the equipment shall be thoroughly cleaned and then inspected by the Engineer in charge and the contractor jointly for correctness and completeness of installation and acceptability for startup leading to initial pre-commissioning tests at site. The list of pre commissioning tests to be performed shall be mutually agreed and included in contractor's quality assurance Programme. The contractor's commissioning /start up engineers specially identified as far as possible shall be responsible for carrying out all pre-commissioning tests. On completion of inspection, checking and after pre-commissioning tests are satisfactorily over the complete equipment shall be placed on initial operation during which period, the complete equipment shall be operated integral with sub-system and supporting equipment complete plant.

4.2 Commissioning spares

The contractor shall make Arrangements for an adequate inventory at site, of necessary commissioning spares prior to commissioning of equipment furnished and erected so that any damage or loss during these commissioning activities necessitating the requirements of spares will not come in way of timely completion of works under contract.

4.3 Registration and statutory Inspection

All the registration and statutory inspection fees if any in respect of work pursuant to this contract shall be to the account of contractor. Should any such inspection on registration need to be re-Arranged due to the fault of contractor, the additional fees for such inspection shall also be borne by the contractor.

4.4 Progress Reports and Photographs

During various stages of works in pursuant of the contract the contractor shall at his own cost submit periodic progress reports as may be reasonably required by the Engineer in charge with such materials as charts, networks, photographs, test certificates etc. Such progress reports and photographs shall be in the form and size as may be required by the Engineer in charge and shall be submitted in at least three copies and shall contain the date, the name of the contractor and the title of the photographs. The report shall also indicate reasons for variance between the schedule and actual progress and the action proposed for corrective measures whatever necessary.

4.5 Work and Safety Regulations

a) The contractor will notify the Engineer in charge of his intention to bring on to the site any equipment or any container with liquid or gaseous fuel or other substance, which may create hazards. The Engineer in charge shall have right to prescribe the condition under which such equipment or container may be handled and used during the performance works and the contractor shall strictly adhere to such instructions. The Engineer in charge shall have the right to inspect any construction plant and to forbid its use if in his opinion it is unsafe, no claim due to such prohibition shall be entertained by the owner.

b) Where it is necessary to provide and / or store petroleum products or petroleum mixtures and explosives the contractor shall be responsible for carrying out such provision and/or storage in accordance with the rules and regulations laid down in Petroleum Act 1934 Explosive Act 1948 and petroleum and carbide of calcium manual. All such storage shall have prior approvals necessary from chief Inspector of Explosives or any Statutory Authorities. The contractor shall be responsible for obtaining the same.

4.6 Electrical Safety Regulations

a) In no circumstances will the contractor interfere with the fuses and electrical equipment belonging to the owner or other contractor

b) Before the contractor connects any electrical appliances to any plugs or sockets belonging to owner or other contractor he shall

1) Satisfy the Engineer in charge that the appliances are in good working conditions.

2) Inform the Engineer in charge of maximum current rating voltage and phases of the appliances.

3) Obtain the permission of the Engineer in charge, detail the sockets to which appliances may be connected.

c) The Engineer in charge will not grant permission to connect until he is satisfied that

1) The appliance is in good condition and is fitted with suitable plug.

2) The appliance is fitted with suitable cable having two earth conductors one of which shall be an earthed metal sheath surrounding the core.

d) No electric cable in use by the contractor shall be in use by the contractor/owner will be disturbed without prior permission.

No weight at any description will be imposed on any such cable and no ladder of similar equipment will rest against or to be attached to it.

e) No work will be carried out on any live equipment. The equipment must be made safe to work issued before any work is carried out.

f) The contractor shall employ the necessary number of qualified full time electricians to maintain the temporary electrical installation.

Contractor shall make necessary Arrangements for the following

I) It is necessary to carry out the testing of number of equipments in the manufacturers works. This is stated in the item wise specification. However the items, which require third party inspection as tested below with brief requirement of tests.

II) The Arrangements for this shall be Arranged by the contractor, the cost of testing in factory payable to manufacturer (including power charges etc.) The testing fees of inspecting authorities etc. shall be Arranged by the contractor without any extra cost to the department.

Whenever department Engineers will be attending the inspection and testing to and fro charges will be born by the department as per Govt. civil service rules. However all other Arrangements shall be made by the contractor.

