NAVI MUMBAI MUNICIPAL CORPORATION

DEVELOPMENT OF RENEWABLE ENERGY PROJECT FACILITIES OF HYDRO ELECTRIC POWER PLANT OF 1.5 MW AND FLOATING SOLAR PV POWER PLANT OF 100 MW

AT

"MORBE DAM"

TECHNICAL SPECIFICATIONS - PART - 2

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SECTION 1

GENERAL REQUIREMENTS

2.1 GENERAL REQUIREMENTS

2.1.1 Materials Generally

The term “materials” shall mean all materials, goods and articles of every kind whether raw, processed or manufactured and equipment and plant of every kind to be supplied by the Contractor for incorporation in the Works.

Except as may be otherwise specified for particular parts of the Works, the provisions of clauses in “Materials and Workmanship” shall apply to materials and workmanship for any part of the Works.

All materials shall be new and of the kinds and qualities described in the Contract and shall be at least equal to approved samples.

As soon as practicable after the date of issue of order of commencement of works, the Contractor shall inform the Engineer of the names of the suppliers from whom he proposes to obtain any materials but he shall not place any order without the approval of the Engineer which may be withheld until samples have been submitted and satisfactorily tested. The Contractor shall thereafter keep the Engineer informed of orders for and delivery dates of all materials.

Materials shall be transported, handled and stored in such a manner as to prevent deterioration, damage or contamination.

2.1.2 Samples and Tests of Materials

Pursuant to the Conditions of Contract the Contractor shall submit samples of such materials as may be required by the Engineer and shall carry out the specified tests directed by the Engineer at the Site, at the supplier’s premises or at a laboratory approved by the Engineer.

Samples shall be submitted and tests carried out sufficiently early to enable further samples to be submitted and tested carried out sufficiently early to enable further samples to be submitted and tested if required by the Engineer.

The Contractor shall give the Engineer seven day’s notice in writing of the date on which any of the materials will be ready for testing or inspection at the supplier’s premises or at a laboratory approved by the Engineer. The Engineer shall attend at the appointed place within the said seven days failing which the test may proceed in his absence, provided that the Contractor shall in any case submit to the Engineer within seven days of every test such number of certified copies (not exceeding six) of the test readings as the Engineer may require.

Approval by the Engineer as to the placing of orders for materials or as to samples or tests shall not prejudice any of the Engineer’s powers under the Contract particularly as to the provisions in the Conditions of Contract.

The provisions of this clause shall also apply to materials supplied under any nominated sub-contract.

2.1.3 Standards

Materials and workmanship shall comply with the relevant Indian Standards (with up to date amendments) current at the thirty-first day of December of the year preceding the Tender Date, unless a more recent amendment is specified hereinafter, or with the requirements of any other authoritative standard approved by the Engineer which shall be no less exacting in the opinion of the Engineer than the corresponding standard quoted herein.

Where the relevant standard provides for the furnishing of a certificate to the Purchaser, at his request, stating that the materials supplied comply in all respects with the standard, the Contractor shall obtain the certificate and forward it to the Engineer.

If no standard is indicated, the relevant Indian Standard, if any, shall apply. Indian Standards are published by :-

Bureau of Indian Standards,
ManakBhavan,
9, Bahadur Shah Zafar Marg,
New Delhi – 110 002

PART 2

SECTION 2

EARTHWORKS

2.2 EARTHWORKS

Applicable Codes

The following Indian Standard Codes, unless otherwise specified herein, shall be applicable. In all cases, the latest revision of the codes shall be referred to :

a.	IS 783	Code of Practice for Laying of Concrete Pipes.
b.	IS 1200	Methods of Measurement of Building and Civil Engineering Works (Part 1 to Part 28)
c.	IS 3764	Excavation Work – Code of Safety
d.	IS 2720	Methods of Tests for Soils
	Part 2-	Determination of Water Content
	Part 7-	Determination of Water Content-Dry Density Relation Using Light Compaction
	Part 8-	Determination of Water Content – Dry Density Relation Using Heavy Compaction
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	Part 31 -	Field Determination of California Bearing Ratio

2.2.1 General

2.2.101 Earthwork General

Clauses 2.2.101 to 106 hereof are of general application and shall be read in conjunction with other clauses in Section 2.2 (Earthworks).

2.2.102 Definitions

The following terms shall have the meanings hereby assigned to them:

"Topsoil"	means any surface materials, including turf, suitable for use in soiling areas to be grassed or cultivated.
"Ordinary and Hard Soils"	means all kinds of soils containing kankar, sand, silt, murum and /or shingle, gravel, and clay, loam, peat, ash, shale, etc. which can generally be excavated by spades, pick axes and shovels. This shall also include embedded rock boulders not longer than 1 metre in any direction and not more than 200 mm in any one of the other two directions.
"Soft and Decomposed Rock" rock	means rock, boulders and other materials which in the opinion of the Engineer could normally be removed by picks, hammer, crow bars, wedges and pneumatic breaking equipment. This shall also include rock boulders longer than 1 metre in any direction and not more than 500mm in any one of the other two directions. Excavation in macadam & tarred roads and pavements and dismantling masonary shall also be included under this item.
"Hard Rock"	Means rock occurring in large continuous masses which in the opinion of the Engineer could be loosened by blasting or by other rock quarrying methods. Rock boulders in sixes not classified under Ordinary/Hard Soils and Soft & Decomposed Rock shall be considered as hard rock.

"General Excavation"	Means excavation in open cut in top soil, ordinary & hard soils or soft & decomposed rock or hard rock (excluding Trench Excavation) down to levels specified on the Drawings or Otherwise as being the general levels after completion of excavation but excluding excess excavation.
"Trench Excavation"	Means excavation of trenches in any material into which pipes are to be laid to levels and limits specified on the Drawings or otherwise.
"Excess Excavation"	Means excavation outside the limits specified for General or Trench Excavation (see also CI. 2.2.106) (Excess Excavation will not be paid for.)
"Controlled Blasting"	Means blasting under express control by designing and limiting the charge of blast to ensure that the peak particle velocity due to blast at the nearest structure as measured by engineering seismograph does not exceed 5 mm per second.

2.2.103 **Levels to be Recorded**

Before the surface of any part of the Site is disturbed or the works thereon are begun, the Contractor shall take and record levels of any such part, in the manner specified or as agreed with the Engineer, in the presence of the Engineer and such levels when agreed with the Engineer shall form the basis for measurement.

2.2.104 **Explosives and Blasting**

General

The Engineer shall have the power to regulate, restrict or prohibit blasting if in his opinion it is necessary to do so for the safety of persons or property or to safeguard the Works. No blasting shall be carried out in any part of the Works without the permission in writing of the Engineer. Such permission shall not absolve the Contractor from any of his obligations or liabilities under the Contract, and he shall take all necessary precautions including the use of blasting nets to avoid damage, loss or injury to persons and to public or private property. All safety measures in respect of storage, transport of explosives and maintenance as detailed out in IS 4880 and IS4081 shall be strictly followed.

The Contractor shall acquaint himself with all the laws and regulations concerning transporting, storing, handling and the use of explosives. All such laws, regulations, rules and safety codes, etc. as are current from time to time shall be binding on the Contractor. The provisions detailed in this specification are supplementary to the above laws, rules and regulations. Further, the Engineer may issue modifications, alterations, and new instructions from time to time.

The Contractor shall obtain the necessary licences for the storage, transport and handling of explosives and shall provide a store or stores suitable for explosives and shall carry out every aspect of blasting work in full conformity with the regulations of all competent authorities including the police and Inspector of Explosives, MaharashtraState. Only experienced and competent blasting operatives possessing licences from the Commissioner of Police shall be employed on blasting work.

The Contractor shall keep the Engineer fully informed at all times when blasting is proposed to be carried out and of any details the Engineer may require concerning strength of charges and their positions. Contractor shall employ a competent and experienced supervisor and licensed blaster in-charge for each set of operation who shall be held personally responsible to ensure that all safety regulations are followed.

Before any blasting is carried out the Contractor shall intimate the Engineer obtain his approval. He shall intimate the hours of firing charges, the nature of extent of explosive to be used and the precautions to be taken by him for general safety .

Blasting shall be carried out during fixed hours of the day, which shall have the prior approval of the Engineer. The hours once fixed shall not be altered without the prior approval of the Engineer. In special cases, the Engineer may permit blasting for excavation without restriction of fixed time, provided that, he is satisfied that proper precautions are taken to give sufficient warning to all concerned and that the work of other agencies on the site is not unduly hampered. The area shall be encircled by red flags.

The Contractor shall ensure that all workmen and the personnel at site are excluded from the unsafe area, to be determined by the Engineer, at least 15 minutes before firing time by sounding warning siren or whistles. Similar warning shall be given when blasting operation is over.

Audible and visible warning (such as the waving of red danger flags and beating of gongs) shall be given for at least five minutes before blasting is due to begin. The Contractor's foreman or other responsible persons shall inspect the whole of the blasting area during the warning period to ensure that no one remains within or is likely to enter the danger area. All operatives except those responsible for detonating the explosives shall be removed to a safe distance, which in any case shall not be less than two hundred metres. If combustible fuses are used these shall be cut to length before insertion.

Materials used for blasting

All materials such as explosives, detonators, fuses, tamping materials, etc. that are proposed to be used in the blasting operations shall be got approved from the Engineer before use.

Procurement of Explosives

The Engineer may render necessary help to the Contractor to obtain licence for explosives. However, it is the Contractor's responsibility to obtain the licence paying the necessary fees, etc.

Explosives

Only gun powder, gelatine and other safe explosives shall be used wherever possible. Explosives with Nitro-glycerine shall be used only under exceptional circumstances with prior approval of the Engineer.

Fuse

The use of the fuse with only protective coat is prohibited. The fuse shall be sufficiently water resistant as to be unaffected when immersed in water for thirty minutes. The rate of burning of the fuse shall be uniform and not less than 4 seconds per 25 mm of length with 10% tolerance on either side.

Before use, the fuse shall be inspected and moist, damaged or broken ones discarded. The rate of burning of all new types of fuse, or fuses kept in stock for long, shall be tested before use.

Detonator

The detonators used shall be capable of giving effective blasting of the explosives. Moist or damaged detonators shall be discarded.

The explosives shall be exploded by means of a primer which shall be fired by a fuse instances detonator (FID) or other approved cables. The detonators with FID shall be connected by special nippers.

Personnel

Excavation by blasting will be permitted only under the personal supervision of competent and licensed blasters and trained workmen.

All supervisors and workmen in charge of make up handling, storage and blasting work shall be adequately insured by the Contractors.

Storage shall be in charge of a very reliable person approved by the Engineer, who may, if necessary, cause police enquiries to be made as to his reliability, antecedents, etc. The Contractor shall have to produce a security for the person in-charge of the explosives, if and when required by the Engineer, or the civil authorities of the district.

The Contractor shall make sure that his supervisors and workmen are fully conversant with all the rules to be observed in storing, handling and use of the explosives. It shall be ensured that the supervisor in charge is thoroughly acquainted with the details of the handling of explosives and blasting operations.

Storage of Explosives

The Contractor shall have to make necessary storage facilities for the explosives as per rules of the local authorities and the Govt. of India.

Disposal of Surplus / Deteriorated Explosives

i) No explosive shall be abandoned. The surplus / damaged explosives shall be disposed off or destroyed strictly in accordance and manner as specified in the Explosives Rules 1983 and IS : 4081 of 1986 or latest. Chief Controller of Explosives or his representative of the jurisdiction shall be contacted for the same. The quantity of the deteriorated explosives to be disposed off shall be intimated to the Engineer, prior to its disposal.

ii) Explosives, caps, boxes lines or material used in packing of explosives shall not be left lying around in places to which children or unauthorised persons or live stock can have access.

iii) Paper or fibrous material employed in packing explosives shall not be put to any subsequent use. Such material shall be destroyed by burning in the presence of a Contractor's responsible representative and Site Engineer.

Account of Explosives :

i) A careful day to day account of explosives shall be maintained in an approved register and manner in accordance with the Explosives Rules 1983 and in the prescribed forms stated therein. This account shall be open to inspection at all times to' the Controller of Explosives Authorities and other concerned Authorities like Police and the Site Engineer.

ii) Explosives shall be issued only on competent persons, upon written requisition signed by the blaster or by the Contractor's authorised representative for the purpose and only against signature or thumb impression. Such requisitions shall be preserved by the Contractor's person in charge of the Magazine.

Preparation of Primer

The primers shall not be prepared near open flames or fires. The work of preparation of primers shall always be entrusted to the same personnel. Primers shall be used as soon as possible after they are ready.

Charging of Holes

Holes for charging explosives shall be drilled with pneumatic drills. The drilling pattern being so planned that rock muck produced due to blasting can be handled without necessity of secondary blasting. Pattern of drill holes should be got approved by the Engineer. The work of charging shall not commence before all the drilling work at the site is completed, and the supervisor has satisfied himself to that effect by actual inspection.

While charging, open/naked lamps shall be kept away.

Only wooden tamping rods, without any kind of metal on them, shall be allowed to be used. The tamping rods shall have cylindrical ends.

Bore holes must be of such a size that the catridges can easily pass down the hole.

Only one cartridge shall be inserted at a time and gently pressed home with tamping rod. Sand or clay or other tamping material used for filing the hole completed shall not be tamped too hard.

<u>Controlled Blasting</u>

Whenever required by the Engineer, the rock blasting shall be carefully controlled so that vibrations generated during the blasting do not cause damage to the buildings and installations around and the rock pieces do not fly off the pits and thus endanger these buildings and installations around. Apart from the general precautions mentioned in the preceeding paragraphs, following protective measures and limits for use of explosives are suggested as guidelines. The Contractors shall carefully check the site conditions and submit the details of the scheme he proposes to adopt for controlling the blast:

a) The hole shall be covered with 0.6 to 1.0 sq.m. mild steel plate of 6 mm thickness.

b) Reinforcement bar mesh not less than 20 mm dia. at 150 mm centres in both directions shall be placed over the steel plates.

c) Sand filled bags of 6 to 8 layers shall be placed over the mesh suitably covering the whole region under blasting operation.

d) Steel plate and reinforcement shall be inspected after every blasting operation and all twists shall be removed before re-use to the satisfaction of the Engineer.

e) The whole arrangement shall be duly approved by the Engineer.

f) The Contractor shall design and calculate the charges required to limit the peak particle velocity due to blast as measured by the engineering seismograph, less than 5 mm/sec at the nearest existing structure.

g) Explosives shall not be used within fifteen metres, or such greater or lesser distances as the Engineer may direct, of concrete placed in the Works, or any existing structure, water main, electric cable, sewer or other services.

h) Line drilling and preshearing technique in rock shall be resorted to where rock blasting is to be carried out in the close proximity of existing structures, equipment, etc. (Specifications for line drilling and preshearing technique are given separately below).

<u>Electric Blasting</u>

The Contractor shall resort to only electric blasting unless otherwise specially approved by the Engineer. Only the Supervisor in-charge shall possess the key of the firing apparatus and he shall keep it always with himself. Special apparatus shall be used as a source of current for the blasting operations. Power lines shall not be tapped for the purpose. Only approved make firing apparatus can be used on the job.

The detonators shall be checked before use. For blasting in series only detonators of the same manufacture and of the same group of electrical resistance shall be used. Such of the electrical lines as could constitute danger for work of charging, shall be removed from the site. The firing shall be done with a proper insulating cover so as to avoid short circuiting due to contact with water, metallic parts or rock etc. The use of earth as a return line shall not be permitted. The firing cable shall be connected to the source of power only when nobody is in the area of blasting. Before blasting the circuit shall be checked by suitable apparatus. After firing, whether with or without an actual blast, the contact between the firing cable and the source of current shall be cut-off before people are allowed to leave the shelters.

During storms, charing with electrical detonators shall be suspended. The charges already placed in the holes shall be blasted as soon as possible, but taking all safety precautions and giving necessary warning signals. If this is not possible, the site shall be evacuated till the storm has passed.

<u>Precautions after Blasting</u>

After the blast the supervisor must carefully inspect the work and satisfy himself that all the charges have exploded.

<u>Removal of Toxic Gases</u>

After the blast takes place in underground works, the workmen shall not be allowed to go to the face till all toxic gases are evacuated from the face.

<u>Misfires</u>

If it is suspected that part of the blast has failed to fire or is delayed, sufficient time shall be allowed to elapse before entering the danger zone. When fuse and blasting caps are used, a safe time should be allowed and then the Supervisor alone shall leave the shelter to inspect the blasting zone.

Under no circumstances shall the removal of an unexploded charge be attempted. The hole containing the charge shall be marked and. filled with water. A second hole shall be drilled some 450 mm away, charged and fired. This 'procedure shall be repeated until the foreman is satisfied that both charges have exploded. In general the size of explosive charges used shall be the smallest compatible with efficient working so as to minimise the chances of danger to persons and property.

Before leaving his work, the Supervisor shall inform the Supervisor of the relieving shift of any case of misfires and should point out the position with a red cross denoting the same and also stating what action, if any, he has taken in the matter.

The Supervisor should also at once report at the offices of the Contractor and Engineer all cases of misfires, the cause of the same and what steps were taken .in connection with these.

The names of the day and the night shift Supervisors must be noted daily in the Contractor's office.

If a misfires has been found to be due to a defective detonator or dynamite the whole quantity or box from which the defective article was taken, must be thoroughly inspected by the Contractor.

Drilling in holes not completely exploded by blasting shall not be permitted.

<u>Line Drilling and Pre-shearing</u>

Line drilling and pre-shearing in rock shall be resorted to when so specified or directed by the Engineer. This technique shall be used when the excavation in rock has to be carried out to exact lines and levels and when absolutely no over excavation is permissible. It shall also be used where rock blasting is required to be carried out in the close proximity of existing structures, equipment, etc.

This technique consists of drilling holes, as close as warranted by the rock conditions and to such depth as may be necessary, along the periphery (or line) of the area within which excavation has to be carried out. This will ensure that when rock inside the area is blasted, over excavation/over break and damage to adjoining property is avoided as the rock shears off along the line of drilled holes.

The diameter, depth and spacing of holes, shall be designed by the Contractor and reviewed by the Engineer. The holes shall generally be 35 mm in dia. The Engineer may direct a second line or subsequent lines of holes to be drilled in addition at a suitable location/s to facilitate safe excavation.

The layout of the interior blasting holes shall be carefully planned. Only light blasting is permitted in the interior holes, which are close to the line drilled holes.

The Contractor shall have to carry out tests to determine the amount of explosives required to ensure an even break at the line as also over breaks are avoided.

After the interior holes are blasted any irregularities in the vertical line drilled face which was line drilled face which was line drilled shall be removed and trimmed by wedging, splitting, chiselling and barring.

Excavation shall generally be carried from the centre to the outside.

The Engineer may direct a trench to be cut between adjacent line drilled holes. In such a case, rock between line drilled holes shall be blasted with such pattern of holes as will not cause any damage to any structure close by and also not shatter or render unsuitable any good rock outside the line drilled holes.

Excavation in Hard Rock by Chiselling

This includes rock which is easily excavated by blasting, but due to close proximity of structures or any other reason that the Engineer may consider, will have to be excavated by chiselling.

The Contractor may resort to any of the following methods to excavate rock by chiselling:

(a) Wedging by means of chisels, wedges, pneumatic drills and crowbars,

(b) Heating and quenching,

(c) Controlled blasting with a small charge just sufficient to make a crack in rock which will be subsequently removed by wedging.

No claim for extra payment shall be entertained by the Corporation, for using explosives for excavation in hard rock as mentioned above where excavation by chiselling is specified or directed by the Engineer.

2.2.105 Disposal of Materials

All requirements herein for the disposal by the Contractor, of materials arising from site clearance or from excavations are subjected to the provisions in Conditions of Contract.

2.2.106 Excess Excavation to be made good

The Contractor, at his own expense, shall, if directed, remove from the Site all materials resulting from Execss Excavation and shall make good the same with such kind of fill material or such class of concrete as may be reasonably required by the Engineer having regard to the circumstances.

2.2.200 Site Clearance

2.2.201 General

All areas of the Site falling within the area marked for site grading and excavation or from which material is to be excavated or upon which filling is to be deposited, as directed by the Engineer shall be cleared by the Contractor to the extent required by the Engineer, of all buildings, walls, gates, fences and other structures and obstructions and of all bushes, hedges, trees and stumps (of girth upto 300mm), roots and other vegetation except for trees marked for preservation and trees with girth greater than 300mm. Material so cleared shall so far as suitable be preserved and stacked for further use but shall otherwise be burnt to ash or disposed off the Site as directed by the Engineer within a lead of 5.0 km.

2.2.202 Trees

Where directed by the Engineer trees shall be uprooted or cut down as near to ground level as possible. Branches and foliage shall be removed and burnt to ash or disposed off the Site. Useful timber shall remain the property of Corporation and shall be cut into suitable lengths and transported a distance not exceeding 5.0kilometres to a location designated by the Engineer where it shall be offloaded and stacked.

2.2.203 Stumps

Stumps and roots whether existing or remaining after tree felling shall where directed by the Engineer be grubbed out and disposed off the Site up to 5.0 km. The resulting hole shall be filled with approved material deposited in 225 mm layers and compacted to the same dry density as the adjoining soil.

2.2.204 Forestry Regulations

The Contractor shall familiarize himself with all local rules and regulations governing land clearance including the special requirements for forestry areas and shall carry out his work in strict compliance with all such requirements.

2.2.205 Measurement of Site Clearance

Items in the Bill of Quantities for Excavations shall include for clearing the Site, including felling of trees and grubbing up of stumps of trees of girth less than or equal to 300 mm. Work involving breaking of concrete or brickwork during site clearance shall be paid separately as per items in the Bill of Quantities.

Items for felling trees exceeding 300 mm girth shall include for felling, cuttingup, and transporting useful timber to the Municipal stockyard as directed by the Engineer. Trees shall be classified for measurement according to their girth measured at 1.5 metres above mean ground level. Separate measurement will not be made for trees with girth less than 300 mm. Items for felling trees shall also include for grubbing up and disposal off the Site of stumps and roots and for filling up the resulting hole all as directed by the Engineer.

2.2.300 General Excavation

2.2.301 General

General excavation means excavation required for general site grading, structures, roadworks and borrow areas and shall not include Trench Excavation. General excavation may also include miscellaneous isolated lengths of trenches inside or adjacent to other structures.

The ground shall be excavated by such methods and to such dimensions and depths as shall allow for the proper construction of the Works and safety of personnel and equipment used on excavation.

Slopes required for stable formation of sides shall be catered to in the rates quoted for the item.

Where nominal payment limits of excavation are not shown in the Drawings or otherwise specified, they shall be deemed to be the minimum net limits which would allow the outline of the completed structure to be lowered vertically from ground level into its final position. The Contractor shall make his own allowance for any working space required, and any excavation outside the aforesaid limits which has not been ordered by the Engineer, whether it be excavated to suit the Contractor's method of working or unavoidable over break or due to his carelessness or error, shall be held to be Excess Excavation and shall not be paid.

2.2.302 Stripping Topsoil

Where ordered by the Engineer, Topsoil shall be stripped to such depth and over such areas as he may direct, as a separate operation prior to any further excavation, which may be required.

2.2.303 Soft & Decomposed Rock and Hard Rock in General Excavation

Any material in General Excavation which the Contractor considers may be classified as Soft & Decomposed Rock or Hard Rock shall be notified to the Engineer before excavation of the material is begun. The quantities of this material excavated from within the nominal limits of excavation shall be recorded and the record shall be signed by the Engineer and the Contractor each day or at such shorter intervals as the Engineer may require. Only such proportion of material so notified and recorded as the Engineer classifies as Soft & Decomposed Rock or Hard Rock shall qualify for additional payment under respective items of BOQ. Overbreak (that is excavation outside the nominal limits of excavation) shall be kept to a minimum and shall be held to be Excess Excavation.

The excavation in earth, murrum, boulders and soft rock shall be carried out to the correct levels required and specified and no tolerance, plus or minus, shall be permitted. However, if any depressions are formed due to removal of boulders, they shall be made good by filling with M7.5 concrete upto the bottom of the blinding layer below footing/raft. No payment for the excavation below the specified level and for filling such hollows with M7.5 concrete shall, however, be made. Excavation in hard rock may be done either by blasting or chiseling depending upon the site conditions. When excavation has reached within 300 mm of the prescribed formation level, further excavation shall be carried out carefully either by blasting or chiseling. Where blasting is resorted to, small charges shall be used to minimize occurance of heavy overcuts. The Contractor shall make every effort to carry out the excavation to the correct formation level as far as practicable. However, undercuts and overcuts upto 200 mm in case of blasting and 80 mm in case of wedging and/or chiseling from the formation level shall only be permitted, whichever method of excavation is adopted. All overcuts below the formation shall be made good by filling in with M7.5 concrete upto the bottom of the blinding layer below footing/raft. All excavation within the permissible limits of overcuts and filling in with M7.5 concrete shall be paid for separately. In case of undercuts the payment of excavation shall be restricted to the actual line of excavation done by the Contractor.

2.2.304 Supporting Excavations

The Contractor shall well and effectively support the sides and ends of all excavations to prevent any fall or run from any portion of the ground outside the excavation and to prevent settlement or damage to structures adjacent to the excavation. Any extra excavation necessary to provide space for such support or other working space shall be held to be Excess Excavation. If, for any reason, any portion of the bottoms, sides or ends of any excavations shall give way, the Contractor shall at his own expense take all necessary remedial measures including the excavation and removal of all the ground thereby disturbed both within and outside the nominal limits of excavation and such extra excavations shall be held to be Excess Excavation.

Where the Contractor elects and is permitted by the Engineer to perform excavations with sloping faces (other than sloping excavations required as permanent features of the Works) and without shoring, the excavated faces shall be to stable slopes and heights and the resulting extra excavation shall be held to be Excess Excavation.

2.2.305 <u>Trimming Excavations</u>

When excavating to specified levels for the foundation of any structure or to specified 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 Engineer shall permit otherwise. Should the Contractor have excavated to within 150 mm above these specified levels or to within 150 mm of these specified limits before he is ready or able to commence the constructional work he shall, where required by the Engineer, excavate further so as to remove net less than 150 mm of material immediately before commencing the constructional work and such further excavation shall be held to be Excess Excavation.

Before commencement of any constructional work all shattered and loose material shall be removed from the excavations by hand so as to ensure that the work rests on a solid and perfectly clean foundation or abuts against solid ground.

2.2.306 <u>Inspection by the Engineer</u>

When the specified levels or limits of excavation are reached, the Engineer will inspect the ground exposed and if he considers that any part of the ground is by its nature unsuitable he may direct the Contractor to excavate further. Such further excavation shall be refilled to the specified levels or limits with concrete, selected excavated material or selected imported material as directed by the Engineer, but shall not be held to be Excess Excavation.

Should the material forming the bottom of any excavation, while acceptable to the Engineer at the time of his inspection, subsequently become unacceptable to him due to exposure to weather conditions or due to flooding or have become puddled, soft or loose during the progress of the Works, the Contractor shall remove such damaged, softened or loosened material and excavate further by hand. Such further excavation shall be held to be Excess Excavation.

2.2.307 <u>Disposing Excavated Material</u>

All excavated material shall remain the property of Employer. The disposal of excavated material within the Site will, unless the Engineer orders otherwise, be at the Contractor’s discretion but shall be so arranged as to suit the overall requirements for the construction of the Works.

The Contractor shall ensure that no excavated material which is suitable for and is required for reuse in the Works is transported to the Engineer’s tip unless so ordered by the Engineer.

The Term “excavation” shall be deemed to include for disposing excavated material within the Site in any of the following ways :-

Backfilling to excavations and completed structures (except where such backfilling is specified as special filling) using suitable excavated material and including placing in temporary spoil tips and any double handling required all so 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 specified 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 and any double handling required.

2.2.308 <u>Backfilling, General Site Grading, & Sand Filling</u>

(a) <u>Fill Material</u>

All fill material whether such material is brought from outside borrow areas or excavation within the site, will be subject to Engineer's approval. Notwithstanding any approval given to the fill material or borrow areas from which fill material is proposed to be brought, the Engineer reserves the right to reject such material which in his opinion either does not meet the specification requirements or is unsuitable for the purpose for which it is intended.

It shall be Contractor's responsibility to locate suitable borrow areas for required fill material. Such areas will be inspected by Engineer and approved before Contractor makes arrangements to borrow the fill material. The topsoil, which may contain vegetation, rubbish, slush etc. shall not be used. If required by Engineer, Contractor shall arrange to have trial pits of specified dimensions and numbers dug at specified locations, for the Engineer to examine the nature and type of material likely to obtained form the borrow areas.

Unless separately provided for, all lead, lift and transportation required for bringing in the fill material from borrows areas or from excavation from within the site shall be included in the Contractor's quoted unit rates.

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

Roads, of temporary nature, required to be constructed for access and for movement of men, materials, equipments, transport vehicles, vehicles carrying fill material etc. to or over borrow areas and/or to or over areas on which fill has to be deposited shall be constructed by the Contractor at his own cost. Such costs shall be deemed to have been included in the unit rates quoted by Contractor. Such access roads shall be maintained in good condition during all seasons to ensure completion of the work according to the time schedule.

(b) <u>Backfilling</u>

Excavated material used as backfilling to excavations or completed structures shall be free from rubbish, vegetation, clods and lumps and shall be approved by the Engineer. The approved materials shall be placed in layers, not exceeding 225 mm in depth before compaction and shall be compacted to a dry density not less than 95% of the maximum dry density obtained by the test in Part 7 of IS2720 or to such higher density as is specified hereinafter or shown on the Drawings. During compaction the backfill shall have a uniform moisture content equal to or a little above the optimum moisture content recorded in the IS Compaction Test. Where necessary the Contractor shall adjust the moisture content of the backfill either by drying out or by adding water. After such drying out or adding of water the backfill shall be thoroughly mixed until the moisture content is uniform.

Soft material shall not be used as backfilling around structures in rock. The Contractor shall backfill such excess excavation with concrete, rubble, stone or rockfill as directed by the Engineer. Filling other than concrete shall be placed in layers not exceeding 300 mm in thickness, shall be thoroughly compacted and have adequate fines content to fill the voids.

Should the material being placed as backfilling, while acceptable at the time of selection, become unacceptable to the Engineer due to exposure to weather conditions or due to flooding or have become 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.

The Contractor shall when placing the backfilling make due allowance for any settlement that may occur before the end of the Defects Liability Period. Where necessary, the Contractor shall during the Defects Liability Period and at or before the end of the Defects Liability Period remove any excess material or make up any deficiency or backfilling to the specified levels.

Backfilling as per specification the sides of foundations of columns, footings, structures, walls, tanks, rafts, trenches, etc. with excavated material will be paid for separately. It shall be clearly understood that the rate quoted for excavation shall include conveying of selected stacked material to the place of final backfill, compaction, etc. as specified. As a rule material to be backfilled shall be stacked temporarily within the basic lead of 300 metres for such material, the conveyance of the material for the extra distance over the basic lead of 300 metres for backfilling will be paid for.

Payment for fill inside plinth or similar filling with selected excavated material will be made separately. Payment for this work will be made based on measurement of plinth dimensions filled. The plinth ground levels shall be recorded before hand for this purpose.

Backfilling, plinth filling and site grading with borrowed earth will be paid for at rates quoted. The quoted rate shall include all operations such as lead and transport, fill, compaction, etc. as specified. Actual quantity of consolidated filling or actual quantity or excavation in the borrow pits (less such top soil which has been excavated and not used for filling) whichever is less shall be measured and paid for in cubic metres. The lead, lift etc. shall be as indicated in the schedule of quantities.

Compaction shall be carried out to achieve at least 95% of standard Proctor Dry Density at an optimum moisture content determined in accordance with the relevant IS Specification. It shall be ensured however that the minimum compacted dry density is not less than 1.6 $M.T./M^3$. As the work progresses field density tests shall be conducted on each layer at the rate of one test for every 1000 square metres to check whether the desired compaction has actually been achieved.

(c) <u>General Site Grading</u>

Site grading shall be carried out as indicated in the drawings and as directed by Engineer.

Excavation shall be carried out as specified . Filling and compaction shall be carried out unless otherwise indicated below.

The approved material shall be placed in layers not exceeding 225 mm indepth before compaction and shall be compacted to a dry density not less than 95 percent of the maximum dry density obtained by the test in Part 7 of IS 2720 or to such a higher density as shown on the drawing.

To ensure that the fill has been compacted as specified, field and laboratory tests shall be carried out by the Contractor at his own cost.

Field compaction test shall be carried out at different stages of filling and also after the fill to the entire height has been completed. This shall hold good for embankments as well.

The Contractor shall protect the earthfill from being washed away by rain or damaged in any other way. Should any slip occur, the Contractor shall remove the affected material and make good the slip at his own cost.

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

If specifically permitted by Engineer, compaction can be obtained by allowing loaded trucks conveying fill or other material to ply over the fill area. Even if such a method is permitted, it will be for Contractor to demonstrate that the desired / specified compaction has been obtained. In order that the fill may be reasonably uniform throughout the material should be dumped in place in approximately uniform layers. Traffic over the fill shall then be so routed to compact the area uniformly throughout.

If so specified, the rock as obtained from excavation may be used for filling and leveling to indicated grades without further breaking. In such an event, filling shall be done in layers not exceeding 50 cms approximately. After rock filling to the approximate level indicated above has been carried out, the void in the rocks shall be filled with finer materials such as earth, broken stone, etc. and the area flooded so that the finer materials fill up the voids. Care shall be taken to ensure that the finer fill material does not get washed out. Over the layer so filled, a 100 mm thick mixed layer of broken material and earth shall be laid and compaction carried out by a 12 tonne roller. Not less than twelve passes of the roller shall be accepted before subsequent similar operations are taken up.

(d) <u>Sand Filling in Plinth and Other Places</u>

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

(e) <u>Measurment</u>

Actual quantity of the consolidated sand filling shall be measured and paid for in cubic metres. Payment for filling upto the proposed finished grade level shall be made under general site grading and filling from proposed finished grade level to proposed plinth level shall be made under plinth filling.

2.2.309 <u>Local Rules and Regulations</u>

The Contractor shall familiarize himself with the local rules and regulations governing the excavation, quarrying operations, etc. and the work shall be carried out strictly in accordance with rules and regulations, if any. Whenever a quarry is required to be opened in connection with the execution of work covered under this Contract, the Contractor shall investigate that it shall yield stones and other materials such as sand, murrum, soil etc., of approved quality and shall satisfy himself as to the availability in desired quantity. He shall supply free of cost necessary quantity of sand, stone, metal aggregate, etc. to the Engineer for carrying out tests as required by the Engineer and well in advance of its use so as to get approval to the quality of the material. The cost of opening and operating and transporting the material from the quarry shall be borne entirely by the Contractor.

The Contractor shall obtain all necessary permission from the concerned authorities before opening the quarry. In case of quarries in private lands, it is for the Contractor at his cost to arrange for quarrying of the material on payment of whatever charges as may be due to the owner. The Contractor shall abide by the revised procedure regarding royalty for materials vide G. R. Revenue and Forest Department's No. MMR/2169/15403-B dated 8/12/1970.

2.2.310 Spoil Tips on the Site

The limits of permanent spoil tips shall be as shown on the Drawings or as may be required by the Engineer for landscaping purposes. Temporary spoil tips may be used to store excavated material as required and shall be arranged by the Contractor subject to the Engineer's approved having regard to any particular requirements of the Contract.

Only material which is required by the Engineer shall be placed in the various spoil tips, topsoil being placed in separate spoil tips where so ordered. No tree trunks, stumps, roots, branches or rubbish of any kind shall be placed in spoil tips.

The Contractor shall form separate spoil tips of useful materials as follows :-

i) Good quality rubble and hardcore
ii) Khandkies and corner stones
iii) Inferior quality rubble
iv) Soft rock, earth and murrum
v) Hard rock

Permanent spoil tips shall be finished to shapes as indicated on the Drawings or as required by the Engineer. Temporary spoil tips shall be so shaped as to maintain stability and good drainage at all times.

2.2.311 Disposal of Excavated Material off Site

Excavated material which is not required for or is unsuitable for re-use in the works shall be disposed off as directed to locations designated by the Engineer (Engineer's tip). Such material shall remain the property of the Corporation and shall be transported and deposited at places designated by the Engineer. Material so deposited shall be shaped up or spread and leveled as directed by the Engineer. Any necessary work to provide access to Engineer's tips or other preliminary work in connection therewith shall be carried out by the Contractor in consultation with the Engineer and the expenses thereof shall be included in the rate quoted for the item.

2.2.312 Field drains in General Excavation

Should any existing sub-soil or field drains be uncovered during general excavation, the Contractor shall either carefully replace them when backfilling, or, if this is impracticable shall divert them to new drains or ditches, or otherwise relay them as the Engineer may direct, and all work in this connection shall be ordered by the Engineer as additional work.

2.2.313 Dewatering

All excavations shall be kept free of water. Grading in the vicinity of excavations shall be controlled to prevent tidal and surface water running into excavated areas. Contractor shall remove by pumping or other means any water inclusive of rainwater and subsoil water accumulated in excavation and keep all excavations dewatered until the foundation work is completed and backfilled. Sumps made for dewatering must be kept clear of the excavations/trenches required for further work. Method of pumping shall be acceptable to the Engineer, but in any case, the pumping arrangement shall be such that there shall be no movement of subsoil or blowing in due to differential head of water during pumping. Pumping arrangements shall be adequate to ensure no delays in construction.

When there is a continuous inflow of water and quantum of water to be handled is considered in the opinion of Engineer as large, well point system, single stage or multistage, shall be adopted. The Contractor shall submit to Engineer his scheme of well point system including the stages, the spacing, number and diameter of well points, headers etc., and the number, capacity and location of pumps for approval. Unless separately provided for in the schedule of prices, the cost of dewatering shall be included in the item rate for excavation.

2.2.314 Timber Shoring

Close timbering shall be done by completely covering the sides of the trenches and pits generally with short, upright members called ‘polling boards’. The boards shall generally be placed in position vertically side by side without any gap on each side of the excavation and shall be secured by horizontal walings of strong wood at maximum 1.2 metresspacings and suitably strutted. If the soil is very soft and loose, the shoring shall be progressively done as the excavation progress. The boards shall be placed horizontally against each side of the excavation and supported by vertical walings, which in turn shall be suitably strutted. The lowest boards supporting the sides shall be driven into the ground and no portion of the vertical side of the trench or pit shall remain exposed, so as to render the earth liable to slip out.

The shoring material shall not be of sizes less than those specified below unless steel sheet piling is used or unless otherwise approved by the Engineer in writing :

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

Timber shoring shall be ‘close’ or ‘open’ type, depending on the nature of soil and the depth of pit or trench. The type of timbering shall be as acceptable to the Engineer. It shall be the responsibility of the Contractor to take all necessary steps to prevent the sides of excavations, trenches, pits, et., from collapsing.

Timber shoring may be required to keep the sides of excavation vertical to ensure safety of adjoining structures or to limit the slope of excavations, or due to space restrictions or for other reasons. Such shoring shall be carried out, except in an emergency, only under instructions from Engineer.

The withdrawal of the timber shall be done very carefully to prevent the collapse of the pit or trench. It shall be started at one end and proceeded systematically to the other end. Concrete or masonry shall not be damaged during the removal of the timber. No claim shall be entertained for any timber, which cannot be retrieved.

In the case of open timbering, the entire surface of the side of trench or pit is not required to be covered. The vertical boards of minimum 25cm 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 spacings shall be subject to the approval of Engineer. In all other respects, specification for close timbering shall apply to open timbering.

In case of large pits and open excavations, where shoring is required for securing safety of adjoining structures, the method of shoring shall be submitted to the Engineer for his approved. If, the Engineer directs any timbering to be left-in, Contractor shall be paid for at an agreed rate for such left-in timbering.

Unless separately provided for in the Schedule of Quantities, shoring is deemed to have been included in the unit rates quoted for excavation. If separately provided in the Bill of Quantities the actual effective area of shored faces as approved by Engineer shall be measured in sq.m. All planks, boards, walings, verticals, struts, props and all other materials required for shoring and subsequent safe dismantling and removal shall be deemed to be included in the quoted unit rates.

2.2.315 Anti-termite Treatment

This part of specification covers chemical treatment of soils for the protection of builders from attack by subterranean termites.

Applicable codes

IS 6313 (Part 1) - Constructional measures

IS 6313 (Part 1) - Pre-constructional chemical treatment Measures

IS 6313 (Part 1) - Treatment for existing buildings

Materials

Chemicals toxic to subterranean termites may be used effectively to check termite infestation in the soil. Chemicals conforming to Indian standards in water emulsion shall be applied uniformly over the area to be treated.

Mound Treatment

If termite mounds are found within the plinth area, these shall be destroyed by means of insecticides in form of water suspension or emulsion which should be poured into the mounds at several places after breaking open the ear hen structure and making holes with crow bars. For a mound volume of about one cabicmetre, 4 litres of an emulsion in water of one of the following may be used:

a) 5 percent DDT

b) 0.5 percent BHC

c) 0.25 percent dieldrin

d) 0.25 percent aldrin

e) 0.5 percent heptachlor

f) 0.5 percent chlordane

Soil Treatment

Soil beneath the building and around the foundation shall be treated with soil insecticide. The purpose of treatment is to create chemical barrier between the ground from where termites come and woodwork and other cellulosic materials in the building. Any one of the following chemicals in water emulsion shall be applied uniformly over the area to be treated.

Chemical	Concentration by weight, percent
Dieldri	0.5
Aldrin (conforming to IS 1306)	0.5
Chlordane (conforming to IS 2863)	0.5
Heptachlor (conforming to IS 6432)	0.5

2.2.316 Measurement of General Excavation

Items in the Bill of Quantities for “excavations” except where expressly indicated otherwise shall apply to excavation in any material and shall include not only all works in connection with excavation and backfill but also stacking the excavated material on the Site for being used as backfill or disposing the excavated material to permanent spoil tips or to embankments all as specified.

Items for “Disposal to Engineer’s tip” measured extra over excavation items, shall include for the disposal of excavated material to any tipping location designated by the Engineer, all as specified, at a distance from the place of excavation not exceeding five kilometers. By the most direct practicable route. Material disposed off at an Engineer’s tip at a distance greater than five kilometers shall qualify for additional payment under a further E.O item for “Haulage”to Engineer’s tip in excess of five kilometers.

Items for “Excavation in Soft & Decomposed Rock or Hard Rock”, measured E.O. other excavation items, shall include for all additional work in connection with excavation in Soft & Decomposed Rock or Hard Rock and also for any allowance the Contractor considers necessary to cover overbreak and the making good thereof.

All work in connection with excavation and subsequent disposal of excavated material as specified shall be valued by measurement of such items as are set forth in the Bill of Quantities for “Excavation” and where appropriate, items for “Soft & Decomposed

Rock or Hard Rock and for disposal to the Engineer’s tips. All such measurement shall be the net volume of the material excavated to the specified levels and limits described herein or shown on the Drawings, no allowance being made for bulking. No separate payment shall be made in respect of Excess Excavation.

Anti-termite treatment shall be paid for on the basis of SQ.M of the area treated with anti-termite chemicals.

2.2.400 <u>Pipe Trenches</u>

2.2.401 <u>General</u>

Trench Excavation (as previously defined) means excavation of trenches into which pipes are to be 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 required by the Engineer. Before commencing Trench Excavation, the route of the trench shall be pegged out accurately and the ground levels shall be agreed with the Engineer. Strong sight rails shall then be fixed andd maintained at each change of gradient and at as many intermediate points as may be necessary. On these rails shall be marked the center line and the level to which the excavation is to be carried out, such rails being not more than thirty five metres apart.

2.2.402 <u>Trench Excavation Generally</u>

Trench excavation shall be carried out by such methods and to such lines, dimensions and depths as shall allow for the proper construction of the Works, provided always that, unless the Engineer permits otherwise, no Trench Excavation shall be less than 500 mm in width and no Trench Excavation for pipes larger than 200 mm diameter shall exceed the widths stated :-

(i)	excavation in firm ground or soft rock, no shoring required	D + 1000 mm
(ii)	excavation in soft ground or any conditions requiring shoring	D + 1400 mm
(iii)	excavation in Rock	D + 1000 mm

Where D is the inside diameter of the pipe in mm.

Notwithstanding the foregoing, any Hard Rock in Trench Excavation shall be so excavated that the clearance between the pipe when laid and the Hard Rock sides and bottom of the trench is kept to the minimum limits necessary to provide for the specified thickness of bedding haunching and surround to the pipe. Any excavation outside these limits whether for working space or due to overbreak shall be held to be Excess Excavation.

The sides of Trench Excavation shall be vertical unless the Engineer permits otherwise.

Any widening or deepening of Trench Excavations necessary to accommodate curves, joints or bends in the pipe as shown on the drawings or when ordered by the Engineer shall be held to be general excavation but that required by the Contractor to provide extra working space for the construction thereof shall be held to be Excess Excavation.

For the purpose of measuring certain work in connection with Trench Excavation, “nominal limits” of Trench Excavation and any excavation outside these limits, which has not been ordered by the Engineer, shall be held to be Excess Excavation.

No length of Trench Excavation shall be started until the pipes to be laid in that length are available on the Site.

2.2.403 Trial Pits or Trenches

The Engineer may require trial pits or trenches be excavated well ahead of the trench excavation to such depths as he shall order to determine the alignment for the trench.

Any further trial pits or trenches required by the Contractor to determine the position of underground services, sub-soils, drains or for any other reason shall be excavated and reinstated at the Contractor’s expense.

The Contractor shall arrange for the refilling and reinstatement of trial pits or trenches to be carried out immediately after the required information is obtained. The reinstatement of the surfaces of trial pits or trenches shall be carried out to the approval of the Engineer.

2.2.404 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 width of the carriageway shall be obstructed at a time. Road drains and grips shall be kept free from obstruction. In a event the Contractor shall take special precautions, which shall include the continuous support of the sides of the excavation, from the time when 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 grass margin or road pavement, the margin or road pavement shall on completion of refilling be restored entirely to its original condition and left free from loose stones.

2.2.405 Trench Excavation in Fields etc.

The term “fields” includes fields, moorlands, grass verges 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 Engineer permits otherwise. Temporary fencing shall not be removed without the Engineer’s permission which will not normally be given until the Trench Excavation has been refilled and reinstated to the original ground condition or as directed by the Engineer.

The Contractor shall have particular regard to the safety of livestock in fields or which may be introduced to the fields, and shall ensure that all open excavations, access routes and steep or loose slopes arising from the Contractor’s operations in these fields are adequately fenced and protected.

After the erection of temporary fencing Contractor shall remove Topsoil to such depth and over such areas as may be necessary to provide sufficient material to ensure adequate surface reinstatement of the working areas occupied by the Contractor for construction of the pipeline.

2.2.406 Soft & Decomposed Rock and Hard Rock in Trench Excavation

Any material in trench Excavation which the Contractor considers may be classified as Soft & Decomposed Rock or Hard Rock shall be notified to the Engineer before excavation of the material is begun. The quantities of this material excavated from within the nominal limits of Trench Excavation shall be recorded and the record signed by the Engineer and Contractor each day or at such shorter intervals as the Engineer may require. Only such proportion of material so notified and recorded as the Engineer classifies as Soft & Decomposed Rock or Hard Rock shall qualify for payment under respective items of BOQ. Overbreak shall be kept to a minimum and shall be held to be Excesss Excavation.

2.2.407 Supporting Trench Excavations

The Contractor shall well and effectually the sides of Trench Excavation 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 such extra excavation shall be held to be Excess Excavation.

Where the Contractor elects and is permitted by the Engineer to execute. Trench Excavation with battered sides instead of providing support as aforesaid they shall be excavated to stable slopes and heights and the resulting extra excavation shall be held to be Excess Excavation.

2.2.408 Trimming Trench Excavations

When excavating to specified levels for Trench Excavation or to specified limits for the face of any structure therein required to about undisturbed ground, the Contractor shall not excavate the last 150 mm until immediately before commencing constructional work except where the Engineer permits otherwise. Should the Contractor have excavated to within 150 mm above these specified levels or to within 150 mm of these specified limits before he is ready to able to commence the constructional work he shall where required by the Engineer excavate further so as to remove not less than 150 mm of material immediately before commencing the constructional work and any such further excavation shall be held to be Excess Excavation.

Where no bedding material is specified 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 then 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 of greater than 20 mm in size shall be picked out of 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 specified, all shattered and loose material shall be removed from the bottom of the Trench Excavation so that the bedding material rests on a solid and clean foundation.

2.2.409 Inspection by Engineer

When the specified levels of Trench Excavation are reached the Engineer will inspect the ground exposed and if he considers that any part of the ground is by its nature unsuitable he may direct the Contractor to excavate further and to refill the further excavation with such material as he may direct but such further excavations shall not be held to be Excess Excavation.

Should the bottom of any Trench Excavation while acceptable to the Engineer at the time of his inspection subsequently become unacceptable 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. Such further excavation shall be held to be Excess Excavation.

2.2.410 Disposing Material from Trench Excavations

Subject to any specified requirements of the Contract, the Contractor shall make his own arrangements for the temporary storage of any excavated material which is required for use in refilling Trench Excavations, including any necessary double handling. In this connection the Contractor shall have regard to the working areas available to him for the construction of the pipeline particularly where this is located in roads or in other places to which the public has free access. Any temporary tips alongside the Trench Excavations shall be to stable slopes and heights.

Where the nature of the excavated material is suitable the Contractor's temporary storage as aforesaid shall include for the separate storage as the Engineer may direct of any of the various grades of material hereinafter specified for the refilling and surface reinstatement of Trench Excavation, namely, soft material, coarse material, hard material and topsoil.

Any excavated material not required for or not suitable for use as refilling as aforesaid or for use elsewhere in the Works shall become property of the Corporation and shall be dealt with .

2.2.411 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 reasonable practicable after the pipes have been laid and jointed.

Pipelaying 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 Excavation may become flooded, and these precautions may include the partial refilling of the trench leaving pipe joins exposed while awaiting tests of the joints.

If the Engineer 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 Excavations.

2.2.412 Refilling Trench Excavation

Trench excavations shall normally be refilled using suitable materials selected from excavations carried out within 300 meters of the length to be refilled. Special requirements for bedding and backfilling around thin walled pipes are given in part 4 Clause 1.11.

Soft material (free from stones greater than 75mm in size for pipes without bitumen sheathing and 20 mm in size for pipes with bitumen sheathing) shall be deposited in 150mm layers and thoroughly rammed under and around the pipe with suitably shaped rammers working alternately 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 up to the crown of the pipe and thereafter until the soft filling has been carried up at least 300mm above 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 Engineer, sufficiently dense to prevent materials 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 225mm 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 further 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 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 compacting of the material.

Should the material being placed as refilling, while acceptable at the time when approved, become unacceptable to the Engineer due to exposure to weather conditions or due to flooring or have become puddled, soft or segregated during the progress of the Works, the Contractor shall at his own expense remove such damaged, softened or segregated materials ands replaced it with fresh approved material.

Where directed by the Engineer, Trench Excavations shall be refilled with concrete.

2.2.413 Soft Refill Material Special Measures

Where in the opinion of the Engineer, sufficient supplies of the aforesaid soft material for trench refilling cannot reasonably be obtained from trench Excavations within three hundred meters of the length of trench to be refilled without resorting to sieving or other special means, then the Engineer may order the Contractor.

(a) to carry out such work as may be necessary to sieve out stones, or

(b) to transport suitable soft materials from Trench Excavations at distances greater than three hundred meters from the length to be refilled ("overhaul"), or

(c) to excavate soft material from suitable borrow areas and transport it to the length of trench to be refilled.

The Contractor shall carry out any or all of these above-mentioned items as directed by the Engineer.

2.2.414 Surface Reinstatement in Fields, etc.

After he has refilled Trench Excavations in fields and grass verges in the manner and to the level specified, the Contractor shall replace all Topsoil 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.

2.2.415 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 subgrade level of the adjacent road surface. The balance portion including surface pavements shall be made good with similar material as that of the adjacent road, and shall be so maintained (including topping up when necessary) until the end of the Defects Liability Period or until remain over for permanent reinstatement by the appropriate authority, or, taking over certificate whichever is sooner.

2.2.416 <u>Other Structures along the Pipeline</u>

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

2.2.417 <u>Land Drains</u>

Where land drains, mole drains or field drains are severed by Trench Excavation they shall be kept in effective temporary operation during construction of the pipeline.

At the appropriate stage of refilling the Trench Excavation, the drains shall be permanently restored as follows :-

The drain on either side of the Trench Excavation shall be cut back for at least 300 mm and a suitable length and diameter of pitch fiber or other approved pipe shall be jointed to the existing drain and laid resting at the ends on solid ground with clay or other stopping to prevent the subsequent run of land drainage water into the pipe trench. During trench refilling, earth shall be carefully placed and thoroughly compacted under the drainpipes to give them adequate support.

2.2.418 <u>Existing Service</u>

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 Engineer, 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 Engineer, 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 positions of all mains, pipes and cables whether underground or overhead, within or near the Site.

2.2.419 <u>Hedges, Fences and Walls</u>

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 Engineer may order for permanent restoration of such barriers.

2.2.420 <u>Crossing Watercourses etc.</u>

Where the pipeline crosses rivers, culverts and other watercourses, 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.

2.2.421 <u>Measurement of Trench Excavation</u>

Items for Trench Excavation shall apply to excavation in any material and shall include not only for all work in connection with excavation including timber shoring but also for refilling of trenches and for disposal of surplus material, for temporary fencing and, in fields, for the stripping and subsequent reinstatement of the top surface all as specified. Disposal of surplus excavated material shall be as specified.

The depth of Trench Excavation shall be measured vertically from the original ground level or, where appropriate, from the ground level remaining after the completion of any general excavation or filling down to the specified invert level of the pipe plus the thickness of the pipe plus, where appropriate, the specified thickness of bedding for the pipe.

For the purpose of measuring quantities of other items additional to Trench Excavation (such as Incidental Excavation, surface reinstatement, land drains and services) Trench Excavations shall be deemed to be of the nominal dimensions stated below :-

(a) The nominal depth shall be depth as defined in the preceding paragraphs.

(b) The nominal width shall be as set out .

The sides of Trench Excavation shall be deemed to be vertical and the nominal widths shall apply to any depth of trench and whether or not bedding or surround to the pipe is specified.

Storing and dewatering shall be deemed to be included in the unit rates quoted for trench excavation unless separately provided for in the schedule of quantities.

Trench Excavation and all work is connection therewith as specified shall be valued by the measurement only of such items as are set forth in the Bill of Quantities except where expressly provided for otherwise by the inclusion in the Bill of Quantities of any of the following further items :

<u>Incidental Excavation for trial pits and trenches</u> ordered by the Engineer shall be measured as the volume excavated and shall include for supporting the excavation and for refilling the trial pits and trenches and, where in fields, for surface reinstatement.

<u>Incidental Excavation for structures</u> situated in the pipeline shall be measured only to the extent that the net excavation required to accommodate the structure falls outside the nominal dimensions of the Trench Excavation.

<u>Incidental Excavation for removal of unsuitable material</u> shall (unless it is held to be Excess Excavation) be measured as the volume ordered by the Engineer to be excavated beyond the nominal dimensions of Trench excavation and shall include for the disposal of the excavated material.

<u>Soft & Decomposed Rock or Hard Rock,</u> measured E.O. Trench Excavation items, shall include for all additional work in connection with excavation in Soft & Decomposed Rock or Hard Rock and within the nominal limits of Trench Excavation in rock. Items for E.O. Incidental Excavation shall be measured similarly.

<u>Excess Excavation</u> and the backfilling thereof shall not be measured for payment.

<u>Concrete refill</u>(excluding bedding and surround) to such lengths of Trench Excavation as may be ordered by the Engineer shall be measured as the volume of concrete required to fill such lengths to the depth ordered and to the nominal width of the trench, a deduction having been made for the volume occupied by the pipe, and shall include for any shuttering required and for disposal of additional surplus material.

Concrete bedding and surround to pipes shall be measured as indicated under Pipelines.

Imported or sieved bedding to pipes shall be measured as indicated under Pipelines.

Granular bedding and surround to thin walled pipes shall be measured as under Pipelines.

Surface reinstatement of Trench Excavations in roads and in footpaths as specified shall be measured as the area calculated by multiplying the length of the Trench Excavation to be so reinstated by its nominal width. The stripping of the top surface and the surface reinstatement of Trench Excavation in fields shall be included in Trench Excavation and shall not be separately measured.

Crossing land drains shall include for all temporary and permanent measures for dealing with land drains and the like as specified and shall be measured as the length of land drains so dealt with within the nominal width of Trench Excavation.

Crossing services shall include for all temporary measures for dealing with service pipes and cables of any size as specified and shall be measured as the length of such services so dealt with within the nominal width of Trench Excavation. Any permanent measures required by the Engineer shall be ordered by him as additional work.

Crossing hedges, fences and walls shall include for all temporary measures for dealing with such barriers as specified and shall be measured as the length of such barriers so dealt with within the nominal width of Trench Excavation. Any permanent measures required by the Engineer shall be ordered by him as additional work.

Crossing rivers, culverts and other watercourses shall include for all additional measures necessary to make the crossings as specified. Only such crossings as may be itemized in the Bill of Quantities will be measured (E.O. Trench Excavation) for additional payment.

Overhaul of refill material (E.O. Trench Excavation or Excavation in borrow areas) shall apply in cases where the Engineer orders refill material to be transported from locations of excavation which are more than three hundred metres from the length of trench to be refilled, the”overhauldistance”being the distance in excess of three hundred metres.

Sieving of refill material where ordered by the Engineer shall include for transporting the refill material a distance of up to three hundred metres to the length of trench to be backfilled.

PART 2

SECTION 3

CONCRETE AND ALLIED WORKS

2.3 CONCRETE AND ALLIED WORKS

2.3.1 Scope

This specification covers the general requirements for concrete to be used on jobs using on-site production facilities including requirements in regard to the quality, handling, storage of ingredients, proportioning, batching, mixing and testing of concrete and also requirements in regard to the quality, storage, bending and fixing of reinforcement. This also covers the transportation of concrete from the mixer to the place of final deposit and the placing, curing protecting, repairing and finishing of concrete.

2.3.2 Applicable Codes and Specifications

The following specifications, standards and codes are made a part of this specification. All standards, tentative specifications, specifications, codes of practice, referred to herein shall be the latest editions including all applicable official amendments and revisions.

In case of discrepancy between this specification and those referred to herein this specification shall govern.

a) **Material**

1) IS 269 - Specification for 33 grade ordinary Portland cement.

2) IS 8112 - Specification for 43 grade ordinary Portland cement.

3) IS 12269 - Specification for 53 grade ordinary Portland cement.

4) IS 455 - Specification for Portland slag cement.

5) IS 12330 - Specification for sulphate resisting Portland cement.

6) IS 1489 (Parts 1 & 2) - Specification for Portlandpozzolana cement.

7) IS 4031 (Parts 1 to 15) - Methods of physical tests for hydraulic cement.

8) IS 650 - Specification for standard sand for testing cement.

9) IS 383 - Specification for coarse and fine aggregates from natural sources for concrete.

10) IS 2386 (Parts 1 to 8) - Methods of test for aggregates for concrete.

11) IS 516 - Method of test for strength of concrete.

12) IS 1199 - Methods of sampling and analysis of concrete.

13) IS 2062 - Steel for general structural purposes.

14) IS 3025 - (Parts 1 to 49) Methods of sampling and test (physical and chemical) for water and wastewater.

15) IS 432 - (Parts 1 & 2) - Specification for mild steel and medium tensile steel bars and hard-drawn steel wire for concrete reinforcement.

16) IS 1566 - Specification for hard-drawn steel wire fabric for concrete reinforcement.

17) IS 4990 - Specification for plywood for concrete shuttering work.

18) IS 2645 - Specification for integral cement waterproofing compounds.

19) BS 4449 - Specification for carbon steel bars for the reinforcement of concrete.

20) IS 10262 - Recommended guidelines for concrete mix design.

21) SP 23 - Handbook on concrete mixes (based on Indian Standards).

22) IS 458 - Specification for precast concrete pipes (with and without reinforcement).

23) IS 1786 - Specification for high strength deformed steel bars and wires for concrete reinforcement.

24) IS 13620 - Fusion Bonded Epoxy Coated Reinforcing Bars- Specification

25) IS 1893 - Criteria for Earthquake Resistance Design of structures

26) IS 13290 - Code of Practice for Earthquake Resistance Design and Construction of Buildings

b) **Equipment**

1) IS 1791 - Specification for batch type concrete mixers.

2) IS 2438 - Specification for roller pan mixer.

3) IS 2505 - Specification for concrete vibrators-immersion type-general requirements.

4) IS 2506 - Specification for general requirements for screed board concrete vibrators.

5) IS 2514 - Specification for concrete vibrating tables.

6) IS 3366 - Specification for pan vibrators.

7) IS 4656 - Specification for form vibrators for concrete.

8) IS 2722 - Specification for portable swing weigh batchers for concrete (single and double bucket type)

9) IS 2750 - Specification for steel scaffoldings.

c) **Codes of Practice**

1)	IS 456	-	Code of practice for plain and reinforced concrete.
2)	IS 1343	-	Code of practice for prestressed concrete.
3)	IS 457	-	Code of practice for general construction of plain and reinforced concrete for dams and other massive structures.
4)	IS 3370 (parts 1 to 4)	-	Code of practice for concrete structures for the storage of Liquids.
5)	IS 3935	-	Code of practice for composite construction.
6)	IS 3201	-	Criteria for design and construction of precast trusses and purlins.
7)	IS 2751	-	Recommended practice for welding of mild steel plain and deformed bars for reinforced construction.
8)	IS 9417	-	Recommendations for welding cold worked steel bars for reinforced concrete construction.
9)	IS 2502	-	Code of practice for bending and fixing of bars for concrete reinforcement.
10)	IS 3558	-	Code of practice for use of immersion vibrators for consolidating concrete.
11)	IS 3414	-	Code of practice for design and installation of joints in buildings.
12)	IS 4014 (parts 1 & 2)	-	Code of practice for steel tubular scaffolding.
13)	IS 2571	-	Code of practice for laying in-situ cement concrete flooring.

d) **Construction Safety**

1)	IS 3696 (Parts 1 & 2)	-	Safety code of scaffolds and ladders.
2)	-	-	Safety Manual, Central Water & Power Commission Ministry of Irrigation & Power, Govt. of India.

e) **Measurement**

IS 1200 (Parts 1 to 28)	-	Methods of measurement of building and civil engineering works.

2.3.3 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 Engineer shall have the right to inspect the source/s of meterial/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 the Engineer’s approval obtained, prior to starting of concrete work.

2.3.4 Materials for Standard Concrete

The ingredients to be used in the manufacture of concrete shall consist solely of ordinary Portland cement clean water, and admixtures, if specifically called for on drawings or specifications, or due to conditions at site warranting the use of it.

a) **Cement**

Unless otherwise specified in the Bill of Quantities or called for by the Engineer, cement shall be ordinary portland cement in 50 kg. bags conforming to IS 269 or IS 8ll2 or IS 12269. The use of bulk Cement will be. permitted only with the approval of the Engineer Changing of brands or type of cement within the same structure shall be avoided as far as possible. If site condition demand, Sulfate Resisting Cement conforming to IS 12330 may have to used.

A certified report attesting to the conformance of the cement to. IS specifications by the cement. manufacturer's chemist shall be furnished., to the Engineer, at least seven days prior to use in the works.
Following brand cement shall be preferred
L&T Cement ACC
Cement AMBUJA
Cement BIRLA
Cement
BINANI Cement

The contractor shall have to make his own arrangements for the procurement and storage of adequate quantity of cement. Cement in bulk may be stored in bins or silos, which will provide 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 ground and so arranged as to provide ready access. Damaged or reclaimed or partly set cement shall not be permitted to be used and shall be removed from the site. The storage bins and storage arrangements shall be such that there is no dead storage. Not more than 12 bags shall be stacked in any tier. The storage arrangement shall be approved by the Engineer. Consignments of 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 Engineer have reasons to consider that any cement is defective, then irrespective of its origin, date of manufacture and/or manufacturer's test certificate, such cement shall be tested. immediately at Contractor's cost at any approved test 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) “Aggregate" in general designates both fine and coarse inert materials used in the manufacture of concrete.

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

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

An fine and coarse aggregates proposed for use in the work shall be subject to the Engineer'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 Engineer.

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 sirength and/or durability of concrete. The grading of aggregates shall be 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.

Sampling and Testing

Samples of the aggregates for mix design and determination of suitability shall be taken under the supervision of the Engineer and delivery 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 the Engineer in advance of the work for use in determining aggregate suitability. These tests shall also be done periodically on samples of material actually being used in concreting during course of concreting operations; as directed by the Engineer. The costs of all such tests, sampling, etc., shall be borne by the Contractor.

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 aggregate from bins or stock piles. Coarse aggregate shall be piled in layers not exceeding l.20 metres in height to prevent coning or segregation, Each layer 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.

Specific Gravity

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

2.3.5 Fine Aggregate

Fine aggregate except as noted above, and for other than lightweight concrete shall consist of natural or crushed sand conforming to IS 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 fractions.

c) **Foreign Material Limitations**

The percentages of deleterious substances in substance in sand delivered to the mixer shall not exceed the following :

Table 2.3.A

	Foreign Material	Percent by weight Uncrushed	Crushed
i)	Material finer than 75 micron IS 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) **Grading**

Unless otherwise directed or approved, the grading of sand shall be within the limits indicated hereunder :

Table 2.3.B

PERCENTAGE PASSING FOR

IS Sieve Designation	Grading Zone I	Grading Zone II	Grading Zone III	Grading Zone IV
10mm	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
1.18mm	30- 70	55- 90	75-iOO	90-100
600 micron	15- 34	35- 59	60- 79	80-100
300 micron	5- 20	s- 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 IS 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 beused unless mix designs and preliminary tests have shown its unsuitability 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 4.2. The-fineness modulus is determined by adding the cumulative percentages. retained on the following IS sieve sizes (4.75 mm. 2.36 mm, 1.18 mm, 600 micron, 300 micron and 150 micron) and dividing the sum by 100.

2.3.6. Coarse Aggregate

Coarse aggregate for concrete, except noted above and for other than lightweight concrete 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 demanded by the Engineer.

b)**Grading**
Coarse aggregate shall be either in single size or graded. In both cases, the grading shall be within the following limits:

Table 2.3.C

IS Sieve Designation	Percentage passing for single sized aggregate of nominal size					Percentage passing for graded aggregate of nominal size			
	40mm	20mm	16mm	12.5mm	10mm	40mm	20mm	16mm	12.5
63 mm	100	-	-	-	-	100	-	-	-
40 mm	85-100	100	-	-	-	95-100	100	-	-
20mm	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
10mm	0-5	0-20	0-30	0-45	85-100	10-35	25-35	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 conical 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 Engineer; affect adversely the strength and/or durability of concrete. Tile maximum size of coarse aggregate shall be 40 mm for M15 to M30.concrete and 20 mm for M35 and M40 concrete, or as directed by the Engineer or specified otherwise. The maximum size specified above, but in no case greater then ¼ of the minimum thickness of the member, provided that the concrete can be placed without difficulty so as to surround all reinforcement thoroughly and fill the corners of the form. 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 the Engineer. Forheavily 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 nun 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 IS 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 IS 2386.

c) **Foreign Material Limitations**

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

Table 2.3.D

	Foreign Material	Percent by weight Uncrushed	Crushed
i)	Material finer than 75 micron IS 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

2.3.7 Water

Water used for washing, mixing and curing shall be free from injurious amounts of deleterious materials. Potable waters are generally satisfactory for mixing and curing concrete.

In cease of doubt, the suitability of water for making concrete shall be ascertained by the compressive strength and initial setting time test specified in IS 456. The sample of Water taken 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 feast three 15 cm concrete cubes prepared with water proposed to be used shall not be less than 90% of the average strength of three similar concrete cubes prepared with distil1ed water. The cubes shall be prepared, cured and tested in accordance with the requirements of IS 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 mil1Utes and shall not differ by more than 30 minutes from the initial setting time of control test blocks prepared with the appropriate test cement and distilled water. The test blocks shall be prepared and tested in accordance with the requirements of IS 4031.

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

(a) To neutralise 200 ml. sample of water, using Phenolphthalein as indicator it should not require more than 2 ml. of 0.1 NormalNaOH. The details of test shall be as given in IS 3025.

(b) To neutralise 200 ml. sample of water, using methyl orange as an indicator, it should not require more than 10 ml. of 0.1 NormalHCl. The details oftest shall be as given in IS 3025.

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

Table 2.3.E

Solids	Percent	Method of Test (Ref. Clause in IS 3025)
Organic	0.02	10 and 11 (organic solids total solids minus ignited residue)
Inorganic	0.30	11 (ignited residue)

Sulphates	0.05	20
Alkali Chlorides (as Cl)	0.20	24
Suspended matter	0.20	

(d) The pH value of water shall not generally be less than 6.

2.3.8. Steel Shapes Encased in Concrete

Structural steel columns, beams, girders and bracings to be encased in concrete shall be unpainted, if so indicated on the drawings. The encasing shall be done in concrete of gradeM15 with 10 mm maximum size. aggregate unless otherwise specified in drawings. The steel member shall be, wrapped with galvanised wire mesh of the size indicated on the drawings. The galvanised wire mesh shall be kept 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 75 mm, mild steel bars and concrete with 20 mm coarse aggregate shall be used.

2.3.9 Standard 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 in grades as designated in the following table:

Table 2.3.F

Grade of Concrete	Minimum Compressive At 7 Days (N/mm^2)	Strength Specified Characteristic Compressive Strength At 28 Days (N/mm^2)
40	27	40
35	23.5	35
30	20	30
25	17	25
20	13.5	20
15	10	15
10	7	10

Notes : 1) It shall be very clearly understood that whenever the grade of concrete such as M20, M25, etc. is specified, it shall be the Contractor's responsibility to ensure that specified crushing strength" stipulated for the respective grade of concrete is obtained at works.

2) Minimum content in grade M20 concrete, irrespective of the size of aggregate used, shall be 330 kg/m^3 for all structures.

3) The minimum cement content stipulated above shall be adopted irrespective of whether the Contractor achieves the desired strength with less quality of cement. The Contractor’s quoted rates for concrete shall provide for the above eventuality and nothing extra shall become payable to the Contractor on this account. Even in the case where the quantity of cement required is higher than that specified above, nothing extra shall become payable to the Contractor.

2.3.10 Mix Design

a) General

This is to investigate the grading of aggregates water-cement ratio, and the quantity of cement required to give desirable workability ,and the characteristic strength not less than appropriate values as per Table 2.3 F. The proportions of the mix shall be determined by weight. Adjustment of aggregate proportions due to moisture present in the aggregate shall be made. Mix design shall done as per the recommended procedure laid down in IS 10262.

Whenever there is a change in water-cement ratio or workability or the source of aggregates and/or cement, preliminary tests shall be respected 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 shall be derived from Fig.2 of IS 10262 showing the relationship between the 28-day compressive strengths of concrete mixes with different water-cement ratios and the 28 day compressive strength of cement tested in accordance with IS 4031.

b) **Preliminary Test**

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 the Contractor's sole responsibility to carry out these tests and he shall therefore furnish to the Engineer 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 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 IS 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 color. The coarse aggregate shall than be added, mixed and water added and the whole batch mixed thoroughly for a period of not less than two minutes until the resulting concrete is uniform in appearance. Each batch of 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 IS 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 strength tests of concrete cubes shall be made as per IS 516 on 15 cm cubes. Each mould shall be provided with a metal base plate having a plane surface so as to support the mould during filling without leakage. The base plate shall be preferably attached to the mould by spring or screws. The parts of 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 plates of mould shall be 90+0.5 degrees. The internal faces of the mould shall be plane surfaces 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 IS 516.

(v) Curing

Curing shall be as specified in IS 516. The cubes shall be kept in moist air of at least 99% relative humidity at a temperature of 27^0C 2: 2^0C for 24 hours +1/2 hour from 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 27^0C + 2^0C temperature until required for test. Curing water shall be renewed every seven days. A record of maximum and minimum temperatures at the place of storage of the cubes shall be maintained during the period they remain in storage.

(vi) Trial Mixes

The mix proportion for a given grade of concrete, calculated, in accordance with IS 10262, shall be checked by means of trial batches. The quantity of materials of each trial shall be sufficient for at least three cube test specimens and for carrying out workability test according to IS 1199. The procedure for trial mixes shall be as per Clause 4 and APPENDIX D of IS 10262.

2.3.11 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 and fine and coarse aggregates shall be maintained during subsequent concrete batching by means of weights batchers comforming to IS2722 capable of controlling the weights within one percent of the desired value . Except where it can be shown to the satisfaction of the Engineer that the supply of properly graded aggregates of uniform, quality can be maintained over the period of work, the grading of aggregates shall be controlled by obtaining the coarse aggregate in different size and blending them in the right proportions. The different sizes shall be stocked in separate stock piles. The grading of coarse and fine aggregates shall be checked as possible, as determined by the Engineer, to ensure maintaining of grading in accordance with the samples used in preliminary mix design. The material shall be stock piled 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 aggregate 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 segregation of materials or the collection of excessive free water on the surface or 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 or 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 Engineer.

vi) **Proportioning Water Cement Ratio**

The W-C ratio specified for use by the Engineer shall be maintained. The Contractor shall determine the water content of the aggregates as frequently as directed by the Engineer as the work progresses and as specified in IS-2386 (Part 3) and the amount of mixing water added at the mixer shall be adjusted as directed by the Engineer 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 a 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 IS 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 Engineer :

Table 2.3.G

SLUMPS FOR VARIOUS TYPES OF CONSTRUCTION

Item of Work	Slump in millimeters (Maximum)	(Minimum)
Reinforced foundation walls and footings	75	25
Plain footings and substructure walls	75	25
T.G. and massive foundations	50	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 project and shall not be changed except when specifically permitted by the Engineer.

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 shall be loaded evenly. The needle shall be adjusted to zero when the hopper is empty. Fine and coarse aggregates shall be weighed separately. Volume batching will not be permitted. However, the Engineer may permit volume batching by subsequent conversion of the weights of the aggregates into their equivalent volumes knowing their bulk densities, only in the case of small and less important pours involving concrete of not more than 0.25 cubic metres on days when other 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 IS: 1791 and of the approved make with suitable provision for correctly controlling the water delivered to the drum. The quantity of the water actually entering the drum shall be checked with the reading of the gauge or valve setting, when starting a job. The tests 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 2 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.

2.3.12 <u>Sampling and Testing Materials and Corporate in the Field</u>

Facilities required for sampling materials and concrete in the field, if the Engineer so desires, shall be provided by the Contractor at no extra cost. The following equipment with operators shall be made available at the Engineers request (all must be in serviceable condition) :

1.	Concrete cube testing machine suitable for 15 cm cubes of 100 tonnes capacity with proving calibration ring	1 No.
2.	Cast iron cube moulds 15 cm size	6 Nos. (minimum)
3.	Slump cone complete with tamping rod	1 set
4.	Laboratory balance to weigh uptc 5 kg. with sensitivity of 10 gm. .	1 No.
5.	ISsieves for coarse and fine aggregates	1 Set.
6.	Set of measures from 5 litres to 0.1 litre	1 Set
7.	Electric oven with thermostat upto I20C	1 No.
8.	Flakiness gauge	1 No.
9.	Elongation index gauge	1 No.
10.	Sedimentation pipette	1 No.
11.	Pycnometer	1 No.
12.	Calibrated glass jar (1 Hire capacity)	2 Nos.
13.	Glass flasks and metal containers	As req ıired
14.	Chemical reagents like sodiumhydroxide, tannic acid, litmus papers, etc.	As required
15.	Laboratory balance of 2 Kg. capacity and sensitivity of 1 gm.	1 No.

Note : Arrangement can be made by the Contractor to have the cubes tested in an approved laboratory in lieu of a testing machine at site at bis expense, with the prior consent of the Engineer.

a) **<u>Municipal Testing Laboratory</u>**

The Municipal Materials Testing Laboratory is presently located at Lovegrove Pumping Station, Dr. Annie Besant Road, Worli. The Contractor shall bear the cost of delivering the samples, including test cubes, to the Laboratory and shall pay the normal fee for tests. Concrete cube moulds are usually available for hire, if required. The Contractor shall, if required, remove all debris, scrap and unused test-pieces arising from this Contract from the laboratory and dispose them off.

b) **Sampling and Strength Test of Concrete**

The sampling and Testing of strength of concrete shall be carried out in accordance with Clause 14 of IS: 456.

c) **Consistency**

Slump tests shall be carried out as often as demanded by the Engineer and invariably from the same batch of concrete from which the test cubes are made. Slump tests shall be done immediately after sampling.

2.3.13 Admixtures

a) **General**

Admixtures may be used in concrete only with approval of Engineer based upon evidence that, with the passage of time, neither the compressive strength nor its durability be reduced. Calcium chloride shall not be used for accelerating set of the cement for any concrete containing, reinforcement, or embedded steel parts. When calcium chloride is permitted 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 l.5 percent of the weight of the cement in each batch of concrete. When admixtures are used, the designed concrete mix shall be corrected accordingly. Admixture shall be used as per manufacturer's instructions and in the manner and with the control specified by the Engineer.

b) **Air Entraining Agents**

Where specified and approved by the Engineer, 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 G260 "Air Entraining Admixtures for Concrete." The recommended total air; content of the concrete is 4% $\pm$ 1%. The method of measuring air content shall be as per 1S 1199.

c) **Water Reducing Admixtures**

Where specified and approved by the Engineer, water reducing lignosulfonate mixture shall be added in quantities specified by the Engineer. The admixture shall be added in the form of a solution.

d) **Retarding Admixtures**

Where specified and approved by the Engineer, retarding agents shall be added to the concrete mix in quantities specified by the Engineer.

e) **Waterproofing Agents**

Where specified and approved by the Engineer, waterproofing agent conforming to IS 2645, shall be added in quantities specified by the Engineer in accordance with the manufacturer's recommendation but not exceeding 3% by weight of cement.

f) **Other Admixtures**

Engineer may at his discretion instruct the Contractor to use any other admixture in the concrete.

2.3.14 Optional Tests

The Engineer, if he so desires, may order tests to be carried out on cement, sand, coarse aggregate and water in accordance with the relevant Indian Standards. Test on cement shall include (i) fineness tsst, (ii) test for normal consistency, (iii) test for setting time, (iv) test for soundness, (v) test for tensile strength, (vi) test for compressive strength. Tests on sand shall include (i) sieve test, (ii) test for organic impurities, (iii) decantation test for determining clay and silt content, (iv) specific gravity test, (v) test for unit weight and bulkage factor, (vi) lest for sieve analysis and fineness modulus. Tests on coarse aggregate shall include (i) sieve analysis, (ii) specific gravity and unit weight of dry, loose and rodded aggregate, (iii) soundness and alkali aggregate reactivity, (iv) petrographic examination, (v) content of deleterious materials and organic impurities, (vi) test for aggregate crushing value. Any or all these tests shall normally be ordered to be carried out only if the Engineer feels the materials are not in accordance with the specifications or if the specified concrete strengths are not obtained and shall be performed by the Contractor at an approved test laboratory. The Contractor shall bear the charges of-these optional tests.

If the works cubes do not give the stipulated strengths, the Engineer reserves the right to ask the Contractor to dismantle such portions of the work, which in his opinion are unacceptable, and to reconstruct to the standard stipulated at the Contractor's cost. The unit rate for concrete shall be all inclusive, including making preliminary mix design and test cubes, works cubes, testing them as per specifications, slump tests, optional tests etc., complete.

Load Test on Members or Any Other Tests

In the event of any work being suspected of faulty material or workmanship or both, the Engineer requiring its removal and reconstruction may order, or the Contractor may request that it should be load tested in accordance the following provisions:

The test load shall be 125 percent of the maximum superimposed load for which the structure was designed. Such test load shall not be applied before 56 days after the effective hardening of concrete. During the test, struts strong enough to take the whole load shall be placed in position leaving a gap under the members. The test load shall be maintained for 24 hours before removal.

If within 24 hours of the removal of the load, the structure does not show a recovery of at least 75 percent of the maximum deflection shown during the 24 hours under load, the test loading shall be repeated after a lapse of at least 72 hours. The structure shall be considered to have failed the test if the recovery after the second test is not at least 75 percent of the maximum deflection shown during the second test. If the structure is certified as failed by the Engineer, the cost of the load test shall be borne by the Contractor.

Any other tests, e.g. taking out in an approved manner concrete cores, examination and tests on such cores removed from such parts of the structure as directed by the Engineer, sonic testing, etc., shall be carried out by the Contractor if so directed, at no extra cost.

Unsatisfactory Tests

Should the results of any test prove unsatisfactory, or the structure shows signs of weakness, undue deflection or faulty construction, the Contractor shall remove and rebuild the member or members involved or carry out such other remedial measures as may be required by the Engineer. The Contractor shall bear the cost of so doing, unless the failure of the member or members to fulfill the test conditions is proved to be solely due to faulty design. The cost of load and other tests shall be horns by the Contractor it the tests show unsatisfactory results.

2.3.15 Concrete in Alkali Soils and Alkaline Water

Where concrete is liable to attack from alkali salt or alkaline water special cements containing low amount of tricalciumaluninate shall be used, if so specified on the drawings. Such concrete shall have a minimum 28 days compressive strength of 25 N/mm^2 and shall contain not less than 370 Kg of cement per cubic metre of concrete in place. If specified, additional protection shall be obtained by the use of a chemically resistant stone facing or a layer of Plaster of Pans covered with suitable fabric, such as jute thoroughly impregnated with tar.

2.3.16 Preparation prior to Concrete Placement

Final Inspection and approval

Before the concrete is actually placed in position, the insides ofthe 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 easily. Such openings/holes shall besuitably plugged later.

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 embedments to be provided in the concrete as indicated on the drawings or as is necessary for the proper execution of the work. The Contractor shall co-operate fully with all such agencies and shall permit the use of scaffolding, from work, etc., by other trades at no extra rust.

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

All anchor bolls shall be positioned and kept in place with the help of properly manufactured templates unless specifically waived in writing by the Engineer. The use of all such templates, fixtures, etc. shall be deemed to be included in the rates.

Slots, openings, holes, pockets, etc., shall be provided in the concrete work in the positions indicated in the drawings or as directed by the Engineer.

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

Prior to concrete placement, all work shall be inspected and approved by the Engineer and if found unsatisfactory, concrete shall not be poured until after all defects have been corrected at the Contractor's cost.

Approval by the Engineer of any and all materials and work as required herein shall not relieve the Contractor from his obligation to produce finished concrete in accordance with the drawings and specifications.

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 be 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 caused by rains, the works shall be covered with tarpaulins immediately after the concrete has been placed and compacted before leaving the work unattended. 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 water is removed. To avoid flow of water over/around freshly placed concrete, suitable drains and sumps shall be provided.

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 to mortar as specified in paragraph 2.3.26 (c) of this section.

2.3.17 Transportation

a) General

All buckets, containers or conveyances used for transporting concrete shall be mortartight. 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 Engineer and concrete shall not be rehandled before placing.

b) Retempered or Contaminated Concrete

Concrete must be placed in its final position before it becomes too stiff to work. On no account water shall be auded 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 Engineer.

c) Cleaning of Equipments

All equipments 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.

2.3.18 Procedure for Placing of Concrete

a) Engineer's Approval of Equipment & Methods

Before any concrete is placed, the entire placing program, consisting of equipment, layout, proposed procedures and methods shall be submitted to Engineer for approval if so demanded by Engineer and no concrete shall be placed until Engineer's approval has been received. Equipment for conveying concrete shall be of such size and design as to ensure apractically 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 thirty 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 rehandled or caused or to flow in a manner which will cause segregation, loss of materials, displacement of reinforcement, shuttering of embedded inserts or impair is strength. For locations where direct placement is not possible, and in narrow forms, Contractor shall provide suitable drop and "Elephants 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 by Manual Labour

Except when otherwise approved by Engineer, 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) <u>Placing by Mechanical Equipment</u>

The following specification shall apply when placing of concrete by use of mechanical equipment is specifically called for while inviting bids or is warranted considering the nature of work involved.

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

(i) <u>Type of Buckets</u>

Control-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) <u>Operation of Bucket</u>

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 1.00M.The bucket shall he opened slowly to avoid high vertical bounce. Dumping of buckets on the swing or in any manner which results in separation of ingredients or disturbance of previously placed concrete will not be permitted.

f) <u>Placement in RestrictedForms</u>

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) <u>Chuthig</u>

Where it is necessary to use transfer chutes, specific approval ofEngineer 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 mortaragainst the sides of the chutes, the first mixes shall have less coarse aggregate. During cleaning of chutes, the wastewater shall be kept clear of the forms. Concrete shall not I be permitted to fall from the end of the chutes by more than 1.0 M. Chutes when approved for use, shall have slope not flatter than 1 vertical: 2 horizontal, and not steeper than 1 vertical: 2 horizontal. Chutes shall be 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 theconcrete in the forms.

h) <u>Placing by Pumping/Pneumatic Placers</u>

Concrete may be conveyed and placed by mechanically operated equipment e.g. pumps or pneumatic placers only with ihe written permission of Engineer. 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 pneumatic placer is used, the manufacture's advice on layout of 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 advice shall be followed regarding concrete quality and all other related matters when pumping/pneumatic placing equipment are 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 directed by Engineer. These shall be placed as rapidly practicable to prevent the formation of cold joints or planes 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 and 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 Engineer.

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 practicable density, is free of pockets of coarse aggregate and fits tightly against all form surfaces, reinforcement and embedded fixtures. Particular care shall be taken to ensure that all concrete placed against the form faces and into corners 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 vibrations 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 underlayer 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 beallowed 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**

From attached vibrators shall be used only site specific authorization of Engineer.

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 Engineer.

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 thorough bonding, as directed by Engineer.

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 floors 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 Engineer.

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, ity may be necessary to temporarily move the top steel aside to get proper placement and restore reinforcing steel to design position.

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.

2.3.19 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.

The Contractor shall submit to the Engineer for his approval, as soon as Practicable after the acceptance of his Tender and not less than three weeks before the commencement of concreting, drawings showing his proposals for placing concrete on which the position of all construction joints and lifts shall be shown. No concreting shall be started until the Engineer 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 waterstops inserted as the Engineer may require. The position of construction joints and the size of the formwork panels shall be so co-ordinated 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 a 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 surface 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.

Treatment of Construction Joints on Resuming Concreting

A drier mix shall be used for the top lift of horizontal pours to avoid laitance. All laitance and loose stones shall be thoroughly and carefully removed by wire brushing/hacking and surface washed.

Just before concreting is resumed, the roughened joint surface shall be thoroughly cleaned and loose matter removed and then treated with a thin layer of cement grout of proportion specified by Engineer and worked well into the surface. The new concrete shall be well worked against the prepared face before the grout mortar sets. Special care shall be taken to obtain thorough compaction and to avoid segregation of the concrete along the joint plane.

2.3.20 Movement Joints

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

The Contractor shall submit to the Engineer for his approval, as soon as practicable after the acceptance of his Tender and not less than three weeks before the commencement of concreting, details of his proposals for the installation of waterstops. These shall show where joints are to be located and details of the intersections and changes of direction to a scale that shows the position of any joint or shape or any moulded section.

As far as possible jointing on Site shall be confined to the making of butt joints in straight runs of waterstops. Where it is agreed with the Engineer that it is necessary to make an intersection or change of direction of any joint, other than a butt joint in a straight run on Site, a preliminary joint, intersection or change of direction piece shall be made and submitted to such tests as the Engineer any require.

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

The surface of set concrete in a movement joint shall, where specified on the Drawings, be painted with two coats of bituminous paint and new concrete shall be placed against ity only when the paint is dry. Expansion joints shall be formed by a separating strip of approved performed joint fill.

Caulking grooves shall be provided as shown on the Drawings. At the 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 jointing compound applied in accordance with the Manufacturer's instruction. At all caulked joints, the face of the caulking strip and a width of concrete on either side shall be painted with two coats of paint having the same base as the caulking compound.

2.3.21 Waterstops and Joint Fillers

a) General

When proprietary names are given in the drawings they shall be interpreted only as a reference of quality and do not oblige the Contractor to use the product specified. However, all waterstops and joint fillers shall be subject to the approval of the Engineer and applied in accordance with the manufacturer's instructions.

b) Waterstops

At all construction, contraction and expansion joints wherever specified or directed by the Engineer, waterstops shall be provided. The waterstops shall be PVC type or of any other equivalent material as approved by the Engineer. PVC waterstops shall have a tensile strength of not less then 14 MN/m^2 and elongation at break of not les than 300%. Waterstops shall not be exposed to direct sunlight for long periods. Before being concreted in, waterstops shall be cleaned of all foreign materials. Wherever provided, waterstops shall be placed in such a manner that they are embedded in the adjacent sections of the panels for width. The different types of waterstops to be used in liquid retaining structures will be as follows :

Table 2.3H

No.	Type of Joint	Type of Waterstops
1.	Partial/complete contraction joint in walls and slabs	150 mm wide, ribbed with hollow bulb and 5 mm min. thickness.
2.	Expansion joints in walls and slabs	225 mm wide, ribbed, with hollow bulb and 9 mm minimum thickness.

3.	Constructor joint in raft	225 mm wide, ribbed, without hollow central bulb and 9 mm minimum thickness.
4.	Construction joint in wall	150 mm wide, ribbed, with hollow central bulb and 5 mm minimum thickness.
5.	Partial/complete contraction joint in raft	225 mm wide, ribbed, with hollow central bulb and 9 mm minimum thickness.
6.	Expansion joint in raft	225 mm, wide, ribbed, with hollow central bulb and 9 mm minimum thickness.

c) Joint Fillers

Joint fillers shall be of durable, compressible, and non-extruding material.

2.3.22 Sealing Compounds

a) General

Horizontal joints shall, where used in water retaining structures be sealed with a cold pouring polysulphide rubber sealing compound of quality equal to, or better than TECHSEAL RED 941. Horizontal joints in roofs, floors and other non-water retaining structures shall be sealed with an approved sealant with properties equal to or better than TECHSEAL REL 941. Vertical joints and joints in the soffits of slabs shall be sealed with a trowel or gun applied polysulphide rubber sealing compound such as TECHSEAL RDL 940 or equivalent. Sealing compounds shall be fully cured before water is permitted to come in contact At 40^0 C the curing time shall be approximately 7 weeks for a polysulphide compound.

b) Preformed Joint Sealants

Where preformed joint sealants are shown on the drawings, approved material shall be used.

c) Preformed Slip Membrane

Where indicated on drawings, a preformed slip membrane of quality equal to Serviced “Slipstrip” shall be used in accordance with the manufacturer’s instructions and the drawing.

d) No Fines Concrete

No fines concrete shall be made from water, cement and coarse aggregate of 12 mm nominal size. The aggregate/cement ratio shall be 6:1 by volume and sufficient water shall be added to ensure that the cement paste completely coats the aggregate. No fines concrete shall not be mixed by hand, or vibrated. After placing, there shall be no layer of laitance on the surface of the concrete.

2.3.23 Tolerances in Concrete Surfaces

Concrete surfaces for the various classes of unformed and formed finishes specified in various clauses shall comply with the tolerances shown in Table 2.3.I hereunder, except where different tolerances are expressly required by the Specification or shown on the Drawings.

In Table 2.3.I 'line and level' and 'dimension' shall mean the lines, levels and cross-sectional dimensions shown on the Drawings.

Surface irregularities shall be classified as 'abrupt'or 'gradual'. Abrupt irregularities include, but shall not be limited to, off-sets 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 plane 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 2.3.I

Class of Finish	Maximum tolerance (mm) in : Line and level	Abrupt irregularity	Gradual irregularity	Dimension
U1	$\pm$ 12	6	$\pm$ 6	-
U2	$\pm$ 6	3	$\pm$ 3	-
U3	$\pm$ 6	3	$\pm$ 3	-
F1	$\pm$ 12	6	$\pm$ 6	+12-6
F2	$\pm$ 6	6	$\pm$ 6	+12-6
F3	3	3	$\pm$ 3	+6

2.3.24 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.

Class U1 finish is the first stage for Class U2 and U3 finishes and for a bonded concrete surface. Class U1 finish shall be a leveled and screeded, uniform plain or ridge, finish which (unless it is being converted to Class U2, U3, or bonded concrete) shall not be disturbed in any way after the initial set and during the period of curing, surplus concrete being struck off immediately after compaction.

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 a 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 has hardened sufficiently. The concrete shall be worked no more than is necessary to produce a uniform surface free from screedmarks.

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 additin of dry cement, morter or water shall not be permitted during any of the above operations.

2.3.25 Curing, Protecting, Repairing & Finishing

a) <u>Curing</u>

All concrete shall be cured by keeping it continuously damp for the 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 covering 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 may be required for specific concrete surface finish.

Curing of concrete's made of high alumina cement and supersulphated cement shall be carried out as directed by Engineer.

i) <u>Curing with Water</u>

Fresh concrete shall be kept continuously wet a minimum period of 10 days from the date of placing of concrete, following a lapse of 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 placed concrete

ii) <u>Continuous Spraying</u>

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 Engineer.

iii) <u>Alternate Curing Methods</u>

Whenever, in the judgement of Engineer, it may be necessary to omit the continuous spray methods, a covering of clean sand or other approved means such as wet gunny bags which will prevent losss 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 continuosly wet during the curing period.

For curing of concrete in pavements, sidewalks, floors, flat roofs or other level surfaces, the ponding methods of curing are preferred. The methods of containing the ponded water shall be approved by Engineer. Special attention shall be given to edges and corners 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)<u>Curing Compounds</u>

Surface coating type-curing compounds shall be used only by special permission of Engineer. 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)<u>Curing Equipment</u>

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 the elements, from defacements and damage due to construction operations by leaving forms in place for an ample period as specified later in this specifications. Newly placed concrete shall be protected by approved means such as tarpaulins from rain, sun and winds. Steps as approved by Engineer 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, Engineer 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 defective areas called to the attention of Engineer who may permit patching of the defective areas or also reject the concrete unit either partially or in its entirety. Rejected concrete shall be removed and replaced by Contractor at no additional expense to Corporate. 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 through 2.36 mm IS sieve after removing any loose stones adhering to the concrete. Mortar filling shall be struck off flush at the face of the concrete. Concrete surfaces shall be finished as described under the particular items of work.

Superficial honeycombed surfaces and rough patches shall be similarly made good immediately after removal of shuttering, in the presence of Engineer and 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 Engineer, 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 surface. Surface irregularities shall be removed by 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 Engineer shall be final in this regard. If only patching is necessary, the defective concrete shall be cut out till solid concrete is reached (or to a minimum depth of 25 mm) the edges being cut perpendicular to the affected surface or with small under cut 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 Engineer. Epoxies shall be applied in strict accordance with the instructions of the manufacturer.

ii) Methods of Repair

Small size holes having surface dimensions about equal to the depth of the hole, holes left after removal of form 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 until 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 Engineer, to match the shade of the patch with the original concrete.

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 of 24 hours. Thereafter, the patched area shall be kept wet continuously by a fine spray, or sprinkling for not less than 10 days.

iv) **Approval by Engineer**

All materials, procedures and operations used in the repair of concrete and also the finished repair work shall be subject to the approval of Engineer. All fillings shall be tightly bonded to the concrete and shall be sound, free from shrinkage cracks after the fillings have been cured and dried.

d) **Finishing**

The type of finish for formed concrete surfaces shall be as follows, unless otherwise specified by the Engineer.

For surfaces against which backfill or concrete is to be placed, no treatment is required except repair of defective areas.

For surfaces below grade, which will receive waterproofing treatment, the concrete shall be free of surface irregularities, which would interfere with proper application of the waterproofing material, which is specified for use.

Unless specified, surfaces which will be exposed when the structure is in service 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 stopped for drainage. Unless the drawing specifies a horizontal surface or shows the slope required, the tops of narrow surface 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, subfloors to be covered with concrete topping, terrazzo or quarry tile, and similar surfaces shall be smooth screeded and leveled to produce even surfaces. Surface irregularities shall not exceed 6 mm. Surfaces which will not be covered by backfill, concrete or tile toppings 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 the minimum required to produce a surface uniform in texture and free from screed marks or other imperfections. Joints and edges shall be tooled as called for on the drawings or as directed by Engineer.

Standard Finish for Exposed Concrete

Exposed concrete shall mean any concrete, other than floors or slabs, exposed to view upon completion of the job.

Unless otherwise specified on the drawings, 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, projections, etc., removed leaving the surfaces smooth.

Integral Cement Concrete Finish

When specified on the drawings an integral cement concrete finish of specified thickness for floors and slabs shall be applied either monolithic or bonded, as specified on the drawings. 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 and sand shall not be sprinkled directly on the surface of the cement finish to absorb moisture or to stiffen the mix. The work shall be executed in accordance with clause 2.6.213.

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 grout after rubbing. The finished surfaces shall present a uniform and smooth appearance.

e) Protection

All concrete shall be protected against damage until final acceptance by Engineer / Owner.

2.3.26 Preparation of Earth Strata of Foundations

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 as directed by Engineer. 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 Surfaces

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 Engineer. Great care shall be taken in performing this work to avoid removal of too much mortar and 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) <u>Bonding Treatment (Mortar)</u>

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. The 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 Engineer.

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

Mortar shall be placed at such a rate that it can be brushed over the surface just in advance of placement of concrete. Only as much area shall be covered with mortar as can 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 placed at any one time or the area, which it is to cover, shall be in accordance with the Engineer’s directions.

d) <u>Cleaning and Bonding Formed Construction Joints</u>

Vertical construction joints shall be cleaned as specified above or by other methods approved by Engineer. In 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 a 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 aid of vibrators and suitable tools.

e) <u>Expansion and Contraction Joints</u>

Provision shall be made for expansion and contraction in concrete by use of special type joints located as shown on the drawing. Contraction joint surfaces shall be treated as directed by the specifications on the drawings or as directed by the Engineer.

2.3.27 <u>Hot Weather Requirement</u>

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 Engineer.

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 reflective paint on mixers, etc. The temperature of the freshly placed concrete shall not be permitted to exceed 38^0C.

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 during hot winds for a period of at least 7 days immediately after which normal curing procedures may be resumed.

2.3.28 Placing Concrete Underwater

a) General

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:

b) Method of Placement

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

c) Direction, 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 and as directed and approved by the Engineer.

2.3.29 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 on situ concrete. Wherever possible precast units shall be hydraulically pressed.

When ready for incorporation in the works precast units shall be laid, bedded, jointed and fixed to the lines and levels shown on the Drawings. 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. 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 Forms

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 unit 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 Engineer or his representative that the methods he proposes to adopt for these operations will not over-stress or otherwise affect 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 from the directs rays of the sun for at least 7 days after casting and 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. Otherwise curing practice as given in Clause 2.3.25 shall be followed.

2.3.30 Slots, Openings, etc.

Slots, openings or holes, pockets, etc; shall be provided in the concrete work in the positions indicated in the drawings or as directed by Engineer. Any deviation from the approved drawings shall be made good by Contractor at his own expense, without damaging any other work. Sleeves, bolts, inserts, etc; shall also be provided in concrete work where so specified.

2.3.31 Grouting

a) Standard Grout

Grout shall be provided as specified on the drawings.

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 :

Table 2.3.1

	Use	Grout Thickness	Mix Proportions	W/C Ratio (max)
1	Fluid Mix	Under 25 mm	One part Portland Cement to one part sand	0.44
2	General	25 mm and over but less than 50 mm	One part Portland Cement to two part sand	0.53
3	Stiff Mix	50 mm and over	One part Portland Cement to three part 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 boltholes and the bottom of equipment and column base plates shall be cleaned of all oil, grease and 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 boltholes 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 places.

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 Engineer.

b) **<u>Non-shrinking Grout for Equipment Foundations</u>**

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 of a type of expensive 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 kg/ml			
	- min	3 days	-	230
		7 days	-	340
		28 days	-	450
5.	Expansion %			
	-	free	-	0.15-0.20
	-	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.

2.3.32 <u>Inspection</u>

All materials, workmanship and finished construction shall be subject to continuous inspection and approval of Engineer.

All materials supplied by Contractor and all work or construction performed by Contractor rejected as not in conformance with the specifications and drawings, shall be immediately replaced at no additional expense to Corporation.

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 drawings.

All concrete shall be protected against damage until final acceptance by the Engineer.

2.3.33 Clean-Up

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

All debris i.e. empty containers, scrap wood, etc; shall be removed to “dump” daily, or as directed by Engineer.

The finished concrete surfaces shall be left in a clean condition satisfactory to Engineer.

2.3.34 Records of Concreting

An accurate and upto date record showing times, dates, weather and temperature conditions when various positions of the works were concreted will be kept by the Engineer and shall be countersigned by the Contractor or his representative. If the Contractor fails to sign the Engineer’s record it shall nevertheless be regarded as correct and binding on the Contractor.

2.3.35 Storage of Cement

The contractor shall provide a godown of specified capacity for storage of cement bags. The godown shall be provided with two locks on each door. The key of one lock at each door shall remain with the Engineer or his representative and that of the other locks with the Contractor’s authorized person at the work site so that cement is removed from the godown only according to daily requirements with the knowledge of both the parties.

Cement brought to the site shall not be removed from the site without the prior written approval of the Engineer. But whenever the works are finally completed and advances are fully recovered, the contractor shall at his own expense forthwith remove from the site all surplus cement and upon such removal, the same shall revert in and become the property of the Contractor.

The Engineer and his assistants shall have free access to the godown at any time for the inspections of stock of cement.

Attention of the Contractor is invited to Claus 54 of Condition of contract, regarding materials.

Cement Storage Capacity

It is incumbent on the part of the Contractor to construct cement godown of a minimum capacity equal to 1 & 1/2 times of the maximum monthly consumption required for the work. The maximum monthly consumption shall be determined from the work program submitted by the Contractor and approved by the Engineer.

The Contractor may be asked to use Portlandpozzolana cement. No extra payment shall be made to the Contractor, even if the Contractor is asked to increase the deshuttering period considering cube strength results.

Sulphate Resisting cement

The Contractor may be asked to use Sulphate resisting Portland cement conforming to IS 12330 in place of ordinary Portland cement in lining.

2.3.36 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 may be indicated in the plans or as the Engineer, may direct, to meet the various situations encountered in the work.

Soft or spongy areas shall be cleaned out and back-filled with either a soil-cement mixture, lean concrete or clean sand fill compacted to a minimum density of 90% Modified Proctor, unless otherwise mentioned in Schedule of Quantities.

Prior to construction of formwork for any item where soil will act as bottom form, approval shall be obtained from the Engineer as to the suitability of the soil.

2.3.37 Preparation of Rock Strata of 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 Engineer or as indicated on the plans, the rock shall be cut to form rough steps or benches to provide roughness or a more suitable bearing surface.

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

Shortly before concrete is placed, the rock surface shall be cleaned with high pressure water and air jet even through 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 Engineer.

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

2.3.38 Measurement of In-situ Concrete

For concrete placed in situ separate measurements shall be made of plain (i.e. un-reinforced) concrete and of reinforced concrete for each of the specified classes of concrete.

In situ concrete and all work in connection therewith as specified shall be valued by the measurement of only such items as are set forth in the Bill of Quantities but, except where expressly shown to the contrary, reinforcement formwork (including formwork for construction joints and for movement joints), unformed surface finishes of Classes U2 and U3, reinforcement, movements joints, and requirements for prestressing shall be measured separately from, and in addition to, measurement of concrete placed in situ. Measurement of formwork and movement joints and of reinforcement shall be as provided for Clauses 2.4.8 and 2.5.11 respectively. Unformed surface finish Class U1 and spaded finish shall not be measured for payment.

In situ concrete shall be measured to the limits shown on the Drawings and any concrete placed outside such limits by reason of the Contractor's method of working or due to his carelessness or error and whether it has been permitted by the Engineer or not, shall not be measured for payment. No deduction from the measurement shall be made in respect of:

i) Any purpose made hole or opening which has an average cross sectional areas less than 0.2 m^2 or which has a volume less than 0.1 m^3 ;

ii) Any portion of chases, rebates, channels, pipes, ducts or the likes whose cross-sectional area is less than 2500mm^2;

iii) Any chamfer less than 100 mm wide on the splay;

iv) The space occupied by any reinforcement, rails, joists or the like embedded in the concrete;

Foundations, rafts, shall be measured between the top blinding concrete and the top surface of raft;

Columns shall be measured from the top of raft/foundation/slabs, etc. to bottom of upper slabs/floors. Capitals and brackets from columns shall be measured as part of column;

Beams shall measured between supports where resting on columns and below slab bottom.

Unformed surface finishes (classes U2 and U3 only) shall be measured as the net area of concrete surface so finished.

Building paper, or other protection of foundation surfaces, where ordered by the Engineer, shall be measured as the net area so protected and no measurement shall be made of laps or joints.

Admixtures, where ordered by the Engineer, shall be measured as the net weight of admixture properly used in the manufacture of concrete.

Placing concrete in water, where ordered by the Engineer, shall include for all additional measures necessary for placing concrete in water and shall be measured E.O. the appropriate concrete item.

Concrete testing shall be separately measured only if and to the extent that items for tests are provided in the Bill of Quantities.

Waterstops shall be measured as the net length fixed in place, and shall include for all necessary work in dividing formwork to accommodate the waterstops, and for the making of any straight but joints in the waterstops. This shall be deemed to be included in the contract rate quoted for water-stops.

Joint filler shall be measured as the net area (or length) fixed in place.

Joint sealing for caulking grooves shall be measured as the net length of joint sealed and shall include for cleaning, priming, caulking and painting over the joint.

Grouting shall be measured and paid for on cubic metre basis.

2.3.39 Measurement of Precast Concrete

Items for precast concrete shall include work for the manufacture and fixing in the works of the precast unit and all work in connection therewith as specified.

Precast concrete shall be measured as fixed in the Works by number of units, by volume, by area or by length as indicated in the Bill of Quantities. Measurement (except where by numbers) shall include the space occupied by joints between units but not by bedding. Otherwise all measurement shall be net except that no deduction shall be made in respect of any purpose formed hole, duct or the like which has an average cross-sectional area less than 2500 square millimeters.
No separate measurement for payment shall be made in respect of formwork, surface finishes, reinforcement, joggles, dowels, jointing, bedding or the like for precast concrete unless separate items are expressly provided in the Bill of Quantities.

PART 2

SECTION 4

FORMWORK

2.4 FORMWORK

2.4.1 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 impact of placing of concrete and vibration induced while placing the concrete & the effects of weather. The tolerance on line and level shall not exceed 3 mm and the soffits of beams other than prestressed beams shall 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 calculation and designs for the formwork, and, shall submit them to the Engineer 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 faces of the concrete. Where the Contractor proposes to make up the formwork from standard sized manufactured formwork panels, the size of such panels shall be approved by the Engineer before they are used in the construction of the Works. The finished appearance of the entire elevation of structure and adjoining structures shall be considered when planning the pattern of joint lines caused by formwork and by construction joints 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, chippings or other foreign matter. Joints shall be sufficiently watertight to prevent the escape of mortar or the formation of fins or other blemishes on the faces 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 as to be easily closed before placing concrete. Before placing concrete, all bolts, pipes or conduits or any 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 be cut in any concrete without approval of the Engineer.

All exterior angles on the finished concrete of 90 degrees or less shall be given 20mm x 20mm chamfers unless otherwise ordered by the Engineer.

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 Engineer. The whole or 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 if un-reinforced concrete. Holes left after removal of such supports shall be neatly filled with well rammed dry-pack mortar (Clause 2.4.5).

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 Engineer.

2.4.2 Removal

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 Engineer 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 2.4.A, below. Where soffit formwork is constructed in a manner that allows the removal of the majority of the formwork and the retention 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 Engineer, remove the formwork at the earlier times listed below provided that the props are left in position.

Table 2.4.A

Position of formwork	Days for striking
Walls	1
Sides of beans and columns	2
Slabs (props left under)	3
Props to slabs (span not exceeding 4.5m)	7
Props to slabs (span exceeding 4.5m)	14
Beams soffits (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 arrises and projections and without shock or vibration, by gently easing he 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 Engineer, 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 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 from the surface and then the hole shall be made good by sand cement mortar of the same proportions as the concrete just after striking the formwork.

2.4.3 Formed Surfaces-Classes of finish

Finishes to formed surfaces of concrete shall be classified as F1, 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 F1.

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 fiber board, arranged in a uniform approved pattern (Clause 2.4.1) and fixed to back formwork by oval nails. Unfaced 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 (Clause 2.4.1) free from defects likely to detract from the appearance of the surface.

Formwork for Class F1 finish shall be constructed with timber, sheet metal or any suitable materials, which will prevent loss of grout when the concrete is vibrated. Surfaces subsequently to be rendered, plastered or tiled shall be adequately scrabbled 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.

2.4.4 Defects in Formed Surfaces

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

If any blemishes are revealed after removal of formwork, the Engineer'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 discoloration 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 Engineer which may include using a suitable epoxy resin or, where necessary cutting out to a regular dovetailed shape a least 75 mm deep and refilling with concrete over steel mesh reinforcement sprung into the dovetail.

2.4.5 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 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 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.

2.4.6 Tolerances

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

Tolerances for R.C. Buildings

a) Variation from the plumb:

i) In the lines and surfaces of columns, piers, walls and in arrises 5 mm per 2.5 m or 25 mm, whichever is less.

ii) For exposed corner columns and other conspicuous lines

In any bay or 5 maximum - 5 mm

In 10 m or more - 10 mm

b) Variation from the level or from the grades indicated on the drawings:

i) In slab soffits, ceilings, been soffits, and in arrises

In 2.5 mm - 5 mm

In any bay or 5 m maximum - 10 mm

In 10 m or more - 15 mm

ii) 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

c) Variation of the linear building lines from established position in plan and related position of columns, wall & partitions:

In any bay or 5 m max. - 10 mm

In 10 m or more - 20 mm

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

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

Minus - 5 mm

Plus - 10mm

f) Footings

i) Variation in dimension in plan

Minus - 5 mm

Plus - 50 mm

ii) Misplacement or eccentricity

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

iii) Reduction in thickness

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

g) Variation in steps

i) In a flight of stairs

Rise	-	3 mm
Tread	-	5 mm

ii) In consecutive steps

Rise	-	1.5 mm
Tread	-	3.0 mm

Tolerances in Other Concrete Structures

a) All structures

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

In 5 m	-	10 mm
In 10 m or more	-	15 mm

ii) Variation of dimensions to individual structure features from established positions.

In 20 m or more	-	25 mm
In buried construction	-	50 mm

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

In 2.5 m	-	10mm
In 5 m	-	15 mm
In 10 m or more	-	25 mm
In buried construction	-	Twice the above amounts

iv) Variation from level or grade indicated on drawings in slab, beams, soffits, Horizontal grooves and visible arrises.

In 2.5 m	-	5 mm
In 7.5 m or more	-	10 mm
In buried construction	-	Twice the above amounts

v) Variation in cross-sectional dimensions of columns, beams, buttresses, piers andSimilar members.

Minus	-	5 mm

Plus - 10 mm

vi) Variation in the thickness of slabs, wall, arch sections and similar members,

Minus - 5 mm

Plus - 10 mm

b) Footing for columns, piers, walls, buttresses and similar members

i) Variation of dimension in plan

Minus - 10 mm

Plus - 50 mm

ii) Misplacement or eccentricity

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

iii) Reduction in thickness

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

Tolerances in other types of structures shall generally conform to those given in Clause 2.4 of Recommended Practice for Concrete Formwork (ACI 347).

Tolerance in fixing anchor bolts shall be as follows:

i) Anchor bolts without sleeves :# 1.5 mm in plan.

ii) Anchor bolts with sleeves : # 5.0 mm in elevation.

a) For bolts upto and including 28 mm dia # 5 mm in all directions

b) For bolts 32 mm dia and above # 3 mm in all directions.

iii) Embedded parts - # 5 mm in all directions.

2.4.7 Bracing, struts and Props

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

The shuttering for beams and slabs shall be so erected that the shuttering on the sides of the beams and under the soffit of slabs can be removed without disturbing the beam bottoms. Repropping of beams shall not be done except when props have to be reinstated to take care of construction load anticipated being 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 shuttering.

If the shuttering of 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 concrete proceeds, or windows may be left for pouring concrete from the sides to limit the drop of concrete to 1.0 M or as directed by Engineer.

2.4.8 Measurement of formwork

(1) Formwork and all work in connection therewith as specified for each surface finish of classes F1, F2 and F3 shall be valued by measurement of only such items as are provided in the Bill of Quantities under the following categories:

Vertical formwork	to faces of concrete which are vertical or battered upto 10^0 from the Vertical.
Inclined formwork	to faces of concrete battered from 10^0 upto 45^0 from the vertical.
Soffit formwork	to under-faces of concrete, either horizontal or sloping at an angle not exceeding 45^0 from the horizontal, including for cambering of beams
Top-face formwork	to top faces of concrete sloping at more than 15^0 and not exceeding 45^0 from the horizontal. Top faces of concrete sloping at 15^0 or less from the horizontal shall be classed as unformed surface finish and shall not be measured for payment for formwork except where such faces occur in openings, chases, rebates and other similar features. No top-face and concrete surface having a spaded finish shall be measured for payment regardless of its slope.
Curved formwork	to faces of concrete curved to a single radius in one plane. Formwork to faces of concrete for elliptical, parabolic, transitionally curved, conical, domical or other complex curved surfaces shall be separately measured under items that are particularly described.

(2) Main formwork shall be measured as the net area of formwork in contact with the surface of concrete it is required to support. Formwork for special features of any kind including narrow widths, fillets, chambers, movement and construction joints, nibs, pedestals, channels, rebates, holes, and openings shall be similarly measured under items for main formwork except to the extent that separate items for such features are provided in the Bill of Quantities, provided that in case of a fillet or chamfer which is being measured under an item for main formwork and whose width on the splay is less than 150 mm, the measurement shall be calculated from dimensions extending to the point of intersection of the concrete faces as if the angle had been formed without a fillet or chamfer.

No deduction from measurement of formwork shall be made in respect of (i) the area occupied by in situ pipes or ducts of any size passing through the formwork, but an additional measurement for payment shall be made for each pipe or duct to cover the cost of cutting or shaping the formwork to fit the pipe or duct; (ii) the area occupied by the face of any purpose-formed hole or opening in the concrete behind the formwork whose area is less than one square metre.

Where the Contractor's methods of constructions provide, with the permission of the Engineer, for concrete to be supported by some means other than purpose-made formwork, (e,g. against the face of an excavation) then such alternative support shall be measured. Provided that such support shall not be measured as formwork in any case where it is specified that concrete shall be placed against undisturbed ground or excavated faces.

Notwithstanding anything in this Clause, where formwork is stated as being included in other work (e.g. in precast concrete or in bedding and surround to pipes) it shall not be measured for payment.

(3) Formwork for movement joints and for construction joints approved by the Engineer shall be measured in accordance with the foregoing (one face only) and shall further include for all work necessary to accommodate any reinforcement passing through the joints, but unless indicated otherwise any requirement for water-stops, joint fillers, joint sealing, or painting of joint faces as specified in Clause 2.3.20 (Movement joints) shall be additionally measured under relevant items.

PART 2

SECTION 5

REINFORCEMENT

2.5 REINFORCEMENT

2.5.1 Supply

All steel shall be new and procured from original producers. No rerolled steel shall be accepted. The Contractor shall submit to the Engineer the manufacturer's test certificates for chemical analysis and physical properties of steel reinforcement for each consignment of steel at least seven days prior to delivery at site. The Engineer may order physical and/or chemical tests, for confirmation, on such steel reinforcement when he considers necessary. If such confirmatory tests are found to be unsatisfactory, the reinforcement shall not be used in any work. Random tests on steel supplied by the Contractor may be performed by the Corporation as per relevant Indian Standards. All costs incidental to such tests shall be at the contractor's expense. Steel not conforming to specifications shall be rejected.

Only new steel shall be delivered to the site and shall be clean, free from grease, oil, paint, dirt, loose mill scale, loose rust, dust, bituminous materials 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.

Following Brands of Reinforcement Steel shall be prefered
TATA STEEL
SAIL STEEL
ESSAR STEEL
JINDAL STEEL
RINL STEEL

2.5.2 Storage

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

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 Engineer.

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

2.5.3 Quality

Reinforcement shall be TMT deformed bars (Thermo Mechanical Treatment) as per IS:1786. Wire mesh or fabric shall be in accordance with IS : 1566. Substitution of reinforcement will not be permitted except upon written approval form the Engineer.
All Reinforcement for work shall be of fusion bonded Epoxy Coated Steel Bars. The coating specification shall conform to IS: 13620. Coating thickness should be 175 ±50 microns. The Contractor shall produce test certificate from the supplier of the fusion bonded epoxy coating that the quality of coating confirms to IS: 13620 for each lot as per frequency mentioned in IS: 13620 code. Coated bar represented by samples that do not meet the requirements of IS: 13620 specification will be rejected.

2.5.4 Laps

Laps and splices for reinforcement shall be as shown on the Drawings. Splices in adjacent bars shall be staggered and the locations of all splices, except those specified on the Drawings, shall be approved by the Engineer. The bars shall not be lapped unless the length required exceeds the maximum available lengths of bars at site.

2.5.5 Bending

Reinforcing bars supplied bent or in coils, shall be straightened before they are cut to size. Straightening of bars shall be done in clod and without damaging the bars. This is considered as a part of reinforcement bending fabrication work.

All bars shall be accurately bent according to the sizes and shapes shown on the detailed 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 make the material inferior; bars containing cracks or splits shall be rejected. They shall be bent cold, except bars of over 25 mm in diameter, which may be bent hot if specifically approved by the Engineer. 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 (not exceeding 845^0 C) and after bending shall 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 Engineer, injure the material. No reinforcement shall be bent when in position in the work without approval, whether or not it is partially embedded in hardened concrete. Bars having kinks or bends other than those required by design shall not be used.

2.5.6 Fixing

Reinforcement shall be accurately fixed by any approved means and maintained in the correct position shown in the Drawings by the use of blocks, spacers and chairs, as 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.

2.5.7 Cover

Unless indicated otherwise on the Drawings, clear concrete cover for reinforcement (exclusive of plaster or other decorative finish) shall be as follows:

a) At each end of reinforcing bar, not less than 25 mm nor less than twice the diameter of the bar.

b) For a longitudinal reinforcing bar in a column, not less than 40 mm, nor less than the Diameter of the bar. In case of columns of minimum dimension of 20 cm or under, with reinforcing bars of 12 mm and less in diameter, a cover of 25 mm may be used.

(c) For longitudinal reinforcing bars in a beam, not less than 25 mm nor less than the Diameter of the bar.

(d) For tensile, compressive, shear or other reinforcement in a slab or wall not less than 15 mm, nor less than the diameter of such reinforcement.

(e) For any other reinforcement not less than 15 mm, nor less than the diameter of such Reinforcement.

(f) For footings and other principal structural members in which the concrete is deposited directly against the ground, cover to the bottom reinforcement shall be 75 mm. If concrete is poured on a layer of lean concrete the bottom cover may be reduced to 50 mm.

(g) For concrete surfaces exposed to the weather or the ground after removal of forms, such as retaining walls, grade beams, footing sides and top, etc. not less than 50 mm for bars larger than 16 mm diameter and not less than 40 mm for bars 16 mm diameter or smaller.

(h) Increased cover thickness shall be provided, as indicated on the Drawings, for Surfaces exposed to the action of harmful chemicals (or exposed to earth contaminated by such chemicals), acid, alkali, saline, atmosphere, sulphurous smoke, etc.

(i) For reinforced concrete members, totally or periodically immersed in sea water or Subject to seawater spray, the cover of concrete shall be 50 mm more than those specified on (a) to (e) above.

(j) For liquid retaining structures, the minimum cover to all steel shall be 40 mm or the Diameter of the main bar, whichever is greater. In the presence of sea water and soils and water of corrosive character the cover shall be increased by 10 mm.

(k) Protection to reinforcement in case of concrete exposed to harmful surroundings may also be given by providing a dense impermeable concrete with approved protective coatings, as specified on the drawings. In such a case, the extra cover mentioned in (h) and (i) above may be reduced by the Engineer to those shown on the drawings.

(l) The correct cover shall be maintained by cement mortar cubs or other approved Means. Reinforcement for footings, grade beams and slabs on subgrade shall be supported on precast concrete blocks as approved by the Engineer. The use of pebbles or stones shall not be permitted.

(m) The 28 day 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.

(n) The minimum clear distance between reinforcing bars shall be in accordance with IS 456 or as shown in the drawings.

2.5.8 Inspection

Erected and secured reinforcement shall be inspected and approved by the Engineer prior to placement of concrete.

2.5.9 Welding of Reinforcement

Reinforcement which is specified to be welded shall be welded by any process which conforms with the requirements of IS 2751 or IS 9417 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.

Welds in positions other than those shown on the Drawings shall not be permitted. Tack welding to lightly secure reinforcements in place will be permitted subject to approval of the Engineer’s Representative.

2.5.10 Supply of Reinforcing Bars

All the steel reinforcements, M.S. bars/high yield strength deformed bars, etc. required for the Works will be supplied by the Contractor.

All steel brought on site shall be stored in a proper manner as approved by the Engineer so as to avoid distortion, deterioration and corrosion.

2.5.11 Measurement of Reinforcements

Reinforcement and all work in connection therewith shall be valued by measurement of only such items as are provided in the Bill of Quantities.