5.1 Pipe work

M.S. pipe work shall be fabricated from M.S. plates confirming to IS 226. The fabrication pipe shall generally confirm to IS 3589 pipe and specials shall be fabricated from 10 mm and 8/6 mm thick plate as per drawing. Layout of valve and pipe work shall be got approved from the department. Dished end shall be provided at the end of the common manifold and thickness of dished end shall not be less than 12 mm.

Air release Arrangements shall be provided after the discharge head by using 50mm diameter G.I./ M.S. pipe and cock. Joints connecting the valves shall be flanged with flange thickness not less than 25mm joint rubber ring for these joints shall not be less than 3 mm.

The pipe work shall be subject to test pressure of 1.5 times the actual working pressure in the presence of the Engineer in charge.

All the pipes and valves shall be painted with the primer red oxide paint after the surface is cleaned and two coat of enamel paint of approved quality and shade to have finished aesthetic appearance. Cost of breaking the holes in walls and remaking the same as it was is included in this item.

5.2 Dismantling joints –

These shall be provided connected to the flange outlet or discharge head of the pump and Non Return valve. The diameter of this joint shall be same as Non Return valve. This shall be fabricated from M.S. plate designed to withstand pressure of 25 kg/cm2. The plate thickness shall not be less than 10 mm. The design of the joint shall ensure that no forces are transmitted to the pump foundation and flanges of dismantling joints are held rigid during normal working. For dismantling it shall be possible to slide the flanges at one end by at least 25 mm to enable dismantling refitting, General Arrangements drawing shall be got approved before actual fabrication of the joint.

6 ELECTRICAL EQUIPMENTS

I) Electric motors

There shall be vertical, hollow/solid shaft flange mounting type, to operate on 415 volts +/- 10% 3 phase 50 Hz. A.C. supply. The design of motors shall confirm to IS 325. The torque speed and current speed characteristics of motor shall be suitable for pump starting characteristics. The motor shall be designed such that there shall be minimum 10/15% reserve power over the entire head range of pump specified. H.P. of the motor. Starting time and locked rotar with stand time under hot conditions shall have suitable discrimination for proper selection of protection relays. The locked rotar withstand time under hot condition and at 85% rated voltage shall be more by at least 3 seconds than the starting time with driven equipment coupled at 85% rated voltage.

The motor shall be suitable for restricted operation at following conditions.

(a) Accelerating the driven equipment from stand still to full speed within duration of 1 minute or less at 85% of rated voltage.

(b) Operation on load at 75% of rated voltage for five minutes

(c) Two starts at quick succession for cold condition

(d) One hot restart at maximum steady state temperature over ambient temperature 45^0c .

(e) Three starts per hour equally spaced over the duration after attaining thermal equilibrium.

(f) The motor shall be of continuous duty 'S-1' class. The class of insulation of motor shall be 'F' class.

Constructional features

The motor shall be vertical, hollow shaft. The motor shall be statically and dynamically balanced and critical speed shall not be in the range of 80% to 120% of motor speed R.P.M. and direction or rotation of motor shall be same as that of pump.

The motor shall be squirrel cage induction type, with S.P.D.P. construction with degree of protection confirming to IP 24. At least two drain holes shall be provided at the bottom end of the frame.

The motors shall be provided with special designed heavy duty thrust bearing anti friction grease lubricated type to take entire load of pump and motor static and dynamic type. Terminal box shall be designed suitably to accommodate armored aluminum conductor of required rating and shall be manufactured by the motor manufacturer. Suitably designed non-reverse ratchet Arrangements shall be provided to the motor to stop reverse rotation.

(Note – As the V.T. pumps provided are suitable for hollow shaft motor necessary provision of special thrust bearing to take entire thrust a motor pump set shall be made along with non reverse ratchet and clutch type pump motor coupling at top as specified in the pump) as required.

Testing

The motor shall be offered for routine test to the inspecting Authorities and test certificates shall be submitted to the Engineers in charge.

Following document shall be furnished after contract is awarded.

a) General Arrangements drawing

b) Instruction manual for erection and maintenance

c) Test report

d) Torque speed curve

(ii) Auto transformer starter –

Fully automatic A. T. starter motor control panel assembled locally with the contactors of approved makes sheet metal clad enclosure, floor mounting type suitable for operation on 400/440 volts 3 phase 50 cycles A.C. power supply and fitted with

1. Oil immersed Autotransformer with 40%, 50%, 65% and 80% tapings. (Winding of transformer shall be copper only) with withstand capacity for at least six starts per hour. **Transformer will be inspected by third party before dispatch.**

2 Air break contractors of suitable rating, as under of AC3 duty class shall be provided.

3. Bimetallic thermal over load relay.

4 Timer on delay OFF

5 Ammeter and voltmeter with C.T.'s and selector switch

6 No volt release

7 Single-phase current sensing relay.

The wiring on the contactors shall invariably be carried out by using solid copper conductors. The appearance and layout in the panel shall be aesthetic and specious to facilitate easy working. The enclosure shall be factory finished specious and elegant looking and provided with ISMC 75 M.S. base channels painted with best quality enamel paint or powder coated. Interlocking shall be provided so that the panel door shall not be opened when panel is on or alternately the panel should trip in case of opening of door. Contractor shall submit dimensional drawing of the starter, details of the offered components wiring diagram of panel etc. Indicating lamps for three phases On OFF and TRIP shall be provided on the front. Special terminal boxes for incoming and outgoing shall be suitably designed and provided to facilitate easy entry of power cables.

The starter panel shall be tested in the manufacturers work for functional requirements H.V. tests etc. by the competent authorities of the department.

Approved makes of Contactors

L&T / Siemens / Bharatiya Cultter Hammer Adrew yele/Crompton.

ii) Relays L&T Crompton A.B.B.E.E., Siemens

iii) Timer – L&T, Siemens.

iv) Ammeter and Voltmeter A.E. IMP RISHABH

v) Auto Transformer approved standards make.

L.T. Panel

General

L.T. panel comprising 415-Volt switch gear and control gears shall be suitably designed for the functions as under

a) Reception of power from Transformer

b) Distribution of power for pump motors, lighting etc.

Panel Construction

The 415-grade switch gears shall be housed in a totally enclosed sheet metal clad dust and vermin proof of cubicle suitable for floor mounting and are of equal height. The panel shall incorporate the following

i) 3 ½ pole 400A Aluminum bus bars in enclosed compartment in horizontal formation C.

ii) Enclosed vertical bus bar serving the motors

iii) No of identical separate compartments for motor feeders, instruments bus bars, C.T., P.T. cable termination as required.

iv) Internal panel barriers in the bus bar Chamber shall be epoxy.

The panel shall be fabricated from 2 mm thick M.S. sheets. Hinged doors shall be provided at the front and rear with car type handles. Mechanical interlocks shall be provided to prevent the opening of front door in ON position or alternately Arrangements shall be made to trip the supply in event on opening or front door. Suitable stopper shall be provided to restrict the opening of the doors to working requirements and to prevent the rubbing of the door and scratching of paint with adjoining panel structure. Cable entries and exits shall be from the bottom only. Indicating and opening devices shall preferably be at uniform levels and shall not be above 1600 mm from the floor.

The panel framework shall have minimum ISMC 75 channel for base. Angle framework shall be 40 x 40 x 5 mm size M.S. angles.

Bus bars

The bus bars shall be aluminum sections to carry 400 A rated current (minimum) continuously. The bus bar shall be covered with shear resistant P.V.C. sleeves with color code and joints shall be epoxy shrouded. The bus bars shall be supported on durable non-hygroscopic supports rigidly fixed to the framework.

Adequate clearance shall be kept between the bus bars as per relevant IS codes.

Panel cabling and terminations

Power cabling shall be done entirely with P.V.C. insulated 1.1kV grade cables of size designed in confirming with relevant I.S. and shall not be less than 2.5Sq.mm. control cables shall be 650 V grade insulated copper cable not less than 1.5 sq. mm. however the cable for current transformer shall be 2.5 sq. mm or above. Cost of power and control cables in the panel shall deem to be included in cost of panel.

The terminal blocks shall be one piece moulded and screwed type. At least one spare terminal block shall be provided in each panel. Control cable shall neatly run over P.V.C. cable trays and shall be terminated in compression type terminal blocks. Identification codes as approved by the engineers shall be used for cable terminations. Ferrules shall be used for multi core cables.

Current transformers

The current transformer's for metering shall be wound/bar type and shall be rated for 21 KA fault level.

Painting

The panel shall be painted as under primer coat – one coat of red oxide. Intermediate Coat – Enamel paint of shade approved Final coat – Enamel paint as above.

Labels and Danger marks

Scheme of labeling shall be as under

a) Each compartment door shall have title label. The component/ control on each compartment shall have function label.

b) Each internal component and fuse shall have identification label with fuse current capacity where applicable.