Bar reinforcement shall be measured as the calculated weight of reinforcement detailed on the Drawings or otherwise specified, and for this purpose the weight of reinforcement shall be calculated in accordance with Table 2.5.A below.
Reinforcement required in compliance with specified laps of bars shall be included in the weight measured for payment.

Fabric reinforcement shall be measured as the net area of fabric laid and laps shall not be measured.

In no case shall measurement be made in respect of binding wire, welding, chairs, spacers, waste in cutting, or laps introduced by the Contractor (with the Engineer's permission).

Notwithstanding anything in this Clause, where reinforcement is specified as being included in other measured work (for example, in precast concrete) it shall not be measured for payment.

TABLE 2.5.A

Diameter of bar in mm	Weight in kg / m
6	0.22
8	0.39
10	0.62
12	0.89
16	1.58
20	2.47
25	3.85
32	6.31
36	7.99
40	9.87

PART 2

SECTION 6

GENERAL BUILDING WORKS

GENERAL BUILDING WORKS

Applicable Codes and Specifications

The following codes, standards and specifications are made a part of this specification. All standards, tentative specifications, specifications, codes of practices referred to herein shall be the latest edition including all applicable official amendments and revisions.

In case of discrepancy between this Specification and those referred to herein, this Specification shall govern.

IS: 110	:	Ready mixed paint, brushing, grey filler, for enamels for use over primers
IS:269	:	Specification for 33 grade ordinary portland cement
IS 8112	:	Specification for 43 grade ordinary Portland cement
IS 12269	:	Specification for 53 grade ordinary Portland cement
IS:280	:	Specification for mild steel wire for general engineering purposes
IS:287	:	Recommendations for maximum permissible moisture content of timber used for different purposes
IS:337	:	Varnish, finishing interior
IS:348	:	French polish
IS:383	:	Specification for coarse and fine aggregates from natural sources for concrete
IS:412	:	Expanded metal steel sheets for general purposes
IS:419	:	Specification for putty for use on window frames
IS:428	:	Washable Distemper - Specification
IS:702	:	Specification for industrial bitumen
IS:710	:	Specification for marine plywood
IS:712	:	Specification for building limes
IS:733	:	Wrought aluminium and aluminium al1oys, bars, rods and sections for general engineering purposes
IS:777	:	Specification for glazed earthenware tiles
IS:1003	:	Specification for timber panelled and glazed shutters - Part 1 Door Shutters
IS: 1003	:	Specification for timber panelled and glazed shutters - Part 2 Window ventilator shutters
IS: 1038	:	Specification for steel doors, windows and ventilators
IS: 1077	:	Specification for common burnt clay building bricks
IS:1081	:	Code of practice for fixing and glazing of metal (steel &aluminium) doors, windows and ventilators
IS:1124	:	Method of test for detennination of water absorption, apparent specific gravity and porosity of natural building stones
IS: 1237	:	Specification for cement concrete flooring tiles
IS:1322	:	Bitumen felts for water- proofing and damp proofing
IS: 1346	:	Code of practice for waterproofing of roofs with bitumen felts

IS: 1361	:	Specification for steel windows for industrial buildings
IS: 1397	:	Specification for craft paper
IS: 1443	:	Code of practice for laying and finishing of cement concrete flooring tiles
IS: 1477	:	Code of practice for painting of ferrous metals in buildings - Part 1 - Pretreatment
IS: 1477	:	Code of practice for painting of ferrous metals in buildings - Part 2 - Painting
IS: 1542	:	Specification for sand for plaster
IS: 1580	:	Specification for bituminous compounds for waterproofing and caulking purposes
IS: 1597	:	Code of practice for construction of stone masonry: Part 1 Rubble stone masonry
IS: 1659	:	Specification for block boards
IS:1661	:	Code of practice for application of cement and cement-lime plaster finishes
IS: 1834	:	Specification for hot applied sealing compound for joint in concrete
IS: 1838	:	Specification for preformed fillers for expansion joint in concrete pavements and structures (non-extruding and resilient type): Part 1 Bitumen impregnated fibre
IS: 1948	:	Specification for aluminium doors, windows and ventilators
IS: 1949	:	Specification for aluminium windows for industrial buildings
IS:2074	:	Ready mixed paint, air drying, red oxide-zinc chrome, and priming
IS:2114	:	Code of practice for laying in-situ terrazzo floor finish
18:2116	:	Specification for sand for masonry mortars
1S:2185	:	Specification for concrete masonry units (Parts 1,2 & 3)
IS:2202	:	Specification for wooden flush door shutters (Solid core type): Part 1 - Plywood face panels
IS:2202	:	Specification for wooden flush door shutters (Solid core type): Part 2. - Particle board face panels and hardboard face panels
IS:2212	:	Code of practice for brickwork
IS:2250	:	Code of practice for preparation and use of masonry mortars
IS:2338	:	Code of practice for finishing of wood and wood based materials - Part 1 - Operations and workmanship
IS:2338	:	Code of practice for finishing of wood and wood based materials - Part 2 - Schedules
IS:2339	:	Aluminium paint for general purposes, in dual container
18:2395	:	Code of practice for painting Concrete, masonry and plaster surfaces - Part 1 - Operations and Workmanship
IS:2395	:	Code of practice for painting Concrete, masonry and plaster surfaces - Part 2 - Schedule
IS:2402	:	Code of practice for external rendered finishes

IS:2571	:	Code of practice for laying in-situ cement concrete flooring
IS:2572	:	Code of practice for construction of hollow concrete block masonry
IS:2645	:	Specification of integral cement waterproofing compounds
IS:2690	:	Specification for burnt clay flat terracing tiles: Part 1 Machine made
IS:2691	:	Specification for burnt clay facing bricks
IS:2750	:	Specification for steel scaffoldings
13:2835	:	Flat transparent sheet glass
IS:2932	:	Specification for enamel, synthetic, exterior types (a) undercoating, (b) finishing
IS:3036	:	Code of practice for laying lime concrete for a waterproofed roof finish
IS:3067	:	Code of practice of general design details and preparatory work for damp proofing and waterproofing of buildings
IS:3068	:	Specification for broken brick (burnt clay) coarse aggregates for use in lime concrete
IS:3384	:	Specification for bitumen primer for use in waterproofing and damp proofing
IS:3461	:	Specification for PVC-asbestos floor tiles IS:3462

: Specification for unbacked flexible PVC flooring IS:3495 :

Method of test for burnt clay building bricks: Part 1 to 4

IS:3536	:	Specification for ready mixed paint, brushing, wood primer
IS:3564	:	Specification for door closers (hydraulically regulated.)
IS:3696 (Parts 1 & 2)	:	Safety code of scaffolds and ladders
IS:4020	:	Methods of test for wooden flush door (Part 1 to 16)
IS:4021	:	Specification for timber door, window and ventilator frames
IS:4351	:	Specification for steel door frames
IS:4443	:	Code of practice for use of resin type chemical resistant mortars
IS:4457	:	Specification for ceramic unglazed vitreous acid resisting tile
IS:4631	:	Code of practice for laying epoxy resin floor toppings
IS:4832	:	Specification for chemical resistant mortars (Part 2
IS:4860	:	Specification for acid resistant bricks
IS:4948	:	Specification for welded steel wire fabric for general use
IS:5318	:	Code of practice for laying of flexible PYC sheet and tile flooring.
IS:5410	:	Cement paint
IS:5411 (Parts 1 & 2)	:	Specification for plastic emulsion paints (Part 1)
IS:5437	:	Wired and figured glass
IS:5491	:	Code of practice for laying of in-situ granolithic concrete floor topping

IS:6041	:	Code of practice for construction of autoclaved cellular concrete block masonry
1S:6042	:	Code of practice for construction of light weight concrete block masonry
IS:6248	:	Specification for metal rolling shutters and rolling grills
IS:7193	:	Specification for glass fibre base bitumen felts
IS:7452	:	Specification for hot rolled steel sections for doors, windows and ventilators
IS: 8042	:	Specification for white portland cement
IS:8543	:	Methods of testing plastics (Part l/Section 1)
IS:8543	:	Methods of testing plastics (Part l/Section 2)
IS:8543	:	Methods of testing plastics (Part 2/Section 1)
IS:8543	:	Methods of testing plastics (Part 2/Section 2)
IS:8543	:	Methods of testing plastics (Part 2/Section 3)
IS:8543	:	Methods of testing plastics (Part 3/Section 1)
IS:8543	:	Methods of testing plastics (Part 3/Section 2)
IS:8543	:	Methods of testing plastics (Part 4/Section 1)
IS:8543	:	Methods of testing plastics (Part l3/Section 1)
IS:9197	:	Specification for epoxy resin, hardeners and epoxy resin composites for floor topping
IS:9862	:	Specification for ready mixed paint, brushing, bituminous, black, lead-free, acid, alkali, water and chlorine resisting
IS:12200	:	Code of practice of water-stops at transverse contraction joints in masonry and concrete dams

2.6.1 Brickwork

2.6.101 Mortar

Mortar for brickwork, brickwork and stonework shall be prepared in accordance with IS 2250. Cement mortar shall consist of 1 part of portland cement to 4 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.

Portland cement for mortar shall comply with Clause 2.3.4 (a) of the Specification.

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

IS Sieve	Percentage Passing by Weight
4.75 mm	98 - 100
2.36 mm	80 - 100
1.18mm	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 Engineer's approval if ordered.

Water for mortar shall comply with Clause 2.3.7 of the Specification.

2.6.102 **Bricks**

Bricks for common brickwork shall be whole, sound, well burnt clay bricks, free from cracks and best locally available. Samples of bricks to be supplied shall be submitted to the Engineer for his approval prior to procurement. Bricks shall not be tipped on the Site but shall be carefully stacked by hand keeping the different grades. Broken or damaged bricks shall not be used in brickwork.

The crushing strength of ordinary clay bricks shall not be less than 50 kg/cm^2 and its water absorption shall not be more than 20 % for bricks used in panel walls and 15 % for load bearing walls. Tolerances in dimensions of bricks shall be allowed only in conformity with IS 1077 (i.e. ± 3.3%).

2.6.103 **Brickwork**

Brickwork shall be built in accordance with the requirements of IS 2212. Every brick shall be wetted arid 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. The 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 10 mm in thickness and shall be raked out to a depth of 7.5 mm as a key for rendering or plastering. All courses shall be truly horizontal and all perpentas shall be strictly plumb and square.

In cavity walls the two leaves of brickwork shall be bonded with galvanised wall ties 150 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 shail 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 kept 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 weephole. Completed masonry shall be kept wet for a minimum period of 14 days.

All 230 mm thick brick masonry shall be plumb from outside but 350 mm thick brick masonry shall be plumb on both faces.

2.6.104 **Concrete Blocks**

Concrete blocks whether made on or off site shall be manufactured to the shapes, sizes and finishes shown on the Drawings and shall comply with the requirements of IS 2185. The Contractor shall submit full details of his proposed manufacturing arrangements to the Engineer for 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 standard blocks.

Concrete for blocks whether made on or off site shall be made generally in accordance with section 2.3 of the Specification except that the combined aggregate shall have a fineness modules lying between 3.6 and 4 and shall conform with the following grading:

IS Sieve	Percentage Passing by Weight
12.5mm	100
10 mm	>85
4.75mm	> 60
300 microns	> 10

Concrete for blocks shall be of grade M20. Hand mixing shall not be permitted. When ordered by the Engineer, sample blocks from any batch shall be tested as specified in IS 2185.

Finished blocks shall be neatly stacked for storage on firm dry supports and shall be covered to protect them from dht, sun and rain. Damaged blocks shall net be used in the works.

2.6.105 **Blockwork**

Concrete blockwork shall be laid generally as specified in Clause 2.6.103 except where shown otherwise on the Drawings or as directed by the Engineer. The construction of hollow block masonry shall be generally in accordance with IS 2572. Blockwork for partition walls shall be laid in stretcher bond. Fair face blockwork, which is not to be plastered shall be neatly pointed as specified in the Drawings.

2.6.106 **Stone for Facing**

Dholpur stone shall be used for facing and shall be of best quality, soft, of good uniform colour which will remain unchanged on exposure to air; free from flaws, cracks, staining, salt cavities, veins and all deleterious inclusions, and equal in all respects to sample blocks which shall be submitted to the Engineer for approval. Where specified stone shall be dressed in accordance with one of the following requirements: -

"Hammer dressed" stone shall be roughly squared and levelled by knocking off bumps and ridges with a mason's hammer.

"Very rough dressed" stone shall have the bumps and ridges further reduced with a chisel, leaving the faces truly level although rough with depressions. No depression shall exceed 10 mm in depth nor 80 mm^2 in area.

"Rough dressed" stone shall have depressions reduced to not more than 4.5 mm in depth and 50 mm^2 in area.

"Medium dressed" stone shall have depressions reduced to not more than 3 mm in depth and 15 mm^2 in area.

"Fair dressed" stone shall have no more than a few chisel marks visible on the surface.

"Fine dressed" stone shall have no chisel marks and dimples left visible on the surface.

If ordered by the Engineer, samples of the above finishes shall be submitted and, when approved, shall be retained on site for comparison purposes.

2.6.107 **Constructing Stone Facing**

Stone facings shall be constructed in accordance with IS: 4101 (Part 1) to the lines and levels shown on the Drawings or as directed by the Engineer. Every stone shall be well bedded and the perpends completely filled with mortar. The joints shall be raked out as the work proceeds and immediately refilled with mortar to a neat flush joint. Finished masonry shall be continuously sprayed with water and prevented from drying out for at least ten days.

The Contractor shall ensure that adequate wall ties are cast into any concrete wall or set into any other type of wail which is subsequently to have a stone facing.

2.6.108 **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 1.5 times its height and less in length than twice its 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 80 mm and long vertical lines 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 corners and junctions of walls shall be of large sizes and hammer dressed to the correct 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 junctions 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 course 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 sq.m. in area at face and shall extend for the entire thickness of the wall and shall have at least 0.025 sq.m. 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 a tie from 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 Engineer 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 precast headers in Ml 5 grade plain concrete may be permitted at the discretion of the Engineer. 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 consisting of 100 mm diameter AC pipes shall be provided in retaining walls at the rate of one per square metre as shown on the Drawings or where directed. They shall be pointed with 1:3 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. In wet weather newly laid masonry shall be protected from the effects of heavy rainfall by tarpaulins or other approved material.

2.6.109 Pointing of Uncoursed Masonry

Joints in exposed masonry faces shall be formed while the mortar is still green and shall br finished as flushed joints, weathered joints, round recessed joints or square recessed joints as directed by the Engineer. Masonry, which is to be rendered or plastered shall have the joints raked out to a depth of 15 mm to form a key.

2.6.110 Stone Pitching

Stone pitching to slopes shall be earned out where shown on the Drawings or as directed by the Engineer. Stone for pitching shall be obtained from an approved source and shall be hard, sound, durable, clean and generally as specified in Clause 2.6.106. 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 a 75 mm thick layer of crusher run rock or graded coarse aggregate ranging from 75 mm particle size to fines. The slop 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 wedged into the cracks. 50 mm dia weep holes shall be provided where shown at intervals not exceeding two metres in both directions. Joints in stone pitching shall be flushed up with sand/cement mortar on completion.

2.6.111 Rubble 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 Engineer.

Rubble shall be hand packed as directed by the Engineer. They shall be laid closely in position on the sub-grade. All industries between the stones shall be wedged in with smaller stones of suitable size well driven to ensure tight packing and complete filling of interstices. Such filling shall be carried out simultaneously with the placing in position of rubble stones and shall not lag behind.

Interstices shall be filled with small stone chips and hard clean sand and well watered and rammed.

The unit of measurement shall be square metre for the specified thickness of rubble packing.

2.6.112 Measurement of Brickwork and Uncoursed Stone Masonry

Unit of measurement for brickwork shall be cubic metre for 230 mm thickness and above and square metre for 115 mm thickness. Unit of measurement shall be cubic metre for uncoursed stone masonry in foundation and plinth and shall be running metre for compound wall. No deductions will be made for openings less than 0.1 square metre in area in brick or masonry walls. The rates shall include for carrying out the work as specified and no separate payment will be made for cutting, scaffolding, watering, forming openings and reveals, building to shape around other structures, forming cavities, wall ties, building in lintels, pipes and beams and providing weep holes and transoms and mullions as indicated in drawing including shuttering. Only reinforcement shall be paid for extra.

2.6.2 Finishes

2.6.201 Finishes Generally

The Contractor shall demonstrate his ability to apply finishes to the standards required under the Contract. If, in the opinion of the Engineer, the demonstrations do not satisfy the standards required, the Engineer may order the Contractor to employ a specialist firm of sub-contractors approved by the Engineer to carry out all or part of this work.

2.6.202 Floor Screeds

Where 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 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 Engineer, an approved waterproofing admixture such as "Sisco" or "Impermo" shall be added to screed concrete in accordance with the manufacturer's recommendations.

Heavy duty screeds shall be in M10 grade plain concrete with coarse aggregate of size 20 mm downgraded. Light duty screeds shall also be in M10 grade plain concrete but with coarse aggregate of size 10 mm downgraded. Water content shall be kept to the minimum consistent with pioviding adequate compaction. Unless otherwise specified, screeding shall be finished to class U2.

Screeds shall be laid to the falls shown in the drawings subject to a minimum fall of 1 in 120 . The minimum thickness of screed shall be 80 mm for heavy duty and 50 mm for light duty. Curing of screeds and quality of materials shall conform to Section 2.3 of the Specification.

2.6.203 Surface Hardeners Concrete Surfaces

Where shown on the drawings, an approved surface hardener such as Lithurin shall be applied to the concrete surfaces. Application to the finished concrete surface shall be carried out in accordance with the manufacturer's recommendations.

2.6.204 Granolithic Concrete

Floor slabs upon which a granolithic concrete finish is to be laid shall be screeded to the level shown on the drawings. Before the concrete is fully hardened the surface shall be roughened by wire brushing or picking in order to expose the aggregate.

Before laying the finish the concrete shall be thoroughly cleaned with stiff brushes and then soaked overnight. After the excess water has been removed, a thin layer of stiff cement grout shall be well brushed into the roughened surface a few-minutes before the granolithic concrete is laid.

Granolithic concrete shall consist of two parts of cement to five parts of granite by volume. The aggregate shall be graded from 10 mm down with not more than 20% passing a No.200 sieve and shall be free from dust. The water content shall be just sufficient to produce a dense firm concrete of adequate workability. Mixing shall be as for concrete.

The granolithic concrete to floors shall be laid 40 mm minimum thickness in panels not larger than 3 m square. Panel joints shall be formed with approved aluminium or sheet glass strips 3 mm wide finishing flush with the surface. Covers shall be formed with a 75 mm radius and stand 90 mm above finished floor level as shown on the drawings. The arrangement of the panels shall be as symmetrical as possible and shall be approved by the Engineer. The granolithic concrete shall be compacted and checked for any irregularities with wooden straight edges 1.5 m long. Irregularities shall not exceed 3 mm. After checking, the granolithic concrete shall then be allowed to stand until sufficiently hard to permit a final hard steel trowelling, in the course of which any laitance collecting on the trowel shall be removed and not trowelled back. The flooring shall be kept damp and not exposed to any traffic for a period of seven days.

2.6.205 Fully Vitrified Clay Floor Tiles (Quarry Tiles)

Clay floor tiles shall be heavy duty fully vitrified tiles 25 mm thick at least equal to class 1 of IS:1478 or light duty fully vitrified tiles 15 mm thick at least equal to class 3 of IS: 1478. Coved bull nosed skirting with radiused internal and external angles and other special tiles shall be supplied to match the floor tiles. Water absorption shall be less than 3% and hardness as measured by the Mohs' scale shall be greater than 6.

The tiles shall resist acidic action and staining by oil. Jointing material shall be acid resistant where shown.

Floors to be tiled shall be screeded to the levels shown on the drawings. Before the screed has fully hardened, the surface shall be roughened by wire brushing or picking. An undercoat of 1:3 cement/sand mortar screed shall then be laid and bonded to the slab and immediately covered with a thin layer of 1:1 cement/sand slurry on which the tiles shall be laid and levelled. The joints shall, at the same time be carefully filled with cement grout and any surplus wiped off as the work proceeds. Care shall be taken to obtain a neat and uniform joint pattern.

After laying, the tiles shall be protected to the Engineer's approval and on completion of the works the tiles shall be thoroughly cleaned.

2.6.206 **Vinyl Asbestos Floor Tiling**

P.V.C. asbestos tiles shall conform to IS:3461 and shall be made by a reputable manufacturer approved by the Engineer. Tiles shall be laid to the manufacturer's instructions. The Contractor shall protect the finished surface from all damage and shall complete the floor by polishing it, using the manufacturer's recommended polish, on completion of the Works.

2.6 207 **Indian Patent Stone Flooring**

The Indian Patent Stone Flooring shall be 38 mm 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 waterproofing 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 neat cement slurry to the surface in bays of suitable sizes but not exceeding 6 sq.m. each, and to 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 a period of 8 days.

Construction joints shall be formed in between the alternate 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.

2.6.208 **Shahabad / Tandur/ Kotah Stone Flooring**

Stones, should 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 should be laid on a bed of lime mortar of proportion 1:2 or cement mortar of proportion 1:3. Thickness of mortar bedding should not be less than 12 mm and not more than 25 mm. Before laying, the stone slabs should be thoroughly wetted with clean water. Thick cement slurry should be spread over the mortar bed over as much area as could be covered with the slabs within half an hour. The slabs are then laid and gently tapped with mallet till it is firmly and properly bedded. There should be no hollows left. The joints should not be more than 2 mm wide. The joints should be struck smooth. The floor should be kept covered with damp sand or water for a week. Slabs should be of standard sizes and shapes. Slabs supplied should meet all the required properties and test requirements as stipulated in IS 1124.

Kotah stones in skirting shall be laid against a bedding of cement mortar (1:3) 20 mm thick to the full height of skirting, to a true plane, level amd plumb. The workmanship shall be similar to flooring. The skirting shall be lad projected beyond the finished plastered surfaces. The continues horizontal grooves it the top of skirting shall be provided if required. The skirting surfaces shall be repolished with hand to satisfaction of the Engineer. The skirting shall be cured for 7 days. The specifications and workmanship for Kotah stone risers shall be the same as per Kotah stone skirting. Top of exposed skirting shall be machine cut and polished Tiles used at projecting corners shall be suitably levelled to present a neat corner.

2.6.209 Marble Mosaic Flooring

Marble mosaic tiles of approved make and quality shall be used for flooring, where directed or specified by the Engineer. The tiles shall not be less than 25 mm thick. The tiles shall be laid in slope or level as directed, in lime mortar bed cushioning (lime and sand in the proportion of 1:2 or cement mortar 1:3) and shall be finally set in cement float of required colour and as directed. The flooring shall then be machine polished to give smooth surface and left clean after polishing.

2.6.210 White Glazed Tile Flooring and Dado

White glazed tiles including angles, corners, borders and specials shall be of Johnson or B.P.T. 1st quality or any other make and quality approved by the Engineer. They shall be 6 mm thick and 15 cm x 15 cm in size or as approved by the Engineer.

The tiles before laying shall be soaked in water for at least 2 hours and shall be set in lime mortar 1:2 or cement mortar 1:3 for floors and 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 tiled 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 shall not exceed 1.5 mm wide.

2.6.211 Terrazzo and Plain Cement Tiling Work in Flooring and Skirting

The type, quality, size, thickness, colour etc. of the tiles for flooring and skirting work shall be of best quality approved by the Engineer. For this purpose, the Contractor shall provide the Engineer with necessary samples for his selection.

Before the tiling work is commenced, the sub-surface shall be thoroughly cleaned and washed of all loose materials, din and water pools on the surface.

The tiles shall be laid on lime cement mortar bedding of about 25 to 30 mm thick. The proportion of mortar shall be one part of cement, two parts of lime and six parts of sand. The mortar shall be evenly spread on the sub-floor. Over this mortar bed, 5 kg. of cement per sq. m. of floor area shall be spread The tiles shall be fixed on this bed one after another, each tile being gently tapped with a wooden mallet till it is properly bedded and in level with the adjoining tiles. The joints shall be perfectly straight and uniform in thickness. The. tiles shall be laid perfectly in level unless otherwise specified or required or desired by the Engineer. After laying the tiles the joints shall be finished with white cement or cement of approved colour.

For lime mortar, lime from burnt 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 will be rejected.

Floor tiles laid adjoining the wall shall project 12 mm under the plaster, skirting or dado as may be required by the Engineer. Half tiles and pieces shall be avoided as far as possible. After laying, the flooring shall be allowed to cure undisturbed for seven days. Design traffic shall not be allowed on the floor for at least 14 days after laying the tiles.

About a week after laying the tiles, each and every tile shall be lightly tapped with a small wooden mallet to find out if it gives a hollow sound; if it does, such tiles along with any other cracked or broken tiles shall be removed and replaced with a new tile to proper line and level. The same procedure shall be followed again after the tiles are finally polished. For the purpose of ensuring that such replaced tiles match with those curlier laid, it is necessary that the Contractor order enough extra tiles from the factory to meet this contingency. The tiles shall finally be cleaned and polished by using dilute oxalic acid or any other method recommended by the manufacturer and approved by the Engineer.

After the joints have developed sufficient strength, the floors shall be machine polished to the desired finish as approved by the Engineer. Sufficient quantity of water shall always be used during polishing to prevent scratching.

For dado and skirting work, the vertical surface shall be thoroughly-cleaned and wetted. Thereafter it shall be evenly and uniformly covered with about 12 mm thick 1:2 cement mortar. For this work the tiles as obtained from the factory shall be of the size required and practically fully polished. The back of each tile to be fixed shall be covered with a thin layer of neat cement paste and the tile shall then be gently tapped against the wall with a wooden mallet. This shall be done from the bottom of the surface upwards. The joints shall be as close as possible and the work shall be truly vertical and flush.

After the work has set, hand polishing with carborandum stones shall be done so that the surface attains a high glossy finish. Corners and junctions shall be finished true. The workmanship shall conform to IS: 1443.

The work is subject to the approval of the Engineer. If any portion of the work is rejected by the Engineer, the same shall be removed and redone by the Contractor to the satisfaction of the Engineer at no extra cost to the Corporation.

The procedure for laying and finishing cement tiles in floor and dado shall be as for mosaic tiles except that in this case the tiles shall be cement tiles instead of mosaic/terrazzo.

Terrazzo tiles in skirting shall be of size 125 mm x 250 mm and 20 mm thick hydraulically pressed and shall be obtained from the same source as for the terrazzo tiles for flooring. The design and shade of the skirting tiles shall be exactly similar to that of flooring tiles. The specifications for materials and workmanship shall be same as for flooring except that the skirting tiles shall be laid, against a 20 mm thick bedding of cement mortar (1:3) to the full height of skirting. The skirting shall be in true plane, level and plumb. 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 as per drawing or as directed by the Engineer. No extra cost will be paid for grooves. The skirting shall be polished with hand to attain the same finish as for the flooring. The skirting shall be cured for 7 days. The specifications for dados will be the same as for skirting. The tile size however, will be 250 mm x 250 mm x 25 mm thick.

2.6.212 Acid and/or Alkali Resistant Tile Flooring and Dado Materials

Materials

The acid and/or alkali resistant tiles shall have true and straight edges, shall be non-absorbing, without stains, non-fading, and obtained from approved manufacturers. The tiles shall generally be 40 mm thick. 75 mm thick bricks may be necessary, at walls of deep pit for stability or at floor areas having considerable traffic. Tiles used shall be either 100 x 100 x 12 mm thick or 150 x 150 x 20 mm thick in size.

The tenderer shall specify the characteristics of the tiles and shall enclose the manufacturers literature for the same confirming their serviceability for both acids and alkalis. The Contractor shall submit samples of tiles for accepted if it conforms in all respects to the approved samples kept with the Engineer.

Laying and Workmanship

After the underbed is thoroughly dries, a heavy grade bituminous corrosion resisting protective coating shall be applied on the this dust free surface either by brushing or by 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 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 the bituminous undercoat specified above a special mastic of 12 mm minimum thickness or as recommended by the manufacturer shall be 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 compounds of selected fillers and blended bitumen which are solid at ordinary temperature.

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

Care should 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 by 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 so as to form a total thickness of 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 till it forms an even coating. The covering shall be done piece by piece and care taken to keep the correct temperature, 5 a that a perfect weld is made. The special mastic material may be the product of CommandelProdorite Pvt. Ltd. or equivalent. Over this underlay the acid/alkali resistant tiles shall be bedded in special cement mortar and jointed in 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 of chemical resistant mortar comprising an intimate mixture of a solid filler, a setting agent usually contained in the filler and a liquid binder.

The material may be supplied in two 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 in common mineral acids. Cement Prodor S.W.K. of Coromandel Prodorite Pvt. Ltd. or equivalent may be used for the special bedding mortar.

The jointing the tiles shall be done with a self-hardening cement mortar specially designed to resist both acid and alkaline as well as mixed acid and alkaline conditions. For this purpose a resin-type chemical resistant mortar shall be used comprising an intimate mixture of liquid resinous 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 of 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 in 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 1.5 mm.

'Furacin' as marketed by Coromandel Prodorite Pvt. Ltd. containing furane resin or equivalent shall be used for this corrosion resisting cement. The mortal is to be prepared and applied strictly in accordance with instructions. If the material is supplied in two separate parts, and inert powder and a resin based syrup, they must be mixed in the proportions given by 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 pointed.

Mixing shall be carried out very thoroughly and carefully in a clean enameled dish or bowl. Any lumps in the powder must be broken down by careful mixing, mixing should be carried out by adding powder to the syrup. The mixing shall be so arranged that the mixed mortar is used up quickly and does not remain in bulk longer than the time specified by the manufacturer. At temperature 200°C or above the mixing pan and contents should 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 condition; which may lead to a flash set. To avoid this, it is essential that the mixed mortar is spread an 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 o: as recommended by the manufacturer and depending on atmospheric temperature During setting and hardening, no water, steam or acid should come in contact wit! this jointing mortar.

If the flooring has to be sloped the same shall be provided in the concrete slab or an additional graded underbed shall t e provided if required, with cement sand mortar (1:3) by volume as shown, in drawing or as directed Engineer.

The Contractor shall furnish full details regarding the materials for the different treatments described above pertaining to this flooring work as per manufacturer's specifications, and shall lay underlayer, 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 Engineer.

Alternative Proposal

The tenderer may submit any other proposal of laying the acid and/or alkali resistant tiles with complete details of the treatment and material specifications for bedding, pointing, method of laying and other participants in conformity with technical requirement and serviceability for both acids and alkalis.

2.6.213 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 screened off to proper level and tamped with tamper having conical projections so that the aggregate shall be forced below the surface. The surface shall be finished with a wooden float and a trowel with pressure. The finish shall be continued till the concrete reaches its initial set. No cement or cement mortar finish shall be provided on the surface. Where specified, a floor hardener as approved by the Engineer shall be supplied and used as recommended by the manufacturer

2.6.214 Measurement for Flooring and Dado.

Unit of measurement for flooring and dado shall be sq. m. or part thereof of the superficial area. Actual quantity of flooring work carried out will be measured and paid for after making deductions for openings etc. For skirting, unit of measurement shall be linear metre for the specified width.

2.6.215 Waterproofing Work

The Contractor shall give a guarantee for a minimum period of 10 years on stamp paper for all waterproofing against bad or faulty material and construction and shall rectify the work at his own cost during the guarantee 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 "wattas" or as directed by the Engineer.

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 Engineer.

(b) Where bitumen felt water proofing 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.

2.6.216 <u>Stair Nosing</u>

Contract stairs shall have nosing of an approved design, with coloured non-slip inserts and shall be fixed with counter-sunk screws.

2.6.217 <u>Damp Proof Course</u>

Unless otherwise specified damp proof course shall be formed from bituminous felt conforming to IS 1322 with a minimum lap at joints of 150mm. Material for damp proof course shall be subject to the Engineer's approval.

2.6.218 <u>Cement Plaster</u>

a) <u>Cement and sand</u>

Cement and sand shall conform to the specifications as mentioned in Clauses 2.3.4(a) and 2.3.5 respectively.

b) <u>Neeru</u>

Neeru shall be made of the best description of lime, slaked with fresh water andsifted. The lime shall be reduced to fine powder by grinding it on a stone or in a hand mill, with a thick solution of mussalla to be made or as may be desired by the Engineer. The neeru thus prepared shall be kept moist until used and the quantity to be prepared at one time shall be such that it can be used within eight days in the works.

c) <u>Workmanship</u>

All stone or brick masonry shall be thoroughly wetted and joints raked out to a depth of at least 20 mm and walls washed before any plastering is done. The surface shall then be rendered with a mortar of specified parts of portland cement and fine sand, to 20 mm thickness and specified roughness. The surface shall then be floated or set with a thin coat of 3 mm thick cement and polished well with a trowel or flat board. The cement mortar shall be used within 30 minutes after it leave': the mixing board or mill. Before any plaster work is started patches of plastei 150 .mm x 150 mm shall be put on at every 3 metres apart 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. Neeru finish shall be applied to the prepared and partially set but somewhat plastic surface, with steel trowel to a thickness slightly exceeding 1.5 mm, (1/16") and rubbed down to 1.5 mm (1/16") thickness and polished to a perfectly smooth and even finish working from top to bottom.

The junction between beams and brickwork shall be plastered after fixing the expanded metal wire mesh of 300 mm width. The wire mesh shall be of size 20 mm x 20 mm gauge thickness. No separate payment shall be made for fixing such mesh.

2.6.219 Sand Faced and Plain Faced Cement Plaster

The external plaster shall be finished with sand faced cement plaster in two coats. All stone or brick masonry surfaces to be plastered shall be thoroughly wetted for at least 6 hours and the joints raked to a depth of at least 20 mm before plastering.

The first coat of cement plaster in 1:3 proportion shall be applied uniformly all over the surface to be plastered to a thickness of 14 mm 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. Waterproofing compound such as CICO Impermo etc. shall be added in the 1st coat of cement mortar at the rate as specified by the Engineer or by the manufacturer and as approved by the Engineer. The plastered surfaces shall be cured for seven days and thereafter allowed to dry out for 3 days before taking up the second coat of plaster.

The second coat shall be applied in 1:3 proportion using clean sand screened through a mesh of not less than 0.5 mm and not more than 3.00 mm size to a uniform thickness of 6 mm 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 whole surface thoroughly wetted for at least one week.

The plain faced cement plaster shall be in cement mortar 1:4 and shall be 20 mm thick. The workmanship shall be similar to that for sand faced plaster, except that waterproofing compound shall not be added. All surfaces applied with plain faced cement plaster shall be finished with neeru as specified.

2.6.220 Cement Pointing

General

Before pointing work is taken up, the old mortar in the masonry or pitching work shall be raked out of the joints at least to a depth of 20 mm. The dust shall be brushed out of the joints and the walls shall be well wetted with fresh water until the old mortar in the wall is set to the satisfaction of the Engineer. The pointing shall then be made with fine mortar, of cement and fine sand, in the proportions as specified. The joints shall be neatly defined by the jointing, and the same shall be raised or sunk as directed. In no case shall false joints be allowed. The pointing shall be kept wet until the cementing material sets and becomes hard. The whole surface shall be left clean at the completion of the work.

2.6.221 Epoxy Lining

The Contractor shall employ specialist firms approved by the Engineer for the supply and laying of epoxy linings, as specified and shown on the drawings.

2.6.222 Acoustic Tiles

Where specified, acoustic tiles of a design and manufacture approved by the Engineer 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 aluminum scantlings.

2.6.223 **Suspended Ceilings**

Suspended ceilings shall consist of plaster board or an approved alternative and shall be hung from the structural ceiling by galvanised mild steel hangers suitably fixed in accordance with IS: 2441. The Contractor's proposed design shall be submitted to the Engineer for approval prior to commencing the work.

Where applicable, the finished ceilings shall be plastered to a smooth regular finish free from protuberances, indentations or cracks. Cornices and moulded work shall be run clean and accurately to the sections given.

2.6.224 **Soft Board and AC Sheet False Ceiling**

For suspending the false ceiling, hangers shall be provided from the roof work. The hangers shall generally be 10 mm diameter G.M.S. rods with threads at the lower end and anchored secureK in the roof concrete or welded to inserts provided on the underside of slabs, beams etc. In case the roof work is of A.C./G.I. sheeting supported on purlins and trusses, hangers shall be hung from roof steel work. The hangers shall be provided at about 1.2 metrescentre to centre in both directions. 75 mm x 50 mm teakwood runners shall be provided along one direction at about 1.2 metrescentre and these shall be properly secured to the hangers by means of washers and nuts and also by embedding the ends of runners in masonry work. Perpendicular to the teak wood runners, teak battens of size 50 x 50 mm shall be provided 600 mm centre to centre.

The teak wood runners and battens shall be of thoroughly seasoned wood absolutely free from all defects. The rate quoted shall include antitermite treatment and painting of wood work in accordance with relevant specifications. All materials should be approved by Engineer before installation. Perforated soft board of size 600 mm x 600 mm shall be fixed to the battens by means of screws, nails etc. as approved by Engineer. The perforations shall be either uniform or at random as decided by Engineer. Necessary openings shall be provided in the false ceiling work for air-conditioning, lighting and other fixtures. Perforated fibre boards, if used, shall have bevelled edges.

The Boards shall be flame proof or flame retardant quality. Where specified, Thermocole slabs (TF quality) or fibre glass resin bonded slabs shall be used. Where AC sheets are used, they shall be plain, 5 mm thick and of maximum size 1200x1200 mm.

The Contractor shall fully co-operate with other agencies entrusted with work of air conditioning and lighting. Openings in false ceilings which are less than 0.2 sq.m. in area shall not be deducted for the purpose of payment. Additional framing required for air-conditioning, lighting and other fixtures shall be provided without any extra cost to Owner. It is imperative that false ceiling should be perfectly level and all joints uniform. The workmanship expected is of the highest order. After the work is completed, the false ceiling shall be given 2 coats of distemper wash of approved shade. Rate shall be inclusive of the distemper wash.

Removable or hinged type inspection or access trap doors shall be provided at locations specified by Engineer.

2.6.225 **Aluminium False Ceiling**

This part of the specification covers the requirements of aluminium false ceiling work.

Aluminium false ceiling shall be erected strictly as per manufacturer instructions. The drawings for the patterns of the ceiling and supporting arrangement shall be got approved by Engineer prior to placing of order. Contractor shall provide for necessary openings required for air conditioning and lighting fixtures. Unless noted otherwise in the schedule of quantities the aluminium sections shall be anodised.

Contractor shall fully co-operate with other agencies entrusted with work of air conditioning and lighting. Openings in false ceilings which are less than 0.2 sq.m. in area, shall not be deducted for the purpose of payment. Additional framing required for air conditioning, lighting and other fixtures shall be provided without any extra cost to Corporate.

The workmanship expected is of the highest order. It is imperative that false ceiling shall be perfectly horizontal and all joints uniform and in line. Where specified, the aluminium ceiling boards shall have fibre glass boards bonded to them.

2.6.226 **Heavy Duty Abrasion Resistant 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 Engineer. For this purpose, the Contractor shall provide the Engineer with necessary samples for this selection. Tiles shall be hardwearing, resistant to impact, resistant to abrasion, free from slipperiness and also resistant to attack by water, oils and greases.

2.6.227 **Thermal Insulation for Roof / Floor**

Thermal insulation shall be Therrnocole' TF type or Resin bonded Fibre glass boards of thickness as indicated.

Thermocole Boards

Soffit of RCC slab 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 1.5Kg/m^2.

Thermocole boards (T.F. variety of 50 mm thickness of 18 Kg/m^3 density shall be stuck by means of the same grade of hot bitumen.

The boards shall be further secured with screws, washers and plugs.

The joints of the boards shall be sealed with bitumen.

Fibre Glass Boards

Timber pegs 50 mm x 50 mm x 50 mm shall be fixed to the slab at 600 mm centres with 6 mm x 65 mm long wood screws. 20 gauge galvanised iron lacing wire shall be tied to the pegs.

'Crown' 200 fibreglass boards 50 mm thick shall be stuck to the pegs with CPRX compound or any other suitable adhesive and be held in position by the 20 gauge galvanised iron lacing wires.

The insulation boards shall be covered with 20 mm - 24 mm gauge hexagonal galvanised iron chicken wire mesh, nailed to the timber pegs and 30 gauge aluminium sheets shall be fixed over the chicken wire mesh with 50 mm overlap and secured to the timber pegs by screws.

If the insulation is specified to rest on top of the false ceiling, it shall be properly installed and anchored to the frame work. In case additional battens are required for proper installation, Contractor shall include its cost in the rate for insulation.

2.6.228 **Inserts, Bolts, etc.**

Fabricated pipe, plate or moulded, cast or fabricated frame inserts, bolts, etc. shall be provided in masonry and concrete works as indicated on the drawings. It is imperative that all inserts, bolts, fixtures and fittings shall be provided in 'heir 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 Engineer, at no cost to Corporate.

2.6.229 Measurement of Finishes

Floor screeds shall be classified by thickness and measured on the basis of area nett to walls and shall include movement joints, channels and pipes. Formwork and unformed surface finishes of class U2 shall not be measured separately except where specifically stated. Otherwise measurements will be made in accordance with clauses 2.4.8.

Surface hardeners shall be measured as net area of concrete so protected.

Granolithic concrete floors shall be classified by thickness and measured on the basis of area net to walls and shall include forming around walls, columns, doors, movement joints, channels and pipes.
Joints and coves shall be measured on a linear basis.

Vinyl asbestos floor tiling shall be classified by type of tile and measured on the basis of nett area tiled. The rate shall be inclusive of all costs involved including supply of tiles, setting, cutting to any shape, bedding, fixing, cleaning and handing over neat and clean.
Coves shall be measured extra on a linear basis.

The Indian Patent Stone flooringshall be measured and paid for on actual area covered on superficial area basis. The unit rate of the work for providing I.P.S. flooring will be one square metre and the rate shall be held tc include all the cost of material and labour. The linear dimensions shall be measured nett between plastered surface.

The rate for Shahabad/Tandur/Kotah Stone Flooring and Skirting shall be per square metre of flooring laid and shall be inclusive of all costs involved including supplying, setting, pointing, polishing etc. No extra payment shall be made if, the dado is to be made flush with wall surface.

The rate for **Marble Mosaic Flooring**shall be inclusive of all costs including supplying, cushioning, setting, polishing etc. and handing over the work neat and clean.

The rate of **White Glazed Tile Flooring and Dado** shall be inclusive of all costs involved including supply of glazed tiles as specified, setting, cutting to any shape, cushioning on mortar, fixing, cleaning and handing over neat and clean.

Waterproofing Work- For roofs having slopes steeper than 1 in 75, waterproofing work shall be measured as per the actual area covered. For all other roofs, it shall be measured as per the plan area of the roof.

Measurements for **Plain Faced and Sand Faced Cement Plaster** shall be the whole plastered surface of walls, after making deductions for openings and for dressing and other portions not plastered. All plastering shall be measured insuperficial area basis in square metres unless otherwise described or ordered by the Engineer. The unit rate shall be for one sq. metre of plaster.

For the jambs, soffits, sills, etc. of the openings in the above works deductions and additions shall be made in the measurements as indicated below.

(a) No deduction shall be made for ends of joists, beams, posts, etc. and for openings not exceeding 0.5 square metre each. No additions or extra payments shall be made for any reveals, jambs, soffits, sills, etc. of these openings nor for finishing the plaster around the ends of joists, beams, posts, etc.

(b) For openings, in masonry work plastered, exceeding 0.5 square metrebut not exceeding 3 square metres each, no addition or extra payment shall be made for reveals, jambs, soffits, sills, etc. of these openings.

(i) When both faces of walls are plastered with the same type of plaster, item deductions shall be made for one face only,

(ii) When the plaster on both faces of such wall differs, deduction shall be made for the opening area from the respective plaster item measured at the frames for doors, windows, etc. on the side where the width of reveal is less than that on the other side, and no deduction being made for the opening for the plaster on the other side.

(c) In case of opening exceeding 3 square metres each, deductions for the opening shall be made on each side and the areas of jambs, soffits and sills of the openings shall be measured and paid for.

All Cement Pointing work shall be measured and paid for on actual area covered on superficial area basis. The unit of measurement will be square metresand the rates shall be deemed to cover, all relevant works, material, labour, etc. including the cost of dressing and cleaning the joints, pointing, curing etc. complete.

Wall tilingshall be measured on the net area covered and shall include the requirements of Clause 2.6.220 and 2.6.221 including all special tiles cr stones and for cutting and fitting around doors, reveals, pipes, and other items.

Suspended ceilings shall be measured on the nett area covered and shall include the requirements of Clause 2.6.223. No extra payment will be made for plastering the suspended ceilings and the rate of tendered for suspended ceilings shall be deemed to be inclusive of plastering.

Cornices and moulded work shall be measured on nett length covered.

The superficial area of soft board false ceiling shall be measured and paid for at tne unit rate less deductions, if any.

Where moulding is specified, shall be as per details shown in drawings and shall be measured in running metres and paid for.

Rate quoted for Aluminium False Ceiling shall be all inclusive and payment shall be made for work done based on measurement of superficial area of false ceiling less deductions for openings, if any.

Heavy duty abrasion resistant flooring shall be measured and paid for on actual area covered on superficial area basis. The unit of measurement shall be one square metre and the rate shall be held to include all the cost of material and labour.

Thermal insulation for roof/floor

The net superficial area of the insulation shall be measured and paid for.

2.6.3 Woodwork

2.6.301 Woodwork in Doors. Windows. Partitions. Louvers. Railings. etc.

Wood used for all work shall be the best of the respective class specified, 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 any all other defects and blemishes.

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

All joining shall be wrought on all faces and finished off by hand with sand paper, with slightly rounded arrises.

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 as approved.

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

The doors shall be panelled or solid flush doors as described in the item of work.

Single leaf doors :

i) 3 Nos. heavy duty railway type butt hinges 150 mm long.

ii) Godrej 6 lever mortice lock with one oxidised brass 350 mm long 16mm diameter aldrop and with handles on both sides 1 No. (chromium plated brass).

i) Tower bolt 300 mm long.

ii) Door stop 1 No.

Double leaf doors

i) 6 Nos. heavy duty railway type hinges 150 mm long.

ii) Aldrop 1 No.

iii) Tower bolts 300 long, 2 Nos.

iv) Cast handles 4 Nos.

v) Door stops 2 Nos.

Where the singleleaf 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.

Door closures shall be of heavy-duty hydraulic type and shall be separately paid.

Panelled doors shall comprise of 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.

Doors willgenerally have no sills but if a few have to be provided, the Contractor shall do so at no extra cost to Corporate.

The type of window shall be as specified. All fixtures fixed to windows shall be oxidised brass fittings. Each shutter shall have one pair of hinges, two tower bolts (one 225 mm long and another 150 mm long), one handle and one hook with eye andpegstay. Ventilators shall have two mild steel holdfasts and hinges, one handle and one hook and eye at each and one small tower bolt in the centre. Where so directed by the Engineer, the doors and windows shall be provided with parliamentary type hinges at no extra cost.

The workmanship of all door and window shutters shall conform to the requirements of IS 1003 (Parts 1 & 2) and IS 2202 (Parts 1 & 2). If required, flush door panels shall be tested as per IS 4020 at no extra cost to the Corporation.

Cupboards, almirahs and shelves shall be provided as shown in drawings. The doors could be of either hinged type of sliding type as approved by the Engineer. All dimensions as furnished in the drawings shall be followed. Fixtures and fittings as shown on drawings or as directed by Engineer shall be used.

Railings and architraves shall conform to the shape shown on drawings or as approved and fixed by means of screws (counter sunk or otherwise) or bolts.

The finish expected is of a very high order and the work shall be all inclusive whether or not alldetailed specifications have been spelt out and the work shall be free from blemish .

Iron bars or grills shall be provided in the windows or ventilators if expressly specified in drawings or directed by the Engineer. Glass louvered ventilators and windows where specified shall be provided.

Glazed windows, louvers, ventilators and doors shall be as specified in Clause 2.8.4 and shall be provided with either clear or pin-headed class and shall be free from all blemishes and shall conform to IS: 1761. It should be clearly understood that glass which does not have uniform refractive index of which is wavy, will be rejected.

Woodwork shall not be painted, oiled or otherwise treated before it has been approved by the Engineer.

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.

2.6.302 Measurement

All the doors, windows, ventilators, louvers will be measured in square metres. The measurement will be taken to the outside of framework exclusive of horns, projections, etc. The rate quoted shall be all inclusive such as nails, screws, gazing, fixtures, fittings, providing peep holes, locking device, handles, door stops, etc. The rate shall also be inclusive of polishing/painting with 3 coats of approved paint over primer coat. The rate quoted for doors and windows shall include the cost of supplying and fixing frames as well. The rate for all doors, windows and ventilators shall include for providing and fixing only oxidised brass fittings ana fasteners.

2.6.4 Glazing and Metal Doors and Windows

2.6.401 Glass Generally

Glass shall conform to the requirements of relevant IS codes and shall free from bubble, smoke wanes, air holes, scratches and other defects and shall be cut to fit the rebates with due allowance for expansion.

2.6.402 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 in the Bill of Quantities. Sheet glass used for glazing in building shall conform to IS 2835. Modulus of rupture of sheet glass shall be 380 kg/cm^2. Density of sheet glass shall be 2500 Kg/m^3.

2.6.403 Wired Glass

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

2.6.404 Plate Glass

Generally where specified windows shall be glazed in polished plate or float glass of glazing glass quality (G.G) of 6 mm or 10 mm thickness. Modulus of rupture of plate glass shall not be less than 190 Kg/cm^2.

2.6.405 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 an approved special compound manufactured for the purpose.

2.6.406 Glass Blocks

Hollow glass blocks shall be "Insulight" as manufactured by Pilkingtons or similar approved. They shall be joined in cement mortar but the edge of the panel shall be set in nonsetting mastic.

Where required, the blocks shall be set in a reticulated steel security frame. Steel frames for glass blocks shall have a thickness of 5 mm. There shall be no distortion in frames. The whole frame with the exception of lugs and external faces of channels shall be precoated with approved bitumen emulsion or galvanised after manufacture. The rate quoted shall include everything as mentioned above.

2.6.407 Aluminium Doors. Windows and Screens

All extruded sections used in work of aluminium doors, windows etc. shall be 3 mm thick of "Jindal" or "Hindal make”. Al! sections shall be aluminiumanodised. (Thickness of anodising between 15/- microns to 20/- microns) , in matt or polished finish as directed. Aluminium doors, windows etc. of only approved manufacturers shall be used . The aluminium doors and windows shall conform to IS 1948. Fixing of all aluminium doors and windows shall be carried out through the Agency of Manufacturers as per their specifications. Aluminium doors and windows shall be completely water tight. In case the sections as mentioned in the Drawing arc not available, the Contractor shall be allowed to use different sections on approval by the Engineer but the Contractor shall be paid as per tender item and no claim for extra item shall be entertained.

The aluminium windows shall have either side projected or top projected shutters as per Drawing 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 comers and straight edges.

Fittings for doors

(a) Two floor springs of suitable make such as "Everite", "Prabhat" etc. or equivalent having double action spring, unless mentioned otherwise.

(b) Each door leaf shall be fitted with two Nos. of suitable size of aluminiumanodised handles from extruded tube of 100 mm x 50 mm minimum.

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

(d) 6 lever brass lock concealed in section tube and openable from both sides with two keys.

Fittings for windows

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

The rate shall include the cost for fabrication, erection on site, anodising, glass beading, neoprene rubber gaskets, fixtures, fastening, scaffolding, staging etc., if required. The mode of measurements shall be the same as for steel windows.

2.6.408 Steel Windows and Doors

Steel windows and doors, including folding doors shall be supplied complete with frames and fitted with door furniture where appropriate under items in the Bill of Quantities.

Steel is used in fabrication of windows and doors shall have a minimum thickness of 3 mm. Steel frames for glass block windows shall have a thickness of 5 mm. There shall be no distortion in the frames. The whole frame with the exception of lugs and external faces of channels shall be precoated with approved bitumen emulsion or galvanised after manufacture.

2.6.409 Vehicular Doors

Vehicular doors shall be of galvanised metal construction not less than 3 mm thick and shall be of the roller shutter or concertina type as shown on the Drawings. The doors shall be supplied by a reputable manufacturer to the approval of the Engineer 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 Engineer. 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.

2.6.410 Rolling Shutters

The rolling shutters shall conform to the size indicated in drawings and shall be of quality specified in the Schedule of Quantities. The rolling slats shall be in one piece and be made of heavy gauge steel sheets minimum 18 SWG in thickness. A cylindrical hood shall be provided on the top to enclose the shutter when it is open. The rolling shutters shall be provided with suitable locking arrangements and deep channel guides. In case galvanised rolling shutters are specified the rolling shutter shall be made of hot dip galvanised slats, hood, deep channel guides all preferably in one piece.

In case of hand operated pull and push type rolling shutters of sizes larger than 10 square metres in area and in case of very large gear operated and /or as directed by the Engineer, rolling shutters shall be provided with ball bearings for smooth and efficient operation. In case of large rolling shutters and depending upon local wind conditions , the rolling shutters should be provided with special locking type of wider channel guides or it shall be provided with central moveable channel supports to take up the design wind pressures in the area.

The rates quoted shall be inclusive of providing three coats off approved paint over 2 coats of approved primer coat (one shop coat and one coat after erection) where not galvanised. Rates quoted shall also include cost of lever lock and erection. Fixing lugs to be provided to guide channel to suit actual site conditions or as directed by the Engineer at no extra cost.

2.6.411 Measurement

Glass and Glazing

a. No separate payment shall be made for glazing work.

b. No separate payment shall be made for clips, bolts and nuts, mastic cement, putty, beads etc. that may be required for fixing the glass.

c. No separate payment shall be made for cleaning the glass after erection.

d. No separate payment shall be made for cutting the glass panes, to required sizes.

Metal windows, doors shall be classified by the groups shown on the drawings and the requirements of Clauses 2.6.407, 2.6.408, 2.6.409 and 2.6.410 and shall be measured on a square metre opening in masonry and shall include for supply, handling shop-coating, installation defect rectification and glazing work.

Vehicular doors in accordance with 2.6.409 shall be paid per sq.m. opening in masonry.

2.6.5 Water supply and Sanitary Works

2.6.501 General

Plumbing shall be carried out by a specialist Sub-Contractor approved by Corporate and all works shall conform with the requirements of Corporate and the relevant Indian Standards. Building drainage shall conform to IS: 1742. Water supply to buildings shall comply with IS:2065.

2.6.502 Applicable Codes

The following Indian Standard Codes, unless otherwise specified herein, shall be applicable. In all cases, the latest revision of the codes shall be referred to.

a)	IS 1172	Code of basic requirements for water supply, drainage and sanitation
b)	IS 1742	Code of practice for building drainage
c)	IS 4111 (Parts 1 & 2)	Code of practice for ancillary structures in sewerage system
d)	IS 3114	Code of practice for laying of cast iron pipes
e)	IS 783	Code of practice for laying of concrete pipes

f)	IS 4127	Code of practice for laying of glazed stoneware pipes
g)	IS 5329	Code of practice for sanitary pipe work above ground for buildings
h)	IS 2065	Code of practice for water supply in buildings.

2.6.503 Drawings

Drawings showing locations of sanitary and water supply fixtures shall be furnished to the Contractor and all drawings so furnished shall form a part of this specifications. The Contractor shall refer these drawings for all information contained thereon which pertains to and is required for his work. Revisions to drawings and any new drawings made to include additional work by the Contractor shall be considered part of this specification and contract.

Unless otherwise specified, the plans and specifications are intended to include everything obviously requisite and necessary for the proper and entire completion of the work and accordingly the job shall be carried out to completion as required whether each item is mentioned here or not.

Based on the line diagrams/drawings furnished by the Engineer, the Contractor shall prepare detailed working drawings indicating the positions of fittings, valves, joints, nature, type and location of supports, connection to main lines etc. Four prints of each of these detailed drawings shall be submitted to the Engineer for approval and got approved before proceeding with the execution of the works. The Contractor shall obtain permission from all local statutory authorities for all proposed works prior to commencement of execution and necessary fees, etc. shall be borne by him. The Contractor shall, after completion of all works, give as-built drawings incorporating all field changes made for reference and use of Corporate. The final payment due to the Contractor will be effected only after such drawings are finalised.

Construction shall not be started until the Contractor has received copies of such drawings upon which the Engineer has endorsed approval. The approval of the Engineer of any of the drawings shall not relieve the Contractor from his responsibility for correctness of Engineering, workmanship, fit of parts, details, materials, errors or omissions of any and all work shown thereon. The Engineer's approval shall constitute the approval of the design, sizes of pipes and layout only. The approval shall not invalidate any claim Corporate may make for damages on account of faulty construction.

No drawing will be accepted for examination by the Engineer unless entirely complete, first checked and approved by the Contractor.

The Engineer will return one copy of the Contractor's drawings marked with his approval/comments. The Contractor shall furnish the Engineer two prints and one reproducible of all final drawings for record purposes.

All civil works will be measured and paid under respective items of work. Main structural steel framing with holdfasts will be paid under rate quoted for miscellaneous work in general building works.

2.6.504 Sheet Lead for Flashing

The lead shall be new lead in accordance with IS: 405. Unless otherwise specified all lead shall weigh 20 kg/m^2.

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.

2.6.505 Copper Tubing

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

2.6.506 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 bars. Pipes shall be secured to structures at not more than 1.5 m centres, with galvanised malleable cast iron brackets of an approved pattern.

2.6.507 Cocks and Valves

All cocks and valves shall be of types approved by the Engineer and in accordance with IS:6157. Stop valves which are generally concealed shall be made of brass or gunmetal. Stop cocks which are exposed and bib and pillar cocks attached to sanitary fittings shall be brass or gunmetal bodies chromium plated and marked "hot" or "cold" as required.

Ball valves shall be brass in accordance with IS: 1703.

2.6.508 Water Pipes and Fittings

All plumbing works shall be carried out through a Licensed Plumber and the pipes and fittings shall be as per the requirements of the water bye-laws. The Contractor shall get the pipes and fittings work done to the entire satisfaction of the Engineer. The responsibility of getting connection from the water department shall rest with the Contractor. The Contractor shall submit the name of the Licensed Plumber to whom the work is to be entrusted for approval of the Engineer. On completion of the work the Licensed Plumber shall submit a Drainage Completion Certificate, certifying that the works carried out by him have been done in accordance with specifications and provisions of and the relevant bye-laws.

2.6.509 Providing post, boning staves and sight rails for laying out drains

Before laying the drains the centre of each manhole shall be marked by a peg, or otherwise, as determined by the Engineer. The Contractor shall then dig holes for setting up two posts (about 100 mm x 100 mm x and 1.8 m long) at each manhole at nearly equal distance from the peg and at sufficient distance there from 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 75 mm x 50 mm in various lengths, each length being a multiple of half a metre 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 1ength of the boning rod.

The sight-rail (about 100 mm x 25 mm) shall then be screwed with the 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 top 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 sight from rail to rail.

The posts and rails shall in no case be removed until the trenches excavated, the drains constructed, and permission given to proceed with the filling-in.

2.6.510 **Supply of Pipes**

The pipes used in the works shall be of the best approved quality. All pipes shall be perfectly straight and truly cylindrical, glazed inside and outside, free from cracks and flaws, and perfectly burnt. Those not perfectly straight and truly cylindrical, well and uniformly glazed, free from cracks and flaws etc. shall be rejected.

2.6.511 **Formation for Drain Pipes**

The bottom of every trench shall have a true grade throughout and shall be made in perfect straight lines, shown on the plans, or as directed by the Engineer. 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 Engineer.

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, foot-path, 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 re-used it shall be carefully sifted.

2.6.512 **Laying of Drain Pipes**

In laying the drains, care shall be taken that they are laid perfectly true to the grade, inclination 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 to guard against subsidence or fracture of the pipes.

The drainage line shall be stoneware pipes of approved quality and 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 of the best quality and shall be laid vertical and fixed properly, to the satisfaction of the Engineer. The vent pipes shall be raised to about 200 cm. above the terrace floor level.

All pipes in trenches over 4.5 m deep and those in loose grounds, shall be protected and encased with concrete all round as per design.

2.6.513 **Jointing of Pipes**

Stoneware pipes shall be jointed by forcing two strands of tarred gaskets into the joints. The strands shall be sufficiently thick to fit tightly the annular space between the sockets and spigots. The annular space shall then be solidly filled with neat Portland cement, which shall be forced into the socket, so as to fill it and a fillet of cement shall then be worked round the outside of the joint. This fillet shall be kept in position by a band of coarse cloth, which shall be kept moist until the cement has set. Everyjoint of the stone-ware pipes, which is not concreted, shall be further protected by clay placed in the outer sides of the joint of cement (well tampered and tenacious) so as to completely surround the joint.

The joint 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 one 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 of leaving the manhole shall have a splayed fillet of neat cement laid around the same, extending outside the plastering of the manhole by 75 mm. The cost of such fillet shall be deemed to be included in the rates for pipes laid complete.

Care shall be taken after the joints are made to see that the pipes are nut moved or shaken before the cement has thoroughly set, and that they are watertight.

After the joints have thoroughly set, the Engineer or his Representative may inspect the joints, and if he 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 defects are found on such opening, the Engineer may 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.

2.6.514 Refilling of Trenches

After the foundations of any buildings or other works 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 Engineer, the trenches shall be re-filled with the materials taken there from. In re-filling the trenches, utmost care shall be exercised so as not to disturb, break or damage the jointed pipes. Immediately over and around every pipe 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 to above. The back filling shall be done in suitable layers and shall be well rammed properly until it is thoroughly consolidated and watered in addition, if considered necessary by the Engineer. 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.

2.6.515 Testing of Joints for Water Tightness

The joints of stoneware pipes laid under ground shall be tested for 600 mm head of water over the crown of the highest pipe between two inspection chambers.

The lowest end shall be plugged water tight. The water shall then be filled in the inspection chamber at the upper end of the line with 600 mm depth of water over the crown. Any defective joint shall be remade or embedded into M15 cement concrete to make it leakproof.

2.6.516 Manholes

Manholes, shall be constructed in shape and sizes as shown on the drawings, or as directed by the Engineer. The depth of manhole is generally more than 1.5 metres and shall be sufficiently spacious to accommodate a man to clean the same.

The depth of manhole shall be measured from the top surface to the invert level of the manhole.

For the purpose of tender they are divided into two types, viz. (a) ordinary and (b) junction manholes.

Ordinary manholes shall be constructed at places of every change of alignment of pipeline. The junction manholes shall be constructed at places where two or more pipelines converge at a point.

The manhole, whether rectangular or conical, shall be constructed in brick work in cement mortar (1:2) unless otherwise specified and shall be plastered on both sides in cement mortar (1:2). In case of conical manholes, the walls shall be brought up within 180 mm of the road surface and shall be covered with a heavy duty or ordinary cast iron frame and cover as directed or specified.

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The floors shall be cast unless otherwise specified, in 1:2:4 cement concrete. Salt glazed or concrete or hume half channel pipes of required size and curve shall be laid and embedded in cement on the concrete base to the same line and gradient as drain pipes, unless otherwise directed. Both sides of the channel pipes shall be benched up in concrete and rendered in cement mortar 19 mm thick and formed to a slope not less than 1 in 12 to the channel.

Where a pipe enters and leaves a manhole, bricks on edge must be cut to proper form and laid around the upper half of pipe so as to form an arch. All around the pipe, there shall be 13 mm thick joint of cement mortar between the pipes and the bricks. The ends of all pipes shall be properly built in and neatly finished off with cement mortar.

Where the depth of invert exceeds 1 metre below the surface of the ground, galvanised, wrought iron or cast iron steps of approved pattern shall be built in the brick work at every four courses with such additional hand irons as the Engineer may deem necessary for safety.

Cast iron frames shall be bedded in cement mortar (1:3) on the brick works with splayed fillet all round and in such position that the top shall be about 13 mm above the original surface of the road. The covers shall then be placed in position and the whole work shall be left neat and dry.

Covers and frames shall be of cast iron, circular or rectangular, or any other required 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.

2.6.517 Inspection Chambers

Rectangular Inspection Chambers shall be constructed wherever the depth of the invert is less than 1:5 metres. They shall be constructed in brick masonry in cement mortar (1:2) (unless otherwise specified), and shall be plastered on both sides in 20 mm thick cement mortar (1:2). It shall be brought up to about 180 mm above the ground level and shall be covered with cast iron frame and cover or as directed by the Engineer. Floor shall be cast in 1:2:4 cement concrete or otherwise as directed, with haunches and channel etc. in 1:2:4 cement concrete. Cast iron steps of approved quality shall be provided as per details and as directed by the Engineer.

Covers and frames shall be of cast iron conforming to IS 1726. They shall be coated with Dr. Angus Smith's composition. They shall be airtight heavy pattern only, weighing about 150 kg. to 180 kg.

2.6.518 C.I. Nahani Trap

The Contractor shall supply 85 mm diameter nahani traps, bends and pipes with 125 mm diameter CI gratings of the best quality, conforming to IS 3989.

The Contractor shall fix the traps in position as directed by the Engineer. The joints shall be sealed in cement mortar (1:1).

2.6.519 Cast Iron or Asbestos Rain Water Pipes

The Contractor shall supply good quality Cast Iron pipes or Asbestos Cement pipes of specified diameters including all fittings etc. In case of Cast Iron pipes, pipes shall be treated with Dr. Angus Smith's solution.

The tolerance limits for various diameters for Cast Iron rain water pipes shall be as set out in Table 2.6. A.

Table 2.6.A

(IS 1230)

Nominal dia	Ext. Dia.	Tolerance for Ext. dia.	Wall Thickness	Wt. of pipe for 1800 mm length
50 mm	53 mm	± 3 mm	3 mm	7.5 Kg
75 mm	79 mm	± 3 mm	3 mm	11.0 Kg
100 mm	104 mm	± 3.5 mm	3 mm	14.0 Kg
125 mm	130 mm	± 3.5 mm	3 mm	20.0 Kg
150mm	56 mm	± 4 mm	4 mm	26.0 Kg

Tolerance in wall thickness shall be ± 1 mm for all diameters

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The tolerance limits for various diameters for Asbestos Cement pipes shall be as set cut in Table 2.6.B.

Table 2.6.B

[IS 1626 (Part 1)]

Nominal dia.	Ext. Dia.	Tolerances for Ext. dia.	Thickness	Tolerance thickness
50 mm	63 mm	± 1.5 mm	6.5 mm	± 1.0 mm
60mm	73 mm	± 1.5 mm	6.5 mm	± 1.0 mm
80mm	96 mm	± 1.5 mm	8.0 mm	± 1.0 mm
90mm	106 mm	± 1.5 mm	8.0 mm	± 1.0 mm
100mm	116 mm	± 1.5 mm	8.0mm	± 1.0 mm
125 mm	144 mm	± 2.5 mm	9.5 mm	± 1.5 mm
150mm	169 mm	± 2.5 mm	9.5 mm	± 1.5 mm

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

The pipe shall be fixed at the places shown in the drawing. The cavity between brick masonry and the pipes etc. shall be made good in cement mortar, neatly, after the fixing of 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 cast iron 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 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 l/3rd that 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 bricks 300 mm x 300 mm of sufficient height. The Cast Iron pipes shall be painted with one coat of red lead oil paint and two coats of anticorrosive oil paint of approved shade.

Pipes, fittings and joints shall be tested for leaks as specified in clause 2.6.521 and defects, if any, shall be rectified.

2.6.520 <u>Cast Iron or Asbestos Cement soil/vent/waste pipes with necessary fixtures and fittings, etc.</u>

The Contractor shall supply good quality pipes including all fixtures viz. tees, bends, etc. as required, free from cracks, flaws, etc. In case of Cast Iron pipes, they shall be treated with Dr. Angus Smith's solution.

The tolerance limits for various diameters for Cast Iron Soil, Waste and Ventilating pipes shall be as set out in Table 2.6.C.

Table 2.6.C

(IS 1729)

Nominal dia. mm	Ext. dia	Wall Thickness	Tolerance for Ext. Dia.	Wt. of pipe for 1800 mm length –(kg)
50 mm	60 mm	5 mm	± 3 mm	11.41
75 mm	85 mm	5 mm	± 3 mm	16.52
100 mm	110 mm	5 mm	± 3.5 mm	21.67
150 mm	160 mm	5 mm	± 4 mm	31.92

Note:- Tolerance on wall thickness shall be minus 15%

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 walls. 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 yam shall then be wound round the joint with cement mortar (1:1)

In case of Asbestos Cement pipes, the pipes shall be fixed by clamps fixed to the holder batten. The Cast Iron pipes shall be painted with one coat of red lead oil paint and two coats of anti corrosive oil paint of approved shade.

Pipe fittings and joints shall be tested for leaks as specified in clause 2.6.521 and defects if any, shall be rectified.

2.6.521 <u>Testing of Joints of Drainage Pipes and Fittings</u>

The joints of drainage pipes and fittings will be tested by the Contractor without any extra charge to Corporate as per the specifications 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 25 mm 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.

2.6.522 <u>Providing and Fixing Stoneware Gully Traps</u>

This item pertains to the provision of stoneware Gully trap outside the building including construction of brick masonry chambers with lid and frame as specified in the Bill of Quantities.

Salt glazed stoneware gully trap of the size specified shall be of best quality approved by the Engineer.

Stoneware pipes shall conform to IS 651 and shall be of the internal diameter indicated on the drawings or as ordered by the Engineer.

The gully trap shall be set in 1:3:6 cement concrete extending 30 cm beyond trap on three sides over which the brick masonry chamber of dimensions as indicated on the drawing or as directed by the Engineer shall be constructed. The building wall will be on the fourth side. Brick masonry shall have internal and external plaster 20 mm thick in cement mortar (1:4). The top lid including its frame shall be fixed in 1:3:6 cement concrete 10 cm thick. The trap in the chamber shall be provided with a grating.

2.6.523 Providing and Fixing Intercepting Sewer Trap

This item provides for the provision and construction of an intercepting sewer trap, brick masonry chamber, including salt glazed stoneware interceptor with rodding pipe and cover, concrete foundation, concrete channels, fixing the trap, in cement concrete, etc. complete.

The intercepting trap and the half glazed stoneware pipes shall be provided by the Contractor, and shall be of the best quality available in the market.

The intercepting trap shall be provided in the position as indicated on the drawing, or as directed by the Engineer. The inside dimensions shall be 90 cm x 90 cm and the depth shall correspond to the depth of the drain.

The foundation concrete shall be Ml5 and shall be laid to a thickness of 25 cm. The intercepting sewer trap shall be fixed into the extended position 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 (1:5) with inside dimension of 90 cm x 90 cm. During the construction, the rodding pipe of the trap shall be embedded in brick masonry. Channel in M10 cement concrete shall be formed to lead away the sewage. Alternatively half round stoneware pipes can also be provided to form channels. The floor of the chamber shall be sloping towards the channels. The brick masonry chamber shall be plastered on both sides in cement mortar (1:4) 20 mm thick. The cast iron lid and frame shall be fixed in M10 cement concrete, 10 cm thick.

2.6.524 Providing and applying bitumen layer to water closet slab

This item provides for applying bitumen layer over the water closet slab for making it water proof.

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 121^0C (250^0F) evenly throughout and allowed to dry before laying brick bat coba etc.

2.6.525 White Glazed Earthenware Water Closet Pan

This item pertains to the provision and fixing of Indian type white glazed earthenware water closet Pan conforming to IS 2556 (Part 2) of the specified dimension with cast iron high level flushing cistern and other flushing accessories and necessary pipe connections upto the soil and vent pipes fixed on the outside of wall.

The Indian type water closet pan, trap, the cast iron level flushing cistern, 32 mm diameter lead pipe etc. shall be approved quality and make. The Contractor shall obtain the prior approval of the Engineer before fixing the pan and its accessories into place.

Brickbat coba shall be laid as specified by the specialised waterproofing agency.

The water closet pan and the flushing cistern shall be fixed into the places indicated on the drawings or as directed by the Engineer.

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

Brickbat cement concrete 1:2:4 shall be cast and pressed all around the embedded surface of the pan and fittings and pipes to get solid embedding without any hollows. The whole area for water closet shall be provided with 1:2:4 brickbat cement concrete. The pan shall be fixed at a slightly lower level than the 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 indicated on the drawing or as directed by the Engineer.

The lead or galvanised 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 red lead oil paint and two coats of approved shade of good oil paint.

2.6.526 White Glazed Earthenware Urinal

This item includes providing and fixing flat back urinal as mentioned in the item. It shall be of the best Indian make conforming to IS 2556 (Part 6) and as approved by the Engineer. 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 Engineer. All the pipe connections shall be made as shown on the drawings or as necessary for the item.

2.6.527 White GlazedWashHandBasin

This item pertains to providing and fixing of wash hand basin of the specified size conforming to IS 2556 (Part 4) including all necessary fixtures and pipe connections upto the outside face of the wall as mentioned in the Bill of Quantities. The wash basin shall be of approved make and quality.

The basin shall be fixed at the location and level shown on the drawing or as directed by the Engineer, being 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 Engineer.

The brackets shall be securely embedded in or fixed to the wall and the basin fixed on to the brackets.

The waste pipe shall be either galvanised iron or lead and shall be provided as required upto a length of one metre. 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.

2.6.528 Septic Tank

The sewer line shall be connected to a septic tank of adequate capacity and design. The effluent from this tank shall be lead into a soak pit or disposed off as directed by the Engineer, after further treatment through a filter unit.

The septic tank shall be constructed as per details shown in the drawing. The work involved shall be as follows :

All the work involved such as excavation in any material to the required depth, refilling the sides of masonry wall etc., masonry work including external and internal plastering in cement mortar (1:4), covering the chamber and tank with RCC slab, and providing openings with RCC precast covers with handles, providing cast iron steps including inlet and outlet chamber with all accessories, fittings, vent pipe, cowl cap etc. as specified and directed.

All the items mentioned above for the proper and complete construction of the septic tank shall be paid for as specified under relevant clauses for the respective items of work as mentioned in Part 2 of the Specification.

2.6.529 **Soak-Pit**

The effluent from the septic tank shall be led into a soak pit. The soak pit shall be prepared by excavating a pit of adequate size depending on the soil condition and as directed by the Engineer. The pit shall be lined with brick masonry wall 460 mm thick in cement mortaj (1:5) on cement concrete bedding of M10, 600 mm wide and 300 mm thick. The pit shall then be filled with dry rubble with uniform 100 mm size stones for the first 300 mm and with brickbats for the remaining depth. At the ground level 125 mm. thick RCC slab in Ml5 shall be provided having bearing of 460 mm on all sides. This slab shall be provided with inspection chamber frame of size 60 cm x 45 cm with cast iron cover and frame (frame and cover of weight about 102 kgs) and also 6 numbers of galvanised iron steps fixed in the wall.

2.6.530 Providing, Hoisting and Fixing in Position Water Storage Tank :-

General

This item pertains to the provision and installation of the mild steel water storage tank including all necessary fittings.

The mild steel tank made out of sheets 3 mm thick, galvanised iron pipes, ball cocks, stop taps, provided by the Contractor shall be approved by the Engineer.

Unless other sizes are shown in the drawing galvanised iron pipes shall be (i) 25 mm size for overflow, (ii) 38 mm size for scour, (iii) 50 mm 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.

Fabrication and installation

The tank shall cater to the capacity indicated in the Bill of Quantities. This capacity shall be the net water available for use and not the gross content.

The design of the mild steel tank shall be provided by the Engineer. The number of tanks for the proposed capacity shall be as decided by the Engineer

The supporting RS joists shall be paid for separately.

Manholes each having 450 mm diameter opening, shall be provided in the top sheet of the tank as required by the Pest Control Officer and shall be provided with hinged covers and locking arrangements.

Holes of required diameter shall be provided for fixing scour tap, outlet pipes, connecting pipes, overflow pipes, water supply pipes, etc.

The tank shall be painted as directed and erected in the position indicated on the drawing or as directed by the Engineer. Any damage during transport, hoisting etc. shall be made good by the Contractor at his own cost. The position and length of the overflow/scour pipes shall be so as not to damage the floor or the walls. The ball cock shall be fixed at the proper level. All the connections of the overflow pipes, scour pipes, inlet pipes shall be leakproof.

The tank shall be coated with a primary coat of red oxide zinc chromate primer on the inside and outside and two coats of special bituminous black paint on the inside and two coats of approved silver paint or synthetic enamel oil paint on the outside.

On completion of the work, the tank shall be tested for its performance. Any leakage or defect so detected shall be made good without any cost to the Corporation.

2.6.531 Measurement of Plumbing

Measurement of plumbing work shall be by such items as are provided in the Bill of Quantities and these items shall include all work necessary to complete the supply, installation, fixing and testing of the plumbing systems to the approval of the Engineer.

Cocks and valves shall be paid for as per number of cocks and valves installed.

Stoneware pipes laid below ground shall be measured according to the actual length laid and no allowance will be made for any wastage in cutting the pipes to the exact length required. The unit of measurement will be a metre and the unit rate shall be held to include the cost of pipes, labour and material in excavation in any kind of soil or rock if met with, including refilling the excavated trenches, laying in position, making joints, etc. complete as specified and testing the same.

Pipes laid overground will also be measured and paid for according to the actual lengths laid, and no allowance will be made for any wastage in cutting the pipes to the exact length required. The unit of measurement will be a metre and the unit rate shall be held to include the cost of pipes, all labour and materials in laying in position with all necessary fittings, making joints, as specified above and testing of the same, if required.

Manholes and inspection chambers shall be paid for per number of different depths, sizes and diameters. The rate for the manholes and inspection chambers shall include the cost of excavation in any kind of soil or rock if met with, the masonry structure, plastering on both sides, encasement of pipes, branches if any, connection of pipes, foundation concrete, concrete in haunches, floor channel, frame and cover, cast iron or wrought iron steps etc., including refilling the excavated sides with earth etc. complete.

The payment for Nahani traps shall be on the basis of number of nahani traps fixed, which includes the cost of materials and the labour for fixing the same.

Cast iron or asbestos rain water pipes shall be paid for per metre of pipe fixed including supplying, fixing, jointing, painting, testing the pipes etc. complete.

Cast iron or asbestos soil/vent/waste pipes shall be paid for per metre of pipe fixed which shall cover cost of all labour, supplying and fixing all materials, fixtures etc. including fixing the same to the walls and painting as specified.

Stoneware gully traps shall be paid for on the basis of number of gully traps fixed. The rate shall include the cost of all labour and material for providing stoneware gully trap, constructing a chamber including plastering, fixing of lid and frame and grating inside the chamber, etc.

Intercepting sewer traps shall be paid for per number of intercepting traps provided. The foundation concrete, brick masonry, plaster, cast iron lid and cover, haunch concrete etc. will be paid for as per the appropriate items of the schedule.

The item rate for Bitumen layer to water closet slab includes cost of bitumen and labour charges for cleaning, application of bitumen, etc. The rate, will be per square metre of area to which the bitumen is applied including the verticals of beams, etc.

White glazed earthenware water closet pans shall be paid for per number of such water closet pans fixed.

Septic tanks shall be paid for per number of septic tanks installed and the rate shall be held to include provision of the materials required and all the work involved in constructing the septic tank as set out in clause 2.6.528.

White glaad earthenware urinal shall be paid for per number of urinals fixed with all necessary fittings.

White glazed wash hand basin shall be paid for per number of such basins fixed.

Soak pit shall be measured and paid for per number of soak pits and the rate shall include the cost of excavation in any material to the required depth, refilling, construction of brick masonry walls with bed concrete, filling with rubble and brickbats, providing RCC slab with frame and cover of inspection chamber including steel for the RCC slab.

Mild steel water storage tanks shall be paid for on the basis of the net capacity in litres. The rate quoted shall include providing transport, hoisting and fixing in position the mild steel tank. Provision of all necessary pipes, ball cocks, stop taps, mosquito proof coupling, manhole covers, etc., .painting and testing shall be deemed to be included in the rate quoted.

2.6.6 Distempering, White/Colour Washing and Painting

2.6.601 Distempering

The surface to be treated shall be thoroughly cleaned of all dirt and loose particles etc. Inequalities and holes shall be filled with gypsum which should be allowed to set hard before distemper is applied.

Distemper shall be of well known brands of approved make. It shall be applied by a broad stiff brush in two coats over a coat of primer. The fust and second coat shall be applied only after the primer coat has thoroughly dried. The first coat shall be of a lighter tint. The shade of the distemper shall be got approved by the Engineer. Water bound and oil bound distemper shall conform to the requirements of IS:427 and 428 respectively.

2.6.602 WhiteWash

Walls shall be thoroughly cleaned before white wash is applied. White wash shall be of ordinary fat lime and of 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 of lime ready for white washing.

Each coat is to be applied with a brush. 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 costs shall be applied.

2.6.603 ColourWash

Colour wash shall be applied the same way as white wash. Necessary and approved colouring matter shall be added to the white wash which has been strained. Only wash sufficient for the day's work shall be prepared each morning. If the finished surface is powdery and comes off easily or the general appearance is streaky, the work shall be rejected.

2.6.604 Painting Generally

All paints and preserves shall be of approved make and their application shall conform to the manufacturer's instructions. Where more than on undercoat is specified it shall be applied in coats of distinctive tints.

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 Engineer'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 glass paper between ccats. No paint shall be applied to a surface, which is damp, dirty or otherwise inadequately prepared.

Final painting shall not be commenced until substantial completion of the Contract unless otherwise ordered.

2.6.605 Painting of Concrete and Brickwork

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

(a) for interior brickwork and concrete, apply two coats of plastic emulsion paint over a coat of primer.

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

Paint to be used for the various items of work should be approved make and colour. It is imperative that the Contractor should obtain Engineer's permission in regard to the make and colour of paint that he proposes to use for the various items of work. The painting work shall be carried out as directed by the Engineer, keeping, however, in view the recommendations of the manufacturer.

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, dirt and sand papered. One primer coat and two coats of emulsion paint shall be applied. Workmanship shall conform to the requirements of IS 2395 (Parts 1 & 2).

2.6.606 Ironwork and Ungalvaniscd 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 has 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 coat has scraped or chipped off. If rust has spread under the primer the affected surface shall be cleaned down to bare metal to the satisfaction of the Engineer and then re-primed.

Repainting shall be carried out as soon as possible after erection. If it is to be exposed to weather or condensation it shall receive two further coats 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 "Comastic" or "Epilux 5" by Berger Paints, or equivalent. The total coating shall be a minimum of 0.125 mrn thick.

After priming, iron and steelwork to have a decorative finish shall be painted as follows-

(a) interior work shall be given one coat of micaceous iron oxide paint, then one approved undercoat plus one coat of gloss paint.

(b) exterior work shall be as for interior work except that two coats of micaceous iron oxide shall be applied.

2.6.607 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 oxidised adequately to allow adhesion of undercoats, need not have an initial coat of etch primer. However, this decision shall lie with the Engineer.

After priming, galvanised steelwork in constant or intermittent contact with raw or treated water shall bs given two coats of an approved coal tar pitch epoxy paint such as "Epilux 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 :

(a) one coat of an approved micaceous iron oxide paint for interior galvanised steelwork.

(b) two coats of an approved micaceous iron oxide paint for external galvanised steelwork. The F 432 line from I.C.I. Paints or similar approved would be suitable.

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

2.6.608 Bituminous Surfaces

Metalwork items that have been 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.

2.6.609 Aluminum Surfaces

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

The pretreated 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 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 preferably not contain any lead. A recommended priming coat consists of a tung-oil phenolic-resin which is pigmented with equal parts of zinc tetroxy chromate and red iron oxide.

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

2.6.610 **Wood Work**

Woodwork for painting shall be carefully rubbed down, treated with preservative 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 "Aluminum Wood primer Sealer A519-3697" 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 "Dulux Undercoat A522 line" shall be used.

Timber work shall be decoratively finished with one coat of finishing paint of standard equal to, or better than "Dulux Gloss Finish A365 line".

Plaster work shall be rubbed down smooth and any cracks, blisters or other imperfections cut out and made good. The plaster work shall be completely dry before painting is commenced and any efflorescence on the surface shall be removed by dry brushing.

Plaster work shall be sealed with an approved alkali resistant sealer such as "Plaster Sealer A572-PJ-0170" from I.C.I. Paints.

After lightly rubbing down the sealer the surfaces shall be painted with three coats of emulsion paint of quality equal to or better than "Pentalite Emulsion Paint A383 line" from I.C.I, paints.

2.6.611 **Galvanising Steelwork**

Galvanising shall be carried out in accordance with IS : 6159 and 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 Engineer has inspected the coating.

2.6.612 **Step Irons**

The Contractor shall supply and fix galvanisedmelleable iron step irons of the type shown in the drawings. They shall have a 110 mm tail. They shall be built walls truly level and in vertical lines as shown on the drawings or directed by the Engineer.

2.6.613 **Access Ladders**

Access ladders shall be of mild steel and galvanised and painted as specified in Clause 2.6.611. Stringers shall be 60 mm x 12 mm flat spaced 375 mm apart. Rungs shall be 25 mm diameter at 250 mm centres turned to 20 mm diameter each and rivetted to stringers.

Ladders shall be fixed at the top and the bottom and at intervals not exceeding 2 m by brackets of 50 mm x 10 mm flat, of such length that the rungs are not less than

200 mm from the wall, secured by galvanisedragbolts of an approved type. Brackets shall be fixed to the ladders by one 16 mm diameter bolt through each stringer.

Ladders may also be fixed at the bottom by bending the stringers and bolting to the floor.

2.6.614 **Handrails**

Handrails shall be provided on open sides of platforms, stairways and around all openings as shown on drawings. Handrails shall be of standard weight galvanised steel pipe of flush welded construction, ground smooth, using 32 mm nominal bore light class pipe provided with double rail, top rail about 1 meter above platform level and pipe posts spaced not more than two meters apart. Angle handrail posts shall be provided only if specifically called for in the Engineer's drawings.

Smooth uniform curves and bends shall be provided at stair returns and also wherever required / specified. Posts connected to curb plates shall have a neat closure at the bottom and a 6 mm thick plate neatly welded to posts for attachments to curb plate. All necessary fittings including inner dowels at splices, brackets, bolts, bends, flanges and chains, where required shall be furnished by the Contractor. Open ends of all the pipe posts shall be plugged and welded. A minimum radius of 3 times the pipe diameter shall be provided at all points of direction changes in the handrail.

The rate quoted for handrails shall be per running metre of completed handrailinj including posts, fittings, etc. and shall also include galvanising and painting of the same. It shall be clearly understood that individual lengths of runners, posts, etc. vill not be measured for purposes of payment.

2.6.615 **Chequered Plates**

Chequered plates used shall be 6 mm thick or as indicated on drawings and shall be capable of carrying a minimum live load of 750 kg / sq. metre unless otherwise specified on design drawings. Chequered plates shall be fixed by 8 mm diameter cadmium plated mild steel screws with counter sunk heads at a maximum spacing of 400 mm. Members supporting the chequered plates shall have matching holes tapped in them. The chequered plate pattern shall be approved by the Engineer. Chequered plates may also be required to be welded to the structural steel framing. The decision in this regard will be given by the Engineer.

2.6.616 **Chain-Link Fencing**

Where indicated on drawings or instructed by the Engineer, anti-intruder fencing shall be constructed in accordance with IS : 2721. The chain link portion shall be 2.0 m high and shall have stanchions cranked above the chain link portion with three strands of galvanised barbed wire strung and strained between the cranked section.

Fence lines shall ran straight between corners, unless directed otherwise, the stanchion tops shall be graded as far as practicable in straight lines.

Payment shall be as per relevant item in the Bill of Quantities and shall be on a running metre basis.

2.6.617 **Measurement of Painting**

The cost of any shop treatment and priming of surfaces shall be included for in the supply of the item concerned.

The requirements of Clauses 2.6.601 to 2.6.610 shall be measured on the basis of area of surface required to be painted, white/colour washed or distempered.

The area of surface painted at Site shall be measured once only for the number of coats specified herein.

Measurement shall be net with no allowance for boltheads, rivet heads or other protuberances.

The Contractor shall include in his rates for painting pipework all coats of treating brackets and supports and in his rates for walls and ceilings, all costs for painting electrical conduit switch boxes and other small items needing different treatment to the surface on which they are fixed. All costs of making good damaged surfaces shall be included in the rates.

Except where otherwise stated, rates entered in the Bill of Quantities shall allow for the supply of the machinery.

PART 2

SECTION 7

STRUCTURAL STEEL WORKS

2.7 STRUCTURAL STEEL WORKS

2.7.1 Applicable Codes and Specifications

The supply, fabrication, erection and painting of structural steel works shall comply with the following specifications, standards and codes unless otherwise specified herein. All standards, specifications and codes of practices referred to herein shall be the latest editions including all applicable official amendments and revisions.

IS:808	Dimensions for Hot Rolled Steel sections
IS:814	Covered Electrodes for Manual Metal Arc Welding of Carbon and Carbon Manganese Steel
IS:800	Code of Practice for General Construction in Steel
IS:801	Code of Practice for Use of Cold Formed Light Gauge Steel Structural Members in GeneralBuilding Construction
IS:806	Code of Practice for Use of Steel Tubes in GeneralBuilding Construction
IS:7205	Safety Code for Erection of Structural Steel Work
IS:7215	Tolerances for Fabrication of Steel Structures
IS:4000	High Strength Bolts in Steel Structure - Code of Practice
AISC	Specifications for Design, Fabrication and Erection of Buildings
IS:1161	Steel Tubes for structural purposes
IS:102	Ready Mixed paint, Brushing, Red Lead, Non-setting, Priming
IS:110	Ready Mixed paint, brushing, grey filler for enamels for use over primers.
IS:117	Ready Mixed paint, Brushing, Finishing, Exterior Semi-gloss for general purposes, to Indian Standard colours.
IS:158	Ready Mixed paint, Brushing, Bituminous, Black, Lead free, Acid, Alkali and heat resisting.
IS:159	Ready Mixed paint, Brushing, Acid resisting for protection against acid fumes, colour as required.
IS:341	Black Japan, Types A, B and C
IS:2339	Aluminium paint for general purposes, in Dual container
IS:2932	Enamel, Synthetic, Exterior: (a) Undercoating (b) Finishing-Specification
IS:2933	Enamel exterior (a) undercoating, (b) finishing – Specification
IS:5905	Sprayed aluminium and zinc coatings on Iron and Steel
IS:6005	Code of practice for phosphating of Iron and Steel.
IS:9862	Specification for ready mixed paint, brushing, bituminous, black, lead free, acid, alkali, water & chlorine resisting.
IS:13183	Aluminium paint, Heat resistant.
SIS-05-5900	(Swedish Standard)
IS:1239	Mild steel tubes, tubular and other Wrought steel fittings
	Part 1 - Mild steel tubes
	Part 2 - Mild steel tubular and other wrought steel pipe fittings
IS:1363 (Parts 1 to 3)	Hexagon Head Bolts, Screws and Nuts of product Grade C range M5 to M64)
IS:1367 (All Parts)	Technical Supply Conditions for Threaded Fasteners
IS:1852	Rolling and Cutting Tolerances for Hot Rolled Steel Products

IS:1977	Structural Steel (Ordinary Quality)
IS:2062	Steel for General Structural Purposes
IS:2074	Ready Mixed Paint, Air drying, Red Oxide Zinc Chrome and Priming
IS:3502	Steel Chequered Plate
IS:3757	High Strength Structural Bolts
IS:5369	General Requirements for Plain Washers and Lock Washers
IS:5372	Taper Washers for Channels
IS:5374	Taper Washer for 1 Beams
IS:6610	Heavy Washers for Steel Structures
IS:8500	Structural Steel-micro-alloyed (medium and high strength qualities)
IS:803	Code of practice for design, fabrication and erection of vertical mild steel cylindrical welded storage tanks
IS:816	Code of Practice for use of Metal Arc Welding for General construction in Mild Steel
IS:822	Code of Procedure for Inspection of Welds
IS:1182	Recommended Practice for Radiographic examination of Fusion Welded Butt Joints in Steel Plates
IS:1200	Method of Measurement in Building Civil Works
IS:1477	Code of Practice for Painting of (Parts 1&2) Ferrous Metals in Buildings
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:9595	Recommendations for Metal Arc Welding of Carbon and Carbon Manganese Steel

2.7.2 Steel Materials

Steel materials shall comply with the specifications.

All materials used shall be new, unused and free from defects

Steel conforming to IS: 1977 shall be used only for the following:

Fe310-0(St 32-0): For general purposes such as door/window frames, grills, steel gates, handrails, fence posts, tee bars and other nonstructural use.

Fe410-0(St 42-0): For structures not subjected to dynamic loading other than wind loads such as: Platform roofs, foot over bridges, building, factory sheds etc.

Fe510-0(St 42-0): Grade steel shall not be used

a) If welding is to be employed for fabrication

b) If site is in severe earthquake zone

c) If plastic theory of design is used

2.7.3 Drawings prepared by The Vendor / Contractor

The VENDOR/CONTRACTOR shall prepare all fabrication and erection drawings for the entire work. All the drawings for the entire work shall be prepared in metric units.

The drawings shall preferably be of one standard size and the details shown there in shall be clear and legible.

All fabrication drawings shall be submitted to the ENGINEER for approval.

No fabrication drawings will be accepted for ENGINEER's approval unless checked and approved by the VENDOR/CONTRACTOR's qualified structural engineer and accompanied by an erection plan showing the location of all pieces detailed. The VENDOR/CONTRACTOR shall ensure that connections are detailed to obtain ease in erection of structures and in making field connections.

Fabrication shall be started by the VENDOR/CONTRACTOR only after ENGINEER's approval of fabrication drawings. Approval by the ENGINEER of any of the drawings shall not relieve the VENDOR/CONTRACTOR from the responsibility for correctness of engineering and design of connections, workmanship, fit of parts, details, material, errors or omissions or any and all work shown thereon. The ENGINEER's approval shall constitute approval of the size of members, dimensions and general arrangement but shall not constitute approval of the connections between members and other details.

The drawings prepared by the VENDOR/CONTRACTOR and all subsequent revisions etc. shall be at the cost of the VENDOR/CONTRACTOR for which no separate payment will be made.

2.7.4 Fabrication

2.7.401 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/ground smooth true and square where so specified. All holes and edges shall be free of burrs. Shearing and chipping shall be neatly and accurately done and all portions of work exposed to view shall be neatly finished. Unless otherwise approved by the ENGINEER, reference may be made too relevant IS codes for providing standard fabrication tolerance. Material at the shops shall be kept clean and protected from weather.

2.7.402 Connections

Shop/ field connections shall be as per approved fabrication drawings.

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

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

All connections and splices shall be designed for full strength of members or loads. Column splices shall be designed for the full tensile strength of the minimum cross section at the splice.

All bolts, nuts, washers, electrodes, screws etc., shall be supplied/brought to site 10% in excess of the requirement in each category and size. Rates shall cover the cost of this extra quantity.

All members likely to collect rainwater shall have drain holes provided.

2.7.403 Straightening

All materials, shall be straight and, if necessary, before being worked shall be straightened and/or flattened by pressure and shall be free from twists. Heating or forging shall not be resorted to without the prior approval of the ENGINEER in writing.

2.7.404 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 as called for on the drawings. Adjacent sections shall be match-marked to facilitate accurate assembly, welding and erection in the field.

2.7.405 High Strength Friction Grip Bolting

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.

2.7.406 Welding

Welding procedure shall be submitted to the ENGINEER for approval. Welding shall be entrusted to qualified and experienced welders who shall be tested periodically and graded as per IS: 817, IS:7310 (Part 1) and IS:7318 (Part 1).

While fabricating 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 members. Wherever weld reinforcement interferes with proper fit-up between components to be assembled off welding, these welds shall be ground flush prior to assembly.

Approval of the welding procedure by the ENGINEER shall not relieve the Contractor of his responsibility for correct and sound welding without undue distortion in the finished structure.

No welding shall be done when the surface of the members is wet nor during periods of high wind.

Each layer of a multiple layer weld except root and surface runs may be moderately penned with light blows from a blunt tool. Care shall be exercised to prevent scaling or flaking of weld and base metal from overpeening.

No welding shall be done on base metal at a temperature below -5ºC. Base metal shall be preheated to the temperature as per relevant IS codes.

Electrodes other than low-hydrogen electrodes shall not be permitted for thicknesses of 32 mm and above.

All welds shall be inspected for flaws by any of the methods described under Sub-clause 2.7.5. The choice of the method adopted shall be agreed with the ENGINEER.

The correction of defective welds shall be carried out in a manner approved by the ENGINEER without damaging the parent metal. When a crack in the weld is removed, magnetic particle inspection or any other equally positive means approved by the ENGINEER 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. The cost of all such tests and operations incidental to correction shall be borne by the Contractor.

2.7.407 Tolerances

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

Cutting, punching, drilling, welding and fabrication tolerances shall be generally as per relevant IS codes.

2.7.408 End Milling

Where compression joints are specified to be designed for bearing, the bearing surfaces shall be milled true and square to ensure proper bearing and alignment.

2.7.5 Inspection

2.7.501 General

The Contractor shall give due notice to the ENGINEER in advance of the works being made ready for inspection. All rejected material shall be promptly removed from the shop and replaced with new material for the ENGINEER's inspection The fact that certain material has been accepted at the Contractor's shop shall invalidate final rejection at site by the ENGINEER if it fails to conform to requirements of these specifications, to be in proper condition or has fabrication inaccuracies which prevent proper assembly nor shall it invalidate any claim which the Engineer may make because of defective or unsatisfactory materials and/or workmanship.

No materials shall be painted or despatched to site without inspection and approval by the ENGINEER unless such inspection is waived in writing by the ENGINEER.

The Contractor shall provide all the testing and inspection services and facilities for shop work except where otherwise specified.

For fabrication work carried out in the field 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 ENGINEER.

Inspection and tests on structural steel members shall be as set forth below.

2.7.502 Material Testing

If mill test reports are not available for any steel materials the same shall be tested by the Contractor to the Engineer satisfaction to demonstrate conformity with the relevant specification.

2.7.503 Tests on Welds

(a) Magnetic Particle Test

Where welds are examined by magnetic particle testing, such testing shall be carried out in accordance with relevant IS codes. 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 the permission of the ENGINEER.

(b) Liquid Penetrant Inspection

In the case of welds examined by Liquid Penetrant Inspection, such tests shall be carried out in accordance with relevant IS Code. All defects shown shall be repaired and rechecked.

(c) Radiographic Inspection

All full strength butt welds shall be radiographed in accordance with the recommended practice for radiographic testing as per relevant IS code.

2.7.504 Dimensions, Workmanship & Cleanliness

Members shall be inspected at all stages of fabrication and assembly to verify that dimensions, tolerances, alignment, surface finish and painting are in accordance with the requirements shown in the Contractor's approved fabrication drawings.

2.7.505 Test Failure

In the event of failure of any member to satisfy inspection or test requirement, the Contractor shall notify the ENGINEER. The Contractor must obtain permission from the ENGINEER before any repair is undertaken. The quality control procedures to be followed to ensure satisfactory repair shall be subject to approval by the ENGINEER.

The ENGINEER has the right to specify additional testing as he deems necessary, and the additional cost of such testing shall be paid to the contractor, only in case of successful testing.

The Contractor shall maintain records of all inspection and testing which shall be made available to the ENGINEER.

2.7.6 Shop Matching

For structures like bunkers, tanks, etc. shop assembly is essential. For other steelwork, such as columns along with the tie beams/bracings may have to be shop assembled to ensure satisfactory fabrication, obtaining of adequate bearing areas etc., if so desired by the ENGINEER. All these shop assemblies shall be carriedout by the Contractor.

2.7.7 Drilling Holes for Other Works

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

2.7.8 Marking of Members

After checking and inspection, all members shall be marked for identification during erection. This mark shall correspond to distinguishing marks on approved erection drawings and shall be legibly painted and stamped on it. The erection mark shall be stamped with a metal dye with figures at least 20 mm high and to such optimum depth as to be clearly visible.

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

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

2.7.9 Errors

Any error in shop fabrication which prevents proper assembling and fitting up parts in the field by moderate use of drift pins or moderate amount of reaming WILL be classified by the ENGINEER as defective workmanship. Where the ENGINEER rejects such material or defective workmanship, the same shall be replaced by materials and workmanship conforming to the Specifications by the Contractor, at no cost to the Employer.

2.7.10 Painting of Steel Work

All fabricated steel material, except those galvanised shall receive protective paint coating as specified in specification, which is described below.

2.7.1001 **Materials**

Red-oxide-zinc chrome primer shall conform to IS:2074

Synthetic enamel paint shall conform to IS:2932

Aluminimum paint shall conform to IS:2339

All the materials shall be of the best quality from an approved manufacturer. Contractor shall obtain prior approval of the ENGINEER for the brand of manufacture and the colour / shade. All the materials shall be brought to the site in sealed containers.

2.7.1002 **Workmanship**

Painting work shall be carried out only on thoroughly dry surfaces. Painting shall be applied either by brushing or by spraying. Contractor shall procure the appropriate quality of paint for this purpose as recommended by the manufacturer. The workmanship shall generally conform to the requirement of IS: 1477 (Part 2).

The type of paint, number of costs etc. shall be as specified in the respective items of work.

Primer and finish paint shall be compatible with each other to avoid cracking and wrinkling. Primer and finish paint shall be from the same manufacturer.

All the surfaces shall be thoroughly cleaned of oil, grease, dirt, rust and scale. The methods to be adopted using solvents, wire brushing, power tool cleaning etc., shall be as per IS:1477 (Part - I) and as indicated in the item of work.

It is essential to ensure that immediately after preparation of the surfaces, the first coat of red oxide-zinc chrome primer shall be applied by brushing and working it well to ensure a continuous film without holidays. After the first coat becomes hard dry, a second coat of primer shall be applied by brushing to obtain a film free from 'holidays'.

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 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 finishing 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.

Atleast 24 hours shall elapse between the application of successive coats. Each coat shall vary slightly in shade and this shall be got approved by the ENGINEER.

2.7.11 **Acceptance of Steel, its Handling & Storage**

The Contractor shall carefully check the steel to be erected at the time of acceptance. Any fabrication defects observed should be brought to the notice of the ENGINEER.

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 commences to a safe distance to avoid burial under debris.

Scratched or abraded steel shall be given a coat of primer in accordance with the Specifications for protection after unloading and handling prior to erection. All milled and machined surfaces shall be properly protected from rust/corrosion by suit able coating and also from damage.

2.7.12 Anchor Bolts & 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 shown on the drawings. Any discrepancy in the anchor bolts / foundation shall be reported to the ENGINEER.

Levelling of column bases to the required elevation may be done either by providing shims or three nuts on the upper threaded portion of the anchor bolt. 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 M.S. plates and shall be supplied by the Contractor at his cost.

A certain amount of cleaning of foundations and preparing the area is considered normal and 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 levelled as part of the work. All grouting under column base plates or beam bearing plates will be carried out by the Contractor

2.7.13 Assembly & Connections

Field connections may be effected either by riveting, bolting, welding or by use of high strength friction grip bolts as shown on the design and erection drawings

All field connection work shall be carried as per the drawings. All bolts, nuts, washers, rivets, electrodes required for field connections shall be supplied by the Contractor free of cost.

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 to such an extent as to damage the holes. Size of drifts larger than the normal diameter of hole shall not be used. Any damaged holes or burrs must be rectified to the satisfaction of the ENGINEER.

Corrections of minor misfits and reasonable amount of reaming and cutting of excess stock from rivets shall be considered as a part of erection. Any error in the shop, which prevents proper fit on a moderate amount of reaming and slight chipping or cutting, shall be immediately reported to the ENGINEER.

2.7.14 Erection

All structural steel shall be erected as shown on the drawings prepared by the Contractor. 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 ENGINEER in writing. Care shall be taken to see that ropes in use are always in good condition.

Steel columns in the basement, if any, are to be lowered and erected carefully with the help of a crane and/or derrick without damaging the basement walls or floor.

Structural steel frames shall be erected plumb and true. Frames shall be lifted at points such that they are not liable to buckle and deform. Trusses shall be lifted only at node points. In the case of trusses, roof girders, all of the purlins and wind bracing shall be placed simultaneously and the columns shall be erected truly plumb on screed bars over the pedestals. All steel columns and beams shall be checked for plumb and level individually before and after connections are made. Temporary bracings shall be introduced wherever necessary to take care of all loads to which the structure may be subjected, including erection equipment and the operation thereof. Such bracings shall be left in place as long as may be required for safety and stability.

Chequered plates shall be fixed to supporting members by tack welding or by countersunk bolts as shown/specified in relevant drawings and/or as approved by the ENGINEER. The edges shall be made smooth and no burrs or jagged ends shall be left. While splicing, care should be taken so that there is continuity in pattern between the two portions. Care should also be taken to avoid distortion of the plate while welding. The erection of chequered plates shall include:

(a) Welding of stiffening angles/vertical stiffening ribs

(b) Cutting to size and making holes to required shape wherever necessary to allow service piping and/or cables to pass through

(c) Smoothening of edges

(d) Fixing of chequered plates by tack welding or by countersunk bolts

(e) Providing lifting hooks for ease of lifting.

As erection progresses, the work shall be securely bolted 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 ENGINEER. No cutting, heating or enlarging of the holes shall be carried out without the prior written approval of the ENGINEER.

Test certificates shall be furnished by the Contractor

2.7.15 Inspection

The ENGINEER shall have free access to all parts of the job during erection and all erection shall be subjected to his approval. In case of faulty erection, all dismantling and re-erection required will be at the Contractor's cost. No paint shall be applied to rivet heads or field welds or bolts until these have been approved by the ENGINEER.

2.7.16 Painting

After steel has been erected, all bare and abraded spots, rivet heads, field welds, bolt heads and nuts shall be spot painted with primer. Before paint is applied, the surface shall be dry and free from dust, dirt, scale and grease. All surfaces inaccessible after erection shall receive two coats of the approved paint before erection.

2.7.17 Clean Up of Work Site

During erection, the Contractor shall at all times keep the working and storage areas used by him free from accumulation of waste materials or rubbish. Before completion of erection, he shall remove or dispose of in a satisfactory manner all temporary structures, waste and debris and leave the premises in a condition satisfactory to the ENGINEER.

2.7.18 Method of Measurement

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

No allowance will be permitted for weights of rivets, bolts, washers, screws etc. in calculating the weight of the completed structure. No allowances will be permitted for galvanizing, welding or for rolling margins. One tonne for the purpose of payment shall mean One Metric Tonne i.e. 1000 kg.

The weight of a member made out of standard rolled sections such as beams, channels, angles, etc. shall be based on the weight of the member given in IS 808 without deducting for hole, notches, bevel cuts,. etc. Where a component consists of a cut joist or channel, the full weight of the rolled section shall be considered only if more than half the depth of the section is used. Otherwise only half the section unit weight shall be taken. Deductions shall be made in the weight or gussets/plates including chequered plates for skew cuts, notches and openings at900 sq.cm. or larger.

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

The weight of any built-up member shall be separated into the weight of each component.

Erection bolts installed by erector may be left in position on completion erection; however, no additional payment shall be made either for supply or use of such bolts. If erection bolts are removed after erection is complete, holes shall be plug welded and ground smooth. No extra payment shall be made for such welding.

Painting work shall not be measured separately, if primer painting and/or primer and finish painting is deemed to be included in the scope of the item of work of fabrication and erection of structural steel since the rate per tonne of steel is deemed to include for painting as specified.

In cases where primer and/or finish painting work as specified is carried out on erected structural steel executed by a different agency, the method of measurement for painting shall be on the basis of tonnage of steel erected. For this purpose, the tonnage of erected steel as certified for payment to the different agency shall be considered as the basis and no measurement will be carried out separately.

PART 2

SECTION 8

ROADWORKS

2.8 ROADWORKS

2.8.1 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 asphalt macadam roads with premixed seal coat treatment as shown on the drawings or as directed by the Engineer, including all the necessary earthwork for the same.

Application Codes and Specifications

The following specifications, standards and codes are made a part of this specification. All standards, tentative specifications, specifications, codes of practices referred to herein shall be the latest edition including all applicable official amendments and revisions. In case where the requirements of this specification conflict with the requirements of those referred to herein, this specification shall govern.

IS: 73	Specification for Paving Bitumen
IS : 215	Specification for Road Tar
IS : 217	Specification for Cutback Bitumen
IS : 454	Cutback Bitumen from waxy crude - Specification
IS : 460 (Parts 1 to 3)	Specification for Test Sieves
IS : 1077	Specification for common burnt clay building bricks
IS : 1124	Method of test for determination of water absorption, apparent specific gravity and porosity of natural building stones.
IS: 1195	Specification for Bitumen Mastic for Flooring.
IS : 1196	Code of Practice for Laying Bitumen Mastic Flooring
IS : 1834	Specification for Hot Applied Sealing Compounds for Joints in Concrete.
IS : 2386 (Parts 1 to 8)	Methods of tests for aggregates for concrete.
IS : 2720 (Part 5)	Methods of Test for Soils - Part 5 : Determination of Liquid and Plastic Limit
IS : 6241	Method of test for determination of stripping value of road aggregates
IRC: 16	Specification for priming of base course with bituminous primers
IRC : 17	Tentative specification for single coat bituminous surface dressing.
IRC: 19	Standard specification and code of practice for water bound macadam
IRC : 29	Specification for bituminous concrete (Asphaltic concrete) for road pavement
Ministry of Surface Transport (Roads Wing)	Specifications for road and bridge works

All earthwork shall be according to the specifications for Earthworks stipulated under Part 2 of the Specifications.

2.8.2 Materials

(a) General

All materials shall be obtained from local sources and shall be subject to approval by the Engineer prior to use.

Substitution of material shall be on an “Approved equal” basis as determine by the Engineer and shall result in finished roads as designated in this specification and at no additional cost to the Employer.

Mineral aggregates shall consist of natural or crushed stone, gravel or sand, 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 not be more than 20mm.

(c) Coarse Aggregate for Sub-base and Base

Coarse aggregates shall be crushed or broken stone and shall conform to the physical requirement given in Table 2.8.A.

Table 2.8.A

PHYSICAL REQUIREMNETS OF CRUSHED STONE FOR ROAD WORKS

Sr. No.	Test	Limiting Value: For aggregate to be used for Road base and surfacing	Limiting Value: 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 more than 5%
3.	Flakiness Index	Maximum 25%	-
4.	Elongation Index	Maximum 40%	-
5.	Aggregate Impact Value or	Not more than 30%	Not more than 40%
	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 2.8.B.

Table 2.8.B

Grading Requirements of Coarse Aggregates

Sr. No.	SizeRange	IS Sieve Designation	Percent by Weight Passing the Sieve
1.	90 mm to 40 mm	100 mm	100
		80 mm	65-85
		63 mm	25-60
		40 mm	0-15
		20 mm	0-5
2.	63 mm to 40 mm	80 mm	100
		63 mm	90-100
		50 mm	35-70
		40 mm	0-15
		20 mm	0-5
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 gravelly 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 material shall be sound and hard, of a quality not affected by weather and shall be screened at the quarry and shall be freed from all impurities. Any large lumps of murrum shall be broken to pass gradation given in table 2.8.C. 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 2.8.C.

Table 2.8.C Grading for Screenings

Grading Classification	Size of Screenings	IS Sieve Designation	Percent by Weight Passing the Sieve
A.	12.5 mm	12.50 mm	100
		10.00 mm	90-100
		4.75 mm	10-30
		150 microns	0-8
B.	10.0 mm	10.00 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/stone dust/sand 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 2.8.D.

Table 2.8.D

Sr.	Characteristic	Requirement for Grade S35	Requirement for Grade S65	Method of Test Reference to
1.	Specific gravity at 27^{0}C, Min.	0.99	0.99	IS 1202
2.	Water percent by Weight, Max	0.2	0.2	IS 1211
3.	Flash point, Pensky Martens closed type 0^{0}C, Min.	175	175	IS 1209 (Method A)
4.	Softening point, ^{0}C.	50-65	40-55	IS 1205
5.	Penetration, at 25^{0}C, 100g, 5see in 1/100 cm	30-40	60-70	IS 1203
6.	Ductility at 20^{0}C, in cm. Min	50	75	IS 1208
7. (a)	Loss on beating, percent By weight, Max.	1	1	IS 1212
(b)	Penetration of residue	60	60	IS 1203
8.	Matter soluble in carbon Disulphide, percent by Weight, Min.	99	99	IS 1216

2.8.3 <u>Setting Out</u>

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

2.8.4 <u>Earthwork</u>

a) <u>Earthwork in Excavation</u>

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.

Contractor shall on no account excavate beyond the slopes or below the specified grade unless so directed by the Engineer in 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 at his own cost such extra excavation with approved materials, in layers of 150 to 200 mm, watered and compacted as specified for the subgrade.

The excavation shall be finished neatly, smoothly and evenly to the correct lines, grades, sections and side slopes as shown in the drawings or directed by Engineer.

b) Earthwork in Embankment

The ground over which the embankment is to be formed shall be cleared of all brushwood, loose stones, vegetation, bushes, stumps and all other objectionable matter, and materials so removed shall be burnt or disposed off as directed by the Engineer.

Profiles of embankment shall be set up with stout poles to mark the centre and edges of the formation with the top levels of formation clearly marked by paint or cut and the slopes with strings and pegs at every 10 metres on straight portions. Toe line may be marked with pick marks.

Before placing any embankment material, the top 150 mm of the soil strata receiving it shall be scarified.

All clods shall be broken into fine earth and the area roughly leveled. The surface shall then be well watered before the earthwork is started.

Embankment material shall be placed in successive horizontal layers of 200 mm depth extending to the full width of the embankment including the slopes at the level of the particular layer and 300 mm more on both sides to allow compaction of the full specified section. Each layer shall be thoroughly consolidated to obtain the optimum soil density by mixing water and satisfactory rolling as specified below. Before placing the next layer, the surface of the underlayer shall be moistured and scarified with pick axes or spades to provide a satisfactory bond with the next layer. The extra loose stuff at the edges shall be trimmed later after completion of the bank work at no extra cost leaving the correct section fully compacted.

When boulders, broken stones and similar hard materials are mixed up with the embankment materials, care shall be taken to see that they are distributed uniformly into the bank and that no hollows are left near them.

No stone or hard material shall project above the top of any layer. Each layer of embankment shall be watered, leveled and compacted as specified hereinafter before the succeeding layer is placed. The surface of the embankment shall at all times during construction be maintained at such a cross fall as will shed water and prevent ponding.

If the bank material contains less than the optimum moisture, water shall be added to the loose layers of the embankment to bring the moisture uniformly up to requirement. If the material contains more than the required moisture, it shall be slowed to dry until the moisture is reduced to the required extent.

The moistured / dried loose layers shall be compacted with a power roller of 10 to 12 tonnes. The roller shall pass at least twice over the same area, once in the forward move and the second time in backward move.

Compaction shall be carried out to achieve at least 95% of standard Proctor Dry Density at optimum moisture content determined in accordance with the relevant Indian Standard Specification. It shall be ensured however that the minimum compacted dry density is not less than 1.6 M.T./m^3. As the work progresses, field density tests shall be conducted on each layer at the rate of one test for every 1000 square metres to check whether the desired compaction has actually been achieved.

The slopes of the embankment shall be pitched with rubble as specified in 2.8.110 and as shown on the drawing.

Embankment shall be finished and dressed smooth and even, to conform to the alignment, levels, cross section, and dimensions shown on drawings with due allowance for shrinkage. Any damage caused by rain, or any other reason shall be made good in the finishing operations.

2.8.5 <u>Preparation of Subgrade</u>

Immediately prior to the laying of the sub-base metal, the subgrade shall be cleaned of all foreign substances, vegetation, etc. Any ruts or soft yielding patches that appear shall be corrected and the subgrade dressed off parallel to the finished profile. The camber of subgrade shall conform in shape to that of the finished road surface. Camber boards shall be used to get the required section.

The prepared subgrade shall be lightly sprinkled with water, if necessary and rolled with power roller of 10 – 12 tons. The roller shall pass over the same area of the subgrade a minimum of five runs. Any undulations in the surface that develop due to rolling shall be made good with approved earth and subgrade rerolled.

2.8.6 <u>Sub-Base</u>

a) <u>General</u>

The sub-base shall not be constructed on a wet subgrade.

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 80 mm.

b) <u>Spreading and Rolling</u>

The metal shall be spread uniformly and evenly upon the prepared base to a thickness of 120 mm. The spreading shall be done from stockpiles along the side of the roadway. In no case shall be the aggregates be dumped in heaps directly on the surface prepared to receive the metal nor shall hauling over uncompacted 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 wheeled power rollers of 10-12 tons 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 proceeding 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) <u>Application of Screening</u>

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, filling 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

Now 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 Engineer, the second layer shall be laid. The constructional operation for the second layer will be the same as that specified herein for the first.

2.8.7 Water bound Macadam Course

a) Preparation of Base

The base to receive the waterbound 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 conforming to the specification given in clause 2.8.2(c) shall be spread uniformly upon the prepared base to 110 mm, which shall be compacted to 80 mm.

The spreading shall be done from stockpiles along 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 may be 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 over 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 10 to 12 ton capacity or tandem or vibratory rollers of approved types. The weight of the roller shall depend upon the type of aggregate and shall be indicated by the Engineer.

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 the road, in successive passes uniformly lapping the 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 blind-age. During rolling slight sprinkling of water may be done if necessary. Rolling shall not be done when the subgrade is soft or yielding or when it causes a wave-like motion in the subgrade or base course.

The rolled surface shall be checked transversely and longitudinally with templates and any irregularities corrected by loosening the surface, adding or removing necessary amounts of aggregate and re-rolling until the entire surface conforms to the desired camber and grade. In no case shall the use of blindage be permitted to make up depressions.

d) Application of Blindage

After the coarse aggregate has been rolled to Clause 2.8.7(c) blindage conforming to Clause No. 2.8.2(e) to completely fill the interstices shall be gradually applied over the surface. These shall not be damp or wet at the time of application. Dry rolling shall be done while the blindage is being spread so that vibrations of the roller cause them to settle into the voids of the coarse aggregate. The blindage shall not be dumped in piled but be spread uniformly in successive thin layers either by the spreading motion of hand shovels or by mechanical spreader or directly from trucks. Trucks operating for spreading the blindage shall be so driven as not so disturb the coarse aggregate.

The blindage shall be applied at a slow and uniform rate (in three or more applications) so as to ensure filling of all voids. The rate of spreading blindage shall not be less than 3.00 cu.m or more than 4.50 cu.m per 100 sq.m This shall be accompanied by dry rolling and brooming with mechanical brooms, hand brooms or both. In no case shall the blindage 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. The operations shall continue until no more blindage can be forced into the voids of the coarse aggregate.

The spreading, rolling and brooming of blindage 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 blindage have been applied, the surface shall be copiously sprinkled with water, swept and rolled. Hand brooms shall be used to sweep the wet blindage into voids and to distribute them evenly. The sprinkling, sweeping and rolling operations shall be continued with additional blindage applied as necessary until the coarse aggregate had been thoroughly keyed, well-bonded and firmly set in its full depth and a grout has been formed of blindage. 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) Setting and Drying

After the final compaction of water bound macadam course, the road shall be allowed to dry overnight. Next morning hungry spots shall be filled with blindage 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 shall have the discretion to stop hauling traffic from using the completed water bound macadam course if in his opinion it would cause damage to the surface.

Should the subgrade at any time become soft or churned up with the sub-base metal, or the water bound macadam course, the Contractor shall without additional compensation remove the mixture from the affected portion, reshape and compact the subgrade and replace the removed section in accordance with the foregoing requirements.

2.8.8 Asphalt Macadam

(a) Brushing

Prior to spreading of the asphalt surface, the water bound surface shall be swept clean to remove all blindage so as to expose the metal surface.

(b) Application of Macadam

The bituminous macadam shall be laid by mechanical compactor and finisher, the final consolidation being by means of power roller weighing not less than 10 tons. The finished surface shall not vary by more than 12.5 mm above or below the designed level and the average thickness shall not be less than 63 mm after consolidation.

The grading, composition and characteristics of the bituminous macadam shall be as follows :

Table 2.8.E

Aggregate Grading

IS Sieve Designation	Percentage Passing
50 mm	100
40 mm	60-100
25 mm	30-70
20 mm	20-70
6.3 mm	10-20
2.36 mm	0-5

Bitumen (Grade S 65) Content: 3.5% to 4% by weight of total mix

The bituminous macadam may be prepared in a hot mix plant of the bitumen may be cut back with a suitable solvent so that the heated cut back bitumen may be mixed with the aggregate. In either case mixing shall be carried out in a power driven pug mill mixer and shall be continued until all the aggregate is coated.

c) Protection of Pavement

During the period between initial compaction of the coarse aggregate and completion of the seal coat, the surface shall be protected from all traffic other than absolutely essential to its construction.

d) Premixed Seal Coat

After the full grout has been rolled, the interstices shall be completely filled with precoated grit of the following composition:

Table 2.8.F
Aggregate Grading

IS Sieve Designation	Percentage Passing
6.3 mm	100
2.36 mm	70-100
600 micron	25-50
300 micron	0-10

Bitumen (Grade S65) Content: 4.5% to 5% by weight of total mix

The premixed seal may be prepared in a hot mix plant or the bitumen may be cut back with a suitable solvent so that the heated cut back bitumen may be mixed with the aggregate. In either case, mixing shall be carried out in a power driven pug mill mixer and shall be continued until all the aggregate is coated.