All external labels shall be clear painted black in English all internal labels with crome plated nuts and bolts. Size of label shall be 50 mm x 25 mm with height of letter 5 mm.

Compartments not interlocked to an insulator shall have an external danger mark as under "DANGER, LIVE TERMINAL" with flash mark and voltages in red letter on white background.

Capacitor

All the pump motors shall be provided with suitable capacitor banks for improving power factor to 0.95 lagging at normal duty conditions. However KVAR selected shall not exceed 90% of the magnetising KVAR of the motor even if corrected P.F. is less than 0.95 lagging but not less than 90% in any case. The capacitor shall be suitable for operation at rated voltage [415 volts +- 10%] and shall be connected in respective power circuit of the motor with isolating switch tube units.

Capacitor bank shall be complete with structure, earth wire, discharge resisters etc. The capacitor shall be low loss mixed dielectric construction of polypropylene and craft paper insulated aluminum foiled type impregnated with non PCB non toxic non hazardous non flammable synthetic di-electroral oil and fitted with internal element fuse conforming to IS 2834/1981 revised and shall be with ISI mark separate panel shall be fabricated for housing these capacitors.

Testing

The capacitor shall be tested for routine test as specified in IS 2834 and test reports shall be furnished.

Contractor shall Arrange thermal stability test on the unit in the presence of the Engineer In charge.

Cables

Power cable used in 415 Volts system shall be 1.1KV grade 3 ½ core as applicable aluminum conductor P.V.C. insulated P.V.C. sheathed flat steel armored type confirming to IS 1534.

Cable shall be of sizes rated to carry full load current at 0.85 P.F. or to withstand short circuit current 20 KA for duration at least to opening of associated breaker whichever is greater but shall not be less than the size specified in subsequent clause.

Approved make for power cables/cables schedule – Tropodour /Finolex/Asian/ Gloster / Incab / universal / poly cab Nico

Cabling methods

Cables shall be laid in ground ducts and on trays in and out of pump house through R.C.C. trenches etc. with clearance not less than 600 mm below the water mains. Every cable shall be

neatly run vertically, horizontally or parallels to adjacent wall, beam or column. At both ends of terminations the cable shall be approached from a common direction and are individually terminated in all orderly and symmetrical fashion.

The cables shall be terminated in mechanical glands that shall be suitable to provide adequate support by locking on the armour and additional earth continuity. Suitable compression type copper cable lugs shall be used for cable terminations.

The point of entry, exit of cables from the building shall be sealed from out side with an approved asbestos compound followed by 40 mm thick bituminous compound with sealing.

Cable route markers of approved design shall be installed at following positions

a) Entry and exit points of underground duct/trench

b) Exit from building

At every 5 meters distance of straight run

Any other position to trace the route.

A metallic plastic tag bearings cable reference number indicated in cable schedule at every 4 run to part thereof and at both ends shall be provided for case of identification and route tracing. The schedule shall be prepared by the contractor and submitted for approval.

The cable routes shall be such that sharp bench and kinks shall be avoided. The radius at bends for PVC insulated cables shall not be less than twice/thrice the overall diameter of the cable. Laying and termination of 1.1 Kv grade cable shall be as per manufacturers instruction as per practices specified code electrical manual. The cable underground shall be laid as per respective IS and practice in force and as directed by the Engineer In charge.

Loop/extra lengths shall be provided in each cable run located suitably. The loop/extra lengths shall be adequate for two straight through joints as and when needed.

Earthing

Effective earthing shall be provided to all electrical equipments and components. This shall be carried out with G.I. pipe electrode. Buried 2500 mm below ground including excavation of pit in all types of strata with charcoal salt and necessary alum etc. Strip, funnel Arrangements for watering and brick masonry chamber with C.I. frame and cover etc complete as per IS3043 and as per E.I. rules amended up to date.

The electric motors, L.T. panel starter, capacity etc shall be provided using double earthing with G.I. strip of size 25 mm x 3 mm with two independent earth pits. The pipe earth electrodes of 40 mm dia 2.5 m depth shall be used.

Earth pits shall be filled with charcoal salt and alum. They shall be provided with non hole frame and cover at top and water connection for watering the pit at intervals.

The earthing shall be carried out as per IS 3040 of 1966 and amended up to date and I.E. act 1948 amended up to date.

Ground bus or section 25 x 3 mm G.I. strip shall run through out the L.T. panel and shall be bolted to the framework.

All equipment shall be provided with two independent earthing connections and connected to earth strip.

Earth G.I. wire 6 S.W.G. shall run along with the cable from L.T. panel of pure water pumps to incoming of panel for ensuring safety and provide independent earthing to cable. This wire should be connected to armor or cable and cable end boxes at starting and end points.

Illumination to the pump house.

Necessary illumination shall be provided in and out at pump house as per specification given below.

External Illumination

i) This shall be as per direction of Engineer in charge.

Internal Illumination

Internal illumination in pump house and attendant room should be done as per direction of Engineer in charge.

Internal wiring shall be carried out with suitable size copper conductors P.V.C. insulated in appropriate size; M.S. conduit wooden block shall be provided wherever required. Separate wooden board tick wood polished shall be provided mountains the switches etc. Four power plug points with separate switches shall be provided.

8. Test Trial and operation

The plant shall be on trial operation for six months after testing during which period all necessary adjustments shall be made while operating over the full load range enabling the plant to be made ready for performance and guarantee test.

The duration of trial operation of the complete equipment shall be at least three months, out of which at least 72 hours shall be of continuous operation with full load or any other duration as may be agreed to between the Engineer in charge and the Contractor. The trial operation shall be considered successful, provided that each item of the equipment can operate continuously at the specified characteristics for the period of trial operation. Minor interruptions not exceeding four hours at a time, caused during the continuous operation shall not affect the total duration of trial operation. However, if in longer, the trial operation shall be prolonged for the period of interruption.

A trial operation report comprising observations and recordings of various parameters to be measured in respect of the above trial operation shall be prepared by the contractor. This report, besides recording details of the various observations during trials run shall also include the dates of start and finish of the trial operations and shall be signed by the representatives of both the parties. The reports shall have sheets, recording all the details of interruptions occurred, adjustments made and any major repairs done during the trial operation. Based on the observations, necessary modifications/ repairs to the plant shall be carried out by the contractor to the full satisfaction of the Engineer In charge to enable the latter to accord permission to carry out performance and guarantee test on the plant. However, minor defects which do not endanger the safe operation of the equipment shall not be considered as reasons for withholding the aforesaid permission.

Commissioning and Operation

After commissioning and testing, there will be six months trial run and thereafter five years for operation and maintenance of the plant.

During trial run and O & M period, the contractor shall depute his personnel full time to operate, maintain and repair the equipment. The personnel so deputed shall maintain log books and other records as directed by the Engineer In charge. During this period the owner's personnel shall continuously work with Contractor's personnel to take full responsibility of operating, maintaining, repairing, etc. of the equipment plant.

Civil works:

Following civil works are required to be carried out for installation transformer pole structure, fencing gates etc.

The general specifications are given below. However the general Arrangements and the layout or the substation shall be as per drawing approved by the statutory authority.

a) **Transformer platforms**- Suitable size of platform shall be provided for the transformer in 1:2:4 cement concrete as shown in the layout. The height of the transformer shall be such that the live terminal of the transformer shall be at a distance of 4m above the ground level of the transformer ground or as stipulated in I.E. rules amended up to date. The concrete work shall be carried out as per regular civil Engineering practice with excellent finished work. Necessary recess shall be provided to accommodate the outgoing cables --- for L.T. side of two transformers.

Two numbers of M.S. channels shall be embedded on the top of the each plinth for resting the wheels of the transformer.

b) Foundations for poles: These shall be provided to each pole which will be used to receive the power supply, mounting the A.B. switches, lightening arresters, D.O. fuses etc. The size of

foundation shall 60 mm x 60 mm and 180 cm deep in 1:3:6 cement concrete & 45 cm x 45 cm plinth duly plastered with necessary curing etc. in a neat manner.

Cable Trenches

Necessary cable trenches shall be constructed from each transformer to the pump house.

The trench shall be at least .7m deep and of suitable with depending upon the no of cables to be used through and layer of .2m shall be provided at the bottom on trench and bricks shall be placed on both side of the cable.

Suitably designed markers shall be provided and fixed at every 3-4 meters showing the cable path. The earth in trench shall be filled with crown form at the top.

First aid kit shall be kept in the near by room immediate half to the injured person in case of accident.