The premixed seal must be brushed to fill-in the interstices, additional material being applied during rolling if found necessary. The quantity of premixed seal required for this purpose shall be approximately 1.22 cu.m. per 100 sq.m.

e) **Liquid Seal**

On the completion of consolidation, which may be assisted by opening the road to traffic, a liquid seal coat of Grade S65 bitumen shall be applied at a temperature from 163^0C to191^0C (325^0 F to 375^0 F) at the rate of 1.25 Kg per sq.m.The application of bitumen shall be immediately followed with cover coat of clean dry ¼ cubical chippingsat the rate of 1.22 cu.m. per 100 sq.m. The surface shall then be rolled with a power roller weighing not less than 10 ton. The composition of this seal coat shall be as follows:

Table 2.8.G
Aggregate Grading

IS Sieve Designation	Percentage Passing
12.5 mm	100
10 mm	70-100
4.75 mm	20-40
2.36 mm	7-20
75 micron	0-4

Bitumen (Grade S65) Content: 4.5% to 5% by weight of total mix

2.8.9 Quality Control

a) **General**

All works performed shall conform to the lines, grades, cross-sections and dimensions shown on the drawings or as directed by the Engineer subject to the permitted tolerance described hereinafter.

b) **Horizontal Alignments**

These shall be reckoned with respect to the centerline

The edges of the carriageway as constructed and all other parallel alignments shall be corrected within a tolerance of ± 20 mm.

c) **Longitudinal profile**

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

Table 2.8.H

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 permittedin 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 centerline of the road. The transverse profile shall be checked with a camber board at intervals of 30 m. Permitted tolerances are specified in Table 2.8.I.

Table 2.8.I

Permitted tolerances of Surface Regularity for Pavement Courses

Sr. No.	Type of Construction	Longitudinal Profile (Maximum permissible Undulation when Measured with a 3m 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 Macadam	10	8

d) Rectification

Where the surface irregularity of subgrade 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 Engineer :

i) Subgrade

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

ii) Stabilised 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 located shall not be less than 5 m long and 2 m wide.

iii) Waterbound Layer

Where the surface is high or low, the top 75 mm shall be scarified, reshaped with added material as necessary and recompacted to Clause 2.8.7(c). The area treated at a place shall not be less then 5 m long and 2 m 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 course 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 5 m long and 2 m wide.

e) Quality Control Tests during Construction

i) For ensuring the requisite quality of construction, the materials and works shall be subjected to quality control tests, as described hereinafter, by the Engineer. The testing frequencies set forth are the desirable minimum and the Engineer shall have the full 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 frequencies to be adopted for different materials and works shall be as detailed in the following Tables:

Table 2.8.J

Tests on Earthwork for Embankment Construction (Borrow Material)

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 metres of soil.
3.	Deleterious Content	As directed by the Engineer.
4.	Moisture Content	1 test for every 250 cubic metres of soil.
5.	CBR test	As required by the Engineer.

Table 2.8.K

Sr. No.	Type of Construction	Test		Frequency
1.	Sub-base	i)	Gradation	1 test per 2000m^2
		ii)	Plasticity	As required
		iii)	Deleterious	As required

			Constituents	
		iv)	CBR test	As required
		v)	Moisture content prior to compaction	1 test per 250 m^2
		vi)	Dry density	1 test per 500 m^2
2.	Waterbound Macadam	i)	Gradation	1 test per 1000m^2
		ii)	Flakiness index	1 test per 2000 m^2
		iii)	Plasticity of binding material	1 test per 1000m^2
3.	Asphalt Macadam	i)	Quality of Binder	As required
		ii)	Aggregate impact Value	1 test per 50-100 m^2 of aggregate
		iii)	Flakiness index	1 test 50-100 m^2 of aggregate
		iv)	Grading of	2 test per day per plant, aggregates both on the individual constituents and mixed aggregates from the dryer (one at plant and one at an approved laboratory)
		v)	Binder content	Periodic subject to 2 tests per day per plant.
		vi)	Control of temp. of binder and aggregate for mixing and of the mix at the time of laying and rolling.	At regular close intervals
		vii)	Rate of speed of mixed material	Regular control through checks on layer thickness
4.	Seal coat	i)	Quality of binder	As required
		ii)	Aggregate impact valve	1 test per 2000m^2
		iii)	Flakiness index	1 test per 2000m^2
		iv)	Aggregate grading	2 test per day
		v)	Temp. of application	At regular close intervals
		vi)	Rate of spread of material	2 tests per day

ii) Where specific procedure is not indicated for quality control tests in these specifications, the same shall be carried out as per prevalent accepted directions of the Engineer.

iii) **Compaction Control**

Control shall be exercised by taking at least one measurement of density for each 1000 square metres of compacted area or closed 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 any one test but on the mean value of a set of 5-10 density determinations. The number of tests is 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 between individual density results, the minimum number of tests is one set of measurement shall be increased to10. The acceptance work shall be subject to the condition that the mean dry density equals or exceeds the specified density and the standard deviation for any set of results is below 0.08/cc.

However, for earth work in shoulders and in top 500 mm portions of the embankment below the sub-grade at least one density measurements shall be taken for every 500 square metres of the compacted area provided further that the number of tests in each set of measurements shall be at least 10. In other respects the control shall be similar as described earlier.

2.8.10 Slab Culvert

Slab culverts shall be constructed at specified locations of the existing cross drainage works as per drawings, or as directed by the Engineer. The Concrete works specifications for construction of RC slab and the rubble masonry specifications for the supporting rubble walls are given in Sections 2.3 and 2.8 of the specifications respectively 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 contract of RCC slab above in two coats, shall be straight run Bitumen of grade S35, confirming to the specifications given in Table 2.6.D of clause 2.8.2(f)

b) **Graded Gravel Free Draining Backfill**

On each side of the uncoursed rubble walls supporting the slab culvert a free draining backfill of thickness 200 mm shall be provided. The material for this backfill shall be granular consisting of sound, tough, durable particles of crushed or uncrushed gravel, crushed stone or brickbats, which will not become 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 2.8.L of clause 2.8.11(g).

c) **Weep Holes**

Weep holes as directed by the Engineer shall be provided in the masonry to drain water from the backfilling. Weep holes shall be of asbestos cement pipes confirming to IS 6908 in rubble walls with necessary M10 concrete cushioning, 75 mm thick. They shall extend through the full width of the masonry as spacing of 1.5 m c/c and width slope of about 1 vertical to 20 horizontal (or as shown on the drawings) towards the draining face.

2.8.11 Pipe Drains

Wherever required, pipe drains shall be provided for cross drainage purposes. The sequences of constructions shall be as follows:

i) laying of sand / shingle bedding on the original ground,

ii) laying of PCC of M10 grade,

iii) laying of concrete pipes of NP2/NP3 class as per IS 458,

iv) Constructing embankment above in compacted murum, laying of the sub-base and Waterbound Macadam as specified hereinabove.

The details of above works as indicated in the drawing shall be followed.

a) **Material for Pipe Drains**

All materials used in the construction of pipe drains shall conform to the requirements of part 2 of these specifications. Hume pipes class NP2 shall conform to IS 458.

Each consignment of cement concrete pipes shall be inspected, tested if necessary and approved by Engineer 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 shown on the drawings or as directed by the Engineer. The pipes shall be placed in shallow excavation of the natural ground in open trenches cut in the existing embankment, taken down to levels as shown in the drawings. 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, unless other special construction methods are called for as indicated on drawing, such unsuitable material shall be removed up to a depth of 600 mm or as directed by the Engineer. Before any backfill material, exposed surface of the soft soil shall be lightly compacted with one pass of 0.5 T roller. On the lightly compacted surface, coarse sand and shingle shall be spread in two successive layers of 300 mm and each layer shall be compacted by rolling with a min. 0.5 T roller and with a minimum of 10 passes each, both in longitudinal and transverse directions.

When bedrock or boulder strata are encountered, excavation shall be taken down at least 200 mm below bottom level of pipe as directed by Engineer and 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, Contractor shall suggest necessary method 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 part 2 of specifications. 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 Engineer. When pipes are to be laid adjacent to each other, they shall be separated by a distance at least 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 at the cost of the Contractor.

e) Jointing

All the joints shall be made with care so that their interior face is smooth and consistent with the interior surface of the pipes. The ends of the pipes should 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)Backfilling

Trenches shall be backfilled with murrum as per specifications given in this part. Backfilling upto 0.3 metre above the top of pipe shall be carefully done and murrum shall be thoroughly consolidated under the haunches of the pipe.

g)Filter Medium

At each hume pipe crossing, a filter medium shall be provided for 1 m. on either side of the drain. Only granular material shall be used for filter medium unless otherwise specified. This shall consist of sound tough durable particles of crushed or uncrushed gravel, crushed stone or brickbats, which will not become 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 substance. It shall be graded and shall meet the following grading requirements:

Table 2.8.L

Sieve Designation	Percent Passing by Weight
10 mm	100
4.75 mm	30-65
425 microns	5-30
150 microns	0-10

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 as specified on the drawings.

2.8.12 Measurement

a) Earthwork in Excavation

The rate for excavation shall include and cover without any extra charge all the stipulations contained in this specification with regard to shoring, pumping, shaping the trenches, filling the trenches removing the surplus material as directed within a lead of 300 m. Measurement shall conform to Clause 2.2.421 of these Specifications.

b) Earthwork in Embankment

The rate for construction of embankment shall include the cost of all materials, fencing, lighting, haulage, spreading, leveling, watering, rolling, consolidation as well as testing of C.B.R, value of the murrum and field density of compacted soil.

c) Sub-base

Sub-base shall be measured in square metres for the area covered in plan. The rates shall include carrying out the work as specified.

d) Waterbound Macadam Course

Waterbound macadam course shall be measured in square metres for the area covered in plan. The rates shall include the items specified in Clause 2.8.8(b) and (d)

e) Asphalt Macadam

Asphalt macadam course shall be measured in square meters for the area covered in plan. The rates shall include the items specified in Clause 2.8.9.

f) Liquid Seal

Measurement for liquid seal shall be in square metres over area covered in plan. This shall include everything as specified in Clause 2.8.8(e)

g) Slab Culvert

i) Measurement of In situ concrete work shall be as per Clauses 2.3.38 & 2.3.39.

ii) Measurement of masonry shall be as per Clause 2.8.12.

iii) Bitumen at locations of contact with concrete surface shall be measured in square metres over area covered in plan and the rates shall include cleaning the surfaces, applying in two coats, etc., as specified.

iv) Graded gravel free draining backfill shall be measured in cubic metres and the rate shall include supplying, backfilling, etc., as specified.

v) Measurement for weep holes shall be running metres and the rates shall include providing and fixing in rubble masonry walls with necessary concrete cushioning to lines and levels as specified.

h) Pipe Drains

The rate for pipe shall include the cost of pipe including unloading, loading, hauling, handling, storing, laying in position and jointing complete. Ancillary works such as excavation, backfilling, laying P.C.C below pipe, etc., shall be paid for separately, as provided under respective clauses.

SECTION – D – TECHNICAL SPECIFICATIONS:

SUBSTATION AUTOMATION SYSTE (SAS)

Contents

SAS Specification

1 SAS General Requirement:

This technical description covers NMMC's technical, functional, configuration and testing requirements for a substation automation system for extra high voltage substations.

The Substation Automation System (SAS) shall be designed & installed so as to control and monitor all the substation equipment from each bay control unit as well as from the main control room. The offered SAS shall have facility to support remote control and monitoring from Remote Control Centers Hardware gateways.

The power generated from the Hydro Power plant and the Floating Solar PV plant shall the combined & evacuated from single evacuation substation with proper synchronization system.

The system shall be of state-of-the art design suitable for operation under electrical environment present in extra high voltage substations, follow the latest engineering practice, and ensue long-term compatibility requirements and continuity of equipment supply and the safety of the operating staff.

1.1 General System design:

1. The Substation Automation System (SAS) shall be suitable for operation/control and monitoring of the complete substation including future bays, if any.
2. The bay level intelligent electronic devices (IED) for protection and control shall provide direct connection to the switchgear without the need of interposing components and perform control, protection, and monitoring functions. Further, the protection and control IEDs shall be connected to the Ethernet switches independently and both shall support horizontal communication (goose messages).
3. Time synchronization shall be achieved through GPS and automatically by internal clock, For this purpose a GPS antenna, GPS receiver and all necessary links and devices associated with this application shall be included in the supply
4. All Network equipment viz IEDs ,Router ,Ethernet switches etc shall be monitored through Network monitoring system
5. The communication architecture structure of the substation automation system should be of a double loop, this loop shall be of glass fiber.
6. The system shall be designed such that personnel without any background knowledge in microprocessor based technology are able to operate the system. The operator interface shall be intuitive such that operating personnel shall be able to operate the system easily after having received some basic training.

7. The system shall incorporate the control, monitoring and protection functions specified, self-monitoring, signaling and testing facilities, measuring as well as memory functions, event recording and evaluation of disturbance records.
8. Maintenance, modification or extension of components shall not cause a shutdown of the whole substation automation system. Self-monitoring of components, modules and communication shall be incorporated to increase the availability and the reliability of the equipment and minimize maintenance.
9. For numerical IEDs IEC 61850 compatibility relevant docs viz MICS & PICS shall be provided by the Bidder along with the bid.
10. The station level contains the station-oriented functions, which cannot be realized at bay level, e.g. alarm list or event list related to the entire substation etc.
11. It shall be possible to access all protection and control IEDs for reading the parameters (settings) from the station M HMI or from a dedicated monitoring computer.
12. The setting of parameters or the activation of parameter sets shall only be allowed after entering a password through appropriate authorization level.
13. Remote Data transfer capabilities:
    a. Interoperability profile shall be as per needs of SCADA system at SLDC and ALDC. It shall be the bidder's responsibility to make necessary configurations to the substation Gateways so as to successfully achieve substation data visibility to SLDC and ALDC by exchanging of desired data
    b. It shall be the bidder's responsibility that offered system shall be capable of integrating with existing SLDC system for exchange of desired data.
    c. Required IP addresses for SLDC shall be provided by MSETCL and configuration and required testing of the gateway shall be carried out by the vendor at the time of commissioning of SAS system. Presence of data at the gateway shall be emonstrated by the vendor. All data required at SLDC should be verified at substation through IEC 104 Tester by vendor. If communication link is to SLDC is available & SLDC side configurations done; point to point testing of data will be carried in coordination with SLDC.
    d. The substation automation system shall also be capable of communicating to other remote communication centers apart from SLDC and ALDC. The substation automation system shall simultaneously respond to Independent scans and commands from employer's control centers (RCC &ALDC/SLDC).
    e. The substation automation system shall support the use of a different communication data exchange rate (bits per second), scanning cycle, and/or communication protocol to each remote control center. Also, each control center's data scan and control commands may be different for different data points within the substation automation system's database.

1.2 Main functional parts:

1. Redundant Station human machine interface (HMI) on hot standby mode to enable local station control via a PC by means of human machine interface (HMI) (HMI to work on Hot Hot and complies to NO data loss)
2. Control software package, which shall contain an extensive range of supervisory control and data acquisition (SCADA) function.
3. Redundant managed Ethernet switches (complying with IEC -61859 standard requirement) Ethernet Local Area Network communication infrastructure with hot standby.
4. Hardware Gateway for remote supervisory control (SLDC/ALDC /RCC/ DATA WAREHOUSE) via industrial grade hardware through IEC60870-5-101/104 protocol.
5. Time synchronization by GPS including Router, receiver, Digital display clock, antenna etc.
6. Peripheral equipment like printers, power backup, display units, key boards, Mouse etc.
7. Communication shall be made 1+1 mode with failure alarm.
8. Communication network of fiber optic communication cables shall be made in fault tolerant ring in redundant mode, excluding the links between individual bay IEDs to switch wherein the redundant connections are not envisaged, such that failure of one set of fiber shall not affect the normal operation of the SAS. However failure of fiber shall be alarmed in SAS. Each fiber optic cable shall have at least four (4) spare fibers. Use double ring of two separate armored fiber optic cables with LIUs where ever such connectivity is required
9. The S/S Automation System (SAS) for the s/s including control room furniture and all other equipment required for the SAS for the s/s shall be as defined in this specification.
10. Dedicated Bay Control Units (BCUs) and Bay Protection Units (BPU) shall be provided for each bay for Control and protection functionality on IEC-61850-10 standard. The Bay Control and Protection IEDs shall communicate on the IEC61850 standard for Communication Networks and shall comply with the IEC61850-5 for communication requirement, Communication data modeling IEC61850-7-1, 7-4 & IEC61850-6 for Substation Configuration Description Language.

1.3 Extensibility in future

1. Offered substation automation system shall be suitable for extension in future for additional bays with different make of IEDs/BCUs.
2. During such requirement, all the drawings and configurations, alarm/event list etc. displayed shall be designed in such a manner that its extension shall be easily performed by the user.
3. The contractor shall provide all necessary software tools to perform addition of bays in future and complete integration with SAS by the user. These software tools shall be able to configure IED, add additional analogue variable alarm list, event list, modify interlocking logics etc. for additional bays/equipment, which shall be added in future.
4. The SAS shall be capable of integrating IEDs of any make complying IEC 61850 protocol for monitoring as well as control.

1.4 Certification

1. KEMA certificate/ equivalent certificate from development center authorized by UCA working group for all Hardware products conforming to IEC 61850 is to be furnished
2. The product release certificate shall be submitted by the bidder with the bid along with an undertaking of lifecycle support of the components for a period of 10 yrs after the commissioning.

1.5 System Installation

1. Substations up to 220kV level, Bay Control & Protection Panels is to be housed in the Main Control Room itself.
2. Panel should installed as per approved drawing.
3. All cabling should have proper tagging and laying and dressing
4. All hardware should be installed such as to have easy access.
5. Antenna of GPS should be mounted with suitable fixtures and provision to restrict rain water and should not be affected by atmospheric conditions. Antenna should be fixed at top a proper place by providing galvanized support structure and proper fixing and clamping arrangement
6. The cable connecting Antenna and Time Synchronizing unit should be run through HDPE pipe or GI pipe from the location of Antenna fixing to Time Synchronizing panel with.
7. The fiber optic cables shall be run in suitable conduit pipes.
8. All control wiring. Cabling, equipment and accessories shall be protected against fungus growth, condensation, vermin and other harmful effects.

    1. <u>Standards.</u>

The applicable standards for this automation are the following:

IEC - 60870 - 101 to 104	(Standard for tele-control, tele-protection, and associated telecommunications between two electric power systems for monitoring and control.)
IEC - 60255 -1 to 6	(Standard for Measuring relays and protection equipment)
IEC - 60255 - 22	(Standards for measuring relays and protection equipment for power system protection, including the control, monitoring and process interface equipment used with those systems)
IEC - 60255 - 24	(Standards for Common format for transient data exchange (COMTRADE) for power systems)
IEC - 60068 - 2 - 6	(Standard to determine the ability of components, equipment and other articles to withstand specified severities of sinusoidal vibration.)

IEC -61850-1-10	(Standard for vendor-agnostic engineering of the configuration of Intelligent Electronic Devices for electrical substation automation systems to be able to communicate with each other.)

2. Climatic conditions.

This automated digital control and protection system for EHV substations, shall be capable of withstanding the following climatic conditions:

Ambient temperature during operation	:	-5 ^{0C} to +50^{0}C
Ambient temperature during storage	:	-25 ^{0}C to +55^{0}C
Relative humidity	:	5% -90%
Altitude level	:	Up to 1000m above sea level

2 SAS Architecture

1. The SAS shall be based on a decentralized architecture and on a concept of bay- oriented, distributed intelligence. A generalized SAS architecture to be followed is enclosed herewith for reference as Annexure 3. This shall be an indicative architecture and shall be modified as per site specific requirements if any. (However the basic structure indicated shall be followed in all cases)
2. At bay level all IEDs should be in Star topology
3. At Station and Process level all Switches should be in ring topology.
4. The station level switches and Bay level switches shall be distinctively different and in no case shall be combined.
5. Station level switch redundancy shall be maintained.
6. Not more than 8 nos of IEC 61850 devices shall be be connect on one bay level Ethernet switch & 3 spare ports availability of each type shall be ensured.
7. The use of Ethernet Hubs is not permitted as they do not provide collision free transmission. External switches are mandatory as they have the advantage that there is no interruption or reconfiguration of the Ethernet ring if one or several bay devices are taken out of service
8. All meters should be connected independently through Modbus connection and suitable converter to the switch. The Meter connections shall be independent as per voltage level.
9. Independent hot standby patch chord redundancy between switches.
10. Independent hot standby patch chord redundancy to all hardware connected to process and station level.
11. Functions shall be de centralized, object-oriented and located as close as possible to the process.
12. The main process information of the station shall be stored in distributed databases.
13. The typical SAS architecture shall be structured in two levels i.e. station and bay level.
14. At bay level, the IEDs shall provide all bay level functions regarding control, monitoring and protection, inputs for status indication and outputs for commands.
15. The IEDs should be directly connected to the switchgear without any need for additional interposition of transducers.
16. However, all the commands extending for control of switchgear shall be routed through suitable trip/ aux. relays.
17. Transformer /Reactor Oil/ Winding temperatures, OLTC Tap Position & Operation (not AVR) can be interfaced with BCU or any Other device interface through Transducers. These parameters shall appear in Substation Automation System at Local and RCC for regular monitoring & tap control. This shall be indicated in the System Architecture drawings.
18. Each bay control IED shall be independent from each other and its functioning shall not be affected by any fault occurring in any of the other bay control units of the station.
19. The data exchange between the electronic devices on bay and station level shall take place via the communication infrastructure. This shall be realized using fiber optic cables, thereby guaranteeing disturbance free communication.

20. Data exchange is to be realized using IEC 61850 standards with an external managed switched Ethernet communication infrastructure in decentralized ring configuration.
21. The communication shall be made in 1+1 mode, excluding the links between individual bay IEDs to switch, such that failure of one set of fiber shall not affect the normal operation of the SAS. However, it shall be alarmed in SAS.
22. Each fiber optic cable shall have at least four numbers spare fibers.
23. The GPS time synchronizing signal for the synchronization of the entire system shall be provided.
24. Substation LANs:
    1. The structure of the substation automation system should be of a double loop, this loop shall be of glass fiber.
    2. The glass fiber optic cables shall be equipped with rodent protection.
    3. Fibers in all other aspects will be as per IEC 60794-1 and IEC 60794-2
    4. Operation of the Substation LANs shall comply with the IEC 61850-8-1 Ethernet profile using TCP/IP. The ring network of the LANs shall support <u>1Gbps operation</u>, For IED to switch the network shall support 100 Mbps.
    5. All connections to Substation LANs shall be made using ST or SC or LC connectors. Unless otherwise specified, the Substation LANs shall use multi-mode cable and be sheathed for protection against abrasion and cuts.
    6. Fiber optic cable shall be terminated and routed according to best industry practices.
    7. All materials shall be industry standard, commercially available, and supportive of the open systems concept.
    8. A service loop shall be provided at connection points to allow flexibility for future equipment upgrades.
    9. The Substation LAN design shall not require any routine engineering administration or manual reconfiguration to remedy an equipment failure or to facilitate failure recovery
    10. The Substation LAN shall be designed to ensure that, in the event of a single LAN cable or LAN interface module failure, none of the SA system functionality shall be lost and at most one IED server (e.g. BCU) shall be isolated from the CCU.
    11. The bidder shall provide the redundant switched optical Ethernet communication infrastructure for SAS. The bidder shall keep provision of 100% spare capacity for USER'S use.
    12. Communication protocols
        - Between bay level control units and HMI center, the acceptable communication protocol is IEC-61850.
        - Between control center and this substation automation system, the only acceptable protocol is the following IEC 60870-5-101/104 as per the requirement of remote control center.

3 SAS Hardware and functionality:

3.1 IEDs:

1. Bay control unit, Bay protection unit, Substation Auxiliary IED shall be independent.
2. The protection shall be provided by separate protection IEDs-BPU (numerical relays) and other protection devices indicated separately.
3. All IEDs shall be connected to the communication infrastructure for data sharing and shall meet the real-time communication requirements for automatic functions.
4. The data presentation and the configuration of the various IEDs shall be compatible with the overall system communication and data exchange requirements.
5. IEDs shall be equipped with a real-time clock, with full calendar support (including leap year).Clock resolution shall be governed by IEC 60870-4,
6. Clocks shall have an accuracy of ±2ppm and shall not drift more than twenty (20) ms per hour.
7. If necessary, IEDs shall employ software algorithms to counter inaccuracies and drift resulting from crystal ageing.
8. All IEDs that need to maintain precise time for time-stamping shall be capable of supporting IEC 61850 time-synchronization.
9. Maintaining acceptably low drift in time between synchronizations, and time-stamping events with an absolute precision of +/-0.5ms relative to the GPS source
10. IEDs shall support local setting of time and date from the front port or HMI panel. This feature is intended only for use in unusual circumstances, such as the loss of Synchronization or for IED testing. This set of values shall be maintained by the IED until overridden by a successful time synchronization
11. Except for synchronization, the IED's real-time clock shall be completely independent of outside sources, so that the IED can continue to properly handle time related applications, should the time-synchronization mechanism fail
12. All the numerical IEDs must be fully IEC 61850 compliant and must have the following features:
    1. Peer-to-peer communication using GOOSE messages (IEC 61850) for interlocking.
    2. Inter-operability with third party IEC 61850 compliant devices
    3. Generate XML file for integration/engineering with vendor independent SCADA systems should be directly connected to the inter bay bus on IEC 61850 without the use of any gateways/protocol converters.
    4. Connections of bay protection IEDs to the IEC 61850 bus through the bay control units is not acceptable.
    5. The IEDs shall be capable of reporting to at least five clients.

3.1.1. Bay Control unit

1. The Bay control unit shall be industrial grade components flush mounted in the panel based on microprocessor technology, shall use numerical techniques for the calculation and evaluation of externally input analogue signals.
2. Its mimic displays accessible from the front of the panel.
3. The Bay control unit mimic shall dynamically represent the current value of the measurements, state of the devices and control of devices.
4. It shall be possible to remote control the Bay equipment's through the Bay control unit (BCU) from control centers.
5. The Bay control unit shall acquire all the analog measurements, Status of Circuit breakers, Isolators and Earth switches, status of alarms, and provide Control of devices (Circuit breaker/Isolators/Reset of Relays/position selection for Auto reclose etc).
6. The Bay control unit shall also provide synchronization check facility for the circuit breakers according to the Bus configuration arrangements and requirements.
7. It shall incorporate select-before-operate control principles as safety measures for operation via the HMI.
8. It shall perform all bay related functions, such as control commands, bay interlocking, data acquisition, data storage, event recording and shall provide inputs for status indication and outputs for commands.
9. It shall be directly connected to the switchgear.
10. It shall acquire and process all data for the bay (Equipment status, fault indications, measured values, alarms etc.) and transmit these to the other devices in substation automation system.
11. It shall receive the operation commands from station HMI.
12. It shall have the capability to store all the data for at least 24hours.
13. All bay level interlocks are to be incorporated in the Bay level unit so as to permit control from the Bay level unit/local bay mimic panel, with all bay interlocks in place, during maintenance and commissioning or in case of contingencies when the station HMI is out of service.
14. The Bay level unit shall meet the requirements for withstanding electromagnetic interference according to relevant parts of IEC 61850.
15. Failure of any single component within the equipment shall neither cause unwanted operation nor lead to a complete system breakdown.
16. The I/O modules shall form a part of the bay level unit and shall provide coupling to the substation equipment.
17. The I/O modules shall acquire all switchgear information (i.e. data coming directly from the switchgear or from switchgear interlocking devices) and transmit commands for operation of the switchgear.
18. The measured values of voltage and current shall be from the secondaries of instrument transformers.

19. The digital inputs shall be acquired by exception with 1 ms resolution. Contact bouncing in digital inputs shall not be assumed as change of state.
20. For Protection transfer switch function in Transfer bus schemes, the logic for protection transfer from ‘Normal’ to ‘Transfer’ and vice versa, shall be implemented and monitored in BCU.

3.1.2. Bay Protection unit (BPU)

1. Bay protection unit-BPU (relays) are independent of bay control unit.
2. It shall be connected to the communication infrastructure for data sharing and meet the real-time communication requirements for automatic functions.
3. The data presentation and the configuration of the various IEDs shall be compatible with the overall system communication and data exchange requirements.
4. It shall conform to the requirements of IS: 3231/IEC-60255/IEC61000 or other applicable standards.
5. It shall be suitable for flush or semi-flush mounting on the front with connections from the rear.
6. It shall be of numerical type and communication protocol shall be as per IEC 61850.
7. It shall also fulfill the requirements specified for Protection IEDs in CRP specification.
8. It shall be in draw out or plug-in type/modular cases with proper testing facilities. Necessary test plugs/test handles shall be supplied loose and shall be included in contractor's scope of supply.
9. It should contain an event recorder capable of storing at least 200 time-tagged events.
10. The disturbance recorder function shall be as per detailed in section C&R

3.2 Ethernet Switch:

1. The Bay Control unit and the numerical relays supplied under present scope shall be connected to the LAN Ethernet switch(s) (managed switch).
2. Not more than 8 nos of IEC 61850 devices shall be be connect on one bay level Ethernet switch and at least 6 spare ports (3 Optical +3 copper).
3. Ethernet switches that fulfill the hardened requirements concerning temperature, EMC, power supply (220/110 V DC from the Station Battery) and complying to IEC61850- 3, RSTP Protocol enable of the specification suitable to be installed in substations
4. The switches shall support priority tagging and open standards for ring management like fast scanning tree to ensure that e.g. for later system extension utility has not to rely on one switch supplier only

3.3 RTU/DC/ Gateway:

1. The Substation Automation System shall have the capability to support simultaneous communications with 4 independent remote master stations with at least one Control location.
2. The RTU/Gateway shall have adequate sizing to meet the required response time complying with the requirements of IEC 61850-3.
3. Use of industrial PCs as RTU/Gateway will not be accepted.
4. The RTU/DC/Gateway should be capable to integrate the no of IEDs as per system design and in no case less than 100.
5. The gateway/RTU shall be responsible for collection of instantaneous measurement data, status data etc. from the numerical relays. These data shall be made available to the HMI as well to the control center.
6. It shall support web server functionality for Remote access with a web browser for monitoring.
7. All the functions/routines of the gateway shall start automatically upon power up or restart of the equipment.
8. Hardware Gateway for remote control from Remote control centre through IEC60870-5-101 and 104 protocol.
9. Gateway shall be provided with minimum 10 Data ports (2 nos. for IEC 101and 4 nos. for IEC 104 protocol & 4 nos for IEC61850) in each gateway for State Load Dispatch Center (to SLDC) that should be distributed in the cards redundantly.
10. <u>Geo Positioning System (GPS):</u>
    1. Time Synch. Equipment With Antenna & NTP Display, Antenna Cable, Aux. Supply: 90-370V DC, 85-260V AC, 47- 55Hz, (Work on only AC not accepted) Ports: IRIG-B (Modulated), IRIG-B (Un-Modulated), RS232, SNTP, PPS.
    2. The Time synchronization equipment shall receive the co-ordinate Universal Time (UTC) transmitted through Geo Positioning Satellite System (GPS) and synchronize equipment to the Indian Standard Time in substation.
    3. The times synchronization shall be realized using the SNTP protocol to inter system.
    4. Time synchronization equipment shall include antenna, all special cables and processing equipment etc.
    5. It shall be compatible for synchronization of Event Loggers, Disturbance recorders and SAS at a substation through individual port or through Ethernet realized through optic fiber bus.
    6. The synchronization equipment shall have 2 micro second accuracy.
    7. Equipment shall give real time corresponding to IST (taking into consideration all factors like voltage, & temperature variations, propagation & processing delays etc). Including communication time for satellite link to achieve real time signal.
    8. Equipment shall meet the requirement of IEC 60255 for storage & operation.

9. The system shall be able to track the satellites to ensure no interruption of synchronization signal.
10. The output signal from each port shall be programmable at site for either one hour, half hour, minute or second pulse, as per requirement.
11. The equipment offered shall have six (6) output ports. Various combinations of output ports shall be selected by the customer, during detailed engineering, from the following.

a. Voltage signal: Normally 0-5V with 50 milli Seconds minimum pulse duration. In case any other voltage signal required, it shall be decided during detailed engineering.
b. Potential free contact (Minimum pulse duration of 50 milli Seconds.)
c. IRIG-B
d. RS232C
e. SNTP Port

12. The equipment shall have a periodic time correction facility of one second periodicity.
13. Time synchronization equipment shall be suitable to operate from 220V/110V DC supply available at the substation with voltage variation of + 10% and 15%
14. Equipment shall have real time digital display in hour, minute, second (24 hour mode) & have a separate time display unit to be mounted on the top of control panels having display size of approx. 100 mm height and in hh:mm:ss format.
15. GPS Antenna and Receiver
    1. Antenna location : The antenna will be located on the roof of the ehv substation's control building
    2. Antenna housing: The antenna shall be placed in a weather proof plastic housing.
    3. Lightning Protection: Surge protector with response time of ≤1nsec and a discharge current of 10KA, housed in an aluminum case.
    4. Signal strength at the input of the antenna: ~ 1X10 E-16 Watt, i.e. below the general noise level.
    5. Temperature Range : -300C to +850C
    6. Antenna supports: the antenna will be supported by brackets of anodized aluminium and designed to withstand strong winds.
    7. Low-noise preamplifier (optional, depending on the supplier's opinion, given the fact that the antenna receiver cable distance is about 100m): Fitted behind the antenna shall be an extremely low-noise preamplifier. The low-noise preamplifier will be located inside the EHV substation's control building.

8. GPS-receiver location : Inside the EHV substation’s control building, rail mounted
9. GPS-receiver supply voltage : 220V/110V DC
10. GPS-receiver configuration and setup: Via professional “windows” based software which must be included in the supply.
11. GPS-receiver interfaces : Serial interfaces with RS 422 hardware or RS 232 or RS 485
12. Cabling: All required cabling for the connection of antenna, preamplifier and receiver and of the GPS system to the HMI center unit, must be included in the supply. Furthermore the cables must be described in great detail in the offer.
13. The length of cable between antenna and receiver : ~ 100 m

3.4 HMI server:

1. The operator station HMI shall be a redundant system, with hot standby and shall provide basic functions for supervision and control of the substation.
2. The operator shall give commands to the switchgear on the screen via mouse clicks or keyboard commands.
3. The HMI shall give the operator access to alarms and events displayed on the screen. Aside from these lists on the screen, there shall be a printout of alarms or events in an event log.
4. An acoustic alarm shall indicate abnormalities, and all unacknowledged alarms shall be accessible from any screen selected by the operator.
5. All servers/PCs shall be of IEC 61850-3 & IEEE613 certified which can provide high reliability.
6. The Server/PCs shall comply to IEC61850-3 EMC/EMI standards, High CPU performance, flexible expansion, rich communication interface and intelligent functions. .
7. Hardware specification for HMI server/Gateways:
    1. Certification: IEC 61850-3, IEEE-613 ,IEC 60870-2, IEC 61000-4(Test/Details specified in Annexure II)
    2. Warranty: 5 years
    3. Driver Support for OS: Windows7, Windows8, Windows 10, Linux
    4. CPU: Intel dual Core i7 3rd gen & above 2.4GHz
    5. Memory: DDR3L 1.35V ECC 8GB,
    6. Storage: 2 x 2.5’’ SATA HDD (RAID0, RAID1) 1TB
    7. Power Supply: Dual Redundant Power supply, 100-220V AC/ DC ,50/60 Hz,1A (Only on AC not accepted)
    8. Mounting: 2U/3U 19" Rack Mount, ss

9. IP requirement: IP 30
10. Communication Interface:
    1. Serial Ports: 2 x RS-232 (DB9 connectors, Standard) 4 x RS 32/422/485 (Terminal Block) 2,000V isolation
    2. Serial Port Speed:RS-232: 50~115.2 kbps, RS-422/485: 50~921.6 kbps (Max.) LAN 4 x 10/100/1000 Base-T RJ45 ports with Magnetic Isolation Protection of 1.5 kV built-in (Supports Teaming Function, PXE, LAN1 supports AMT)
    3. USB : 6 x USB 2.0 (2 Front & 4 Rear)
    4. Expansion: Standard PCIe slots - 2 PCIe, 2PCI & 1 PCIe x 16 for video card. Provision for expansion of 2 port 1000mbps Fiber card to enable PRP/HSR and 1 Fiber for expansion of IRIG-B is mandatory
11. Display: Intel HD Graphics 4000, 2 VGA output, CRT display pixel resolution with minimum 1920 x 1200
12. Monitoring:
    1. LED's for monitoring of Power, storage, LAN ports & Serial Tx/Rx
    2. Utility for System parameters monitoring like CPU usage, CPU Temperature Memory usage, Motherboard temperature, Disk usage, Main board temperature and main power voltage.
13. Maintenance: Automatic OS recovery tool.
14. LED Monitor: Size: 30", Maximum Resolution: 1920x1080, Backlight: LED Aux. Supply: 220-240 V AC, 50 Hz ± 3 Hz Aspect Ratio: 4:3, Port: VGA.
15. Accessories: Wired multimedia Keyboard, Mouse and Speakers

3.5 Printer

1. It shall be robust and suitable for operation and shall accept and print all ASCII characters via master control computer unit interface.
2. The printer shall have in built testing facility.
3. Failure and dynamic status of the printer shall be monitored in NMS software.
4. Any protocol convertor required for the same, shall be supplied by the vendor.
5. The printer shall have an off line mode selector switch to enable safe maintenance.
6. The maintenance should be simple with provisions for ease of change of print head, ribbon changing, paper insertion etc.
7. Printers mounted in the control room shall be provided with a separate printer enclosure each. The enclosure shall be designed to permit full enclosure of the printers at a convenient level.
8. Plexiglas windows shall be used to provide visual inspection of the printers and ease of reading. The printer enclosures shall be designed to protect the printers from accident external contact and each should be removable from hinges at the back and shall be provided with lock at the front.

9. All reports and graphics prints shall be printed on A4 size color laser printer.
10. Printer shall be continuously online.
11. The printing shall be with a minimum of 132 characters per line. The printing operation shall be quiet with a noise level of less than 45 dB suitable for location in the control room.
12. A4 Color Laser Printer specification:
    Print Resolution: Up To 600x600dpi
    Aux. Supply: 110-240V AC,
    Port: 1 Hi-Speed USB 2.0, 1 Fast Ethernet 10/100base-TX

3.6 Power Backup/ Inverter.

1. Redundant Power supply provision for the substation automation system along with suitable changeover scheme shall be derived from station auxiliary supply.
2. In case of failure of station auxiliary supply, substation DC system (220V volt, with galvanic separation) shall feed the SAS.
3. Inverter of suitable capacity (1 KVA) shall be provided for station HMI and its peripheral devices e.g. printer etc and a backup for 3 Hrs.

3.7 Hardware Functionality.

1. Digital data to BCU shall be taken from potential free contacts.
2. Transformer & Reactor Parameters i.e Oil / Winding temperatures, On Line Monitor Hydran or any other equipment like Transformer management Relay.
3. OLTC Tap Position & Operation (not AVR) shall be interfaced with BCU/ equivalent device through Transducers for monitoring & Control these parameters in Local and RCC
4. All the data (analog & digital) pertaining to firefighting system, Diesel Generator set, ACDC panel, Distribution Transformers etc, shall be taken into SAS through Auxiliary BCUs and they all shall be mapped to SLDs (Pictorial View). The water pressure in fire protection scheme shall be taken into SAS through transducer to BCU/ equivalent device.
5. The status and control of auxiliaries shall be done through separate one or more IED and all alarm and analogue values shall be monitored and recorded though this IED. Necessary interfacing devices / transducers shall also be included in order to integrate station auxiliaries with SAS.
6. The list of signals required shall be provided by MSETCL as per site conditions and requirements. There shall be a provision of binary output card for annunciation in the aux panel BCU.
7. Station auxiliary analog data, meter data shall be taken through RS485 to station BCU.

4 Software structure

The software package shall be structured according to the SAS architecture and strictly divided in various levels. Necessary firewall shall be provided at suitable points in software to protect the system. An extension of the station shall be possible with lowest possible efforts. Maintenance, modification or an extension of components of any feeder may not force a shutdown of the parts of the system, which are not affected by the system adaptation.

4.1 Station level software

1. The operating system on Servers shall be latest version of Windows/Linux or other OS as per design of SAS system.
2. The Application, Database software's shall be of latest version.
3. The updates to all software shall be made available & implemented at the time of commissioning of the SAS & from time to time over the system guarantee period.
4. All servers & work stations shall be protected by suitable Antivirus packs throughout the tenure i. e. from installation to end of warranty period.
5. There shall be suitable Firewall used to protect the system from hacking or any external unauthorized intruder software attacks.
6. The base HMI software package for the operator station shall include the main SAS Functions and it shall be independent of project specific hardware version and operating system. It shall further include tools for picture editing, engineering and system configuration.
7. The user interface shall be based on latest WINDOWS concepts with graphics and facility for panning, scrolling, zooming, de cluttering etc.
8. The system shall be easy to use, to maintain, and to adopt according to specific user requirements. Systems shall contain a library with standard functions and applications.
9. The vendor must provide any upgraded software during the guarantee period free of cost.

4.2 Bay level software.

1. The system software shall be structured in various levels. This software shall be placed in a non-volatile memory.
2. The lowest level shall assure system performance and contain basic functions, which shall not be accessible by the operation and maintenance engineer for modifications.
3. The system shall support the generation of typical control macros and a process database for user specific data storage.
4. In case of restoration of links after failure, the software along with hardware shall be capable to restore it automatically through permissible authorize access & synchronizing with the remaining system without any manual interface. This shall be demonstrated by contractor during integrated system test.

4.3 Application software

1. In order to ensure robust quality and reliable software functions, the main part of the application software shall consist of standard software modules built as functional block elements.
2. The functional blocks shall be documented and thoroughly tested. They shall form part of library.
3. The application software within the control/protection devices shall be programmed in a functional block language.
4. Software for DR downloading & analysis, for providing s/w interlocks, for creating auto data sheets, etc. to be provided.
5. SAS software and configuration tools should have Forward and Backward Compatibility with OS throughout lifecycle support.

4.4 Disturbance analysis Tool

1. The PC based workstation shall have necessary software to evaluate all the required information for proper fault analysis in comtrade format.
2. The tool shall display all analog parameters, binary status, harmonics, phasor diagrams etc.
3. SAS software shall be menu driven and shall have intuitive Graphic User Interface and shall have ease of navigation

4.5 Operation functionality of software

1. Operation of the system by the operator from the Control Room shall take place via industry standard HMI (Human Machine Interface) subsystem consisting of graphic color VDU, a standard keyboard and a cursor-positioning device (mouse).
2. The color screen shall be divided into 3 fields:

   i) Message field with display of present time and date

   ii) Display field for single line diagram

   iii) Navigation bar with alarm/condition indication

3. For display of alarm annunciation, lists of events etc. a separate HMI View note, shall be provided.
4. All operations shall be performed with mouse and/or a minimum number of function keys and cursor keys.
5. The function keys shall have different meanings depending on the operation. The operator shall see the relevant meanings as function tests displayed in the command field (i.e. operator prompting).
6. For control actions, the switchgear (i.e. circuit breaker etc.) requested shall be selectable on the display by means of the cursor keys.
7. The switching element selected shall then appear on the background that shall be flashing in a different color. The operator prompting shall distinguish between: Prompting of indications e.g. fault indications in the switch gear and Prompting of

operational sequence e.g. execution of switching operations

8. The summary information displayed in the message field shall give a rapid display of alarm/message of the system in which a fault has occurred and alarm annunciation lists in which the fault is described more fully.
9. Each operational sequence shall be divided into single operation steps, which are initiated by means of the function keys/WINDOW command by mouse.
10. Operator prompting shall be designed in such a manner that only the permissible keys are available in the command field related to the specific operation step.
11. Only those switching elements shall be accessed for which control actions are possible. If the operation step is rejected by the system, the operator prompting shall be supported by additional comments in the message field.
12. The operation status shall be reset to the corresponding preceding step in the operation sequence by pressing one of the function keys.
13. All operations shall be verified.
14. Incorrect operations shall be indicated by comments in the message field and must not be executed.

5 SAS functionality

5.1 Operation Philosophy:

1. The high-voltage apparatus within the station shall be operated from different places:
    1. Station HMI
    2. Local Bay Controller IED (in the bays)
    3. Operation shall be possible by only one operator at a time.

2. The operation shall depend on the conditions of other functions, such as interlocking, synchro check etc. (see description in "Bay control functions")
3. At station level, the entire station shall be controlled and supervised from the station HMI. It shall also be possible to control and monitor the bay from the bay level equipment at all times.
4. Clear control priorities shall prevent operation of a single switch at the same time from more than one of the various control levels, i.e. station HMI, bay level or apparatus level.
5. The priority shall always be on the lowest enabled control level.
6. Select-before-execute- For security reasons the command is always to be given in two stages; selection of the object and command for operation under all mode of operation except emergency operation. Final execution shall take place only when selection and command are actuated
7. Automatic sequences -The available automatic sequences in the system should be listed and described (e.g. sequences related to the bus transfer). It must be possible to initiate pre-defined automatic sequences by the operator and also define new automatic sequences.

5.2 Command Supervision

i. Bay/station interlocking and blocking

1. Software interlocking is to be provided to ensure that inadvertent incorrect operation of switchgear causing damage and accidents in case of false operation does not take place.
2. In addition to software interlocking hardwired interlocking are to be provided for Bus earth switch interlocking.
3. It shall be a simple layout, easy to test and simple to handle when upgrading the station with future bays
4. For software interlocking the bidder shall describe the scenario while an IED of another bay is switched off or fails.
5. A software interlock override function shall be provided which can be enabled to bypass the interlocking function.

6. A provision for electrical reset command shall be made for 86 and 96 trip relays and relay indication LEDs through SAS HMI.

ii. Run Time Command cancellation

Command execution timer (configurable) must be available for each control level connection. If the control action is not completed within a specified time, the command should get cancelled.

iii. Self-supervision

Continuous self-supervision function with self-diagnostic feature shall be included.

iv. User Configuration

1. The monitoring, controlling and configuration of all input and output logical signals and binary inputs and relay outputs for all built-in functions and signals shall be possible both locally and remotely.

2. It shall also be possible to interconnect and derive input and output signals, logic functions, using built-in functions, complex voltage and currents, additional logics (AND-gates, OR gates and timers).(Multi-activation of these additional functions should be possible).

5.3 Bay level function

1. In a decentralized architecture the functionality shall be as close to the process as possible. In this respect, the following functions can be allocated at bay level:

*Bay control functions including data collection functionality

*Bay protection functions

(Separate IEDs shall be provided for bay control function and bay protection function.)

Bay control functions

- Control mode selection
- Select-before-execute principle
- Command supervision
- Interlocking and blocking
- Double command
- Synchro check, voltage selection
- Run Time Command cancellation
- Transformer tap changer control i.e. manual control from HMI (for power transformer bays)
- Operation counters for circuit breakers
- Operating pressure supervision
- Display of interlocking and blocking

- Breaker position indication per phase
- Alarm annunciation
- Measurement display
- Local HMI (local guided, emergency mode)
- Interface to the station HMI
- Data storage for at least 200events
- Extension possibilities with additional I/O’s inside the unit or via fiber-optic communication and process bus

5.4 Control mode selection

5.4.1. Bay level Operation:

As soon as the operator receives the operation access at bay level the operation is normally performed via bay control IED. During normal operation bay control unit allows the safe operation of all switching devices via the bay control IED.

5.4.2. EMERGENCY mode

Control authority in this mode is given to a higher level (Control Room) and the installation can be controlled only remotely. Control operation from lower levels shall not be possible in this operating mode.

5.4.3. Synchronism and energizing check

The synchronism and energizing check functions shall be bay-oriented and distributed to the bay control and/or protection devices. These features are:

Settable voltage, phase angle, and frequency difference Energizing for dead line - live bus, live line - dead bus or dead line - dead bus with no synchro- check function Synchronizing between live line and live bus with synchro check function.

5.4.4. Voltage Selection

The voltages relevant for the Synchro check functions are dependent on the station topology, i.e. on the positions of the circuit breakers and/or the isolators. The correct voltage for synchronizing and energizing shall be selected automatically by the bay control and protection IEDs.

5.5 System level functions

1. The position of each switchgear e.g. circuit breaker, isolator, earthing switch, transformer tap changer etc. shall be supervised continuously. Every detected change of position shall be immediately displayed in the single line diagram on the station HMI screen, recorded in the event list, and a hard copy printout shall be produced
2. Alarms shall be initiated in the case of spontaneous position changes.

3. The switchgear positions shall be indicated by two auxiliary switches, normally closed (NC) and normally open (NO), which shall give ambivalent signals. An alarm shall be initiated if these position indications are inconsistent or if the time required for operating mechanism to change position exceeds a predefined limit.
4. The SAS shall also monitor the status of sub-station auxiliaries like the battery chargers, ACDBs, DCDBs, T/F cooling systems, Fire protection system.
5. Transformer Tap changer facility
   a. The substation automation system for EHV substation shall have provision to change the taps of all transformers, of the substation

      Tap changer control will be carried out from the following points:

      1. Locally, on the autotransformer itself
      2. The bay control unit.
      3. HMI center (EHV substation's control building)
      4. transmission system's control center

   b. Tap changer position shall be displayed on the visual display unit located in the EHV substation's control building (HMI center) and also in the transmission system's control center

   c. It should also be noted that the system shall contain capability for emergency stop of the tap changing procedure

5.6 Measurements

1. Analog inputs for voltage and current measurements shall be connected directly to the voltage transformers (VT) and the current transformer (CT) without intermediate transducers. The values of active power (W), reactive power (VAR), frequency (Hz), and the rms values for voltage (U) and current (I) shall be calculated
2. The measured values shall be displayed locally on the station HMI and in the control center. The abnormal values must be discarded. The analogue values shall be updated every 1 seconds.
3. Threshold limit values shall be selectable for alarm indications.
4. Substation Automation System (SAS) shall have provision for computation of Monthly, Fortnightly & Daily Energy Audit. Depending upon Bus configuration, it shall be possible for Bus-wise, Section-wise Energy Audit as well.
5. All the necessary reports in this regard shall be generated automatically by the System on operator and engineering servers through HMI menu.

5.7 Event and alarm handling

1. Events and alarms are generated either by the switchgear, by the control IEDs, or by the station level they shall be recorded in an event list in the station HMI.

2. Alarms shall be recorded in a separate alarm list and appear on the screen.
3. All or a freely selectable group of events and alarms shall also be printed out on an event printer.
4. The alarms and events shall be time-tagged with a time resolution of 1 ms.

5.8 Operation functionality

1. On the HMI the object has to be selected first. In case of blocking or if the interlocking conditions are not met, the selection shall not be possible and an appropriate alarm annunciation shall occur. If a selection is valid the position indication will show the possible direction, and the appropriate control execution button shall be pressed in order to close or open the corresponding object. Control operation from other places shall not be possible in this operating mode.
2. Consistent design principles shall be adopted with the HMI concerning labels, colors, dialogues and fonts. Non-valid selections shall be dimmed out.
   - The object status shall be indicated using different status colors for Selected object under command
   - Selected on the screen
   - Not updated, obsolete values, not in use or not sampled
   - Alarm or faulty state
   - Warning or blocked
   - Update blocked or manually updated
   - Control blocked
   - Normal state

5.9 Command procedures

1. In order to ensure a high degree of security against undesired operation, a "select-before-execute" command procedure shall be provided. After the "selection" of a switch, the operator shall be able to recognize the selected device on the screen, and all other switchgear shall be blocked.
2. As communication between control center and device to be controlled is established, the operator shall be prompted to confirm the control action and only then final execute command shall be accepted. After the "execution" of the command the operated switching symbol shall flash until the switch has reached its new position.
3. The operator shall be in a position to execute a command only, if the switch is not blocked and if no interlocking condition is going to be violated.
4. The interlocking statements shall be checked by the interlocking scheme implemented at bay and station level.

5. After command execution, the operator shall receive a confirmation that the new switching position has been reached or an indication that the switching procedure was unsuccessful with the indication of the reason for non-functioning.
6. No provision shall be made for forced operation of isolators and earth switches by bypassing the interlocks.

5.10 Automatic disturbance file transfer

All recorded data from the IEDs of different manufacturers as on the panels with integrated disturbance recorder systems shall be automatically uploaded on exception within one second + auto triggered once a day to a station HMI database. A dedicated computer as relay engineer's console (EWS) shall be offered for analysis of records additionally.

5.11 Network Management System

1. The contractor shall provide a Network Management System (NMS) for following management functions.
    a) Configuration Management
    b) Fault Management
    c) Performance Monitoring
    d) Each hardware upto each port level monitoring
    e) Network Management System (NMS) port level monitoring capabilities are essential for detection of single fiber failure
2. This system shall be used for management of communication devices and other IEDs in the system. This NMS can be loaded in DR workstation and shall be easy to use, user friendly and menu based. The NMS shall monitor all the devices upto the port in the SAS and report if there is any fault in the monitored devices.
3. The NMS shall:
    a) Maintain performance, resource usage, and error statistics for all managed links and devices and present this information via displays, periodic reports and on demand reports
    b) Maintain a graphical display of SAS connectivity and device status
    c) Issue alarms when error conditions occur.
    d) Provide facility to add and delete addresses and link

5.12 IED parameter setting

It shall be possible to access all protection and control IEDs for reading the parameters (settings) from the station HMI or from a dedicated monitoring computer. The setting of parameters or the activation of parameter sets shall only be allowed after entering a password through appropriate authorization level.

6 Screens

1. All Screens should be as per MSETCL site requirement
2. In the MIMIC diagram color identification shall be given to different voltage circuits
3. The colour should change when the circuit is disconnected from active circuit.
4. The supplier shall extend required cooperation for any suitable modifications in screens at site as may be required by MSETCL
5. The process status of the substation in terms of actual values of currents, voltages, frequency, active and reactive powers as well as the positions of circuit breakers, isolators and transformer tap changers shall be displayed in the station single line diagram, System supervision & display
6. The SAS system shall be comprehensively self-monitored such that faults are immediately indicated to the operator, possibly before they develop into serious situations. Such faults are recorded as a faulty status in a system supervision display.
7. This display shall cover the status of the entire substation including all switchgear, IEDs, communication infrastructure and remote communication links, and printers at the station level etc.
8. The following standard screens shall be available from the HMI.
   a. Single line diagram showing the switchgear status and measured values.
   b. Control dialogues with interlocking and blocking details. This control dialogue shall tell the operator whether the device operation is permitted or blocked.
   c. Measurement dialogues
   d. Alarm list, station/bay oriented
   e. Event list, station/bay oriented
   f. System status
   g. Values of tap positions, winding and oil temperatures of all ICTs and T/Fs with hourly logging and trends, cooling system status and healthiness.
   h. Measurands of smart transmitters like online DGA.
   i. Status of T/F fire extinguisher system if available
   j. PLCC counter and healthiness status.
   k. Command buttons for 86 and 96 trip relay reset and relay indications.
   l. SAS Architecture
   m. Online energy status.
   n. Auxiliary Status Screens.
   o. Delay energy measurement error on SLD.
   p. NMS Live status screen.
9. Reports

   Alarms shall be displayed, but separately from the events. The events and alarms shall also be printed on a printer located in the substation's control room. The

Report creation tool shall be made available for enabling the creation of report format as per requirement.

9.1. Event reports-

1. All reports should be design as per site requirements of MSETCL
2. The event list shall contain events that are important for the control and monitoring of the substation.
3. The event and associated time (with 1 ms resolution) of its occurrence has to be displayed for each event.
4. The operator shall be able to call up the chronological event list on the monitor at any time for the whole substation or sections of it.
5. The events shall be registered in a chronological event list in which the type of event and its time of occurrence are specified.
6. It shall be possible to store all events in the computer for at least one month.
7. The information shall be obtainable also from a printed event log.
   a. The chronological event list shall contain:
   b. Position changes of circuit breakers, isolators and earthing devices
   c. Indication of protective relay operations
   d. Fault signals from the switchgear
   e. Indication when analogue measured values exceed upper and lower limits. Suitable provision shall be made in the system to define two level of alarm on either side of the value or which shall be user defined for each measured.
   f. Loss of communication
   g. Filters for selection of a certain type or group of events shall be available. The filters shall be designed to enable viewing of events grouped per:
   h. Date &time
   i. Bay
   j. Device
   k. Function e.g. trips, protection operations etc.
   l. Alarm class
   m. Analog values reports
   n. Event and Alarm reports
   o. Trend Reports
   p. Auxiliary Monitoring Report

      (Ex. Temp. Tap position, Battery voltage, etc)

The data displayed shall comprise:

- Trend reports:

- Day (Max ,Min)
- Month (Max ,Min)
- Semi-annual (Max ,Min)
- Year (Max ,Min)

Historical reports of selected analogue Values:

- Day (at 15 minutes interval)
- Week
- Month
- Year

Storage of all analogue data (at 15 minutes interval) and digital data including alarm, event and trend data for thirty (30) days.

8. The reports shall provide time related follow-ups of measured and calculated values.
9. A user interface for accessing the reports shall be provided on all HMIs
10. It shall be possible to select displayed values from the database in the process display on line.
11. Unsure values shall be indicated. It shall be possible to select the time period for which the specific data are kept in the memory.
12. Following printouts shall be available from the printer and shall be printed on demand.

i. Daily voltage and frequency curves depicting time on X-axis and the appropriate parameters on the Y-axis. The time duration of the curve is 24 hours.
ii. Weekly trend curves for real and derived analogue values.
iii. Printouts of the maximum and minimum values and frequency of occurrence and duration of maximum and minimum values for each analogue parameter for each circuit in 24 hr period.
iv. Provision shall be made for logging information about breaker status like number of operation with date and time indications.
v. Equipment operation details shift wise and during 24hours.
vi. Printout of adjustable time period as well as of demand for MW, MVAR, Current, Voltage on each feeder and transformer as well as Tap Positions, temperature and status of pumps and fans for transformers.
vii. Printout of adjustable time period as well as of demand system frequency and average frequency.

13. Substation Automation System (SAS) shall have provision for computation of Monthly, Fortnightly & Daily Energy Audit. Depending upon Bus configuration, It

shall be possible for Bus-wise, Section-wise Energy Audit as well. All the necessary reports in this regard shall be generated automatically by the System

14. Display, archiving and storage of electrical parameters and user configurable reports in the form of Excel spreadsheet & structured page format shall be possible
15. It shall be possible to illustrate all types of process data as trends - input and output data, binary and analogue data. The trends shall be displayed in graphical form as column or curve diagrams with a maximum of 10 trends per screen. Adjustable time span and scaling ranges must be provided.
16. It shall be possible to change the type of value logging (direct, mean, sum or difference)in the window. It shall also be possible to change the update intervals on line in the picture as well as the selection of threshold values for alarm purposes.

9.2. Alarm reports-

1. Faults and errors occurring in the substation shall be listed in an alarm list and shall be immediately transmitted to the control center.
2. The alarm list shall substitute a conventional alarm tableau, and shall constitute an evaluation of all station alarms.
3. It shall contain unacknowledged alarms and persisting faults.
4. The date and time of occurrence shall be indicated.
5. The alarm list shall consist of a summary display of the present alarm situation. Each alarm shall be reported on one line that contains.
   - The date and time of the alarm
   - The name of the alarming object
   - A description text
   - The acknowledgement state
6. Whenever an alarm condition occurs, the alarm condition must be shown on the alarm list and must be displayed in a flashing state along with an audible alarm.
7. After acknowledgement of the alarm, it should appear in a steady (i.e. not flashing) state and the audible alarm shall stop.
8. The alarm should disappear only if the alarm condition has physically cleared and the operator has reset the alarm with a reset command.
9. The state of the alarm shall be shown in the alarm list (Unacknowledged and persistent, Unacknowledged and cleared, Acknowledged and persistent)
10. Filters for selection of a certain type or group of alarms shall be available as for events. A typical signal list for the SAS shall be as per Annexure 1.However bidder shall provide any additional signals required as per site requirement of MSETCL.

11. Audible alarm for critical (Trip Annunciation)/Status inconsistencies shall be taken in service.

9.3. Metering Report:

1. The information shall be obtainable also from a printed Metering report.
   1. Bay Load, Bus voltages, Active Energy, Reactive Energy, Power factor.
   2. Bus wise Energy Audit
   3. Trend Reports

The data displayed shall comprise:

Trend reports:

- Day (Max ,Min)
- Month (Max ,Min)
- Semi-annual (Max ,Min)
- Year (Max ,Min)

Historical reports of selected Values:

Day (at 15 minutes interval)

- Week
- Month
- Year

Storage of all analogue data and trend data for thirty (30) days.

2. The reports shall provide time related follow-ups of measured and calculated values.
3. A user interface for accessing the reports shall be provided on all HMIs
4. It shall be possible to select displayed values from the database in the process display on line.
5. Unsure values shall be indicated. It shall be possible to select the time period for which the specific data are kept in the memory.
6. Following printouts shall be available from the printer and shall be printed on demand
7. It shall be possible for migrating the above reports to excel format.
8. Daily voltage and frequency curves depicting time on X-axis and the appropriate parameters on the Y-axis. The time duration of the curve is 24 hours.
   1. Weekly trend curves for real and derived analogue values.
   2. Printouts of the maximum and minimum values and frequency of occurrence and duration of maximum and minimum values for each analogue parameter for each circuit in 24 hr period.
   3. Printout of adjustable time period as well as of demand for MW, MVAR, Current, Voltage on each feeder and transformer.

4. Printout of adjustable time period as well as of demand system frequency and average frequency.

9. Test:

The substation automation system offered by the bidder shall be subjected to following tests to establish compliance with IEC 61850-3 for EHV substation equipment installed in sheltered area in the outdoor switchyard and specified ambient conditions. All the hardware components of the SAS shall be type tested for IEC61850 -3 compliance as per Annexure 2 of this document and relevant docs to be submitted by the bidder.

9.4. Type Tests:

Type tests shall be carried out as per relevant IS/IEC standard.

Control IEDs and Communication Equipment: shall be subjected to the following type tests

a. Power Input(burden)

i) Auxiliary Voltage

ii) Current Circuits

iii) Voltage Circuits

iv) Indications

b. Accuracy Tests

i) Operational Measured Values

ii) Currents

iii) Voltages

iv) Time resolution

c. Insulation Tests:

i) Dielectric Tests

ii) Impulse Voltage withstand Test

d. Influencing Quantities

i) Limits of operation

ii) Permissible ripples

iii) Interruption of input voltage

e. Electromagnetic Compatibility Test

i) 1 MHZ, burst disturbance test

ii) Electrostatic Discharge Test

iii) Radiated Electromagnetic Field Disturbance Test

iv) Electrical Fast transient Disturbance Test

v) Conducted Disturbances Tests induced by Radio Frequency Field

vi) Magnetic Field-test

vii) Emission (Radio Interference level)Test

viii) Conducted Interference Test

f. Function Tests

i) Indication

ii) Commands

iii) Measured Value Acquisition

iv) Display Indications

g. Environmental Tests

i) Cold Temperature

ii) Dry Heat

iii) Wet heat

iv) Humidity (Damp heat Cycle)

v) Vibration

vi) Bump

vii) Shock

9.5. Factory Acceptance Tests:

The supplier shall submit a test specification for factory acceptance test (FAT) and commissioning tests of the station automation system for approval. For the individual bay level IEDs, applicable type test certificates shall be submitted.

The manufacturing phase of the SAS shall be concluded by the factory acceptance test (FAT). The purpose is to ensure that the Contractor has interpreted the specified requirements correctly and that the FAT includes checking to the degree required by the user. The general philosophy shall be to deliver a system to site only after it has been thoroughly tested and its specified performance has been verified, as far as site conditions can be simulated in a test lab. If the FAT comprises only a certain portion of the system for practical reason, it has to be assured that this test configuration contains at least one unit of each and every type of equipment incorporated in the delivery system.

If the complete system consists of parts from various suppliers or some parts are already installed on site, the FAT shall be limited to sub system tests. In such a case, the complete system test shall be performed on site together with the site acceptance test (SAT).

9.6. Integration Test:

The integrated system tests shall be performed as detailed in subsequent clauses as per following configuration:

Redundant station HMI, DR works station, gateways, two switches (i.e. for two diameters) along with all IEDs for the printers.

All other switches for complete substation as detailed in section project shall be simulated as needed.

9.6.1. Hardware Integration Tests:

The hardware integration test shall be performed on the specified systems to be used for Factory tests when the hardware has been installed in the factory. The operation of each item shall be verified as an integral part of system. Applicable hardware diagnostics shall be used to verify that each hardware component is completely operational and assembled into a configuration capable of supporting software integration and factory testing of the system. The equipment expansion capability shall also be verified during the hardware integration tests.

9.6.2. Integrated System Tests:

Integrated system tests shall verify the stability of the hardware and the software. During the tests all functions shall run concurrently and all equipment shall operate a continuous 100 Hours period. The integrated system test shall ensure the SAS is free of improper interactions between software and hardware while the system is operating as a whole.

9.7. Field Tests:

The field tests shall completely verify all the features of SAS hardware and software. The contractor shall demonstrate the guaranteed availability by conducting the availability test on the total substation automation system as a whole after commissioning of total substation automation system. The test shall verify the reliability and integrity of all sub-systems. Under these conditions the test shall establish an overall availability of 99.98%. After the lapse of 1000 Hours of cumulative test time, test records shall be examined to determine the conformance with availability criterion. In case of any outage during the availability test, the contractor shall rectify the problem and after rectification, the 1000 hours period start after such rectification.

If test object has not been met the test shall continue until the specified availability is achieved.

The contractor has to establish the availability in a maximum period of three months from the date of commencement of the availability test.

After the satisfactory conclusion of test both contractor and employer shall mutually agree to the test results and if these results satisfy the availability criterion, the test is considered to be completed successfully. After that the system shall be taken over by the employer and then the guarantee period shall start. Concerned SE TCC of MSETCL shall be certifying officer for this.

10. Maintenance

10.1. Maintenance Responsibility during the Guaranteed Availability Period during Guaranteed Availability Period, the Contractor shall take continual actions to ensure the guaranteed availability and shall make available all the necessary resources such as specialist personnel, spare parts, tools, test devices etc. for replacement or repair of all defective parts and shall have prime responsibility for keeping the system operational.

During the Guaranteed availability period the responsibility of the contractor shall be to maintain uptime of the system above 99%.

During Guarantee/Warranty period as specified in tender document, contractor shall arrange yearly visit of their representative to site to review the performance of system and in case any defects / short comings etc. is observed during the period, the same shall be set right by the contractor within reasonable period of time as specified.

10.2. Reliability and availability

The SAS shall be designed so that the failure of any single component, processor, or device shall not render the system unavailable. The SAS shall be designed to satisfy the very high demands for reliability and availability concerning:

- Mechanical and electrical design
- Security against electrical interface(EMI)
- High quality components and boards
- Modular, well-tested hardware
- Thoroughly developed and tested modular software
- Easy-to understand programming language for application programming
- Detailed graphical documentation and application software
- Built-in supervision and diagnostic functions
- After Sales Service
- Security
- Experience of security requirements

- Process know-how Select before execute at operation
- Process status representation as double indications
- Distributed solution
- Independent units connected to the local area network
- Back-up functions
- Panel design appropriate to the harsh electrical environment and ambient conditions
- Panel grounding immune against transient ground potential rise

10.3. Outage terms

a) Outage: The state in which substation automation system or a unit of SAS is unavailable for Normal Operation as defined in the clause 6.11.1 due to an event directly related to the SAS or unit of SAS. In the event, the owner has taken any equipment/system other than substation Automation System for schedule/-forced maintenance, the consequent outage to SAS shall not be considered as outage for the purpose of availability.

b) Actual outage duration(AOD): The time elapsed in hours between the start and the end of an outage. The time shall be counted to the nearest 1/4th of an hour. Time less than 1/4th of an hour shall be counted as having duration of 1/4th of an hour.

c) Period Hours(PH): The number of hours in the reporting period. In a full year the period hour are 8760 h (8784 h for a leap year).

d) Actual Outage hours(AOH): The sum of actual outage duration within the reporting period AOH = " AOD

e) Availability: Each SAS shall have a total availability of 99.98% or better i.e. the ratio of total time duration minus the actual outage duration to total time duration.

11. Guarantees

The availability for the complete SAS shall be guaranteed by the Contractor. The contractor shall demonstrate the availability guaranteed by conducting the availability test on the total substation automation system as a whole after commissioning of total substation automation system. The test shall verify the reliability and integrity of all sub-systems.

Under these conditions the test shall establish an overall availability of 99.98%. After the lapse of 1000 Hours of cumulative test time, test records shall be examined to determine the conformance with availability criterion. In case of any outage during the availability test, the contractor shall rectify the problem and after rectification, the 1000 hours period start after such rectification. If test object has not been met the test shall continue until the specified availability is achieved.

The contractor has to establish the availability in a maximum period of three months from the date of commencement of the availability test.

After the satisfactory conclusion of test both contractor and employer shall mutually agree to the test results and if these results satisfy the availability criterion, the test is considered to be completed successfully. After that the system shall be taken over by the employer and then the guarantee period shall start.

Guarantee period after the demonstration of availability of the SAS system (99.98%) shall be 5 years. Life cycle support of the SAS system shall be 10 years from the date of commissioning.

Submit an undertaking to bear responsibility at his cost to rectify defects and/or effect modification and replacement as demanded by the situation during the guarantee period of the entire project so as to get trouble free service from the equipment besides preventing recurrence of defects once rectified. They shall discharge their responsibility fully as per the above undertaking during the guarantee period by giving co-operation in promptly solving all problems

12. Spares

12.1. Consumables Spares:

All consumables such as paper, cartridges shall be supplied by the contractor till the SAS is taken over by the owner.

12.2. Availability Spares:

The bidder is required to list the spares, which may be required for ensuring the guaranteed availability during the guaranteed availability period. The final list of spares shall form part of scope of supply and accordingly the price thereon shall be quoted by the bidder and shall be considered in the evaluation of the bids. During the guaranteed availability period, the spare parts supplied by the Contractor shall be made available to the Contractor for usage subject to replenishment at the earliest. Thus, at the end of availability period the inventory of spares with the Employer shall be fully replenished by the Contractor. However, any additional spares required to meet the availability of the system (which are not a part of the above spares supplied by the Contractor) would have to be supplied immediately by the Contractor free of cost to the Employer.

List of equipments-

Quantity of equipment shall be decided by bidder in order to achieve guaranteed reliability and availability as declared by bidder.

i. Station HMI
ii. Redundant Station HMI (in Hot-standby mode)

iii. Bay level units with bay mimic

iv. Disturbance Recorder Work Station (Maintenance HMI)

v. A3 size Colour Laser Printer - 1 No. (For Reports & Disturbance records)

vi. Dot matrix printers - (one each for Alarms and log sheets)

vii. Communication infrastructures between Bay level units, Station HMI, printers, redundant LAN etc. as required.

viii. Hardware Gateway for remote communication with SLDC over IEC-60870 101 and 104 ,Modbus-IEC61850 converter.

ix. Storage of all necessary software with two number of license CDs of all software and ICD/CID file data backup must be handed over to concerned TCC office of MSETCL.

x. GPS device

xi. SUX panel

xii. Invertor

13. Training

The Bidder shall provide comprehensive training 10 Days to 5 nos of MSETCL engineers at factory on the following aspects at OEM Factory:

a. Hardware Components

b. System Networking

c. System Configuration

d. Engineering Procedures

e. Computer System Software

f. Application Software

The Bidder shall provide comprehensive Operational and system maintenance training to MSETCL O&M Engineers& Operation staff during the commissioning of the SAS system.

During the course of Commissioning the Bidder shall provide detail training to Project SAS commissioning team on the aspects of Hardware components, System networking and system Configuration & Engineering Procedures

Bidder personnel who are experienced instructors and who speak understandable English shall conduct training. The contractor shall arrange on its own cost all hardware training platform required for successful training and understanding in India.

The Contractor shall provide all necessary training material. Each trainee shall receive individual copies of all technical manuals and all other documents used for training. These materials shall be sent to Employer at least two months before the scheduled commencement of the particular training course. Class materials, including the documents sent before the training courses as well as class handouts, shall become the property of Employer. Employer reserves the right to copy such materials, but for in-house training and use only. Hands-on training shall utilize equipment identical to that being supplied to Employer.

The commissioning certificate of SAS shall be issued by SE TCC concerned only after the confirmation of completion of the Site training procedure

For all training courses, all the expenses shall be borne by the Contractor.

The Contractor shall include the training cost in the Bid

The schedule, location, and detailed contents of each course will be finalized during user and Contractor discussions.

13.1. Computer System Hardware Training:

A computer system hardware course shall be offered, but at the system level only. The training course shall be designed to give Employer hardware personnel sufficient knowledge of the overall design and operation of the system so that they can correct obvious problems, configure the hardware, perform preventive maintenance, run diagnostic programs, and communicate with contract maintenance personnel.

The following subjects shall be covered:

a) System Hardware Overview: Configuration of the system hardware.
b) Equipment Maintenance: Basic theory of operation, maintenance techniques and diagnostic procedures for each element of the computer system, e.g., processors, auxiliary memories, LANs, routers and printers. Configuration of all the hardware equipments.
c) System Expansion: Techniques and procedures to expand and add equipment such as loggers, monitors, and communication channels.
d) System Maintenance: Theory of operation and maintenance of the redundant hardware configuration, failover hardware, configuration control panels, and failover switches. Maintenance of protective devices and power supplies.
e) Subsystem Maintenance: Theory of design and operation, maintenance techniques and practices, diagnostic procedures, and (where applicable) expansion techniques and procedures. Classes shall include hands-on training for the specific subsystems that are part of Employer's equipment or part of similarly designed and configured subsystems. All interfaces to the computing equipment shall be taught in detail.

f) Operational Training: Practical training on preventive and corrective maintenance of all equipment, including use of special tools and instruments. This training shall be provided on Employer equipment, or on similarly configured systems.

13.2. Computer System Software Training -

a) System Programming: Including all applicable programming languages and all stand-alone service and utility packages provided with the system. An introduction to software architecture, Effect of tuning parameters (OS software, Network software, database software etc.) on the performance of the system.
b) Operating System: Including the user aspects of the operating system, such as program loading and integrating procedures; scheduling, management, service, and utility functions; and system expansion techniques and procedures
c) System Initialization and Failover: Including design, theory of operation, and practice
d) Diagnostics: Including the execution of diagnostic procedures and the interpretation of diagnostic outputs,
e) Software Documentation: Orientation in the organization and use of system software documentation.
f) Hands-on Training: One week, with allocated computer time for trainee performance of unstructured exercises and with the course instructor available for assistance as necessary.

13.3. Application Software Training-

The Contractor shall provide a comprehensive application software courses covering all applications including the database and display building course. The training shall include:

a) Overview: Block diagrams of the application software and data flows. Programming standards and program interface conventions.
b) Application Functions: Functional capabilities, design, and major algorithms. Associated maintenance and expansion techniques.
c) Software Development: Techniques and conventions to be used for the preparation and integration of new software functions.
d) Software Generation: Generation of application software from source code and associated software configuration control procedures.
e) Software Documentation: Orientation in the organization and use of functional and detailed design documentation and of programmer and user manuals.

f) Hands-on Training: One week, with allocated computer time for trainee performance of unstructured exercises and with the course instructor available for assistance as necessary.

14. Documentation:

The Bidder shall submit the following Documents to the Engineer in charge concerned before the completion of the SAS project

a) Operating Manual
b) Maintenance Manual
c) Data Back up and Restoration Procedure
d) Trouble shooting manual
e) Engineering procedures

1. IED parameter settings
2. ICD File Extraction
3. SCD file creation
4. Mapping of signals
5. Configuration of controls
6. Configuration of RTU/DC
7. Configuration of Gateway

Storage of all necessary software with two number of license CDs of all software and ICD/CID file data backup must be handed over to concerned TCC office of MSETCL.

15. Annexure-1:

15.1. Basic Monitoring Requirements:

1. Switchgear status indication
2. Switchgear SF6 Gas Pressures and Operating Mechanism Pressures.
3. Measurements (V, I, P, Q, f)
4. Event
5. Alarm
6. Winding & Oil Temperatures of Transformers & Reactors.
7. Ambient temperature.
8. Status and display of 415V LT system, 220V & 48V DC system
9. Status of display of Fire protection system, Fire & Smoke Detector System, Air conditioning system & Generator System including auto change over System.
10. Acquisition of all counters in PLCC panels through potential free contacts from PLCC or independently by counting the receive/send commands.
11. Acquisition of alarm and fault record from protection relays.

12. Disturbance records
13. Monitoring the state of batteries by displaying DC voltage, charging current and load current etc.
14. Tap-position of Transformer
15. Transformer Management Relay or online Hydran Monitoring etc
16. Transformer Parameters & Cooling System Monitoring

15.2. Analogue inputs:

i) For line

Current	R phase, Y phase, B phas
Voltage	R-Y phase , Y-B phase, B-Rphase ,
	R-N phase, Y-N phase, B-N phase

ii) For Transformer/Reactor

Current	R phase, Y phase, B phase
WTI&OTI	(for Transformer and Reactor)
Hydran	(for Transformer and Reactor)

Tap position (for Transformer only)

iii) For TBC & BC

Current R phase, Y phase, B phase

iv) Common

a. Voltage Bus-I, Bus-II and Transfer Bus wherever applicable R-Y phase R-N phase Y-B phase Y-N phase B-R phase B-N phase
b. Frequency for Bus-I and Bus-II
c. Ambient temperature (switchyard).
d. Kiosk / PRR Temperature
e. LT system

    i) Voltage R-Y, Y-B, B-R of Main Switch Board section-I
    ii) Voltage R-Y, Y-B, B-R of Main Switch Board section-II
    iii) Voltage R-Y, Y-B, B-R of Diesel Generator
    iv) Current from LT transformer-I
    v) Current from LT transformer-II
    vi) Current from Diesel Generator
    vii) Voltage of 220V DCDB-I
    viii) Voltage of 220V DCDB-II
    ix) Current from 220V Battery set-I

x) Current from 220V Battery set-II

xi) Current from 220V Battery charger-I

xii) Current from 220V Battery charger-II

xiii) Voltage of 48V DCDB-I

xiv) Voltage of 48V DCDB-II

xv) Current from 48V Battery set-I

xvi) Current from 48V Battery set-II

xvii) Current from 48V Battery charger-I

xviii) Current from 48V Battery charger-II

15.3. Digital Inputs-

The list of input for various bays/system is as follows ,all parameters shall be individual and separately display and do not mix 2 to 3 parameters in one item.

1. Line Bays

i. Status of each pole of CB,
ii. Status of Isolator, Earth switch
iii. CB troubles individually
iv. CB operation/closing lockout
v. Pole discrepancy operated
vi. Trip coils faulty (Individually)
vii. LBB Bay wise operated
viii. Bus bar protection trip relay operated (bay wise)
ix. Auto Re-closer operated (Breaker / Bay Wise)
x. A/R lockout (Breaker / Bay wise)
xi. Direct trip-I and II sent (individually)
xii. Direct trip-I & II received (individually)
xiii. Main I& II blocking (individually)
xiv. Main I/II-Inter trip send (individually)
xv. Main I/II-Inter trip received (individually)
xvi. O/V STAGE - I operated
xvii. O/V STAGE - II operated
xviii. FAULT LOCATOR FAULTY
xix. MAIN-I/II CVT FUSE FAIL
xx. 21L1 MAIN-I PROTN TRIP
xxi. 21L2 MAIN-II PROTN TRIP

xxii. 67N Main-I & Main-2 Operated (Individually)

xxiii. 21M1 MAIN-I PSB ALARM

xxiv. 21M1 MAIN-I SOTF TRIP

xxv. 21M1 MAIN-I R-PH TRIP

xxvi. 21M1 MAIN-I Y-PH TRIP

xxvii. 21M1 MAIN-I B-PH TRIP

xxviii. 21M1 MAIN-I START

xxix. 21 MAIN-I/II Carrier aided trip

xxx. 21 MAIN-I/II fault in reverse direction

xxxi. 21 MAIN-I/II ZONE-2 TRIP

xxxii. 21 MAIN-I/II ZONE-3 TRIP

xxxiii. 21 MAIN-I/II weak end in feed operated

xxxiv. 21M2 MAIN-II PSB alarm

xxxv. 21M2 MAIN-II SOTF TRIP

xxxvi. 21M2 MAIN-II R-PH TRIP

xxxvii. 21M2 MAIN-II Y-PH TRIP

xxxviii. 21M2 MAIN-II B-PH TRIP

xxxix. 21M2 MAIN-II start

xl. 21M2 MAIN-II aided trip

xli. 21 MAIN-I/II fault in reverse direction

xlii. 67 Back-up O/C operated

xliii. 67 Back-up E/F operated

xliv. 220V DC-I/II source fail

xlv. SPEECH CHANNEL FAIL

xlvi. PLCC Protection Channel - I FAIL

xlvii. PLCC Protection Channel-II FAIL

xlviii. High Speed / Master Trip Relays Gr - A & Gr - B Operated

xlix. Single Phase Trip Relays Operated

l. Any other required

li. PLCC channel 1 counter reading Tx, Rx. lii.

PLCC channel 2 counter reading Tx, Rx. liii.

PLCC direct trip 1 counter reading Tx, Rx. liv.

PLCC direct trip 2 counter reading Tx, Rx.

2. Transformer bays

i. Status of each pole of CB, Isolator, Earth switch
ii. CB troubles
iii. CB operation/closing lockout
iv. Pole discrepancy operated
v. Trip coil-1/2 faulty
vi. LBB operated
vii. Bus bar Protection trip relay operated
viii. 87T1 Bias Differential operated
ix. 87T2 HS Differential operated
x. MV OVERFLUX ALARM (MV)
xi. MV OVERFLUX TRIP (MV)
xii. HV OVERFLUX ALARM (HV)
xiii. HV OVERFLUX TRIP (HV)
xiv. HV BUS CVT ½ FUSE FAIL
xv. MV BUS CVT ½ FUSE FAIL
xvi. OTI ALARM/TRIP
xvii. WTI HV / IV / LV Alarm / trip
xviii. PRD OPTD
xix. 50 OVERLOAD ALARM
xx. BUCHOLZ TRIP
xxi. BUCHOLZ ALARM
xxii. OLTC BUCHOLZ / OSR ALARM
xxiii. OLTC/ OSR BUCHOLZ TRIP
xxiv. OIL LOW / MOG ALARM
xxv. 67PHV back-up O/C (HV) operated
xxvi. 67NHV back-up E/F (HV) operated
xxvii. 220V DC-I/II source fail
xxviii. TAP MISMATCH
xxix. 86 GR-A PROTN OPTD HV / MV
xxx. 86 GR-B PROTN OPTD HV/ MV
xxxi. 67PMV back-up O/C (MV) operated
xxxii. 67NMV back-up E/F (MV) operated
xxxiii. 21T Back up Impedance operated
xxxiv. Hydran Alarm
xxxv. All Latch Relays Operation
xxxvi. HV Bus Voltage selection

xxxvii. MV Bus Voltage selection

xxxviii. All Protective Relays operation

xxxix. All inter trip relay Operation, Cooling System Operation

xl. Any Other required

3. LINE / BUS Reactor Bays (As Applicable)

i. Status of each pole of CB, Isolator, Earth switch

ii. CB troubles

iii. CB operation/closing lockout

iv. Pole discrepancy operated

v. Trip coil faulty

vi. LBB operated

vii. Bus bar protection trip relay operated

viii. 64R REF OPTD

ix. 87R Differential OPTD

x. Line/ Bus CVT ½ FUSE FAIL

xi. OTI ALARM/TRIP

xii. PRD OPTD

xiii. BUCHOLZ TRIP

xiv. BUCHOLZ ALARM

xv. OIL LOW /MOG ALARM

xvi. Back-up impedance relay

xvii. 220v DC-I/II source fail

xviii. GR-A PROTN OPTD

xix. GR-B PROTN OPTD

xx. TEED -1 Protection operated

xxi. TEED-2 Protection operated

xxii. Voltage selection relays operation

xxiii. Hydran Alarm

xxiv. All Protective relays Operation

xxv. Any Other required.

4. Bus bar Protection

i. Bus bar Main-I trip

ii. Bus bar Main-II trip

iii. Bus bar zone-I CT open
iv. Bus bar zone-II CT open
v. Bus Transfer CT sup. operated
vi. Bus Transfer bus bar protection operated
vii. Bus protection relay fail

5. Auxiliary system

i. Incomer-I On/Off
ii. Incomer-II On/Off
iii. 415V Bus-I/II U/V
iv. 415V Bus coupler breaker on/off
v. DG set Breaker on/off
vi. Alarm/trip signals as listed in Section: DG set
vii. LT Transformer-I Buchholz Alarm & trip
viii. LT Transformer-II Buchholz Alarm & trip
ix. LT Transformer-I WTI Alarm & trip
x. LT Transformer-II WTI Alarm & trip
xi. LT Transformer-I OTI Alarm & trip
xii. LT Transformer-II OTI Alarm & trip
xiii. PLCC exchange fail
xiv. Time sync. Signal absent
xv. Alarm/trip signals as listed in Section: Battery and Battery charger
xvi. 220v DC-I earth fault
xvii. 220v DC-II earth fault
xviii. Alarm/trip signals as listed in Section: Fire protection system
xix. Alarm signals of Fire & Smoke detector System

6. Bay control Room system

i. AC Compressor 1 On/Off
ii. AC Compressor 2 On/Off
iii. Fire Detection 1 On/Off
iv. Fire Detection 2 On/Off
v. Kiosk/PRR Temperature High

The exact number and description of digital inputs shall be as per detailed engineering requirement apart from the above mentioned digital inputs; minimum of 200 inputs shall be kept for NMMC / MAHATRANSCO use in future. Further, if any new updates or features in IEC61850/SAS shall be incorporated.

16. Annexure- 2 -

Type Test Requirements as mentioned in IEC 61850-3, as below.

Sr. No	Test	IEC 61850-3, clause	Standard	Specification	Port Test applied
1	Impulse voltage withstand	6.3	IEC 60255-5	5kV, 0.5 joule	AC Power Line
2	Conducted Emission	5.8	CISPR22 EN5502 2	Frequency range 0.15 - 30MHz for serial and Ethernet port and power port +/-3.248 dB	Power Line , Serial & Ethernet port
3	Radiated Emission	5.8	CISPR22 EN5502 2	Frequency range 30 - 1000 MHz at 10meter, +/- 4.088 dB	Power Line , Serial & Ethernet port
4	Electro Static Discharge	5.7	IEC 61000-4-2,	Contact discharge +/- 8kV Air discharge +/- 15kV	Enclosure
5	Radiated Susceptibility Test	5.7.2	IEC 61000-4-3	80-1000MHz: 10V/m 80% AM, 1kHz sine wave	Enclosure
6	Electric Fast Transient	5.7.1.4	IEC 61000-4-4,	+/-4 kV, 5/50ns	Power Line, Serial & Ethernet port
7	High Energy Surge Test	5.7.1.2	IEC 61000-4-5,	+/-2kV 1.2/50μs for common mode for serial and Ethernet port +/-1kV 1.2/50μs for differential mode for serial port +/-2kV 1.2/50μs for common mode for power port	Power Line, Serial & Ethernet port
8	Conducted RF immunity	5.7.1.1	IEC 61000-4-6,	0.15 - 80MHz: 10Vrms 1kHz, 80%AM	Power Line, Serial & Ethernet port
9	Power Frequency disturbances	5.7.3	IEC 61000-4-8	40A/m & 1000 A/m	Enclosure

Sr. No	Test	IEC 61850-3, clause	Standard	Specification	Port Test applied
10	Damped Oscillatory Magnetic field Immunity Test	5.7.3	IEC 61000-4-10,	T rise : 75 +/- 20% Oscillation frequency 1MHz : +/- 10% Repetition rate : 400 /s for 1 MHz +/- 10% Burst duration : Not less than 2s Continuous magnetic field strength : 30 A/m	
11	Ripple on DC power line immunity test		IEC61000- 4-17	level: 3 10% of the nominal DC voltage AC line frequency: 50 Hz	
12	Voltage DC dip and interruption test		IEC61000- 4-29	0% short interruption for 0.03 sec 40% & 70% dips for 0.3 sec 80% & 120% variation for 3 sec	
13	Voltage AC dip and Interruption test		IEC 61000-4-11	0% short interruption for 250 cycles 0% of AC mains for 0.5 cycles 40% dips for 5 cycles 70% dips for cycles	AC power port
14	Oscillatory waves	5.7.1.3	IEC 61000-4-12,	+/-2.5 kV, Oscillatory Wave: 1 MHz for AC power +/-2.5 kV 75ns 1MHz common mode, +/-1 kV 75ns, 1MHz differential mode for DC power +/-2.5 kV 75ns 1MHz common mode for serial and Ethernet port	Ethernet, Serial and power port
15	Immunity to conducted common Mode disturbance	5.7.1.3	IEC 61000-4-16,	frequency range 0-150kHz, 3V / 30V test voltage	POWER Line, Serial & Ethernet port
16	Vibration and Shock	5.5	IEC60870-2-2	Vibration: Frequency ange 5 Hz to 500Hz, displacement 3mm peak from 5hz to 9Hz, acceleration 1g peak from 9 to 200HZ, 1.5g peak from 200Hz to 500Hz Shock: 10g for 11msec on three axis (X,Y,Z)	Enclosure & all ports
17	Barometric pressure	5.4	IEC60870-2-2, 3.3.2	Amplitude: 0m (101.3 kPa) to 3000m (70.0 kPa) Temp: 25oC, Altitude ramp rate: 10 m/s	Enclosure & all ports

Sr. No	Test	IEC 61850-3, clause	Standard	Specification	Port Test applied
18	Humidity	5.3	IEC60870-2-2, Table-1	Relative humidity 95% RH, temp set point +55oC and + 25oC, Dwell period six hours at +55oC and eight hour at 25oC six hours at +55oC and eight hour at 25oC	Enclosure & all ports
19	Temperature	5.2	IEC60870-2-2, Table-1	Operation -40Deg C to + 70 deg C	Enclosure & all ports
20	Voltage range & tolerance	6.2, 6.3	IEC60870-2-1, Table-5	176Vac (-20%) to 253 Vac(+15%)	AC power port
21	DC rated control power inputs		IEEE 1613-5.1		
22	Allowable AC component in DC control voltage supply		IEEE 1613-5.2		
23	AC rated control power inputs		IEEE 1613-5.3		
24	Dielectric Strength		IEEE 1613-6.1		
25	Impulse Voltage		IEEE 1613-6.2		

SECTION – E – TECHNICAL SPECIFICATION FOR EHV LINES

Contents

1.0 General

This Section details about the specifications for construction of EHV Transmission Lines.

2.0 Scope OF WORK FOR EHV LINES

The scope of work for the EHV Line will be as under:

a) Check survey of line.

b) Fabrication and supply of towers as per owner supplied tower designs with required extensions, design of special towers,(If required) modification/strengthening of tower extensions,(if required) supply of Bolts & Nuts, Conductors, Earth-wires, insulstors, Insulator hardwares, accessories for conductor, Optical Fibre Ground Wire, OPGW (for 220 kV & above lines) & ground wire and tower accessories including earthing sets, number plates, circuit plates, bird guards, anti climbing devices and all other material required for completion of the line.

c) Clearing of site, casting of tower foundations, with supply of required sand cement, steel, metal, water etc stub setting, erection of complete towers with extensions and providing all accessories, hoisting of insulators, stringing of conductor, 48F OPGW (for 220 kV & above lines) and earthwire, fitting of line hardwares, tower accessories etc. and all other material required for completion of line along with tree cutting as per requirement. The cost of cutting the trees, stacking of cut trees, clearing debris and transportation of cut trees (if required) shall be borne by the contractor.

d) Construction, Testing and commissioning of the line.

e) Design of Foundations for special towers (If required)and also for normal towers, if necessary.

3.0 Material to be supplied by the Contractor

All materials required to complete the line works in all respects shall be arranged by the contractor at his cost. The material to be supplied shall meet the following requirements:

3.1. Tower

Technical details for 220KV, 132KV and Special towers are given in Annexure - I.

3.2. Insulator hardware and conductor accessories

3.2.1. The insulator hardwares shall be suitable for 0.2 ACSR Panther/0.4 ACSR Zebra conductor and disc insulators of EMS ratings 70 KN for suspension location and 120 KN for tension location and shall be in line with the parameters listed in Annexure II and generally as per the drawings enclosed and relevant standards listed in this specification.

3.2.2. The conductor accessories shall be suitable for 0.2 ACSR Panther/0.4 ACSR zebra conductor, OPGW accessories suitable for 11.70 mm dia. size OPGW and earthwire accessories shall be suitable for 7/3.15 mm size G.S. earthwire and shall be in line with the parameters listed in Annexure-III as well as standards listed elsewhere in this specification.

3.3. Insulators

The insulators shall be supplied as per technical details given in ANNEXURE-VII. The insulators considered in the schedules are disc insulators. However rates for long rod insulators shall be quoted separately so that while placing LOA the disc insulators can be replace by long rod insulators if so desired by the owner.

3.4. Conductor, OPGW and Earth-wire

Size of conductor required for the line:

0.2 ACSR Panther(for 132 KV)/0.4 ACSR zebra conductor (for 220 kV) line.
Details of the OPGW for 220 kV line:
48 Fibre G.652D Dual-window Single Mode OPGW, 11.7 mm dia

Size of earthwire required for the line:

7/3.15 mm G.S. wire (For 132 kV lines only)

Aluminium strands of ACSR shall be manufactured from electrolytic grade aluminium rods suitably hard-drawn on wire drawing machines.

Re-inforcing steel wire (galvanized) of ACSR shall be drawn from high carbon steel rods produced by any of the following processes.

a) Acidic or open heat process.

b)Electric furnace process or basic oxygen process.

11.70 mm Dia. size 48F OPGW & OFAC alongwith accessories (For 220 kV lines only)

OPGW means an optical fibre unit embedded in the core or first layer of the ground wire consist of one or more layers of Aluminium clad steel/Aluminium alloy wire.

This section, as per details given in Annexure-X, defines the requirement of 48 Fibers G.652D Dual-window Single mode (DWSM) telecommunications grade fibre optic cable, OFAC and its accessories.

No joints shall be permitted in the Aluminium wires in the outermost layer of ACSR. Similarly, no joints shall be permitted in the galvanized steel wire except those in the base rod or wire before final drawings.

The ACSR Conductor, G/S earthwire and OPGW shall conform to technical specification contained in ANNEXURE-VIII,IX and X respectively.

3.4.1. All the material in the contractor's scope of supply shall be procured from reputed manufacturers having at least Five (5) years experience of supplying similar equipment for 220/132 KV lines. The list of approved vendors is given in Annexure-IV.

3.4.2. Detailed dimensioned drawings of all material to be supplied by contractor shall be got approved by the contractor from owner before type testing of the same.

3.4.3. All material covered under contractor's scope of supply shall be satisfactorily type tested as per relevant standards in presence of owner's representatives before commencement of mass manufacturing.

Conductor, Insulators, OPGW and Earthwire as per technical details given in AnnexureI, shall also be be procured by the contractor.

4.0 Quantity of Conductor, OPGW and Earth-Wire

4.1. The contractor shall intimate the Owner the requirement of line materials based on final tower quantities for approval.

4.2. The procedure to be used for calculation of length of conductor, OPGW and earthwire shall be as follows:

a) Quantity of Conductor = Route length x No. of Circuits x No. of phases (3)

b) Quantity of Earthwire = Route length.

c) Quantity of OPGW = Route length

d) One percent extra quantity on length as calculated above shall be allowed.

4.3. In case of conductor/OPGW/ Earth wire, the permitted extra quantity of one percent is inclusive of sag, jumpering, damage, losses and wastages etc.

5.0 Construction

5.1. The transmission lines shall be constructed with the best industry practice generally as per details given in Annexure-V and Annexure-VI keeping in view the various statutory clearances required en-route.

5.2. Statutory clearances and way leave

The statutory clearances/NOCs such as forest, aviation, PTCC, Railway, National highway/state highway, maritime board etc. which may be required for construction of the line shall be arranged by the contractor. The respective proposal shall be prepared and arranged by the contractor without any financial implication to the owner. The owner will provide all necessary co-operation required for obtaining the same and all statutory fees required for obtaining the clearances/NOC will be reimbursed to contractor by owner on submission of documentary evidence.

Any way leave problem; obstructions etc. shall be cleared by the contractor. The owner, if required shall extend necessary co-operation in resolving the issues. However, the entire responsibility of clearances including any payments such as expenditure required for collection of land documents from revenue department, charges for police protection (if required) etc. shall rest with the contractor. The contractor shall act proactively to achieve the goals.

5.3. Felling of trees, tree cutting, crop compensation would be organized and paid by the contractor. The owner shall render necessary help for fixing compensation through horticulture Dept. or any other appropriate authorities. The compensation so paid by the contractor shall be reimbursed by the owner. However expenses on account of stacking of cut trees, clearing debris and transportation of cut trees (if required) shall be borne by contractor.

6.0 Line profile

Data on the route alignment and ground profile will be supplied by the owner after issuance of letter of Award (LOA).

7.0 Completion period

7.1. All the EHV lines covered in this tender shall be completed within the period as mentioned in Book - I (including monsoon season)from the date of handing over of ground/route profile.

7.2. Time is essence

The time stipulated in the contract for the completion of works shall be deemed to be an essence of the contract. The contractor shall so organize his resources and perform his work so as to complete it not later than the date agreed to.

7.2.1. The contractor shall submit a detailed activity schedule/bar chart within the time frame agreed consisting of adequate number of activities covering various key phases of work, also clearly indicating the completion period for various groups of activities. This network/chart, activity schedule shall also indicate the infrastructure facilities to be provided by the owner and the dates by which such facilities activity schedule are needed. The contractor shall discuss the activity schedule and network/bar chart, activity schedule so submitted with the owner and the agreed network/bar chart which may be in the form as submitted or in revised form in line with the outcome of discussions, before signing of contract, shall form part of the contract. During the performance of the contract, if in the opinion of the engineer proper progress is not maintained, suitable changes shall be made in the contractor's operations to ensure proper progress as per scheduled date of completion.

7.2.2. The above activity schedule/bar chart shall be reviewed and periodic review reports shall be submitted by the contractor as directed by engineer.

7.3. Bar chart indicating detailed programmed of project implementation shall be furnished by the Concessioner in his offer. The bar chart shall include but not be limited to following items with dates of commencement and completion shown against each.

ANNEXURE-I

GENERAL TECHNICAL REQUIREMENTS

1.0 SYSTEM PARAMETERS

Following are the salient parameters of the electrical and environmental systems:

a. Nominal System Voltage : 220/132 KV

b. Frequency : 50 Hz

c. System highest voltage : 245/145 KV : 50 ^{o}C

d. Maximum ambient temperature : 0 ^{o}C

e. Minimum ambient temperature : 32 ^{o}C

f. Maximum daily average temperature : 90

g. Maximum relative humidity (in %) : 1500 to 3800

h. Maximum annual rain fall (in mm) : 90

i. Number of rainy days/year : 50

j. Average number of thunder storm : Moderately polluted as per IEC:71-2
(days per annum)

k. Pollution level category

2.0 LINE DATA

		132 KV line	220 kV line
a.	Conductor	: 0.2 inch^2	: 0.4 inch^2
	Code Name & type	: ACSR Panther	: ACSR Zebra
b.	Number of Conductors Per phase	: One	: One
c.	No. of Earth wires	: One	: One
	Type and size	: 7/3.15 mm	: OPGW E/W (11.70 mm Dia.)
		110 KGF Qlty.	110 KGF Qlty.
d.	Phase Configuration	: Vertical	: Vertical

e.	Max. Wind pressure	: 43 Kg/m^2 : 45 Kg/m^2	: 43 Kg/m^2 on wires : 45 Kg/m^2
f.	Ruling design span	: 320 meters	: 350 meters

The G.I earthwire of 7/3.15 mm shall be used for 132 kV lines and Optical Fibre Ground Wire, OPGW of 11.70 mm dia. shall be used for 220 kV lines.

3.0 Material to be supplied by the contractor

3.1. Insulator String Hardware inclusive of but not limited to

a) Anchor shackle

b) Ball eye

c) Line and tower side yoke plates

d) Ball clevis

e) Arcing horns

f) Socket clevis

g) Clevis tongue

h) External link

i) Y-clevis

j) Free centre type suspension clamp

k) Compression type dead end clamp

3.2. Accessories for Conductor, OPGW and Earthwire

a) Mid span compression joints.

b) Repair sleeves.

c) Copper Earth Bond.

d) Vibration Damper (For conductor & OPGW only).

e) Suspension Clamp for Earthwire

f) Tension Clamp for Earthwire

g) P. A. Rods

3.3. Towers

3.3.1. Standard 220/132 KV D/C, Horizontal and Special towers are to be fabricated as per the approved structural drawings provided by the owner, details of the same are given in Statement-III(Enclosure).

The structural drawings would be spared to the successful Concessioner only. The Concessioner shall fabricate proto type towers and offer them for inspection by the representative of MSETCL before taking up mass production of towers.

3.3.2. Erection Mark

These shall be marked with a 16 mm dia distinctly on each member of the tower. The notation shall be as follows:

A - BB - CC - DDD

Where A = Owner's code-Alphabet.(in this case 'M)'

BB = Contractor's Mark - Numerical.

CC = Tower Type - Alphabet.

DDD = Mark Number -Numerical.

The details in respect of 'CC' are given in Statements III and V. Other details are to be furnished by the Concessioner.

For tower members having length more than three (3) mtrs the markings shall be provided at both the ends.

a) The details of fabrication of towers shall be in conformity with IS:802 (Part-II):1978 except to the extent modified herein.
b) Butt splices shall be used and the inside angle and outside plate shall be so as to transmit the load and the inside cleat angle shall not be less than half the thickness of heavier member connected plus 2mm. Lap splice may be used for connecting members of unequal size. The inside angle of lap splice shall be rounded at the heel to fit the fillet of the outside angle. All splices shall develop full stress in the members connected through bolts. Butt as well as lap splice shall be made as close to the main panel point as possible.
c) Joints shall be so arranged as to avoid eccentricity as far as possible. The use of gusset plates for joining tower members shall be avoided as far as possible. However, where the connections are such that the elimination of the gusset plates would result in eccentric joints or where more than three members are joining at a particular point, gusset plates and spacer plates may be used in conformity with modern practices. The thickness of the gusset plates, required to transmit stress, shall not be less than that of members connected.
d) The use of filler in connection shall be avoided as far as possible. The diagonal web members in tension may be connected entirely to the gusset plate where necessary to avoid the use of filler and it shall be connected at the point of intersection by one or more bolts.
e) The tower structures shall be accurately fabricated to bolt together easily at site without any undue strain on the bolts.

f) No angle member shall have the two leg flanges brought together by closing the angle.

g) The structure shall be such that all parts shall be accessible for inspection and cleaning. Drain holes shall be provided at all points where pockets of depressions are likely to hold water.

h) All similar parts shall be made strictly interchangeable. All steel sections before any work is done on them, shall be carefully levelled, straightened and made true to detailed drawings, by methods which will not injure the materials so that when assembled the adjacent matching surfaces are in close contact throughout. No rough edges shall be permitted in the entire structure.

3.3.3. DRILLING AND PUNCHING

a) Before any cutting work is started, all steel sections shall be carefully straightened and trued by pressure and not by hammering. They shall again be trued after being punched and drilled.

b) Holes for bolts shall be drilled or punched with a jig but drilled holes shall be preferred.

The following maximum tolerance of accuracy of punched holes is permissible.

i) Holes must be perfectly circular and no tolerance in this respect is permissible.

ii) The maximum allowable difference in diameter of the holes on the two sides of plates or angle is 0.8mm i.e. the allowable taper in a punched holes should not exceed 0.8mm on diameter.

c) All burrs left by drills or punch shall be removed completely. When the tower members are in positions the holes shall be truly opposite to each other. Drilling or reaming to enlarge defective holes shall not be permitted.

d) The strain plate holes shall be chamfered properly and sharp edges removed.

3.3.4. GALVANISING

Fully galvanised towers and stubs shall be used for the lines. Galvanising of the member of the towers shall conform to IS:2629-1966 and IS:4759-1968. All galvanised members shall withstand tests as per IS:2633-1972. For fasteners, the galvanising shall be done after all fabrication work is completed, except that the nuts may be tapped or re-run after galvanising. Spring washers shall be electro- galvanised as per Grade 4 of IS:1573-1070.

3.3.5. FASTENERS : BOLTS, NUTS and WASHERS

a) All bolts and nuts shall confirm to IS:6639-1972 or IS.12427 - 1988 as applicable and shall be of approved makes only. All bolts and nuts shall be galvanised and shall have hexagonal heads and nuts. The heads shall be forged out of the solid, truly concentric, and square with the shank, which must be perfectly straight. The material shall be as per makes approved vendors by NMMC / M.S.E.T.C.L., list is available on the website. `However, if the Concessioners desires to procure bolts & nuts from any other vendor the same can be approved by the owner, if the credentials of such vendors are submitted for verification to the owner and the owner finds the same to be acceptable for use on transmission lines.

b) Fully threaded bolts shall not be used. The length of bolts shall be such that the threaded portion will not extend into the place of contact of the members. All bolts shall be threaded to take the full depth of the nut and threaded enough to permit firm gripping of the members, but not further. It shall be ensured that the threaded portion of each bolt protrudes not less than 3mm and not more than 8mm when fully tightened. All nuts shall fit hand tight to the bolt. Threads of bolts and nuts shall have a neat fit and shall be such that they can be turned with finger throughout the length of the threads of bolts and they shall be capable of developing full strength of the bolts.

c) Flat and tapered washers shall be provided where necessary. Spring washers shall be provided for insertion under all nuts. These washers shall be of steel electro-galvanised, positive lock type and 3.5mm thick for 16mm dia. bolt and 4.5mm thick for 24mm dia. bolt.

d) The contractor shall furnish bolt schedules giving thickness of members connected, the nut and the washer, the length of shank, the threaded portion of bolts and sizes of holes and any other detail of this nature.

e) The bolts shall be of class 5.6 and nuts shall be of property class 5. For normal towers 16mm dia. bolts of required length shall be used. For special towers 24 mm dia. bolts may also be used. The ultimate shear stress on bolts shall be 3160 Kg/cm^2 and ultimate bearing stress shall be 5500 Kg/cm^2 In case of connection with MS angles and plate the ultimate bearing stress shall be 4440 Kg/cm^2.

f) To obviate bending stress in bolts or to reduce it to minimum, no bolt shall connect aggregate thickness of more than three (3) times its diameter.

g) Bolts at the joints shall be so staggered that nuts may be tightened with spanners without fouling.

h) The minimum bolt spacing and rolled edge distance and sheared edge distances of sections from the centers of bolt holes to be maintained are given in following Table:

Diameter of bolts (mm)	Hole diameter (mm)	Bolt spacing (mm)	Min. rolled distance (mm)	Min. edge distance (mm)	Min.sheared
16	17.5	40	20	23	

3.3.6. STEP BOLTS/LADDER AND TOWER ACCESSORIES

a) <u>Step Bolts & Ladders</u>

Each tower shall be provided with step bolts of not less than 16mm diameter and 175mm long, spaced not more than 450mm apart and extending from about 3.5 metres above the ground level to the top of the tower. The step bolts shall be provided with two nuts on one end to fasten the bolt securely to the tower and button head at the other end to prevent the foot from slipping away. The step bolts shall be capable of withstanding a vertical load not less than 1.5 KN. For towers, where the height of the super structure exceeds 50 metres, ladders alongwith protection rings as per the Owner approved design shall be provided in continuation of the step bolts on the longitudinal face of the tower from 30 metres above ground level to the top of the super structure. From 3.5m to 30m height of superstructure step bolts shall be provided. Suitable platform using 6mm thick checkered plates alongwith suitable railing for access from step bolts to the ladder and from the ladder to each cross-arm and the groundwire support shall also be provided on tower above 50 mtrs.

b) Anticlimbing Device

Provision for inserting fully galvanised barbed wire type anticlimbing device as per drawing enclosed shall be made for all towers. This shall be provided at 3.5m above ground level on the tower. The galvanised barbed wire and accessories shall be supplied by the Contractor.

c) Danger, Number & Phase Plates

i) The provision for fixing Danger, Number and Phase Plates shall be made on transverse face of the tower during development of the structural drawing. The arrangement for fixing these accessories shall not be more than 4.5m above the ground level and shall be provided above anti-climbing device.

ii) The letters, figures and the conventional skull and bones mark of danger plate shall conform to IS : 2551-1963 and shall be in a signal red colour on the front of the plate.

iii) Typical drawings of Number plate, phase plate, danger board are enclosed.

3.4. Conductor Earthwire OPGW and insulators

ACSR conductor, G.S earthwire, Optical Fibre Ground Wire, OPGW and Insulators are also to be supplied by the contractor as per relevant Specifications.

4.0 Stub Setting Templates

Stub templates shall be arranged by the Contractor at his own cost for all types of towers with or without extensions for the line in the scope. Stub templates for standard towers and tower with extensions shall be of adjustable type. The stub templates shall be galvanized or painted. One set of each type of stub setting template will be retained by the owner on completion of the project, supply of which shall be included in the scope of the Contractor at no extra cost to the owner.

5.0 Aviation Requirements

The river crossing towers and the crossing span shall be painted and provided with markers respectively to caution the low flying air-craft as given below:

5.1. Span marker of size 600mm x 600mm shall be provided on the earthwire. Each face of the marker shall be divided into two triangles by drawing a line along one of the diagonals of the markers, one of the triangles thus formed shall be painted in orange or red and other in white. These markers shall be suspended from earthwire at intervals of 36m. The design of the markers and their fixing arrangement should be such that they can withstand the wind pressure.

5.2. The full length of the towers shall be painted over the galvanized surface in contrasting bands of orange or red and white. The bands should be horizontal and not less than 1.5m and not more than 3m in height. The bands on the extremities should be orange or red in color.

a) Surface Preparation

The etching of galvanized surface of erected tower members with suitable etching or wash primer is to be done as per IS:1477-1971 to enhance the adhesion of subsequently applied paint coating. After etching of galvanized surface of tower one coat of zinc primer is to be applied.

b) Painting of Towers

Two coats of international orange or red and white paint at alternate interval (bands) as explained above are to be applied. The painting of towers shall generally conform to relevant provisions in IS: 1477-1977 parts II & I. The paints to be used for painting shall be in accordance with IS: 2074-1962.

5.3. Obstruction lights

Fixed lights, red in color, having intensity sufficient to ensure conspicu ity considering the intensity of the adjacent lights and the general level of illumination against which they would normally be viewed shall be provided on the river crossing towers. In no case the intensity of the light shall be less than 107.6 Lox of red lights. If the height of the towers are more than 45m above the level of surrounding ground, additional lights shall be provided at intermediate levels. The numbers and arrangement of lig hts at each level to be marked shall be such that the towers are visible from all sides.

5.4. The lighting fixture, paint and L.T. power supply for the aviation light requirements shall be arranged by the owner.

6.0 SPECIAL TOWERS

a) Special towers shall be used for major river crossing, for very long spans and railway track or line crossings. The special towers shall be offered in such a way that after suitable truncation the same tower can be used for crossing the spans of 700 M, 800 M, 900 M or 1000M. These towers including their foundations, soil testing, tower erections and stringing shall form part of the scope. The Contractor shall submit the most economical design for the towers and foundations.

b) All the requirements for standard towers shall be applicable for special towers. Wind pressure on towers for height beyond 45 metres shall be as per following Table.

Height of support Unit	45m	50m	60m	70m	80m	100m	120m
Kgf/m^2							
Light	140	145	150	154	159	165	172
Medium	210	217	224	230	238	249	258

6.1. Angle of Deviation for special tower

The angle of deviation to be considered for special tower is minimum 2^0 and all the live material clearance to be computed considering double 'X' suspension string.

6.2. Factor of safety for special tower

The minimum factor of safety for special tower shall be as follows:

a) 2.5 under normal conditions
b) 2.0 under broken wire conditions

6.3. Maximum tension for conductor and earth wire

The minimum factor of safety for conductor and earthwire shall be 2.5 for the maximum tension corresponding to 2/3 full wind pressure at 0 ^{0}C or full wind pressure at 32 ^{0}C such that the initial unloaded tensions at 32 ^{0}C do not exceed 30 % of their ultimate strength and the final unloaded tension at 32 0C do not exceed 20 % of the ultimate strength of conductor, OPGW and Earthwire.

6.4. Wind Loads

a) The procedure for wind load calculation on tower, conductor, OPGW and earthwire shall be the same as adopted for normal structure.

b) The wind pressure acting at an angle of 450 to the tower body and 900 to the conductor acting simultaneously shall also be considered for designing the structure.

6.5. Under normal condition, unbalanced longitudinal pull due to difference in tension in ruling span for river crossing towers on one side and span of the line on the other side shall also be considered for the design of anchor towers on case to case basis.

6.6. During designing and detailing for the river crossing tower, provision for ladders, platform etc. shall be made.

6.7. The rates for special towers shall be quoted on the basis of per ton. However the payment shall be released as per the approved BOM weight.

7.0 STANDARDS

The manufacturing, fabrication, galvanizing, and materials used for manufacture of towers shall conform to the following Indian Standards (IS) Codes and Rules which shall mean latest revisions, with amendments/changes adopted and published, unless specifically stated otherwise in the specification. In the event of supply of equipment conforming to standards other than IS, the features of comparison of the relevant standard and IS shall be brought out and furnished.

Sr. No.	Indian Standards IS	Title
1.	IS:209-1966	Specification for zinc
2.	IS:2062-1992	Structural steel(Standard quality)
3.	IS:8500	High Tensile Steel

4. IS:800-1962 Code of practice for use of structural steel in general Building construction.

5. IS:802 Part I 1978 Code of practice for use of structural steel in overhead transmission line.

Part I: Load and permissible stresses.

IS:802 (Part-II)1978 Code of practice for use of structural steel in overhead transmission line.

Part II : Fabrication, Galvanising, inspection and Packing.

IS:802 (Part-III) 1978 Code of practice for use of structural steel in overhead transmission line towers.

Part III : Testing

6. IS:1367-1992 Technical supply conditions for threaded fasteners (First Revision).

Sr. No.	Indian Standards IS	Title
7.	IS:2016-1992	Plain Washers
8.	IS:2551-1992	Danger Notice Plates.
9.	IS:2629-1992	Recommended practice for hot dip galvanising of iron and steel.
10.	IS:2633-1994	Method of testing uniformity of coating of zinc coated articles.
11.	IS:3063-1994	Single Coil Rectangular Section spring washers for bolts, nuts, screws.
12.	IS:5358-1969	Hot dip galvanised coatings on fasteners.
13.	IS:6610-1991	Specification for heavy washers for steel structures.
14.	IS:6639-1990	Hexagonal bolts for ISO/R 272-1968 steel Structures.
15.	IS:6745-1972	Methods for determination of weight of zinc coating for zinc coated iron and steel articles.
16.	IS:5613-1993	Code of practice for design, installation and maintenance of overhead power lines Section-1 Designs Section-2 Installation Maintenance

17. Indian Electricity Rules - 1956 and revisions thereof
18. Publication No. 87/Elect/112/1 Regulation for Electrical Crossing of Railway Tracks amended update
19. IS-961 H.T.Steel
20. IS-12427-1988 Specification for Transmission Tower Bolts.
21. Indian Electricity Act – 2003

ANNEXURE-II

TECHNICAL PARTICULARS FOR INSULATOR HARDWARES

1.0 TECHNICAL DESCRIPTION

1.1. GENERAL

This section details the technical particulars of the Hardware fittings for 132/220 KV Line. The insulator hardwares shall be suitable for 0.2 ACSR Panther conductor (for 132 KV line) and 0.4 ACSR Zebra conductor (for 220 KV line).

1.1.1. DETAILS OF HARDWARE FITTINGS

The hardware fittings shall generally be as per drawings enclosed with this specification & suitable for hot line maintenance.

1.2. DIMENSIONS OF INSULATORS STRING ALONGWITH HARDWARE FITTING

The various limiting dimensions of the various suspension and tension strings along with hardware fittings shall be as per the drawings attached with this specification. The hardwares shall be suitable for use with 'Normal' and 'Antifog' type insulators.

1.3. INTERCHANGEABILITY

The hardware together with ball and socket fittings shall be of standard design so that these hardware are interchangeable with each other.

1.4. BALL AND SOCKET DESIGNATION

The dimensions of the ball and socket shall be of 16 mm for 70 KN and 20 mm for 120 KN disc insulators in accordance with the standard dimensions stated in IS:2486 (Part-II) - 1974.

1.5. SECURITY CLIPS AND SPLIT PINS

Security clips for use with ball and socket coupling shall be R-shaped, hump type which provides positive locking of the coupling as per IS:2486 (Part-III) 1974. There shall be no risk of the locking device being displaced accidentally or being rotated when in position. Under no circumstances shall the locking device allow separation of fittings.

1.6. ARCING HORN

The arcing horn shall be provided on line side of the hardware fittings. The same shall be either ball ended rod type for 132 KV and tubular type for 220 KV.

1.7. FREE CENTRE TYPE SUSPENSION CLAMP

a. The suspension clamp shall have a slip strength between 12.5% to 20% of breaking load of conductor.
b. The suspension assembly shall be designed, manufactured and finished so as to avoid any possibility of hammering between suspension assembly and conductor due to vibration. The suspension assembly shall be smooth so that it shall not damage the conductor.

1.8. DEAD END ASSEMBLY

a. The dead end assembly shall be of compression type with provision for compressing jumper terminal at one end. The angle of jumper terminal to be mounted, should be 30^0 with respect to the vertical line.
b. The assembly shall not permit slipping off, damage to or failure of the complete conductor or any part thereof at a load less than 95% of the ultimate tensile strength of the conductor.
c. The steel sleeve of dead end assembly shall be made by drop forging method and shall not involve any welded joints.

1.9. FASTENERS

All fasteners shall conform to IS: 6639-1972. All fasteners shall be hot dip galvanised.

1.10. WORKMANSHIP

a) All the equipment shall be of the latest design and conform to the best modern practices adopted in the Extra High Voltage field.
b) The design, manufacturing process and quality control of all the materials shall be such as to give maximum possible working load, highest mobility, elimination of sharp edges and corners to limit corona and radio interference, best resistance to corrosion and a good finish.
c) After award of contract, the contractor shall submit to the Owner, within one month, 2 copies of Quality assurance plan for approval.
d) Minimum weight of zinc coating shall be 300 gm/m^2 for fasteners and 610 gm/m^2 for all other hot dip galvanised articles.

1.11. BID DRAWINGS

The proposal shall include fully dimensioned assembly and component drawings for all items quoted. All drawings shall be neatly arranged, and all drafting and lettering shall be standard and legible. The minimum size of lettering shall be one eighth of an inch. Dimensions shall be in the customary units. The drawings shall give following information:

a) The bill of material indicating quantity, nature, grade and reference standard of the material used for various parts. The thickness of plain/spring washers, size and length of bolts shall also be indicated.
b) Technical details like ball and socket designation, method of manufacture,

Hardness, Proof Load, slip strength, UTS, installation torque, make of Nuts, bolts, plain/spring washers, security clip and identification mark of the manufacturer.

c) After award of contract the contractor shall submit to the Owner, within one month, 2 copies of drawings for approval. The Owner shall accord approval for the drawings in reasonable period provided the same are as per specification. The Contractor shall endeavor to furnish all the clarification required by the Owner for approving the drawings promptly.

d) Once the drawings have been approved, no alteration or modification should be carried out without prior approval of the Owner.

1.12. TESTS

A) TYPE TESTS

The contractor shall offer the hardwares and accessories which are already type tested within the last five years and manufactured by the reputed manufactures approved by MSETCL

In case the items are not type tested within 5 years as on the date of LOA, fresh type tests as per relevant IS standards and MSETCL specification shall be carried out, in presence of purchasers representative, before supply of material.

The list of type tests to be conducted is as follows:

Sr. No.	Particulars of test		Reference standard
I)	Suspension hardwares:		
1)	Visual examination	}	
2)	Verification of Dimensions	}	
3)	Mechanical strength test on clamp and components	}	
4)	Slip strength test on clamp	}	IS:2486(I)/ MSETCL specification
5)	Magnetic power loss test on suspension clamp assembly	}	
6)	Galvanising/Electroplating test	}	
II)	Tension hardwares:		
1)	Visual examination	}	
2)	Verification of Dimensions	}	
3)	Mechanical strength test on components	}	
4)	Mechanical/slip strength test on dead end assembly	}	

5) Heating cycle test }
6) Electrical resistance test }
(Before and after heat }
cycle test) }
7) Galvanising/Electroplating }
test }

III) Tests on locking devices(Security clip):
1) Verification of resistance }
to bending }
2) Hardness test }
3) Operation test }

B) <u>ACCEPTANCE TESTS</u>:

This shall mean those tests which are to be carried out on samples taken at random from a lot for acceptance of the lot.
The item wise list of acceptance tests to be conducted is as follows:

Sr. Particulars of test Reference
standard
No.

I)	Suspension hardwares:	
1)	Visual examination	}
2)	Verification of Dimensions	}
3)	Mechanical strength test	}
	on clamp and components	} IS:2486(I)
4)	Galvanising/Electroplating	}
	test	}
II)	Tension hardwares:	
1)	Visual examination	}
2)	Verification of Dimensions	}
3)	Mechanical strength test	}
	on components	} IS:2486(I)
4)	Mechanical/slip strength	}
	test on dead end assembly	}
5)	Galvanising/Electroplating	}
	test	
III)	Tests on locking devices(Security clip):	
1)	Verification of resistance	}
	to bending	} IS:2486(IV)
2)	Hardness test	}
3)	Operation test	}

C) <u>ROUTINE TESTS</u>:

This shall mean those tests, which are to be carried out on each item to check the requirements which are likely to vary during production.