9. RISING AND DISTRIBUTION MAINS

Centrifugally cast iron or ductile iron spun pipe shall be used for laying Rising and Distribution Mains as shown in drawing. Centrifugally cast iron spun pipe (LA-Class) conforming to IS 5382-1969 and ductile iron (class K-7/K-9) confirming IS 8329:2000 shall be used requisite number of CI Sluice valves and Scour valves will be provided on the mains. Necessary chambers for valves as per type design shall be constructed. Necessary CI Specials conforming to ISS:- 1538-1969 or DI specials confirming to IS 9523:2000; pig lead conforming to ISS:- 782-1978,yarn conforming to ISS:- 6587-1972 will be supplied and fixed by the contractor and making lead caulked joints or push on joints with rubber gasket as per IS Specification and direction. Thrust blocks will also be provided at places like bends and wherever directed. **The successful tenderer will have to get pipes, pumps, motor, transformers etc inspected by DGSD/SGS/RITS/BIS before dispatch to site at their own cost and will submit inspection report to consignee accordingly**. The materials will be accepted by the consignee after proper verification at the consignee end

The pipes shall be tyton jointed. Rubber gaskets conforming to IS 5382-1969 shall be used for tyton joints.

Laying of CI/DI pipes shall be as per IS 12288:1987. The width of trench at top and bottom, between faces of sheeting shall be such as to provide minimum 30 cms clearance on either side of the pipe for pipe diameters less than 600 mm and 45 cms for pipe diameters 600 mm and above.

Before laying of pipe the bottom of trench shall be trimmed off to present a plain surface and all irregularities shall be leveled. Where large stone or boulders or rock is met in excavation, murum or sand bedding of 10 cms thick shall be provided below pipe. All care should be taken to protect the pipe and the coating.

10. Excavation in average soil, soft and hard murum, concrete boulders etc.

a) General: The trench shall be so dug that the pipe may be laid to the required alignment, at the required grade and depth

b) As per direction of the Engineer in charge. The depth of the trench should be sufficient to have a minimum cover of 100 cms. In cases where this is not feasible a decision in this regard shall be taken as directed by Engineer in charge. The trench shall be excavated only so far in advance of pipe laying as per the orders of the Engineer in charge. The trench shall be so braced and drained that the workmen may work there in safely and there shall be no danger to the nearby structures. If any stems and roots of trees are encountered in the excavation of trenches these will have to be cut and destroyed under the supervision and direction of Engineer in charge. If water lines, drainage lines, Electric or Telephone cables are encountered in the excavation of trenches, the work of excavation or laying of line etc. will have to be carried out without damaging the lines and cables and under the supervision of the concerned staff. Appropriate clearances shall be kept from the existing utilities as directed by Engineer in charge. Extra claim for dewatering will not be entertained.

c) Barricades, guards and safety provisions: To protect from injury and to avoid damage to property, adequate barricades, construction signs, torches, red lanterns and guards as required shall be placed and maintained during the progress of the work and until it is safe for traffic to use the road ways. All material, pipe equipment and pipes which may serve as obstructions to traffic shall be enclosed by fences or barricades and shall be protected by proper lights when visibility is poor.

d) Maintenance of traffic and closing streets: The work shall be carried in such a manner which will cause the least interruption to traffic, and the road street may be closed in such a manner that it causes the least interruption to the traffic. Where it is necessary for traffic to cross open trenches, suitable bridges shall be provided. Suitable signs indicating that the work is under progress or a street is closed etc. shall be placed and necessary detour signs for the proper maintenance of traffic shall be provided.

e) Structure Protection: Temporary support, adequate protection and maintenance of all underground and surface structure drains, sewers cables and other obstructions encountered in the progress of the work shall be furnished under the direction of Engineer in charge.

Refilling of Trenches.

a) General: The refilling of trenches shall be carried out immediately after the Flow test is over. Refilling shall be done for 25 cms above the ground level and then it shall be thoroughly wetted and properly compacted with a mechanical earth rammer so that mud etc. shall not be formed.

i) Clearing up the site: All surplus material and all tools and temporary structures shall be removed from the site as directed by Engineer in charge. All dirt, rubbish and excess earth from

the excavation shall be hauled to a dump and the work site left clean to the satisfaction of the Engineer in charge. The item includes bailing out water manually or by dewatering pump sets. The pumped water shall be carefully disposed off in nearby nalla etc. without causing any damage or inconvenience to neighboring existing structures and property holders.