The list of routine tests to be conducted is as follows:

Sr. No.	Particulars of test	Reference standard
I)	Insulator String fittings:	
1)	Visual Inspection	} IS:2486(I)
2)	Mechanical routine test	}
II)	Tension Clamp:	
1)	Visual Inspection	} IS:2486(I)

D) <u>TESTS DURING MANUFACTURING</u>:

Stage tests during manufacture shall mean those tests which are to be carried out during the process of manufacturing to ensure quality control such that the end product is of the designed quality conforming to the intent of this specification.
The list of tests to be conducted during manufacturing is as follows:

Sr. No.	Particulars of test	Reference standard
1)	Visual inspection, Chemical analysis, tensile strength, Hardness, inclusion rating, Grain size, Forgeability, proof load and magnetic particle examination tests for ferrous forgings.	As per relevant IS Standards
2)	Visual inspection, Dimensional check, Chemical analysis, tensile strength and hardness test for steel fabricated components.	- do -
3)	Chemical analysis test for aluminum alloy ingots.	- do -
4)	Visual inspection, Dimensional check and chemical analysis test for aluminum, aluminum alloy tubes and flats.	- do -
5)	Chemical analysis of zinc for galvanising.	- do -

Sr. No.	Particulars of test	Reference standard
6)	Visual inspection, Dimensional check, chemical analysis and	}

	hardness test for Stainless steel bolts, U-bolts, Nuts and washers. }	- do -
7)	Visual inspection, Dimensional check, Resistance to bending, Operation, Hardness and Resistance to internal corrosion tests on security clip. }	- do -
8)	Visual inspection, Dimensional check and mechanical strength tests on M.S bolts, nuts and plain washers. }	- do -
9)	Visual inspection, Dimensional check, Twist, Permanent load and hardness tests on spring washers. }	- do -

E) <u>ADDITIONAL TESTS</u>

The Owner reserves the right of having at his own expenses any other test(s) of reasonable nature carried out at Contractor's premises, at site, or in any other laboratory in addition to the aforesaid type, acceptance and routine tests to satisfy himself that the material complies with the specification. The owner also reserves the right to repeat the full series or a particular type test at any time during the pendency of contract.

1.13. GUARANTEED TECHNICAL PARTICULARS

The Guaranteed Technical Particulars for insulator hardwares enclosed with this Annexure shall be duly filled in and submitted along with the offer.

1.14. IDENTIFICATION MARK

All components of hardwares made by forging/casting shall invariably be marked by embossing with identification mark of the manufacturer. The identifying letters and numbers shall be raised 1 mm and shall be at least 5 mm high. They shall be die stamped or cast on one or both sides of the assembly. The characters shall be distinct, durable, and conspicuous after galvanising.

1.15. STANDARDS APPLICABLE

Except as modified in this specification, the materials to be supplied shall conform to the latest version, with amendments thereof, of the following Bureau of Indian Standards and other International Standards.

Sr. Bureau of Indian
Titl
e No. Standard No.

1)	IS 2486-1993 Part-I	Metal fittings of insulators for overhead power lines with a nominal voltage greater than 1000 V - General requirements and tests
2)	IS 2486-1989 Part-II	Insulator fittings for overhead power lines with a nominal voltage greater than 1000 V - Dimensional requirements
3)	IS 2486-1974 Part-III	Insulator fittings for overhead power lines with a nominal voltage greater than 1000 V - Locking devices
4)	IS 2486-1981	Insulator fittings for overhead Part-IV power lines with a nominal voltage greater than 1000 V - Tests for Locking devices
5)	IS:2121-1981	Conductor and Earthwire accessories Part I for overhead power Lines - P.A.Rod
6)	IS:2121-1981	Conductor and Earthwire accessories Part II for overhead power Lines - MSCJ & Repair Sleeves
7)	IS 9708-1993	Stockbridge vibration dampers for Overhead power lines
8)	IS 2004-1991	Carbon steel forgings for general Engineering Purposes
9)	IS 2062-1992	Steel for general structural purposes.
10)	IS 5082-1981	Wrought aluminum and aluminum alloy bars, rods, tubes and sections for electrical purposes
11)	ASTM A 276-96	Standard specification for stainless steel Bars and Shapes
12)	IS 6603-1972	Stainless steel bars and flats
13)	IS 4759-1984	Hot dip zinc coatings on structural steel and other allied products
14)	IS 2633-1986	Method of testing uniformity of coatings on zinc coated articles
15)	IS 3063-1994	Single coil rectangular section spring washers for bolts, nuts & screws
16)	IS 6639-1972	Hexagonal bolts for steel structures
17)	IS 2016-1967	Specification for plain washers
18)	IS 5358	Specification for hot dip galvanize coatings on fasteners.

19)	IS 1573-1986	Electroplated coatings of zinc on iron and steel
20)	IS 1363-1984	Black hexagonal bolts, nuts and lock nuts and hexagonal screws.
21)	IS l367-1991 Part-I	Technical supply conditions for threaded steel fasteners - Introduction and general information
22)	IS l367-1979 Part-III	Technical supply conditions for threaded steel fasteners - Mechanical properties and test methods for Bolts, screws & studs with full loadibility
23)	IS l367-1980 Part-VI	Technical supply conditions for threaded steel fasteners - Mechanical properties and test Methods for nuts with specified proof loads
24)	IS l367-1979 Part-IX	Technical supply conditions for threaded steel fasteners - Surface discontinuities on Bolts, screws & studs
25)	IS l367-1979 Part-X	Technical supply conditions for threaded steel fasteners - Surface discontinuities on nuts
26)	IS l367-1979 Part-XIII	Technical supply conditions for threaded steel fasteners - Hot dip Galvanized coatings on threaded fasteners
27)	IS 9997-1991	Aluminum alloy redrawn rods for Electrical purposes
28)	IS 3703	Code of practice for Magnetic Power flaw detection

2.0 GUARANTEED TECHNICAL PARTICULARS FOR INSULATOR HARDWARE SUITABLE FOR ACSR Panther/Zebra

Manufacturer's name and address •

Identification mark on
forged & cast components •

Sr. No.	Item	Material	Grade
A)	Single Suspension hardware		
1)	Horn holder ball hook	•	
2)	Tower side arcing horn	•	
3)	Horn holder Socket eye	•	
4)	Line side arcing horn	•	
5)	Anchor/Twisted Shackle	•	
B)	Double Suspension hardware		
1)	Tower side Twisted Shackle	•	
2)	Tower side yoke plate	•	
3)	Tower side arcing horn	•	
4)	Ball clevis	•	
5)	Socket clevis	•	
6)	Line side yoke plate	•	
7)	Line side arcing horn	•	
8)	Clevis eye	•	
9)	Line side Twisted/ Anchor Shackle		•
C)	FCT Clamp assembly (Common for suspension hardwares)		
1)	Saddle and link strap	•	
2)	Keeper piece	•	
3)	Suspension clamp	•	
D)	Single tension hardware		

1) Anchor Shackle •

2) Horn holder ball link •

3) Tower side arcing horn •
4) Horn holder Socket eye •

5) Line side arcing horn •

E) Double tension hardware

1) Anchor Shackle •

2) Chain link •

3) Tower side yoke plate •

4) Tower side arcing horn •

5) Ball clevis •

6) Socket clevis •

7) Line side yoke plate •

8) Line side arcing horn •

9) Clevis eye •

Sr. No.	Item	Material	Grade
F)	Clamp assembly (Common for tension hardwares)		
1)	Steel sleeve •		
2)	Compression tube and jumper •		

Sr.No. Particulars	Guaranteed value
1) Minimum failing load of	
a) Single suspension hardware	•
b) Double suspension hardware	•
c) Single tension hardware	•
d) Double tension hardware	•
2) Length of suspension clamp	•

3) Slip strength of suspension clamp	•
4) Magnetic power loss in watts for suspension clamp at 800 Amps.	•
5) Slip strength of tension clamp	•
6) Electrical resistance of tension joint after compression	•
7) Standard specification to which galvanising confirm	•

ANNEXURE-III

TECHNICAL PARTICULARS OF CONDUCTOR & EARTHWIRE ACCESSORIES

1.0 Accessories suitable for 0.2 ACSR Panther conductor(for 132 kV line), 0.4 ACSR Zerbra Conductor (for 220 kV line) and 7/3.15 mm earth wire shall be offered.

2.0 MID SPAN COMPRESSION JOINT (CONDUCTOR)

Mid Span Compression Joint shall be used for joining two lengths of conductor. The electrical resistance of joint shall be less than 75% of measured resistance of equivalent length of conductor. The joint shall not permit slipping off, damage to, or failure of the complete conductor or any part thereof at a load less than 90% of the ultimate tensile strength of the conductor. The joint shall be made of aluminium alloy.

3.0 REPAIR SLEEVE (CONDUCTOR)

Repair Sleeve of compression type shall be used to repair conductor with not more than two strands broken in the outer layer. The sleeve shall be manufactured from aluminium alloy. The repair sleeve shall comprise of two pieces with a provision of seat for sliding of the keeper piece. The edges of the seat as well as the keeper piece shall be so rounded that the conductor strands are not damaged during installation.

4.0 PRE-FORMED ARMOUR RODS

P. A. Rods shall be used for wrapping on the conductor before installation of suspension clamp on line. The rods shall be made of aluminum alloy grade 6201 having tensile strength not less than 35 Kg/mm^2. The electrical conductivity of each rod shall not be less than 40% of IACS(International Annealed Copper Specification). The shape of ends of each rod shall be Parrot bill. The center point of each rod shall be marked with indelible black paint.

5.0 VIBRATION DAMPER

Vibration damper of 4R-stock bridge type with four different resonant frequencies spread within the specified aeolian frequency band-width shall be used for suspension and tension points on each conductor in each span to damp out aeolian vibrations. Two dampers on each side shall be used at tension points and one damper on each side at suspension points, for normal spans. The Concessioner shall furnish damper placement charts along with the bid for spans ranging from 100 m to 600 m.

The clamp of the vibration damper shall be made of aluminium alloy. The clamp shall be capable of supporting the damper during installation and prevent damage or chafing of the conductor during erection or continued operation.

The messenger cable shall be made of high tensile strength steel wire with a minimum strength of 135 kg/mm^2. The damper mass shall be made of cast iron, hot dip galvanized or a permanent mould cast zinc alloy.

The vibration analysis of the system, with and without damper, dynamic characteristic of the damper shall be submitted by the Concessioner along with his bid.

6.0 SUSPENSION CLAMP (EARTH WIRE)

At all suspension towers suitable envelop type suspension clamp shall be used to hold earthwire. The suspension clamp shall be provided with an eye hook suitable for M16 size bolt, for attaching it to the hanger plate. The design of the assembly shall be such that the direction of run of the earthwire through the clamp shall be same as that of the earthwire.

The suspension clamp shall be provided with M12 size U&J bolts, nuts and plain washers of Mild steel and spring washers of spring steel for connecting earth bond to the tower body.

The suspension clamp shall have a slip strength between 12.5% to 20% of ultimate tensile strength of the earthwire. The breaking load of suspension clamp shall not be less than 50 KN.

7.0 TENSION CLAMP (EARTH WIRE)

At all tension towers suitable compression type tension clamps shall be used to hold earthwire. 16 mm diameter anchor shackle shall be supplied which shall be suitable for attaching the tension clamp to strain plate.

The tension clamp shall be provided with jumper plate, for attaching jumper terminal to it. The same shall be attached with 2xM12 size bolts, nuts and plain washers of mild steel and spring washer of spring steel. The length of one of the bolts shall be more than the other for connecting earth bond to the tower body.

The electrical resistance of the clamp when compressed on the earthwire shall be less than 75% of measured resistance of equivalent length of earthwire. The slip strength of the assembly shall not be less than 90% of the ultimate tensile strength of the earthwire. The angle of jumper terminal shall be 30o with respect to the vertical line.

The clamp shall be complete with all the components including anchor shackle, bolt, nuts, washers, split pin, jumper arrangement etc.

8.0 MID SPAN COMPRESSION JOINT (EARTHWIRE)

Mid Span Compression Joint shall be used for joining two lengths of earthwire. The joint shall be made of Mild Steel. The joint shall not permit slipping off, at a load less than 90% of the ultimate tensile strength of the earthwire. The electrical resistance of joint shall be less than 75% of measured resistance of equivalent length of earthwire.

9.0 EARTH BOND

The earth bond shall be made of E.C. grade (% of Copper > 99.5%) tinned flexible copper cable of size 37/7/0.417 mm and copper area equivalent of 35 mm^2. The length of earth bond shall not be less than 750 mm. Two tinned copper lugs having suitable holes for 12 mm & 16 mm diameter bolts shall be press jointed at either ends of the copper cable. One 45 mm long galvanised Mild Steel bolt with nut and plain, spring washer shall also be provided. This shall be suitable for providing proper bondage between earthwire hardware and tower body. The pull off load shall not be less than 300 kg.

10.0 WORKMANSHIP

a) All the equipment shall be of the latest design and conform to the best modern practices adopted in the Extra High Voltage field.

b) The design, manufacturing process and quality control of all the materials shall be such as to give maximum possible working load, highest mobility, elimination of sharp edges and corners to limit corona and radio interference, best resistance to corrosion and a good finish.

c) Minimum weight of zinc coating shall be 300 gm/m^2 for fasteners and 610 gm/m^2 for all other hot dip galvanised articles.

11.0 BID DRAWINGS

The proposal shall include fully dimensioned assembly and component drawings for all items quoted. All drawings shall be neatly arranged, and all drafting and lettering shall be standard and legible. The minimum size of lettering shall be one eighth of an inch. Dimensions shall be in the customary units. The drawings shall give following information:

a) The bill of material indicating quantity, nature, grade and reference standard of the material used for various parts. The thickness of plain/spring washers, size and length of bolts shall also be indicated.

b) After award of contract the contractor shall submit to the Owner, 2 copies of drawings for approval within one month. The Owner shall accord approval for the drawings in reasonable period provided the same are as per specification. The Contractor shall endeavor to furnish all the clarification required by the Owner for approving the drawings promptly.

c) Once the drawings have been approved, no alteration or modification should be carried out without prior approval of the Owner.

12.0 TESTS

A) <u>TYPE TESTS</u>

The contractor shall offer the accessories which are already type tested within the last five years and manufactured by the reputed manufactures approved by the Board.

In case the items are not type tested within 5 years as on the date of LOA, fresh type tests as per relevant IS standards shall be carried out, in presence of purchasers representative, before supply of material.

The list of type tests to be conducted is as follows:

Sr. Particulars of test Reference standard
No.

Sr. No.	Particulars of test		Reference standard
I)	Conductor accessories:		
A)	MSCJ		
1)	Visual examination	}	
2)	Verification of Dimensions	}	IS:2121
3)	Mechanical/slip strength test	}	
4)	Heat cycle test	}	IS:2121
5)	Electrical resistance test (Before and after heat cycle test)	}	
B)	Repair Sleeves		
1)	Visual examination	}	
2)	Verification of Dimensions	}	
3)	Mechanical/slip strength test	}	IS:2121
4)	Electrical resistance test	}	
C)	P.A.Rod		
1)	Visual examination	}	
2)	Verification of Dimensions	}	
3)	Slip strength test	}	
4)	Tensile Strength test	}	IS:2121
5)	Bend test	}	
6)	Resilience test	}	
7)	Electrical resistance test	}	
D)	Vibration Damper		
1)	Visual examination	}	
2)	Verification of Dimensions	}	
3)	Mass pull off test	}	
4)	Magnetic power loss test	}	
5)	Clamp slip test (Before & after fatigue test)	}	IS:9708
6)	Clamp bolt torque test	}	
7)	Resonance frequency test	}	
8)	Fatigue test	}	
9)	Galvanising/Electroplating test	}	
10)	Dynamic characteristics test (Before & after fatigue test)	}	
11)	Vibration analysis/ Damper Efficiency test	}	

Sr. No.	Particulars of test	Reference standard
II)	Earthwire accessories:	
A)	Suspension clamp	
1)	Visual examination	
2)	Verification of Dimensions	IS:2486
3)	Mechanical strength test	
4)	Clamp slip test	
5)	Galvanising/Electroplating test	
B)	Tension clamp	
1)	Visual examination	
2)	Verification of Dimensions	IS:2486
3)	Mechanical/Slip strength test	
4)	Electricalresistancetes	
5)	Galvanising/Electroplating test	
C)	MSCJ	
1)	Visual examination }	
2)	Verification of Dimensions }	
3)	Mechanical/slip strength test }	IS:2121
4)	Electrical resistance test }	
5)	Galvanising test }	
D)	Earth Bond	
1)	Visual examination }	
2)	Verification of Dimensions }	IS:2121
3)	Slip strength test }	

B) <u>ACCEPTANCE TESTS</u>:

This shall mean those tests which are to be carried out on samples taken at random from a lot for acceptance of the lot.

The item wise list of acceptance tests to be conducted is as follows:

Sr. No.	Particulars of test	Reference standard
I)	Conductor accessories:	
A)	MSCJ	
1)	Visual examination }	
2)	Verification of Dimensions }	IS:2121
3)	Mechanical/slip strength test }	

B) Repair Sleeves
1) Visual examination }
2) Verification of Dimensions } IS:2121
3) Mechanical/slip strength }
test }

C) P.A. Rod
1) Visual examination }
2) Verification of Dimensions }
3) Tensile Strength test } IS:2121
4) Resilience test }
5) Electrical resistance test }

D) Vibration Damper
1) Visual examination }
2) Verification of Dimensions }
3) Mass pulloff test }
4) Fatigue test } IS:9708
5) Clamp slip test after }
fatigue test }
6) Resonance frequency test }
7) Galvanising/Electroplating }
test }

II) Earthwire accessories:
A) Suspension clamp
1) Visual examination }
2) Verification of Dimensions }
3) Mechanical strength test } IS:2486
4) Galvanising/Electroplating }
test }

B) Tension clamp
1) Visual examination }
2) Verification of Dimensions }
3) Mechanical strength test } IS:2486
on clamp & components }
4) Galvanising/Electroplating }
test }

C) MSCJ
1) Visual examination }
2) Verification of Dimensions }

Sr. Particulars of test Reference
standard
No.

3) Mechanical/slip strength } IS:2121
test }
4) Galvanising test }

D)	Earth Bond		
1)	Visual examination	}	
2)	Verification of Dimensions	}	IS:2121
3)	Slip strength test	}	

C) ROUTINE TESTS:

This shall mean those tests, which are to be carried out on each item to check the requirements which are likely to vary during production.

The list of routine tests to be conducted is as follows:

Sr. No.	Particulars of test		Reference standard
I)	Conductor accessories:		
A)	P.A. Rod		
1)	Visual Inspection	}	
2)	Verification of Dimensions	}	IS:2121
B)	MSCJ & Repair Sleeves		
1)	Visual Inspection	}	
2)	Verification of Dimensions	}	IS:2121
C)	Vibration Damper		
1)	Visual Inspection	}	IS:9708
II)	Earthwire fittings:		
A)	Suspension clamp		
1)	Visual Inspection	}	IS:2486
2)	Mechanical routine test	}	
B)	Tension Clamp		
1)	Visual Inspection	}	IS:2486
C)	MSCJ		
1)	Visual Inspection	}	
2)	Verification of Dimensions	}	IS:2121
D)	Earth Bond		
1)	Visual Inspection	}	IS:2121

D) TESTS DURING MANUFACTURING:

Stage tests during manufacture shall mean those tests which are to be carried out during the process of manufacturing to ensure quality control such that the end product is of the designed quality conforming to the intent of this specification.

The list of tests to be conducted during manufacturing is as follows:

Sr. No. Particulars of test Reference standard

1) Visual inspection, Dimensional} check, Chemical analysis and mechanical strength tests for malleable Cast Iron castings. } As per relevant } IS standards }

2) Dimensional check and chemical} analysis test for Copper wire/} bars. - do - }

3) Chemical analysis of zinc for galvanising. } - do -

E) ADDITIONAL TESTS

The Owner reserves the right of having at his own expenses any other test(s) of reasonable nature carried out at Contractor's premises, at site, or in any other laboratory in addition to the aforesaid type, acceptance and routine tests to satisfy himself that the material complies with the specification. The owner also reserves the right to repeat the full series or a particular type test at any time during the pendency of contract.

13.0 GUARANTEED TECHNICAL PARTICULARS

The Guaranteed Technical Particulars for conductor and earthwire accessories enclosed with this Annexure shall be duly filled in and submitted along with the offer.

14.0 IDENTIFICATION MARK

All components made by forging/casting shall invariably be marked by embossing with identification mark of the manufacturer. The identifying letters and numbers shall be raised 1 mm and shall be at least 5 mm high. They shall be die stamped or cast on one or both sides of the assembly. The characters shall be distinct, durable, and conspicuous after galvanising.

GUARANTEED TECHNICAL PARTICULARS FOR MSCJ FOR 0.2 sq.in. ACSR Panther/0.4 ACSR zebra

Manufacturer's name and address •

Sr. No.	Particulars		Guaranteed Value
1)	Material	•	
2)	Before Compression dimensions		
i)	Aluminium Sleeve		
a)	Outer Diameter	•	
b)	Inner Diameter	•	
ii)	Steel Sleeve		

a) Outer Diameter •
b) Inner Diameter •

3) After Compression dimensions
a) Corner to Corner •
b) Flat to Flat •

4) Length before Compression •

5) Slip strength •

6) Electrical resistance of JointafterCompression •

GUARANTEED TECHNICAL PARTICULARS FOR REPAIR SLEEVES FOR 0.2 sq. in. ACSR Panther/ 0.4 ACSR Zebra

Manufacturer's name and address •

Sr. No.	Particulars	Guaranteed Value
1)	Material	•
2)	Before Compression dimensions	
a)	Outer Diameter	•
b)	Inner Diameter	•
3)	After Compression dimensions	
a)	Corner to Corner	•
b)	Flat to Flat	•
4)	Length before Compression	•
5)	Slip strength	•
6)	Electrical resistance of Joint after Compression	•

GUARANTEED TECHNICAL PARTICULARS FOR P.A.ROD FOR 0.2 sq.in. ACSR Panther/0.4 ACSR Zebra

Manufacturer's name and address •

Sr. No.	Particulars	Guaranteed Value

1) Material •

2) Dimensions •

a) Length of each rod (in mm) •
b) Diameter of each rod (in mm) •
c) No. of rods per set •
d) Tolerance on length of
each rod •

3) Conductivity •

4) Direction of lay •

5) Shape of end •

6) Tensile strength •

<u>GUARANTEED TECHNICAL PARTICULARS FOR VIBRATION DAMPER FOR 0.2 sq.in. ACSR Panther/0.4 ACSR Zebra</u>

Manufacturer's name and
address •

Identification mark •

Sr. No.	Particulars	Guaranteed Value
1)	Type •	
2)	Material, Grade and	
1	Standard of •	
a)	Clamp •	
b)	Messenger cable •	
c)	Weights (Damper mass) •	
3)	Weight of damper mass	
4)	Total weight of damper	
5)	Slip strength of clamp	
a)	Before fatigue •	
b)	After fatigue •	
6)	Maximum possible Dynamic strain on the conductor with damper •	
7)	Resonance frequency	

8) Mass pull off load •

9) Magnetic power loss
at 800 Amps. •

10) Standard specification to
which galvanizing confirm •

GUARANTEED TECHNICAL PARTICULARS FOR SUSPENSION CLAMP FOR EARTHWIRE

Manufacturer's name and
address •

Identification mark •

Sr. No.	Particulars	Guaranteed Value
1)	Type	•
2)	Material, Grade & Standard for	
a)	Clamp body	•
b)	Keeper piece	•
c)	U&J bolt and nut	•
d)	Eye hook	•
3)	Breaking load of clamp	•
4)	Slip strength	•
5)	Length of clamp	•

GUARANTEED TECHNICAL PARTICULARS FOR COPPER BOND

Sr.No.	Particulars	Guaranteed value
1)	Material, Grade and Standard for	
a)	Connecting lugs	•
b)	Flexible bond	•
2)	Stranding	•
3)	Length	•
4)	Pull off load	•

GUARANTEED TECHNICAL PARTICULARS FOR TENSION CLAMP FOR EARTHWIRE

Manufacturer's name and
address •

Identification mark •

Sr. No.	Particulars		Guaranteed Value
1)	Material, Grade & Standard for		
a)	Clamp body	•	
b)	Jumper	•	
2)	Before compression dimensions		
a)	Outer Diameter	•	
b)	Inner Diameter	•	
3)	After compression dimensions		
a)	Corner to Corner	•	
b)	Flat to flat	•	
4)	Slip strength	•	
5)	Length before compression	•	
6)	Electrical resistance of Joint after compression	•	
7)	Standard specification to which galvanizing confirm	•	

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GUARANTEED TECHNICAL PARTICULARS FOR MSCJ FOR EARTHWIRE

Manufacturer's name and
address •

Sr. No.	Particulars		Guaranteed Value
1)	Material, Grade & Standard for sleeve	•	
2)	Before compression dimensions		
a)	Outer Diameter	•	
b)	Inner Diameter	•	
3)	After compression dimensions		
a)	Corner to Corner	•	
b)	Flat to flat	•	

4)	Length before compression	•
5)	Slip strength	•
6)	Electrical resistance of joint after compression	•
7)	Standard specification to which galvanizing confirm	•

ANNEXURE-IV

GENERAL TECHNICAL REQUIREMENTS OF FOUNDATION, STUB SETTING AND EARTHING

1.0 GENERAL

Cement concrete/Reinforced concrete footings shall be used for all types of Towers in conformity with the present day practice followed in the country and the specifications laid herein.

Foundation works shall include all items of work related to supply and installation of foundations such as form installation work, excavation, concreting, curing, backfilling, stub setting, providing reinforcement etc. Supply of materials such as cement, sand, coarse aggregate and reinforcement steel is included in the scope of the contractor.

The foundation designs and drawings for a few types of soil for 220/132 KV towers are available and shall be spared to the successful Concessioner. The foundation designs required for any other type of soil shall be developed by the Concessioner as per the details given and shall be submitted to the owner for approval.

2.0 CLASSIFICATION OF SOIL AND FOUNDATIONS

2.1. CLASSIFICATION OF SOILS

The soil shall be classified for the excavation asked upon the type of soil, subsoil water level and the presence of surface water as under:

a) Normal Soil

Soil for which removal by means of an ordinary pick, axe, spade and shovel is possible.

b) Wet Soil

Where the sub-soil water table is encountered within the range of foundation depth or/and where pumping or bailing out of water is required due to presence of surface water.

c) Rocky Soil

i) Fissured Rock

Lime stone, literate, hard conglomerate or other soft or fissured rock which can be quarried or split with crow bars, wedges or pickaxes shall be classified as Fissured Rock. However, if required, light blasting may be resorted to for loosening the material, but this will not in any way entitle the material to be classified as hard rock.

ii) Hard Rock

Soil other than specified under fissured rock above for which blasting, drilling, chiseling are required, for excavation.

iii) Black Cotton Soil

Where soil is clayey type loose not necessarily black in colour, which shrinks when dry & swells when wet resulting in differential movement extending to a maximum depth of about 3.5 meters below ground level, the foundation shall be classify as black cotton.

3.0 Classification of Foundations

The foundation design shall depend upon the type of soil, sub-soil water level and the presence of surface water which have been classified as follows:

3.1. Normal dry

Where cohesive or non-cohesive soils or soft murrum are met in dry conditions, the foundations shall be classified as normal dry.

3.2. Wet

Where sub-soil water is met at 1.5 meters or more below the ground level or where surface water is present for long periods with water penetration not exceeding one meter below the ground level e.g. the paddy fields, the foundation shall be classified as wet.

3.3. Partially submerged

Where sub-soil water table is met between 0.75 meter to 1.5 meter below the ground level, the foundation shall be classified as partially submerged.

3.4. Fissured Rock

Where decomposed or fissured rock, Soft Rock, hard gravel, kankar, limestone, laterite or any other soil of similar nature is met, the foundations shall be classified as Fissured Rock and Undercut type foundation is to be used for these types of locations.

3.5. Hard Rock

Where hard rock is encountered at 1.5 mtr. or less below ground level and excavation by Chiseling, drilling and blasting is required

3.6. Black cotton soil

Where soil is clayey type loose not necessarily black in colour, which shrinks when dry & swells when wet resulting in differential movement extending to a maximum depth of about 3.5 meters below ground level, the foundation shall be classify as black cotton.

4.0 Properties of soil

Properties of soil encountered in general in the state of Maharashtra are given in following table:

PROPERTIES OF EARTH

Sr. No.	Particulars	Unit	Value
1)	Weight of earth		
a)	Dry	KN/m^3	14.12
b)	In presence of surface water	KN/m^3	14.12
c)	In presence of subsoil water	KN/m^3	9.22
2)	Normal Dry		
a)	Ultimate bearing capacity	KN/m^2	90
b)	Weight of earth	KN/m^3	14.40
c)	Angle of respose degree	Degrees	30^0
3)	Soft Rock/Fissured Rock		
a)	Ultimate Bearing Capacity	KN/m^2	612.19
b)	Weight of earth	KN/m^3	14.12
c)	Angle of Repose	Degrees	20^0
4)	Wet Fissured Rock		
a)	Ultimate bearing capacity	KN/m^2	612.19
b)	Weight of Earth	KN/m^3	9.22
c)	Angle of Repose	Degrees	10^o
5)	Hard Rock		
a)	Ultimate Bearing Capacity	KN/m^2	1250.0

Sr. No.	Particulars	Unit	Value
b)	Ultimate bond between steel and concrete	KN/m^2	0.147

6)	Black Cotton Soil(On Dry portion)		
a)	Ultimate Bearing Capacity	KN/m^2	122.58
b)	Weight of Earth	KN/m^3	14.22
c)	Angle of Repose	Degrees	0^o
7)	Black Cotton Soil(On Wet portion)		
a)	Ultimate Bearing Capacity	KN/m^2	122.58
b)	Weight of Earth	KN/m^3	9.22
c)	Angle of Repose	Degrees	9.0^o

5.0 DESIGN OF FOUNDATIONS

All the four footings of the tower and its extension shall be similar, irrespective of down thrust an up-lift.

5.1. The total depths of foundations below the ground level shall not be less than 1.5 meters and more than 3.5 meters. To maintain the interchangeability of stubs for all types of foundations, for each type of tower, the same depths of stub below ground level shall be used for different types of foundations. Common foundation design shall be suitable for normal tower and tower with 3M/ 6M extension.

For designing foundations at locations involving black cotton soil the soil is to be considered as fully submerged in nature.

In case of fissured rock locations where water table is met at 1.5 meter or more below ground level wet type fissured rock foundations shall be adopted. If after soil investigation, water level is encountered less than 1.5m below ground level, a separate foundation design for partially submerged condition as applicable shall be developed by the Contractor for execution.

5.2. The foundation shall be designed to withstand the specific loads of the super-structure and for the full footing reactions obtained from the structure stress analysis in conformity with the relevant safety factors.

5.3. The reactions on the footings shall be composed of the following type of loads for which they shall be required to be checked.

(a) Maximum tension or uplift along the leg slope.

(b) Maximum compression or down thrust along the leg slope.

(c) Maximum horizontal shear on side thrust.

5.4. The additional weight of concrete in the footing below ground level over the earth weight and the full weight of concrete above the ground level in the footing and embedded steel parts will also be taken into account adding to the down thrust.

5.5. Foundations in B.C. soil shall be designed with zero degree angle of repose and also for fully submerged condition.

5.6. 16 mm dia. deformed bars and 6 mm dia. stirrups shall be used for reinforcement.

5.7. Reinforcement bars shall be provided in the chimney portion in all types of soil.

6.0 FACTOR OF SAFETY

6.1 The factor of safety of 2.2 and 1.65 shall be adopted in normal condition and broken wire conditions respectively. The working loads on normal tower or extensions whichever is critical, shall be multiplied by appropriate factor of safety to arrive at the ultimate foundation loads.

7.0 STABILITY ANALYSIS

7.1 In addition to the strength design, stability analysis of the foundation shall be done to check the possibility of failure by over-turning, uprooting, sliding and tilting of the foundation.

7.2 The following primary types of soil resistance shall be assumed to act in resisting the loads imposed on the footing in earth:

a) Resistance against uplift:

The uplift loads will be assumed to be resisted by the weight of earth in an inverted frustum of a conical pyramid of earth as per formula detailed in drawing enclosed of this specification on the footing pad whose sides make an angle equal to the angle of repose of the earth with the vertical, in average soil.

The weight of concrete embedded in earth and that above the ground will also be considered for resisting the uplift. In case where the frustum of earth pyramids of two adjoining legs superimpose each other, the earth frustum will be assumed truncated by a vertical plane passing through the centerline of the tower base. The self-weight of tower shall not be considered with FOS while calculating uplift.

b) Resistance against down-thrust:

The down-thrust loads combined with the additional weight of concrete above earth will be resisted by bearing strength of the soil assumed to be acting on the total area of the bottom of the footing.

c) Resistance against side-thrust:

The contractor has to check the foundation against side thrust force as detailed in drawing enclosed. If uplift and down thrust are computed in vertical direction for foundation design, full resultant horizontal shear shall be taken at footing tip for design of the footing to resist side thrust.

8.0 PROPERTIES OF CONCRETE

8.1 The cement concrete used for the foundations shall be grade M-150 corresponding to 1:2:4 nominal mix ratio or M-20 corresponding to 1:1.5:3 nominal mix ratio with 20mm coarse aggregate for chimney portion and 40mm coarse aggregate for pyramid or slab portion depending on foundation design and relevant foundation drawing.

All the properties of concrete regarding its strength under compression, tension, shear, punching and bend etc. as well as workmanship will conform to IS:456-1978.

8.2 The weight of concrete to be considered for design of foundation is given in following Table:

WEIGHT OF CONCRETE

Type of Concrete	Weight in dry region $KN/M^3(Kg/M^3)$	Weight in presence of subsoil water $KN/M^3(Kg/M^3)$
Concrete	21.96 (2240)	12.16(1240)
Reinforced Concrete	23.54 (2400)	13.73(1400)

9.0 DETAILING OF FOUNDATIONS

9.1. The thickness of concrete in the chimney portion of the tower footing would be such that it provides minimum cover of not less than 100mm from any part of the stub angle to the nearest outer surface of the concrete in respect of all dry locations limiting the minimum section of chimney to 300 mm x 300 mm. In respect of all wet location, the chimney should have all round clearance of 150mm from any part of stub angle considering the minimum chimney size of 450 mm x 450 mm.

9.2. The chimney top or muffing must be at least 225mm above ground level and also the coping shall be extended up to the lower most joint level between the bottom lattices and the main corner legs of the tower.

9.3. The spread of concrete pyramid or slabs shall be limiting to 45^0, with respect to the vertical. However, Concessioners can design foundation with reinforced concrete pyramid/slab, in which case the limitation of 45^0 is not applicable. Mild steel bars shall not be used for reinforcement steel.

9.4. At least 50mm thick pad of size equal to the base of pyramid with its sides vertical will be provided blow the pyramid to account for the unevenness of soils impurities likely to be mixed in concrete due to direct contact of wet concrete with earth and also for allowing stone aggregate reaching up to corner edges. This pad will also be provided in cases where pyramids are provided over concrete slabs.

9.5. In case of partially submerged and fully submerged type foundation, at least one base slab of not less than 200mm thick shall be provided. In case of reinforced concrete slab, the slab thickness should not be less than 300mm.

9.6. The minimum distance between the lowest edge of the stub angle and the bottom surface of concrete footing shall not be less than 75mm or more than 100mm in case of dry locations and not less than 100mm or more than 150mm in case of wet locations.

9.7. In case of foundations having steel reinforcement in pyramid or slab and for all wet, partially submerged locations at least 50mm thick pad of lean concrete corresponding to 1:3:6 shall be provided prior to pad/slab mentioned in clauses 9.4 and 9.5 to avoid the possibility of reinforcement rods being exposed to unevenness of the bottom excavated pit and to avoid direct contact of concrete slab with water.

9.8. The portion of the stub in the pyramid (or slab) shall be designed to take full down-thrust or uplift loads by the cleats combined with the bond between stub angles and pyramid concrete. The Contractor shall furnish the calculation for uprooting of stub along with the foundation design.

10.0 MARKING OF TOWER LOCATION

The check survey shall be carried out and pit markings of foundation as per approved excavation chart shall be made on the ground.

11.0 EXCAVATION

11.1. Except as specifically otherwise provided, all excavation for footing shall be made to the lines and grades of the foundation. The excavation wall shall be vertical and the pit dimensions shall be such as to allow a clearance on all sides from the foundation pad. The Contractor should ensure that clearance is maintained as advised by Engineer incharge of owner from the foundation pad is maintained as per advice of engineer incharge for quality work. All excavation shall be protected so as to maintain a clean sub grade, until the footing is placed, using timbering, shoring etc., if necessary. Any sand, mud, silt or other undesirable materials which may accumulate in the excavated pit shall be removed by the Contractor before placing concrete.

11.2. No extra charge shall be admissible for the removal of the fallen earth in the pit, when once excavated. Shoring shutting and timbering as approved by authorized representative of the Owner shall be provided by the Contractor when the soil condition is so bad that there is likelihood of the falling of earth.

11.3. Where rock is encountered, the holes for tower footings, shall preferably be drilled, but where blasting is to be resorted to as an economy measure it shall be done with utmost care to minimize the use of concrete for filling the blasted areas. All necessary precautions for handling and use of blasting materials shall be taken. In case where drilling is done, the stubs may be shortened suitably with the approval of the Owner or his authorized representatives. Further it may be noted that the contractor may be required to do controlled blasting if the site conditions so warrant.

11.3.1. When intermediate soil strata is encountered the owner will modify the foundation drawings as per requirement with under cut position of reinforcement The Contractor shall supply requisite blasting material and be responsible for storage and use of this material.

11.4. The Contractor shall record the types of soil encountered during excavation of pits for different strata and soil.

12.0 SETTING OF STUBS

12.1. The stubs shall be set correctly in accordance with approved method at the exact location and alignment and precisely at correct levels with the help of stub setting templates and leveling instrument. Stubs shall be set in the presence of Owner's representative available at site where required and for which adequate advance intimation shall be given to the Owner by the Contractor. No extra charges shall be payable while cutting/cleaning of earth required for setting of stub setting template.

12.2. Setting of stub at each location shall be approved by the Owner's representative.

13.0 RAISED FOUNDATIONS

Wherever normal towers and extensions are to be spotted at locations which fall under highest flood level of adjacent rivers, the chimney shall be suitably raised above HFL. The stub length for such locations shall be suitably increased and provided through out the chimney and frustum.

14.0 BASE PLATES AND ANCHOR BOLTS

At some special locations/normal locations, it may be necessary to provide Anchor bolts and Base plates instead of stubs. These shall be designed and submitted by the Contractor for the approval of the Owner. The Contractor shall supply the anchor bolts, base plates, tower footing and template for setting of anchor bolts.

15.0 CEMENT, AGGREGATES & REINFORCEMENT STEEL

15.1. The cement shall be arranged by the contractor. Also cement should be stacked in an approved manner and only fresh cement not more than three months old from the date of manufacture should be used for foundations. Empty cement bags shall be retained by the Contractor.

15.2. a) The Portland cement used in concrete shall conform to IS:269-1967.

b) The Puzzolena cement if used in concrete shall conform to IS:1489-1976. The curing time of Puzzolena cement will be decided at the time of execution of the Contract.

c) The minimum cement content for the various grades of concrete shall be as follows:

M 20 (1:1.5:3)	400 kg/m^3
M 15 (1:2:4)	330 kg/m^3
Lean concrete M 10 (1:3:6)	260 kg/m^3
M7.5 (1:4:8)	180 Kg/m^3
1:5 Cement & kg/m^3 sand mortar	105

d)The Concessioner shall use the cement of following brands:

i) L & T
ii) KESORAM
iii) ACC
iv) Ambuja

15.3. Concrete aggregates shall conform to IS:383-1970. It may be noted that the metal to be used shall be black trap metal machine-crushed and it should be without skin-material.

15.4. The water used for mixing concrete shall be fresh, clean and free from oil, acids and alkalis, organic materials or other deleterious substances. Potable water is generally satisfactory.

15.5. Reinforcement shall conform to IS:432-1966 for M.S. bars and hard drawn steel wires and to IS:1139-1966 an IS:1786 for deformed and cold twisted bars respectively. All reinforcement shall be clean and free from loose mill scales, dust, loose rust, and coats of paint, oil or other coatings, which may destroy or reduce bond. Contractor shall supply, fabricate and place reinforcement with fusion bonded epoxy coating to shapes and dimensions as indicated or as required to carry out the intent of drawings and specifications.

16.0 MIXING, PLACING AND COMPACTING OF CONCRETE

16.1. The concrete shall be mixed in the mechanical mixer. However, in case of difficult terrain hand mixing may be permitted at the discretion of Owner's site Engineer. The water for mixing concrete shall be fresh, clean and free from oil, acids and alkalies. Saltish or brakish water shall not be used.

16.2. Mixing shall be continued until there is uniform distribution of material and the mix is uniform in colour and consistency, but in no case the mixing be done for less than two minutes. Normally mixing shall be done close to the foundation, but in case it is not possible, the concrete may be mixed at the nearest convenient place. The concrete shall be transported from the place of mixing to the place of final deposit as rapidly as practicable by methods which shall prevent the segregation or loss of any ingredient. The concrete shall be placed and compacted before setting commences.

16.3. Form boxes shall be used for casting all types of foundation. The concrete shall be laid down in 150 mm layers and consolidated well, so that the cement cream works up to the top and no honey-combing is left in the concrete. The mechanical vibrator shall be employed for compaction of the concrete. However, in case of difficult terrain, manual compaction may be permitted at the discretion of site engineer. After concreting the chimney portion to the required height, the top surface should be finished smoothly with a slight slope towards the outer edge, to drain off any rain water falling on the coping.

16.4. In wet locations, the site must be kept completely dewatered, both during placing of the concrete and for 24 hours thereafter. There should be no disturbance of concrete by water during this period. No extra charges shall be paid for dewatering.

16.5. After the form work has been removed if the concrete surface is found to be defective, the damage shall be repaired with rich cement and sand mortar to the satisfaction of the Owner's representative before the foundation pits are backfilled.

17.0 BACK-FILLING AND REMOVAL OF STUB TEMPLATES

17.1. After opening of form work and removal of shoring and timbering if any, backfilling shall be started, after repairs, if any, to the foundation concrete. Backfilling shall normally be done with the excavated soil, unless it consists of large boulders/stones, in which case the boulders shall be broken to a maximum size of 80mm. At such locations where borrowed earth is required for backfilling, this shall be done by the Contractor at his own cost, irrespective of lead.

17.2. The backfilling materials should be clean and free from organic or other foreign materials. The earth shall be deposited in maximum 200mm layers, leveled and wetted and tempered properly before another layer is deposited. Care shall be taken that the back filling is started from the foundation ends of the pits, towards the outer ends. After the pits have been backfilled to full depth, the stub template may be removed.

17.3. The backfilling and grading shall be carried to an elevation of about 75mm above the finished ground level drain out water. After backfilling 50mm high earthen embankment (bandh) will be made along the sides of excavation pits and sufficient water will be poured in the backfilling earth for at least 24 hours.

18.0 CURING

18.1. The concrete shall be mixed in the mechanical mixer. However, in case of difficult terrain hand mixing may be permitted at the discretion of Owner's site Engineer. The water for mixing concrete shall be fresh, clean and free from oil, acids and alkalies. Saltish or brakish water shall not be used.

18.2. Mixing shall be continued until there is uniform distribution of material and the mix is uniform in colour and consistency, but in no case the mixing be done for less than two minutes. Normally mixing shall be done close to the foundation, but in case it is not possible, the concrete may be mixed at the nearest convenient place. The concrete shall be transported from the place of mixing to the place of final deposit as rapidly as practicable by methods which shall prevent the segregation or loss of any ingredient. The concrete shall be placed and compacted before setting commences.

18.3. Form boxes shall be used for casting all types of foundation. The concrete shall be laid down in 150 mm layers and consolidated well, so that the cement cream works up to the top and no honey-combing is left in the concrete. The mechanical vibrator shall be employed for compaction of the concrete. However, in case of difficult terrain, manual compaction may be permitted at the discretion of site engineer. After concreting the chimney portion to the required height, the top surface should be finished smoothly with a slight slope towards the outer edge, to drain off any rain water falling on the coping.

18.4. In wet locations, the site must be kept completely dewatered, both during placing of the concrete and for 24 hours thereafter. There should be no disturbance of concrete by water during this period. No extra charges shall be paid for dewatering.

18.5. After the form work has been removed if the concrete surface is found to be defective, the damage shall be repaired with rich cement and sand mortar to the satisfaction of the Owner's representative before the foundation pits are backfilled.

19.0 BACK-FILLING AND REMOVAL OF STUB TEMPLATES

19.1. After opening of form work and removal of shoring and timbering if any, backfilling shall be started, after repairs, if any, to the foundation concrete. Backfilling shall normally be done with the excavated soil, unless it consists of large boulders/stones, in which case the boulders shall be broken to a maximum size of 80mm. At such locations where borrowed earth is required for backfilling, this shall be done by the Contractor at his own cost, irrespective of lead.

19.2. The backfilling materials should be clean and free from organic or other foreign materials. The earth shall be deposited in maximum 200mm layers, leveled and wetted and tempered properly before another layer is deposited. Care shall be taken that the back filling is started from the foundation ends of the pits, towards the outer ends. After the pits have been backfilled to full depth, the stub template may be removed.

19.3. The backfilling and grading shall be carried to an elevation of about 75mm above the finished ground level drain out water. After backfilling 50mm high earthen embankment (bandh) will be made along the sides of excavation pits and sufficient water will be poured in the backfilling earth for at least 24 hours.

20.0 CURING

The concrete after setting for 24 hours shall be cured by keeping the concrete wet continuously for a period of 21 days after laying. The pit may be back filled with selected earth sprinkled with necessary amount of water and well consolidated in layers not exceeding 200mm of consolidated thickness after a minimum period of 24 hours and thereafter both the backfilled earth and exposed chimney top shall be kept wet for the remainder of the prescribed time of 10 days. The uncovered concrete chimney above the backfilled earth shall be kept wet by providing empty cement bags dipped in water fully wrapped around the concrete chimney for curing and ensuring that the bags are kept wet by the frequent pouring of water on them.

21.0 SPECIAL FOUNDATIONS

The Owner may desire to construct a few special foundations in marshy locations, loose soil etc. if necessary.

21.1. FACTOR OF SAFETY FOR SPECIAL FOUNDATIONS

The factor of safety of 2.75 and 2.2 shall be adopted in normal condition and broken wire conditions respectively. The working loads on normal tower or extensions whichever is critical, shall be multiplied by appropriate factor of safety to arrive at the ultimate foundation loads.

21.2. EARTHING

The footing resistance of all towers shall be measured by the Contractor in dry weather after tower erection and before the stringing of earth-wire. All the towers are to be earthed, however, in no case tower footing resistance shall exceed 10 ohms. Pipe type earthing and counterpoise type earthing wherever required shall be done in accordance with the stipulations made in IS:3043-1987 and IS:5613 (Part-II/Section-2) 1985. The details for pipe and counterpoise type earthing are given in drawing enclosed.

22.0 Benching

When the line route passes through hilly/undulated terrain, for a few tower locations it may be required to level the ground for casting of tower footings on same elevation. All the activities related to make the required area of ground in same elevation for casting of foundation, shall be termed as benching work. Benching work shall include cutting of excess earth and removing the same to a suitable point of disposal as required by the Owner. The excavated earth should be used for filling the slopping area for leveling the ground. Benching shall be resorted to only after getting specific approval from the Owner. Volume of the earth to be cut shall be measured before cutting and got approved from the Owner. This volume of earth shall be considered for the purpose of payment against the head of benching work. It may be noted that the activity related to making the area of ground to same elevation for level difference less than one meter shall not be considered as benching. No payment shall be made for benching works excavation up to the level of 1 meter from top. For level difference more than 3.0 mtr. between legs, the Concessioner shall provide the towers with unequal legs. The required unequal legs with bracings shall be designed by the Concessioner.

23.0 PROTECTION OF TOWER FOOTING

23.1. The work shall include all necessary stone pitching and concreting after earth filling above ground level and the clearance with stacking, of all surplus excavated soil at site for providing revetment. Special measures for protection of foundation close to or in nallas, river beds, hilly undulated terrain, etc. shall be arranged by providing suitable revetment with stone pitching and galvanized wire netting and meshing packed with boulders. The top seal cover of the stone revetment shall be done with M-15 concrete (1:2:4 mix). The Contractor shall furnish recommendations for providing protection at these locations wherever required.

23.2. Retaining Wall

In case level difference between tower footing is more, the retaining wall of suitable height at the low lying part shall be provided with Rubble stone, masonry in 1:5 mix mortar with necessary excavation, lean concrete, rubble stone masonry & provision of 100 mm thick M-15 concrete at top of wall. The tower footing will be leveled by back filling with excavated soil or borrowed soil inside the retaining wall. The height of retaining wall, its length and width shall be got approved by the contractor before taking up the work from engineer in-charge not below the rank of Executive Engineer.

23.3. The quantity of excavated earth obtained from a particular location shall generally be utilised in back filling work in protection of tower footing of same location, unless it is unsuitable for such purposes. In the latter case, the back-filling shall be done with excavated soil is not sufficient to achieve the leveled filling borrowed earth of suitable quality irrespective of lead, as per the rate provided in the letter of award. The consolidation of earth shall however, be done after backfilling free of cost.

24.0 STANDARDS

24.1. The erection procedure and materials used for design and construction of foundations shall conform to the following Indian Standards (IS) which shall mean latest revisions, with amendments/changes adopted and published, unless specifically stated otherwise in the specification.

24.2. The material and services covered under these specifications shall be performed as per requirements of the relevant standards/codes referred hereinafter against each set of equipment and services. Other internationally acceptable standards which ensure equal or higher performance than those specified shall also be accepted.

Sr. No.	Indian Standards IS	Title
1.	IS:269-1967	Ordinary rapid hardening and low heat Portland Cement
2.	IS:388-1970	Coarse and fine aggregates from natural sources for concrete
3.	IS:432-1966 (Part I & II)	Mild steel and medium tensile bars and hard drawn steel wire for concrete reinforcement

4. IS:456-1978 Code of practice for plan and reinforced concrete

5. IS:800-1962 Code of practice for use of structural steel in general Building construction.

6. IS:1139-1966 Hot rolled mild steel medium high yield strength steel deformed bars for concrete reinforcements.

7. IS:1489-1976 Portland Pozzolena Cement

8. IS:1786-1966 Cold twisted steel bars for concrete reinforcements

9. IS:1893-1965 Criteria of Earth quake resistant design of structures

10. IS:3043-1972 Code of practice for earthing(with amendments No.1 & 2)

11. IS:4091-1967 Code of practice for design and construction of foundation for transmission line towers and poles.

ANNEXURE-V

GENERAL TECHNICAL REQUIREMENTS OF ERECTION WORKS

1.0 General

1.1. The scope of erection work shall include the labour, all tools and plants and all other incidental works in connection with the setting up of site stores, unloading at the destination the various materials, transportation to stores, storage, safe custody, movement to work site, erection, stringing, and testing and commissioning of the line.

1.2. Contractor shall set up required number of stores along the line and the exact location of such stores hall be discussed and agreed to between the Contractor and the Owner.
The insulators packed in wooden crates should be stacked properly so as to cause no damages. The insulators should be taken to site in packed crates and not in loose condition so that there are no breakages during transit. It will be the responsibility of the contractor to see that damaged insulators are not used.

1.3. All galvanised members shall be thoroughly inspected. If any defects are found in case of hot-dip galvanised members, the members if acceptable to Owner shall be repaired by applying zinc rich protection paint.

1.4. Treatment of Joints
Before starting assembly, the surfaces at joints shall be cleaned and applied with a coat of Zinc-rich paint, if required. However for the lines in coastal or highly polluted areas, the above painting shall necessarily be carried out.

1.5. Assembly
The method followed for the erection of towers, shall ensure the points mentioned below :

a) Straining of the members shall not be permitted for bringing them into position. It may, however, be necessary to match hole positions at joints and to facilitate this, tummy bars not more than 450mm long may be used.
b) Before starting erection of an upper section, the lower section shall be completely braced and all bolts provided and tightened adequately in accordance with approved drawings to prevent any mishap during tower erection.
c) All plan diagonals relevant to a section of tower shall be placed in position before assembly of upper section is taken up.
d) The bolt positions in assembled towers shall be as per IS:5613 (Part-II/Section-2)-1976.
e) Tower shall be fitted with number plate, danger plate, pole plates, circuit plate and ant climbing device as described.

2.0 Tightening and Punching of Bolts and Nuts

2.1. All nuts shall be tightened properly using correct size spanners and torque wrench. Before tightening, it will be seen that filler washers and plates are placed in relevant gaps between members, bolts of proper size and length are inserted, and one spring washer is inserted under each nut. In case of step bolts, spring washers shall be placed under the outer nuts. The tightening shall progressively be carried out from the top downwards, care being taken that all bolts at every level are tightened simultaneously. The threads of bolts projecting outside the nuts shall be punched at their position on the diameter to ensure that the nuts are not loosened in course of time. If during tightening a nut is found to be slipping or running over the bolt threads, the bolt together with the nut shall be replaced.

2.2. The threads of all the bolts projected outside the nuts shall be welded at two diametrically opposite places. The circular length of each welding shall be at least be 10mm. The welding shall be provided from ground level to first panel or six meters height whichever is higher. After welding, cold galvanized paint having at least 90% zinc content shall be applied to the welded portion. At least two coats of the paint shall be applied. The cost of welding and paint including application of paint shall be deemed to be included in the tower erection price.

2.3. Instead of tack welding of nuts with bolts, as de-scribed above, the Contractor can also propose some alternative arrangements, like use of epoxy resin adhesive which can serve the purpose of locking the nut permanently with the bolt and thus preventing pilferage of the tower members.

In case the contractor offers some alternative to tack welding, as stated above, he shall have to furnish all the technical parameters of the same, to facilitate the owner to technically evaluate its acceptability.

3.0 Insulator Hoisting

3.1. Suspension insulator strings shall be used on suspension towers and tension insulator strings on angle and dead end towers. These shall be fixed on all the towers just prior to the stringing. Damaged insulators and fittings, if any, shall not be employed in the assemblies. Before hoisting all insulators shall be cleaned in a manner that will not spoil, injure or scratch the surface of the insulator, but in no case shall any oil be used for the purpose. Corona control rings shall be fitted in an approved manner. The yoke arrangements shall be horizontal for tensions and longitudinal for suspension strings. Torque wrench shall be used for fixing different line materials and their components like suspension clamp for conductor and earthwire, etc. wherever recommended by the manufacturer of the same.

4.0 Handling of conductor and earthwire

4.1. The Contractor shall be entirely responsible for any damage to the towers, conductors and earthwire during stringing. While running out the conductors, and earthwire, care shall be taken that these do not touch and rub against the ground or objects which could cause scratches or damages to the strands. The conductors shall be run out of the drums from the top in order to avoid damage due to chafing. Immediately after running out, the conductor shall be raised at the supports to the levels of the clamp and placed into the running blocks. The groove of the running blocks shall be of such a design that the seat is semicircular and larger than the diameter of the conductor/earthwire and it does not slip over or rub against the sides. The grooves shall be lined with hard rubber or neoprene to avoid damage to conductor and shall be mounted on properly lubricated bearings.

4.2. The running blocks shall be suspended in a manner to suit the design of the cross-arm. All running blocks especially those at the tensioning end, will be fitted on the cross arms with jute cloth wrapped over the steel work and under the slings to avoid damage to the slings as well as to the protective surface finish of the steel work. In case tension or section towers are used even for temporary terminations, if this be unavoidable, they shall be well guyed and steps shall be taken by the Contractor to avoid damage. Guying proposal along with necessary calculations shall be submitted by the Contractor to Engineer-in-Charge for the approval. Proper T&P shall also be made available to the Owner by the Contractor for checking the tensions in the guy wires. The drums shall be provided with a suitable braking device to avoid damages, loose running out and kinking of the conductor. The conductor shall be continuously observed for loose or broken strands or any other damage. When approaching end of a drum length at least three coils shall be left when the stringing operations are to be stopped. These coils are to be removed carefully, and if another length is required to be run out, a joint shall be made as per the recommendations of the accessories manufacturers.

4.3. Repairs to conductors, if necessary, shall be carried out during the running out operations, with repair sleeves. Repairing of conductor surface shall be done only in case of minor damage, scuff marks etc. keeping in view both electrical and mechanical safe requirements. The final conductor surface shall be clean, smooth without any projections, sharp points, cuts, abrasions etc.

4.4. Conductor splices shall be so made that they do not crack or get damaged in the stringing operation. The Contractor shall use only such equipment/methods during conductor stringing which ensure complete compliance in this regard.

4.5. Derricks shall be used where roads, rivers, channels, telecommunication or overhead power lines, railway lines, fences or walls have to be crossed during stringing operations. It shall be ensured that normal services are not interrupted or damage caused to property. Shut down shall be obtained when working at crossing of overhead power lines. The Contractor shall be entirely responsible for the proper handling of the conductor, earthwire and accessories in the field.

4.6. The sequence of running out shall be from top to downwards, i.e. the earthwire shall be run out first, followed by the conductors in succession Unbalances of loads on towers shall be avoided as far as possible.

4.7. The proposed transmission line may run parallel for certain distance with the existing 400 KV, 220 kV, 132 KV lines which may remain energized during the stringing period. As a result there is a possibility of dangerous voltage build up due to electromagnetic and electrostatic coupling in the pulling wire of conductors and earth wires which although comparatively small during normal operation can be severe during switching. It shall be the Contractor's responsibility to take adequate safety precautions to protect his employees and others from this potential danger.

4.8. B, C and D angle type of towers are not designed for one side stringing. Therefore proper guying arrangements shall be made for 'B', C and D type of towers during stringing on one section while the other section is not strung. The Contractor has to submit the detailed proposal along with the calculation for guying which shall be approved by Engineer-in-Charge. Proper T&P shall be made available to the Owner by the Contractor for checking the tension in the guy wires. All the expenditure on account of the above work is deemed to be included in the bid price and no extra payment shall be made for the same.

5.0 Stringing of earthwire and conductor

The sequence of stringing shall be first earthwire, then phase conductor.

5.1. An allowance of 500 mm should be given to compensate the conductor creep.

5.2. The contractor shall give complete details of the stringing methods which he proposes to follow. Before the commencement of stringing, the Contractor shall submit the stringing charts for the conductor and earthwire showing the initial and final sags and tension for various temperatures and spans, along with equivalent spans in the lines for the approval of the Owner. The stringing chart shall be prepared for actual spans based on tower schedule and shall cover the entire line details.

6.0 Jointing

6.1. All the joints on the conductor and earthwire shall be of compression type, in accordance with the recommendations of the manufacturer for which all necessary tools and equipment like motorized compressors, dies processes etc. shall have to be arranged by the contractor. Each part of the joint shall be cleaned by wire brush to make it free of rust or dirt etc. all be properly greased with anti-corrosive compound, if required and as recommended by the supplier before the final compression is done with the compressors.

6.2. All the joints or splices shall be made at least 30 meters away from the structures. No joints or splices shall be made in the spans crossing overmain roads, railways, small rivers with tension spans. Not more than one Joint per sub-conductors shall be allowed in one span. The compression type fittings used shall be self centering type or care shall be taken to mark the conductors to indicate when the fitting is centered properly. During compression or splicing operation the conductor shall be handled in such a manner as to prevent lateral or vertical bearing against the dies. After pressing the joint the aluminum sleeve shall have all corners rounded, burrs and sharp edges removed and smoothened.

6.3. During stringing of conductor to avoid any damage to the joint the Contractor shall use a suitable protector with mid span compression joints in case joints are to be passed over pulley blocks/aerial rollers. The size of the groove of the pulley shall be such that the joint along with projection can be passed over it smoothly.

7.0 Sagging-in-Operation

7.1. The conductors, and earth wire shall be pulled unto the desired sag and left in running block for at least one hour after which the sag shall be re-checked and adjusted, if necessary, before transferring the conductors from the running blocks to the suspension clamps. The conductors shall be clamped within 36 hours of sagging in.

7.2. The sag will be checked in the first and the last span of the section in case of sections up to eight spans and in one intermediate span also for sections with more than eight spans. The sag shall also be checked when the conductors have been drawn up and transferred from running blocks to the insulator clamps.

7.3. The running blocks, when suspended from the transmission structure for sagging shall be so adjusted that the conductors on running blocks will be at the same height as the suspension clamp to which it is to be secured.