1. Excavation in soft rock, dewatering, refilling etc. as above.

2. Excavation in hard rock by chiseling, refilling etc. as above. Specifications are the same as above except that the excavation will have to be carried out in hard rock. The excavation in hard rock is to be carried out by chiseling or any other method (This includes excavation done by poclain, Splitter or any other mechanical means) to the required width and depth. Other specifications are the same as above. Blasting will not be allowed in the work. Extra claim for dewatering will not be entertained.

GENERAL

Soil testing reports of the recognized institute must be submitted by the tenderer before start of the work at own cost. The design must be on the basis of soil testing report. The design shall be in accordance with various relevant I.S. specifications (I.S. 456-2000, I.S. 875-1987, I.S. 3370-1965, I.S.432 part-1, I.S. 1786, I.S. 1139)

The design shall satisfy the stipulations as per I.S. 1893-1984 and I.S. 13920-1995 for seismic forces and I.S. 11682-1985 for RCC staging of overhead water tank.

Plain round M.S. bar grade-I conforming to I.S. 432 part –1 or high yield strength deformed bars I.S. 1786 of 1139 shall be used. Grade II M.S. bars shall not be used.

Entire structure shall be as per latest IS specifications.

19 cm thick cement plaster (1:3) with 5% water proofing compound of approved quality shall be provided over the bottom floor and inside surface of tank wall. 12 mm thick cement plaster (1:4) shall be provided over the exposed surface of columns, beams, bracings, bottom dome and tank wall outside surface etc. 12 mm thick cement plaster (1:6) shall be provided for the inside and outside surface of rooms.

Three coats of exterior painting over a coat of cement primer shall be provided in the water tower. Irrespective of the foundation proposed in the design, one set of bracing be provided at the ground level. The scope of pipe assembly work shall be up to 5 meter beyond the out side face of the wall including the cost of pipes, valves and specials including laying and jointing.

The job includes designing the structure for uplift pressure and dewatering if required during entire execution and disposal of surplus excavated stuff within a lead of 50 meter as directed by the Engineer in charge.

C.I. D/F pipe be as per relevant I.S. standard shall be used for rising, delivery, overflow and washout main of the water tower.

R.C.C roof shall be constructed at the level of first and second bracing under which rooms shall be constructed by 250 mm thick brick masonry walls for key man and operational staff or office accommodation with Toilet including W.C. Septic tank Soak pit and necessary electrification. Sufficient number of doors and windows shall be provided in the rooms.

Provision shall be made for spiral RCC stairs from outside of staging with 25 mm G.I. pipe railing on both sides for going in the tank.

Spacing between two braces should not be more than 3m C/C.

Provision shall be made for cylindrical ventilator fitted with mosquito proof net and two manholes with M.S. frame and cover with locking Arrangements of adequate size both in the roof slab as well as top dome.

Provision shall be made for lightening conductor as per I.E. rules

Provision shall be made for M.S. water level indicator with 450 mm diameter copper ball etc.

Part rate shall be payable for reinforcement concrete and plastering item of all types of water retaining structure till satisfactory hydraulic testing for water tightness test is given and till that work shall be treated as incomplete.

The Design and Drawing of the water Tower/underground service reservoir shall be vetted by NIT, Patna or any other NIT/IIT, for which no payment will be done by BRJP. The bidder has to bear the cost.

VALVES

A)Sluice Valve

The valves shall be as per IS and of standard required size

The manufacturers test certificate for the material shall be provided at the time of the testing. Required supports to the valves in C.C. shall be provided.

The dimensional drawing shall be submitted by the contractor prior to manufacture showing all the construction details etc. of valve for approval. The valves shall be painted after testing as directed by the Engineer in charge.

Kinetic Air Valve

These shall be as per IS and of standard required size. The air valve shall be designed to operate satisfactorily at normal working pressure of 10 kgf/cm2 Kinetic air valve body shall be tested for 10 kg/cm2. Air valve shall be provided with isolating sluice valve, which shall generally comply IS applicable to sluice valve.

C) VALVE CHAMBERS

The valve chambers should be constructed for protection of valves from traffic load to avoid damage by people. The valves should be constructed as per the type design drawings. The construction of the chamber should be in R.C.C and should be able to withstand the superimposed load due to vehicular traffic. The top of the chamber should be covered by RCC pre cast slabs. All the civil work should be as per the general specification mentioned earlier and as per applicable I.S. standards.