7.4. At sharp vertical angles, the sags and tensions shall be checked on both sides of the angle, the conductor and earthwire shall be checked on the running block for equality of tension on both sides. The suspension insulator assemblies will normally assume vertical positions when the conductor is clamped.

7.5. Tensioning and sagging operations shall be carried out in calm weather when rapid changes in temperatures are not likely to occur.

7.6. Tensioning and Sagging of Conductors and Earth wire shall be done accordance with the approved stringing charts before the conductors and earthwire are finally attached to the towers through the clamps for the earthwire and insulator strings for the conductor. The 'Initial' stringing chart shall be used for the conductor and `final' stringing chart for earthwire should be employed for this purpose. Dynamometers shall be employed for measuring tension in the conductor and earthwire. The dynamometers employed shall be periodically checked and calibrated with a standard dynamometer.

8.0 Clipping in

8.1. Clipping of the conductors in position shall be done in accordance with the recommendations of the manufacturer. Conductor shall be fitted with the Armour rods where it is made to pass through suspension clamps.

8.2. The jumpers at the section and angle towers shall be formed to parabolic shape to ensure maximum clearance requirements. Pilot suspension insulator string shall be used, if found necessary, to restrict the jumper swings to the design values.

8.3. Fasteners in all fittings and accessories shall be secured in position. The security clip shall be properly opened and sprung into position.

9.0 Fixing of Conductor/Earthwire Accessories

Vibration dampers for conductor and other conductor and earthwire accessories to be supplied by the Contractor shall be installed by the Contractor as per the design requirements and respective manufacturer's instructions within 24 hours of the conductor/ earthwire clamping. While installing the conductor and earthwire accessories proper care shall be taken to ensure that the surfaces are clean and smooth and no damage shall occur to any part of the accessories.

10.0 Replacement

If any replacements are to be effected after stringing and tensioning or during maintenance, leg members and bracings shall not be removed without reducing the tension on the tower with proper guying or releasing the conductor. If the replacement of cross arms becomes necessary after stringing, the conductor shall be suitably tied to the tower at tension points or transferred to suitable roller pulleys at suspension points.

11.0 Returnables

The Contractor shall not be required to return to the owner, empty wooden drums of conductor and earthwire and shall dispose off the same at his cost.

12.0 Final checking, testing and commissioning

After completion of the works, final checking of the line shall be done by the Contractor to ensure that all the foundation works, tower erection and stringing have been done strictly according to the specifications and as approved by the Owner. All the works shall be thoroughly inspected keeping in view the following main points:

a) Sufficient backfilled earth is lying over each foundation pit and it is adequately compacted.
b) Concrete chimney and their copings are in good finely shaped conditions.
c) All the tower members are correctly used, strictly according to final approved drawing and are free of any defect or damage, whatsoever.
d) All bolts are properly tightened and punched/tack welded.
e) The stringing of the conductors and earthwire has been done as per the approved sag and tension charts and desired clearances are clearly available.
f) All conductor and earthwire accessories are properly installed

g) All other requirements to complete the work like fixing of danger-plate, phase plate, number plate, anticliming device, aviation signal(wherever required) etc. are properly installed.

h) Wherever required it should be ensured that revetment is provided.

i) The original tracings of profile, route alignment and tower designs, structural drawings, bill material, shop drawings of all towers other than the towers designed by the Owner are submitted to the owner for reference and record.

j) The line insulation is tested by the Contractor by providing his own equipment, labour etc. to the satisfaction of the owner.

k) All towers are to be properly earthed.

l) The line is tested satisfactorily for commissioning purpose.

ANNEXURE - VI

TECHNICAL SPECIFICATION FOR PORCELAIN DISC / LONGROD INSULATORS & GLASS DISC INSULATORS

1.0 GENERAL

This section details the technical particulars of Porcelain disc / Longrod insulators and Glass disc insulators for 132KV / 220 KV / 400 KV Transmission Lines. The Insulators shall conform in all respects to high standards of Engineering, design, workmanship and latest revisions of relevant standards

Contractor may quote for disc insulator made of either electro-porcelain or toughened glass or porcelain longrod insulator.

2.0 STANDARDS APPLICABLE

2.1 Except as modified in this specification, the insulators to be supplied shall conform to the latest version, with amendments thereof, of the following Bureau of Indian Standards and equivalent International Standards.

Sr. No. Indian Standard	Title	International Standard
1. IS: 206	Method for Chemical Analysis of Slab Zinc	
2. IS: 209	Specification for Zinc	BS: 3436
3. IS: 731	Porcelain insulators for overhead power lines with a nominal voltage greater than 1000V	BS 137(I&II) IEC:274
4. IS: 2071 Part (I to III)	Method of High Voltage Testing	
5. IS: 2486	Specification for Insulator fittings for overhead power lines with a nominal voltage greater than 1000V	
Part I	General Requirements and Tests	BS: 3288
Part II	Dimensional Requirements	IEC: 120
Part III	Locking Devices	IEC: 372
Part IV	Tests for Locking Devices	IEC: 372

Sr. No.	Indian Standard	Title	International Standard
6.	IS: 2629	Recommended practice for Hot Dip Galvanization for iron and steel	
7.	IS: 2633	Testing for Uniformity of Coating of Zinc coated articles	
8.	IS: 3188	Dimensions for Disc Insulators	IEC: 305
9.	IS: 6745	Determination of Weight of Zinc coating on Zinc coated iron and steel articles	
10.	IS: 8263	Methods of RIV Test of HV Insulators	IEC: 437, NEMA Publication No. 107/1964 CISPR
11.	IS: 8269	Methods for Switching impulse test on HV insulators	IEC: 506
12.		Thermal Mechanical performance test and mechanical performance test on string insulator units	IEC: 575
13.		Tests on insulators of Ceramic material or glass or glass for overhead lines with a nominal voltage greater than 1000V	IEC: 60383

2.2 Insulators conforming to any other International standards are also acceptable provided always that such standard are equivalent to or better than the corresponding standards specified in 2.1 above. However, in such an event the salient points of comparison between the standards adopted and the standards quoted herein shall be detailed in the offer. One copy of authentic English version of such standards shall be submitted (in physical form) along with the offer.

3.0 GENERAL REQUIREMENTS:

a) All raw materials to be used in the manufacture of insulators shall be subject to strict raw material quality control and to stage testing/quality control during manufacturing stage to ensure the quality of the final end product. Manufacturing shall conform to the best engineering practices adopted in the field of extra high voltage transmission. Concessioners shall therefore offer insulators as are guaranteed by them for satisfactory performance on transmission lines.

b) The design, manufacturing, process and material control at various stages shall be such as to give maximum working load, highest mobility, best resistance to corrosion, good finish, elimination of sharp edges and corners to limit corona and radio interference voltages.

c) The design of the insulator shells shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to deterioration. Shells with cracks shall be eliminated by temperature cycle test followed by mallet test. Shells shall be dried under controlled conditions of humidity and temperature.

d) The cap and pin shall be designed to transmit the mechanical stresses to the shell by compression and develop uniform mechanical strength in the insulator. The cap shall be circular with the inner and outer surfaces concentric and of such design that it will not yield or distort under loaded conditions. The head portion of the pinball shall be suitably designed so that when the insulator is under tension the stresses are uniformly distributed over the pinhole portion of the shell. The pinball shall move freely in the cap socket either during assembly of a string or during erection of a string or when a string is placed in position.

e) Insulator units after assembly shall be concentric and coaxial within limits as permitted by Indian/International standards.

f) The insulator design shall be such that when units are coupled together to form a string, there shall be no contact between the shell of one unit and metal of the adjacent unit.

g) Metal caps shall be free from cracks, seams, shrinks, air holes, blowholes and rough edges. All metal surfaces shall be perfectly smooth with no projecting parts or irregularities, which may cause corona. All load bearing surfaces shall be smooth and uniform so as to distribute the loading stresses uniformly. Pins shall not show any microscopically visible cracks, inclusions and voids.

h) Cap, Pin shall not be manufactured by joining, welding, shrink fitting or by any other process from more than one piece of metal.

i) The insulator design shall be such that the insulating medium shall not directly engage with hard metal. The surface of porcelain shall be coated with resilient paint to offset the effect of difference in thermal expansion of these materials.

j) The porcelain longrod insulators shall have sheds of 'open aerodynamic profile' with good self cleaning properties. Insulator shed profile, spacing, projection etc. shall be strictly in accordance with the recommendations of IEC:60815.

k) For 400 KV and 220 KV strings, the porcelain longrod insulators shall be supplied with intermediate ball pins and intermediate arcing horns.

4.0 DETAILS OF INSULATORS:

4.1 <u>DISC INSULATORS</u>:

a) The insulator strings shall consist of standard discs for a three phase 50 Hz, effectively earthed 400 KV transmission system in a moderately polluted atmosphere. The discs shall be cap and pin, ball and socket type.

b) The size of disc insulator, minimum creepage distance, the number to be used in different type of strings, their electromechanical strength; and mechanical strength of insulator string alongwith hardware fitting shall be as follows:

Type of String	Size of disc insulator (mm)	Minimum creepage distance of each disc (mm)	No. of standard discs (Nos.)	Mechanical strength of insulator string with H/W fitting (KN)

<u>400 KV</u>					
Single Susp-ension 'I' string/pilot string	(N)	255x145	320	23	120
	(AF)	280x145	430	23	120
Double Susp-ension 'I' string	(N)	255x145	320	2x23	240
	(AF)	280x145	430	2x23	240
Single Suspen-sion 'V' string	(N)	280x170	320	2x23	210
	(AF)	280/305x170	430	2x23	210
Double Suspen-sion 'V' string	(N)	280x170	320	2x2x23	420
	(AF)	280/305x170	430	2x2x23	420
Double Tension string	(N)	280x170	320	2x24	320
	(AF)	280/305x170	430	2x24	320
Quadruple Tension String	(N)	280x170	320	2x2x24	640
	(AF)	280/305x170	430	2x2x24	640
<u>220 KV</u>					
Single Susp-ension	(N)	255x145	320	14	70
	(AF)	280x145	430	14	70
Double Susp-ension	(N)	255x145	320	2x14	2x70
	(AF)	280x145	430	2X14	2X70
(KN)Single tension	N)	255x145	320	15	120
	(AF)	280x145	430	15	120
Double tension	(N)	255x145	320	2x15	2x120
	(AF)	280x145	430	2X15	2X120
<u>132 KV</u>					
Single Susp-ension	(N)	255x145	320	9	70
	(AF)	280x145	430	9	70
Double Susp-ension	(N)	255x145	320	2x9	2x70
	(AF)	280x145	430	2X9	2X70
Single tension	(N)	255x145	320	10	120
	(AF)	280x145	430	10	120
Double tension	(N)	255x145	320	2x10	2x120
	(AF)	280x145	430	2X10	2X120

NOTE: Details applicable for strings required only be considered.

4.2 LONGROD INSULATORS:

a) The insulator strings shall consist of standard longrod insulators for a three phase 50 Hz, effectively earthed 400 KV/220 KV/132 KV transmission system in a moderately polluted atmosphere. The insulators shall be cap and pin, ball and socket type.

b) The length of longrod insulator, minimum creepage distance, the number to be used in different type of strings and mechanical strength of insulator string alongwith hardware fitting shall be as follows:

Type of String	Length of longrod insulator (mm)	Minimum creepage distance of each string (mm)	No. of units per string (Nos.)	Mechanical strength of insulator string with H/W fitting (KN)
400 KV				
Single Susp- (N)	3335	7360	1x3	120
ension 'I' (AF) string	3335	9890	1x3	120

Type of String	Length of longrod insulator (mm)	Minimum creepage distance of each string (mm)	No. of units per string (Nos.)	Mechanical strength of insulator string with H/W fitting (KN)
Double Susp- (N)	3335	7360	2x3	240
ension 'I' (AF) string	3335	9890	2x3	240
Single Susp- (N)	4075	7680	2x3	210
ension 'V' (AF) string	4075	10320	2x3	210
Double Susp- (N)	4075	7680	2x2x3	420
ension 'V' (AF) string	4075	10320	2x2x3	420
Double (N)	4075	7680	2x3	320
Tension (AF) string	4075	10320	2x3	320
Quadruple (N)	4075	7680	2x2x3	640
Tension (AF) string	4075	10320	2x2x3	640
220 KV				
Single Susp- (N)	2030	4480	2	70
ension (AF)	2030	6020	2	70

Double Susp-ension	(N)	2030	4480	2x2	140
	(AF)	2030	6020	2x2	140
Single tension	(N)	2175	4800	2	120
	(AF)	2175	6450	2	120
Double tension	(N)	2175	4800	2x2	240
	(AF)	2175	6450	2x2	240
132 KV					
Single Susp-ension	(N)	1305	2880	1	70
	(AF)	1305	3870	1	70
Double Susp-ension	(N)	1305	2880	1x2	70
	(AF)	1305	3870	1x2	70
Single tension	(N)	1450	3200	1	120
	(AF)	1450	4300	1	120
Double tension	(N)	1450	3200	1x2	240
	(AF)	1450	4300	1x2	240

NOTE: Details applicable for strings required only be considered.

c) The electro-mechanical strength of individual disc/longrod in strings mentioned above are as follows:

Sr. No.	Type of String	Electro-Mechanical strength of individual disc/longrod insulator
A)	400 KV	
1)	Single/Double Suspension 'I' string	120 KN
2)	Single Suspension 'Pilot' string	120 KN
3)	Single/Double Suspension 'V' string	160 KN
4)	Double Tension string	160 KN
5)	Quadruple Tension string	160 KN
B)	220/132 KV	
1)	Single/Double Suspension string	70 KN
2)	Single/Double Tension string	120 KN

NOTE: Details applicable for strings required only be considered.

5.0 DRAWINGS:

5.1. The Concessioner shall furnish outline drawings of disc insulator unit/longrod indicating all dimensions for scrutiny and approval. All drawings shall be neatly arranged, and all drafting and lettering shall be standard and legible. Dimensions shall be in SI units. The drawings shall give following information:

1. The bill of material indicating quantity and nature of material used for various parts
2. Details like Ball and Socket designation, Maximum Axial & Radial Runout, Minimum

& Protected Creepage distance, Colour of Glaze, Electro-mechanical strength, Identification mark and weight of insulator.

3. Electrical characteristics like One minute power frequency withstand and flashover voltage under dry and wet conditions, Lightening impulse withstand and flashover voltage, Switching surge impulse withstand voltage, Visible discharge and Radio Interference Voltage.
4. After award of contract, the Concessioner shall submit 3 sets of drawings to C.E.(Tr. Proj.), giving details as mentioned above, for scrutiny and approval. Once the drawings have been approved, no alteration or modification will be carried out without prior approval of the Purchaser.

6.0 SPECIFIC TECHNICAL REQUIREMENTS:

IA) NON-METALLIC PARTS (PORCELAIN)

a) PORCELAIN

The porcelain used in the manufacture of the shells shall be ivory white, nonporous, of high dielectric, mechanical and thermal strength, free from internal stresses, blisters, laminations, voids, foreign matter, imperfections or other defects which might render it in any way unsuitable for insulator shells. Porcelain shall remain unaffected by climatic conditions, ozone, acid, alkalis, zinc or dust. The manufacturing shall be by the wet process and impervious character obtained by thorough vitrification.

b) PORCELAIN GLAZE

Surfaces to come in contact with cement shall be made rough by sand glazing. All other exposed surfaces shall be glazed with ceramic materials having the same temperature coefficient of expansion as that of the insulator shell. The thickness of glaze shall be uniform throughout and the colour of glaze shall be brown. The glaze shall have a visible luster, shall be smooth on surface and be capable of satisfactory performance under extreme tropical climatic weather conditions and prevent ageing of the porcelain. The glaze shall remain under compression on the porcelain body throughout the working temperature range.

c) FILLER MATERIAL

Cement to be used, as a filler material shall be quick setting, fast curing portland cement. It shall not cause fracture by expansion or loosening by contraction. Cement shall not

react chemically with metal parts in contact with it and its thickness shall be as small and as uniform as possible.

IB) NON-METALLIC PARTS (TOUGHENED GLASS)

The glass used for the shells shall be sound, free from defects such as flaws. bubbles, inclusions etc. and be of uniform toughness over its entire surface. All exposed glass surfaces shall be smooth.

II) METALLIC PARTS

a) BALL PINS / TWIN BALL PINS

These shall be made of forged steel of grade EN-8D(BS:970)/CL-IV(IS:2004) or equivalent, by drop forging method and normalised. They shall not be manufactured by joining, welding, shrink fitting or by any other process from more than one piece of metal. The ball pins shall be free from forging defects.
The Concessioner shall specify the grade, composition and mechanical properties of steel used in manufacture of ball pin, in Quality Assurance Plan.

b) METAL CAP

The caps shall be cast from black heart malleable cast iron of grade BM 320 (IS: 14329) or equivalent and annealed. The caps shall be made in single piece and shall be free from casting defects like misrun, cold shut etc.

The Concessioner shall specify the grade, composition and mechanical properties of steel used in manufacture of caps, in Quality Assurance Plan.

c) INTERMEDIATE ARCING HORN

For 220KV and 400 KV longrod insulators besides arcing horn on tower side of the hardware fittings, intermediate arcing horns along with fixtures and fasteners shall also necessarily be provided. The arcing horn shall be of mild steel tube.

d) SECURITY CLIPS

i) These shall be made of Stainless Steel grade AISI 304/316 (ASTM A276) or Phosphor Bronze.

ii) The security clips to be used as locking device for ball and socket coupling shall be 'R' shaped hump type to provide for positive locking of the coupling as per IS:2486 (Part IV). 'W' type security clips are also acceptable. The legs of the security clips shall allow for spreading after installation to prevent complete withdrawal from the socket. The locking device shall be resilient, corrosion resistant and of sufficient mechanical strength. There shall be no possibility of the locking device to be displaced or be capable of rotation when placed in position and under no circumstances shall it allow separation of insulator units.

iii) The hole for the security clip shall be countersunk and the clip shall be of such design that the eye of the clip may be engaged by a hot line clip puller to provide for disengagement under energized conditions.

iv) The force required for pulling the R-clip into its unlocked position shall not be less than 50 N (5 Kgs) or more than 500 N (50 Kgs).

v) The force required for pulling the W-clip into its unlocked position shall not be less than 25 N (2.5 Kgs) or more than 250 N (25 Kgs).

7.0 GALVANISING:

a) All ferrous parts shall be hot dip galvanized in accordance with IS: 2629 and IS: 2633. Before galvanization, the steel section shall be thoroughly cleaned of any paint, grease, rust, scale, acid/alkali or such other foreign matters as are likely to interfere with the galvanizing process or with the quality and durability of the zinc coating. Pickling shall be very carefully done and shall be proper.

b) Before ball fittings are galvanized, all die flashing on the shank and on bearing surface of the ball shall be carefully removed without reducing the designed dimensional requirements.

c) The zinc used for galvanizing shall be of grade Zn 98 (% of zinc ≥ 99.95%) as per IS: 209. The mass of zinc coating shall not be less than 610 gm/m^2 (86 microns).

d) The galvanized surface shall consist of continuous and uniformly thick coating of zinc, firmly adhering to the surface of steel. The finished surface shall be clean and smooth and shall be free from defects like discolored patches, bare spots, unevenness of coating, spelter which is loosely attached to the steel, globules, spiky deposits, blistered surface, flaking or peeling off etc. The presence of any of these defects noticed on visual or microscopic inspection shall render the material liable to rejection.

e) There shall be no flaking or loosening when struck squarely with a chisel faced hammer. The galvanized components shall withstand minimum four one minute dips in standard copper sulphate solution as per IS: 2633.

f) Defect in any component indicating presence of impurities in the galvanizing bath in quantities larger than that permitted by the specifications, or lack of quality control in any manner in the galvanizing plant, shall render the entire production in the relevant shift liable to rejection.

8.0 BALL AND SOCKET DESIGNATION:

The dimensions of ball and socket for 120 KN and 160 KN discs shall be 20 mm in accordance with the standard dimensions stated in IS: 2486 (Part II)/IEC:120.

9.0 INTERMEDIATE BALL PIN DESIGNATION:

The dimensions of intermediate ball pin shall be in accordance with standard dimensions stated in IEC:471.

10.0 DIMENSIONAL TOLERANCES:

a) <u>DISC INSULATORS</u>

The dimensions of the disc insulators shall be within the limits specified below:

<u>Diameter of Disc</u> (in mm)	Standard	Maximum	Minimum
120 KN (N)	255	266	244
120 KN (AF)	280	293	267
160 KN (N)	280	293	267
160 KN (AF)	280/305	293/318	267/292

Ball to Ball Spacing between Discs (in mm)

120 KN (N, AF)	145	149	141
160 KN (N, AF)	170	175	165

b) LONGROD INSULATORS

The tolerance on all dimensions e.g. diameter, length and creepage distance shall be as follows:

$\pm$ (0.04d + 1.5) mm when d < 300 mm
$\pm$ (0.025d + 6) mm when d > 300 mm

where d stands for dimensions in millimeters for diameter, length or creepage distance as the case may be.

However, for creepage distance no negative tolerance shall be applicable.

11.0 INTERCHANGEABILITY:

The insulators inclusive of ball and socket fittings shall be of standard design suitable for use with hardware fittings of any make conforming to relevant Indian Standards.

12.0 CORONA AND RIV PERFORMANCE:

All surfaces shall be even, smooth, without cuts, abrasions or projections. No part shall be subjected to excessive localized pressure. The metal parts and porcelain shall not produce any noise-generating corona under all operating conditions. The insulators and metal parts shall be so designed and manufactured that it shall avoid local corona formation and not generate any radio interference beyond specified limit under operating conditions.

13.0 SUITABILITY FOR LIVE LINE MAINTENANCE:

a) The insulators shall be compatible for use with hot line or live line maintenance techniques so that usual hot line operations can be carried out with ease, speed and safety.

b) All insulators shall be designed to facilitate cleaning and insulators shall have minimum practical number of sheds and grooves. All grooves shall be so proportioned that any dust deposit can be removed without difficulty either by wiping with cloth or by remote washing under live line condition.

14.0 FREEDOM FROM DEFECTS:

Insulators shall have none of the following defects:

a) Ball pin shake
b) Cementing defects near the pin like small blowholes, hair cracks, lumps, etc.
c) Sandfall defects on the surface of the insulator.

15.0 STRING CHARACTERISTICS:

The characteristic of the complete string shall be as follows:

Sr. No.	STRING TYPE ►		SUSPENSION			TENSION		
	complete str Including co Rings, arcin		400 KV	220 KV	132 KV	400 KV	220 KV	132 KV
1	Switching Surge Withstand Voltage (Dry & Wet) (KVp)	N	1050	--	--	1050	--	--
		AF	1050	--	--	1050	--	--
2	Dry Lightning Impulse Withstand Voltage (KVp)	N	1600	1050	650	1700	1050	675
		AF		1080	670		1110	690
3	50% Lightning Impulse flashover voltage (KVp)	N	1650	1100	680	1770	1100	710
		AF		1130	700		1125	720
4	Dry Power frequency withstand voltage (KV rms)	N	740	510	335	740	550	375
		AF		520	365		570	380
5	Wet Power frequency withstand voltage (KV rms)	N	690	460	300	690	500	350
		AF		480	330		520	360
6	Corona extinction Voltage (KV rms)	N	320	176	105	320	176	105
		AF	320	176	105	320	176	105
7	Maximum RIV for complete string Including corona Rings, arcing horns, clamps etc. at 1.1 times max. Line to Ground Voltage (μV)	N	500	500	--	500	500	--
		AF	500	500	--	500	500	--
8	Maximum voltage across any disc	N	9%	13%	--	10%	13%	--
		AF	9%	13%	--	10%	13%	--

16.0 TESTS

16.1 TYPE TESTS:

a) The Concessioner shall offer the Insulator that are already type tested within the last five years and manufactured by reputed manufacturer approved by MSETCL. In case the insulators are not type tested within last 5 (five) years as on the date of opening of bids, fresh type tests as specified hereunder shall be carried out in presence of purchaser’s representative before supply of materials

b) In case of manufacturers of foreign origin, reports for all the type tests specified under Clause No. 15.1.1 of this specification, conducted in internationally accredited laboratories (accredition based on ISO/IEC vide 25/17025 or EN 45001 by the National accredition body of the country where laboratory is located) or at the manufacturers works in presence of users representative can also be submitted alongwith the offer as evidence to establish the fulfillment of above requirement. However, in such a case all type tests as specified under clause No. 15.1.1 of this specification shall be organised by the successful Concessioner, after award of contract, in presence of Purchaser's representative, at the cost of Concessioner. The arrangement of journey of purchaser’s representative (2 nos.) from his headquarter to the place of testing shall be made by the Concessioner at his cost.

c) In case, the test(s) on insulator have been conducted earlier than 5 years, the respective type test(s) shall be carried out by the successful Concessioner, after award of contract, in presence of purchaser's representative, free of cost.

d) <u>If there is any change in manufacturing process or insulator design since after earlie</u>r passing of the type tests, all the type tests as specified under Clause No. 15.1.1 shall be carried out by the successful Concessioner, after award of contract, in presence of purchaser's representative, free of cost.

16.1.1. LIST OF TYPE TESTS

The list of type tests to be conducted is as follows:

I) <u>On Disc/Longrod Insulator Unit</u>:

Sr. No.	Particulars of test		Reference Standard
a)	Visual examination	}	IS:731
b)	Verification of dimensions test	}	IS: 731
c)	Thermal-Mechanical performance test	} } }	IEC: 575 and Annexure-a of this specification
d)	Power frequency voltage flashover test i) Dry ii) Wet	} } }	IEC:60383
e)	Lightning Impulse voltage withstand test (Dry)	} }	IEC: 60383
f)	50% Lightning Impulse voltage flashover test (Dry)	} }	IEC: 60383
g)	Visible Discharge test (Dry)	}	IS:731
h)	Radio Interference Voltage test (Dry)	} } }	IEC: 60437 & Annex.-a of this specification

i)	Residual strength test (On 160KN disc insulator only)	} }	As per Annex.-a of this specification
j)	Steep wave front test (On 160KN disc insulator only)	} }	As per Annexure - a of this specification

II) On complete insulator string with hardware fittings:

a) The type tests on 132KV and 220KV strings specified hereunder, shall be conducted on Single Suspension (1x70 KN) and Double tension (2x120 KN) insulator strings along with hardware fittings except for mechanical strength test which shall be conducted on all strings mentioned.

b) The type tests on 400KV strings specified hereunder, shall be conducted on Single 'I' Suspension (1x120 KN) and Double tension (2x160 KN) insulator strings alongwith hardware fittings.

Sr. No.	Particulars of test		Reference Standard
A)	<u>On 132KV String of 70KN & 120KN insulators</u>		
a)	Power frequency voltage withstand test i) Dry ii) Wet	} } } }	IEC:60383
b)	Lightning Impulse voltage withstand test (Dry)	}	IEC:60383
c)	50% Lightning Impulse voltage flashover test (Dry)	} }	IEC:60383
d)	Mechanical strength test on i) Single suspension string ii) Double suspension string iii) Single Tension string iv) Double Tension string	} } } } }	As per Annexure-II of this specification
B)	<u>On 220KV String of 70KN & 120KN insulators</u>		
a)	Power frequency voltage withstand test i) Dry ii) Wet	} } }	IEC:60383
b)	Lightning Impulse voltage withstand test (Dry)	} }	IEC:60383
c)	50% Lightning Impulse voltage flashover test (Dry)	} }	IEC:60383

d)	Voltage distribution test (For Disc insulator only)	}	IEC:60383
e)	RIV test under dry condition	} }	As per Annexure-II of this specification
f)	Mechanical strength test on i) Single suspension string ii) Double suspension string iii) Single Tension string iv) Double Tension string	} } } }	As per Annexure-II of this specification
C)	<u>On 400KV String of 120KN & 160KN insulators</u>		
I)	On 1st sample		
a)	Power frequency voltage withstand test with corona control/grading rings and arcing horn i) Dry ii) Wet	} } } }	IEC:60383 and Annexure-a of this specification
b)	Switching Surge voltage withstand test (Wet)	} } }	IEC:60383 and Annexure-a of this specification
c)	Lightning Impulse voltage withstand test (Dry)	} } }	IEC:60383 and Annexure-a of this specification
d)	50% Lightning Impulse voltage flashover test (Dry)	} } }	IEC: 60383 and Annexure-a of this specification
e)	Voltage distribution test	} } }	IEC: 383 and Annexure-a of this specification
f)	Corona and RIV test under dry condition	} }	As per Annexure - a of this specification
g)	Mechanical strength test i) Single 'I' suspension string ii) Double Tension string	} } }	As per Annexure-a of this specification

Sr. No.	Particulars of test	Reference Standard
II)	On 2nd sample	

h)	Dynamic test (Vibration test)	} }	As per Annexure - a of this specification
III)	On 3rd sample		
i)	Time Load test	} }	As per Annexure - a of this specification

16.2 ACCEPTANCE TESTS:

This shall mean those tests, which are to be carried out on samples taken from each lot offered for predespatch inspection for the purpose of acceptance of the lot.

16.2.1 LIST OF ACCEPTANCE TESTS:

The following acceptance tests shall be conducted on 70KN, 120KN and 160KN disc (Porcelain/Glass) / longrod insulators in presence of purchasers representative for the purpose of acceptance of a lot:

Sr. No.	Particulars of test		Reference Standard
a)	Visual examination	}	IS:731
b)	Verification of dimensions	}	IS: 731
c)	Temperature cycle test	}	IS: 731
d)	Galvanizing test	}	IS: 731
e)	Mechanical performance test	}	IEC: 60575
f)	Test on locking device for ball and socket coupling	} }	IS: 2486(IV)
g)	Eccentricity test (Axial & Radial Runout)	}	IEC:60383/60168
h)	Electro-mechanical strength test	}	IS: 731
i)	Puncture test (Only for Porcelain Disc insulators)	}	IS: 731
j)	Porosity test (Only for Porcelain Disc insulators)	}	IS: 731
k)	Thermal shock test (Only for Glass Disc insulators)	}	IEC:60383
l)	Steep wave front test/Puncture test (Only for Glass Disc insulators)	} }	As per Annexure - a of this specification
m)	Mechanical failing load Test (Only for Glass Disc insulators)	} }	As per Annexure - a of this specification
n)	Power frequency voltage withstand test (Dry) (Only on Disc insulator)	} }	IEC: 60383

o)	Mechanical strength test (On longrod insulator only)	}	IEC:60383-1

16.3 ROUTINE TESTS:

This shall mean those tests, which are to be carried out on each insulator to check the requirements which are likely to vary during production.

16.3.1 LIST OF ROUTINE TESTS:

The following routine tests shall be conducted on each insulator and results certified by the manufacturer:

Sr. No.	Particulars of test	Reference Standard
a)	Visual Inspection	IS: 731
b)	Mechanical routine test	IS: 731
c)	Electrical routine test (For disc insulator only)	IEC: 60383
d)	Thermal shock routine test (for glass insulator only)	IEC: 60383
e)	Polarised Light Inspection (for glass insulator only)	As per Annexure - a of this specification

16.4 TESTS DURING MANUFACTURING:

Stage tests during manufacturing shall mean those tests, which are to be carried out during the process of manufacturing to ensure quality control such that the end product is of the designed quality conforming to the intent of this specification.

16.4.1 LIST OF TESTS DURING MANUFACTURING:

The following tests, including but not limited to, shall be conducted on raw and in process material during the process of manufacturing:

Sr. No.	Particulars of test		Reference Standard
a)	Fineness, Raw appearance, Fired appearance, Free Magnetic Iron content, Grain size, Chemical /International/ Analysis, Free Moisture Content on raw materials like Quartz Powder, Feldspar Powder, China Clay, Ball Clay etc.	}	Relevant Indian Plant standard
b)	Raw appearance, Fired appearance, Chemical Analysis of Glaze material	}	Relevant Indian /International/
c)	Visual inspection, Grain size, Compressive Strength, Optimum water content, Initial and final setting time, Auto Clave Expansion of Cement	}	Relevant Indian /International/

d)	Hydraulic Pressure Proof load test, High Frequency test on Porcelain Shell	} Relevant Indian /International/
e)	Visual inspection, Dimension/Guage Checking, Chemical Analysis, Tensile Strength, Hardness, Grain size, Inclusion rating, Heat treatment, Magnetic Particle Inspection on ball pins	} As per Annexure - a of this specification
f)	Visual inspection, Dimension/ Guage Checking, Chemical Analysis, Tensile Strength, Hardness, Microstructure, Magnetic Particle Inspection on MCI caps	} As per Annexure - a of this specification
g)	Visual inspection, Dimensional verification, Resistance to Bending, Operation test, Hardness test on Security Clip	} As per Annexure - a of this specification
h)	Chemical analysis of Zinc used for galvanizing	} As per Annexure - a of this specification

17.0 TEST VALUES:

For all type and acceptance tests, the acceptance values shall be the values guaranteed by the Concessioner in the guaranteed technical particulars or the acceptance value specified in this specification or the relevant standard whichever is more stringent for that particular test.

18.0 TEST PROCEDURE AND SAMPLING NORMS:

a) The test procedure and sampling norms for carrying out type tests; acceptance tests and routine tests shall be as per reference standards specified under clause No. 15.0 of this specification.

b) The test procedure and sampling norms for carrying out tests during manufacturing shall be as per relevant Indian/ International Standard where applicable and plant standard for others. The sampling norm for conducting tests on bought out items shall be as outlined in Annexure-a of this specification.

c) The Concessioner shall furnish details regarding sampling norm and reference standard followed, in Quality Assurance Plan.

19.0 ADDITIONAL TESTS:

The Purchaser reserves the right for carrying out any other test(s) of a reasonable nature at the works of the supplier or at any other recognized laboratory/research institute in addition to the above mentioned type, acceptance and routine tests at the cost of the Purchaser to satisfy himself that the material complies with the intent of this specification.

20.0 IDENTIFICATION MARK:

a) The shell of each disc/longrod insulator shall be legibly and indelibly marked with the trade mark/name of the manufacturer, the month and year of manufacture, country of manufacture, guaranteed electro-mechanical strength in Kilo-Newton's abbreviated by 'KN' to facilitate easy identification and proper use. The marking shall be printed and not impressed and the same shall be applied before firing.
b) The metal cap of each disc/longrod insulator shall bear the name of manufacturer by embossing. The identifying letters shall be at least 5 mm high. The characters shall be distinct, durable, and conspicuous after galvanizing.

21.0 INSPECTION:

a) The work and materials covered by this specification shall be subject to inspection by the authorised representative of the Purchaser at manufacturer's/ sub-vendors work.
b) Inspector shall have free access at all times to all parts of the shop where raw material is stacked, and where material is being manufactured and shall be provided with all reasonable facilities for inspection and tests. Equipments and instruments required for carrying out the tests shall be furnished by the manufacturer. No material shall be dispatched without inspection unless such inspection is waived in writing by Purchaser.
c) Inspection by inspector or waival of inspection shall neither relieve the manufacturer from the responsibility of supplying materials confirming to the requirements of this specification nor invalidate any claims which may be made because of defective or unsatisfactory material, workmanship, galvanizing etc.
d) The correct grade and quality of raw material shall be used by the manufacturer. To ascertain the grade of material, the Purchaser may at his discretion get the material tested at an approved laboratory of his choice.
e) The arrangement of journey (by air) of purchaser's representative (2 nos.) from his headquarter to the place of testing and boarding/lodging shall be made by the Concessioner at his cost.

22.0 PACKING & FORWARDING:

a) All disc/longrod insulators shall be packed in strong seasoned wooden crates. The gross weight of the crates alongwith insulators shall not normally exceed 50 Kg for disc insulators and 65 Kg for longrod insulators to avoid handling problem.
b) The packing shall be of sufficient strength to withstand rough handling during transit, storage at site and subsequent handling in the field.
c) Suitable cushioning, protective padding, dunnage or spacers shall be provided to prevent damage or deformation during transit and handling.
d) All packing cases shall be marked legibly and correctly so as to ensure safe arrival

at their destination and avoid the possibility of goods being lost or wrongly despatched on account of faulty packing and faulty or illegible markings. Each wooden case/crate shall have all the markings stenciled on it in indelible ink.

23.0 GUARANTEED TECHNICAL PARTICULARS FOR INSULATORS:

The Guaranteed Technical Particulars for Insulators enclosed as SCHEDULE- "IIC" shall be duly filled in and submitted along with the offer.

SCHEDULE- IIC

A) GUARANTEED TECHNICAL PARTICULARS FOR UNIT DISC INSULATOR

Sr. No.	INSULATOR TYPE ► PARTICULARS ▼	70 KN (N)	70 KN (AF)	120 KN (N)	120 KN (AF)	160 KN (N)	120 KN (AF)
1)	Manufacturers name, address and country						
2)	Size and designation of Ball & Socket and standard to which it will conform (mm)						
3)	Outside diameter of disc (mm)						
4)	Spacing (mm)						
5)	Eccentricity of disc						
a)	Axial runout(mm)						
b)	Radial runout(mm)						
6)	Creepage distance of disc (mm)						
7)	Electro-mechanical strength of disc(KN)						
8)	Withstand voltage of disc						
8.1	Power frequency						
a)	Dry (kV rms)						
b)	Wet (kV rms)						
8.2	Impulse voltage (1.2/50 µsec)						

a)	+ve (kV peak)						
b)	−ve (kV peak)						
9)	Flashover voltage of disc						
9.1	Power frequency						
a)	Dry (kV rms)						
b)	Wet (kV rms)						
9.2	50% Lightning impulse voltage (1.2/50 µsec)						
a)	+ve (kV peak)						
b)	−ve (kV peak)						
10)	Corona inception voltage (kV rms)						
11)	Corona extinction voltage (kV rms)						
12)	Max. RIV at 1 MHz and 10 KV AC (rms)						
13)	Weight of each disc (kgs)						

SCHEDULE- IIC

B) GUARANTEED TECHNICAL PARTICULARS FOR 132KV AND 220KV DISC / LONGROD INSULATOR STRING

Sr. No.	STRING TYPE ▶ PARTICULARS ▼	SINGLE SUSPENS-ION (70 KN)	DOUBLE SUSPENS-ION (2x70KN)	SINGLE TENSION (120KN)	DOUBLE TENSION (2x120 KN)
1)	No. of insulator discs per string				
2)	Withstand voltage of complete string				
2.1	Power frequency				
a)	Dry (kV rms)				
b)	Wet (kV rms)				
2.2	Impulse voltage (1.2/50 µsec)				
a)	+ve (kV peak)				
b)	−ve (kV peak)				
3)	Flashover voltage of complete string				
3.1	Power frequency				
a)	Dry (kV rms)				
b)	Wet (kV rms)				
3.2	50% Lightning impulse voltage (1.2/50 µsec)				
a	+ve (kV peak)				
b	−ve (kV peak				
4	Corona inception voltage (kV rms)				

Sr. No.	STRING TYPE ► PARTICULARS ▼	SINGLE SUSPENS-ION (70 KN)	DOUBLE SUSPENS-ION (2x70KN)	SINGLE TENSIO N (120KN)	DOUBLE TENSIO N (2x120 KN)
5)	Corona extinction voltage (kV rms)				
6)	Max. RIV for complete string including corona rings, arcing horns, clamps etc. at 1.1 times maximum line to ground voltage (in µvolts)				
7)	Max. voltage (%) across any disc in the string				
8)	Electromechanical strength of complete string (KN)				

SCHEDULE- IIC

C) GUARANTEED TECHNICAL PARTICULARS FOR 400 KV DISC / LONGROD INSULATOR STRING

Sr. No.	STRING TYPE ► PARTICULARS ▼	SINGLE SUSPENS-ION (70 KN)	DOUBLE SUSPENS-ION (2x70KN)	SINGLE TENSIO N (120KN)	DOUBLE TENSIO N (2x120 KN)
1)	No. of insulator discs per string				
2)	Withstand voltage of complete string				
2.1	Power frequency				
a)	Dry (kV rms)				
b)	Wet (kV rms)				
2.2	Impulse voltage (1.2/50 µsec)				
a)	+ve (kV peak)				
b)	−ve (kV peak)				
3)	Flashover voltage of complete string				
3.1	Power frequency				
a)	Dry (kV rms)				
b)	Wet (kV rms)				
3.2	50% Lightning impulse voltage (1.2/50 µsec)				
a	+ve (kV peak)				
b	−ve (kV peak				
4	Corona inception voltage (kV rms)				
Sr. No.	STRING TYPE ► PARTICULARS ▼	SINGLE SUSPENS-ION (70 KN)	DOUBLE SUSPENS-ION (2x70KN)	SINGLE TENSIO N (120KN)	DOUBLE TENSIO N (2x120 KN)
5)	Corona extinction voltage (kV rms)				

6)	Max. RIV for complete string including corona rings, arcing horns, clamps etc. at 1.1 times maximum line to ground voltage (in µvolts)				
7)	Max. voltage (%) across any disc in the string				
8)	Electromechanical strength of complete string (KN)				

ANNEXURE - a
TEST PROCEDURE

1.0 PROCEDURE FOR MOUNTING INDIVIDUAL DISC AND COMPLETE STRING FOR MEASUREMENT OF RIV, VOLTAGE DISTRIBUTION & VISIBLE DISCHARGE:

a) The insulator unit or insulator string shall be suspended vertically by means of an earthed wire rope or other suitable means from a supporting structure. The distance between the upper most point of the insulator metal work and the supporting structure shall be not less than 1 meter. No other object shall be nearer to the insulator than 1 meter or 1.5 times the length of the insulator string, whichever is greater. A length of conductor in the form of a straight smooth metal rod or tube shall be attached to the lower integral fitting of the insulator unit or insulator string so that it lies in a horizontal plane and the distance from the lowest shed of porcelain part to the upper surface of the conductor shall be as short as possible but greater than 0.5 times the diameter of the lowest insulator.
b) The diameter of the conductor shall be about 1.5% of the length of the insulator unit or insulator string with a minimum of 25 mm.
c) The length of the conductor shall be at least 1.5 times that of the insulator unit or insulator string and it shall extend at least 1 meter on each side of the vertical axis.
d) Precaution shall be taken to avoid flashover from the ends of the conductor.
e) The test voltage shall be applied between the conductor and earth.

2.0 MOUNTING PROCEDURE FOR COMPLETE STRING FOR WET POWER FREQUENCY, WET SWITCHING SURGE AND DRY IMPULSE WITHSTAND TESTS:

a) The insulator string shall be suspended vertically in an arrangement simulating a tower body and cross arm. The cross arm is simulated by a horizontal member, the insulator string being at one end and the vertical member simulating the tower body at the other. Both members and the link supporting the insulator string shall be earthed. The width of each member facing the insulator string shall be from 400 mm minimum to at least 20% of the length of the insulator string. The distance between the axis of the insulator string and the vertical member simulating the tower body shall be between 1.2 and 1.5 times the length of the insulator string. The distance between the upper most point of the insulator string and the lower part of the horizontal member simulating the cross arm shall be equal to about 300 mm. The member simulating the tower body shall extend to at least twice the length of the insulator string below the member simulating the tower cross arm.
b) A bundle consisting of two/quad sub conductors in the form of straight smooth metal rods or tubes shall be attached to the lower integral fittings of the insulator string at right angles to the cross arm. The two/quad sub conductors of the bundle shall be maintained parallel by means of horizontal spacers, the sub conductor spacing shall be equal to about one tenth of the length of the insulator string. The bundle shall extend approximately for the length of the insulator string on each side of the axis of the insulator string and diameter of each sub conductor shall be between 0.75% and 1.25% of the length of insulator string. To avoid spark over from the two ends of the bundle, each end shall be protected by means of a suitable device (for instance by means of metal ring). The height of the conductor above ground shall be equal to about 1.5 times the length of the insulator string

but not less than 6 meters.

c) The test voltage shall be applied between the conductor bundle and earth, the H.V. connection being made at one end of the conductor bundle.
d) During the test, no object other than those described in this clause shall be nearer to the live end of the insulator string than 1.5 times the length of string.
e) The insulator string shall be complete with those parts, which are considered necessarily associated with the string and are specified as such by the manufacturer.

3.0 TESTING PROCEDURE FOR DYNAMIC TEST (VIBRATION TEST):

Complete string is to be subjected to aeolian vibrations by suitable arrangement, while keeping the tension at every day stress (e.d.s). The string shall be vibrated at frequencies and double amplitude as already agreed between purchaser and supplier for 10 million cycles. After 5 million cycles, the string shall be rotated through 90 in horizontal plane. For 'V'/'I' suspension string & quad tension string, the e.d.s. will be 4600 kgs per conductor. All discs shall be thoroughly checked for any damage, cracks, loosening of pins/caps. Thereafter, all the discs will be subjected to electrical routine test, electro mechanical failing load test and porosity test. The string shall be deemed to have passed the dynamic test if it withstands all these tests.

4.0 TESTING PROCEDURE FOR WET POWER FREQUENCY WITHSTAND TEST :(As per IEC: 60383/IS: 731)

a) The insulator string shall be mounted as per mounting arrangement given above in Clause 2.0.
b) The characteristics of artificial rain shall be in accordance with Clause 3.3 of IS 2071 (Part-I).
c) The test voltage to be applied to the insulator string shall be the wet power frequency withstands voltage adjusted for atmospheric conditions at the time of test.
d) A voltage of about 75% of the test voltage so determined shall be applied and then increased gradually with a rate of rise of about 2% of this voltage per second. The test voltage at full value shall be maintained for one minute. No flashover or puncture shall occur during this period.

5.0 TESTING PROCEDURE FOR WET SWITCHING SURGE WITHSTAND TEST: (As per IEC: 60381/IS: 731)

a) The insulator string shall be mounted as per mounting arrangement given above (Clause 2.0). The impulse generator shall be adjusted to produce a 250/2500 μ second impulse wave. Impulse waves of both positive and negative polarity shall be used. Wet tests shall be made under the conditions prescribed in specified standards.
b) The withstand test shall be performed at a specified switching impulse voltage with application of corrections for atmospheric conditions. Fifteen impulses shall be applied to the insulator string under test. If the number of flashovers on the external insulation does not exceed two, the insulator string shall be deemed to have complied with this test requirement.

c) The insulators shall not be damaged by the test but slight marks on the surface of the insulating parts or chipping of the cement or other material used for assembly is permitted.

6.0 TESTING PROCEDURE FOR DRY LIGHTNING IMPULSE VOLTAGE WITHSTAND TEST: (As per IEC: 60383/IS: 731)

a) The insulator string shall be arranged as per mounting arrangement given above (Clause 2.0). Impulse waves of both positive and negative polarity shall be used. However, when it is evident which polarity will give the lowest flashover voltage it will suffice to test with that polarity.

b) The impulse generator shall be adjusted to produce a standard 1.2/50 µ second impulse wave of a value equal to the specified value of the impulse withstand voltage corrected for atmospheric conditions.

c) Five such impulses shall be applied. If there is no flashover or puncture, the insulator shall be considered to have passed the test. If during the application of these five impulses, puncture occurs or if there is more than one flashover, the insulator shall be considered to have failed to comply with the test requirement. If only one flashover occurs, a new series of ten impulses shall be applied. The insulator will be considered to have passed the test only if during this new series of impulses there is no flashover or puncture.

d) The insulators shall not be damaged by the test but slight marks on the surface of the insulating parts or chipping of the cement or other material used for assembly is permitted.

7.0 TESTING PROCEDURE FOR MECHANICAL STRENGTH TEST ON STRING:

a) The complete disc/longrod insulator string consisting of number of units as stipulated alongwith its hardware fitting excluding arcing horn, corona control ring/grading ring and suspension/dead end assembly shall be mounted in the Tensile Testing Machine.

b) The assembly shall then be subjected to a tensile load equal to 50% of the specified minimum ultimate tensile strength (UTS) which shall be increased at a steady rate to 67% of the minimum UTS specified. This load shall be maintained on the string for five minutes and then removed. After removal of the load the string shall be unloaded and dismantled with hand or small hand tools and the string components shall be inspected for visual deformation. Should any difficulty be experienced in dismantling and re-assembling the string with hand or small hand tool and/or if there is any visual deformation caused by the application of the above load, the string shall be deemed to have failed in this test.

c) If the string can be re-assembled, it shall again be mounted in the tensile testing machine and loaded up to 50% of UTS and the load shall be further increased at a steady rate till the specified minimum UTS is reached and held there for one minute. No fracture should occur during this period. The applied load shall then be increased until the failing load is reached and the value recorded. The string shall be deemed to have passed the test if the breakage occurs at a load not lower than guaranteed E&M strength.

8.0 TESTING PROCEDURE FOR TIME LOAD TEST:

a) The insulator string shall first be subjected to 5 minutes power frequency routine test. After successful completion of this test, the insulator string shall be mounted vertically/horizontally and subjected to a load equal to 66% of the specified mechanical strength for duration of 24 hours.

b) After the completion of above period if the string is found to be intact on visual examination, it shall again be subjected to 5 minutes power frequency routine test. The string shall be deemed to have passed the time load test if it successfully withstands 5 minutes power frequency routine test.

9.0 TESTING PROCEDURE FOR VOLTAGE DISTRIBUTION TEST:

The voltage across each insulator unit shall be measured by sphere gap method. The result obtained shall be converted into percentage and proportionate correction be applied so as to give a total of 100% distribution. The voltage across any disc shall not exceed the specified values.

10.0 TESTING PROCEDURE FOR CORONA EXTINCTION VOLTAGE TEST (Dry):

The sample assembly when subjected to power frequency voltage shall have a corona extinction voltage of not less than the value specified under dry condition.

There shall be no evidence of corona on any part of the sample when all possible sources of corona are photographed in a darkened room.

11.0 TESTS ON INDIVIDUAL DISCS:

11.1 VISUAL EXAMINATION:

a) Visual examination shall be made at random on the lot of insulators. The color of the insulator shall approximate to the color specified. Some variation of color shade is permitted and shall not justify rejection of the insulator. The insulator shall be free from physical distortion of shape within tolerance specified. Defects such as looseness of pins/caps, cracks etc. in the metal part shall be checked.

b) The area specified as glazed on the drawing shall be covered by a smooth hard glaze, free from cracks and other defects prejudicial to satisfactory performance in service.

c) Out of the areas specified as glazed on the drawing the total area not covered by glaze shall not exceed.

$$1 + \frac{DF}{2000}\ cm^2$$

Also the area of any single glaze defect shall not exceed:

$$0.5 + \frac{DF}{20000}\ cm^2$$

Where:

D is the greatest diameter of the insulator in cm.
F is the creepage distance of the insulator in cm.

11.2 VERIFICATION OF DIMENSIONS:

The dimension of the insulator shall be checked with the approved drawing. Unless otherwise specified, the tolerance in the diameter shall be:

± (0.04D + 1.5) mm for D less than or equal to 300 mm and ± (0.03D + 6) mm for D more than 300 mm.

Where: D = Specified insulator diameter in mm.
The tolerance in spacing shall be ± (0.03S + 0.3) mm. Where:
S = Specified insulator spacing in mm.

11.3 ECCENTRICITY TEST (AXIAL RUNOUT & RADIAL RUNOUT):

The insulator shall be vertically mounted on a fixture using dummy pin and socket. A vertical scale with horizontal slider shall be used for the axial run out. The pointer shall be positioned in contact with the bottom of the outermost petticot of the disc. The disc insulators shall be rotated with reference to the fixture and the slider shall be allowed to move up and down on the scale but always maintaining contact with the bottom of the outermost petticot. After one full rotation of the disc the maximum and minimum position the slider has reached on the scale can be found out. Difference between the above two readings shall satisfy the guaranteed value for axial run out.

Similarly, using a horizontal scale with vertical slider the radial run out shall be measured. The slider shall be positioned on the scale to establish contact with the circumference of the disc insulator and disc insulator rotated on its fixture always maintaining the contact. After one full rotation the maximum and minimum position of the slider reached on the scale are found out. The difference between the above readings shall satisfy the guaranteed value for radial run out.

11.4 DRY LIGHTNING IMPULSE VOLTAGE WITHSTAND TEST:

Please refer to Clause No. 6.0 for Testing Procedure.

11.5 WET POWER FREQUENCY WITHSTAND TEST:

Please refer to Clause No. 4.0 for Testing procedure.

11.6 RADIO INTERFERENCE VOLTAGE TEST :(As per IS 8263)

a) Insulator string or insulators shall be mounted as per mounting arrangement given above (Clause 1). As radio interference level may be affected by fibres or dust setting on the insulator, the insulators may be wiped with a clean cloth before taking a measurement. The atmospheric conditions during tests shall be recorded. It is not known what correction factors apply to radio interference testing, but it is known that test may be sensitive to high relative humidity exceeding 80%.
b) The test circuits may be either NEMA-107 or as per Fig.1 of IS: 8263. The measuring set shall be tuned to 1MHz + 10% frequency and the results shall be

expressed as dB above 1 µ volt across a resistance of 300 Ohm.

c) A voltage of 10% higher than the specified test voltage shall be applied to the object under test and maintained for at least 5 minutes. The voltage shall then be decreased by steps down to 30% of the specified test voltage, raised again by steps to the initial value and finally decreased by steps to the 30% value. At each step, a radio interference level as recorded during third run v/s the applied voltage shall be plotted.

The curve so obtained is the radio interference characteristics of the insulator. Each voltage step shall be approximately 10% of the specified test voltage.

d) The insulator unit passes the radio interference test if the radio interference level at the specified test voltage, as read from the radio interference characteristic, does not exceed the specified radio interference level. Furthermore, no sudden increase shall be found on the radio interference characteristic between the specified test voltage and 1.1 times the specified test voltage. Because of high variability, it is preferable to make radio interference measurements on a number of insulators. The radio interference characteristic is the mean corona obtained after taking into account all measurements made on insulators of one type.

11.7 TEST PROCEDURE FOR THERMAL-MECHANICAL PERFORMANCE TEST (As per IEC 575)

The test shall be conducted on string of 5 or 10 or 15 units.

a) This test has an initial stage of thermal cycles together with mechanical loading and unloading and a concluding stage of testing the insulator units to failure. Such a failing load test constitutes the basis of the thermal mechanical performance test in judging the test results.

b) During the initial stage of test, the insulator units shall be subjected to four 24 hours cycles of cooling and heating and to a tensile load equal to 60% of the specified electro-mechanical failing load. The tensile load shall be applied to the insulator units at room temperature before starting the first thermal cycle.

c) Each 24 hours cycle shall comprise a cooling to -30 ± 5^0 C and a heating to +40 ± 5^0 C. The temperature limits for temporary range of 40^0 C may be suitably changed where the prevailing conditions so require. The temperature sequence shall be first cooling, then heating. The temperature equipment shall be such as to permit keeping of minimum and maximum temperatures each for at least four consecutive hours of the temperature cycle.

d) The tensile load shall be completely removed and reapplied towards the end of each heating period, the last one excepted.

e) On completion of the fourth 24 hours cycle and cooling to room temperature the tensile load shall be removed on the same day. After this load removal, the insulator units shall be subjected individually to an electromechanical strength test.

f) The performance of insulator unit will be determined by comparison of the failing load values and the fracture pattern obtained during the electromechanical strength test.

11.8 RESIDUAL STRENGTH TEST

The test shall be conducted in accordance with clause No. 4.4 and 4.5 of IEC: 797 proceeded by temperature cycle test. The sample size shall be 25 and the evaluation of results and acceptance criteria shall be as per Clause No. 4.6 of IEC: 797.

11.9 POLARISED LIGHT INSPECTION (Only for Glass Disc Insulator)

The disc insulator shall be held over a polarised light source and the stress lines viewed thereon. There shall be no uneven stress distribution in the toughened glass insulators. This shall be carried out on 100% glass shells.

11.10 STEEP WAVE FRONT TEST (Only for Glass Disc Insulator)

Following test shall be performed on 10 insulator units in case of disc insulators selected at random from the lot offered for inspection.

a) Each insulator unit shall be subjected to five successive positive and negative impulse flashovers with a wave having minimum effective rate of rise of 2500 kV per microseconds.

b) Each unit shall then be subjected to three dry power frequency voltage flashovers.

Acceptance Criteria

An insulator shall be deemed to have met the requirement of this test if, having been successfully subjected to the ten impulse flashovers, the arithmetic mean of the three subsequent dry power frequency voltage flashover values equals or exceeds 95% of the rated dry power frequency flashover voltage.

An insulator shall be deemed to have failed to meet the requirement of above testing if,

(a) It has not flash over when the oscillogram or peak voltage indicator shows a marked reduction in voltage.

or

(b) Any one of the subsequent three dry power frequency voltage flashover value is less than 80% of the value specified.

In case of failure of any one unit either in the steep wave front or subsequent low frequency voltage test, above tests shall be conducted on double number of units.

11.11 MECHANICAL FAILING LOAD TEST

The test shall be performed in accordance with clause No. 18 and 19 of IEC 383 with the following acceptance criteria:

(i) X greater than or equal to R + 3S

Where
X = Mean value of the electro-mechanical/mechanical failing load. R
= Rated electro-mechanical / mechanical failing load.
S = Standard deviation.

(ii) The minimum sample size shall be taken as 20 for disc insulators units and 5 for long rod units. However, for larger lot size, IEC 591 shall be applicable.

(iii) The individual electro-mechanical/mechanical failing load shall be at least equal to the rated value. Also electrical puncture shall not occur before the ultimate fracture.

12.0 HYDRAULIC INTERNAL PRESSURE TEST ON SHELLS:

The test shall be carried out on 100% disc insulator shells before assembly. The insulator should withstand required pressure for the preset time of one second (min.) without breaking.

13.0 HIGH FREQUENCY TEST ON SHELLS:

The test shall be carried out on 100% disc insulator shells before assembly. The insulators should withstand applied High Frequency voltage for 5 minutes without puncture.

A) TESTS ON BOUGHT-OUT ITEMS:

1) Forged Components (Ball Pins):

a) <u>Visual inspection</u>: All material (100% samples) shall be visually checked for forging defects and general appearance.

b) <u>Dimensional check</u>: At random check of not less than 1 sample per lot. The acceptance norm shall be dimensions as per drawing.

c) <u>Guage Check</u>: The test shall be conducted on 100% samples with 'GO' and 'NO GO' gauges. The acceptance norm shall be dimensions as per approved drawing/relevant IS.

d) <u>Normalising</u>: Time temperature chart/Graph from output of recorder shall be verified. The same shall conform to required standard.

e) <u>Hardness test</u>: The test shall be conducted on minimum of 2 samples per lot of 1000 nos. The acceptance norm shall be hardness as per IS:1500/175-210 BHN.

f) <u>Grain Size</u>: The test shall be conducted on minimum of 2 samples per lot of 1000 nos. The acceptance norm shall be grain size of 6 microns and above (ASTM No. 6 and above).

g) <u>Inclusion rating</u>: The test shall be conducted as per IS: 4163 on minimum of 1 sample per lot of 1000 nos. The acceptance norm shall be inclusion rating of ASTM 2 thick series or less.

h) <u>Chemical analysis</u>: The test shall be conducted on minimum of 1 sample per lot per heat no. The acceptance norm shall be chemical composition as per BS: 970 for EN-8D steel or equivalent.

i) <u>Failing Load test</u>: At random check of not less than 2 samples per lot of 1000 nos. The sample shall be subjected to proof load limit and held for one minute. The load shall be released and there shall not be any crack or permanent deformation.

Thereafter, the sample shall be subjected to further loading up to its recommended breaking load and actual breaking load shall be noted.

j) Magnetic Particle Examination: The test shall be conducted on 100% samples as per IS: 3703 for detection of longitudinal and transverse cracks. There shall not be any surface or sub-surface cracks.

2) Malleable Cast Iron Cap:

a) Visual inspection: All material (100% samples) shall be visually checked for freedom from casting defects and identification mark. The surface shall be free from casting defects and shall be cleanly fettled. The cap shall bear identification mark of the manufacturer.

b) Dimensional check: At random check of not less than 1 sample per lot of 1000 nos. The acceptance norm shall be dimensions as per drawing.

c) Guage Check: The test shall be conducted on 100% samples with 'GO' and 'NO GO' gauges. The acceptance norm shall be dimensions as per approved drawing/relevant IS.

d) Hardness test: The test shall be conducted on minimum of 2 samples per lot of 1000 nos. The acceptance norm shall be hardness as per IS:2108/150 BHN max.

e) Chemical analysis: The test shall be conducted on minimum of 1 sample per 5000 nos. The acceptance norm shall be chemical composition confirming to grade BM:320 or equivalent.

f) Failing Load test: At random check of not less than 2 samples per lot of 1000 nos. The sample shall be subjected to proof load limit and held for one minute. The load shall be released and there shall not be any crack or permanent deformation. Thereafter, the sample shall be subjected to further loading upto its recommended breaking load and actual breaking load shall be noted.

g) Magnetic Particle Examination: The test shall be conducted on 100% samples as per IS:3703 for detection of longitudinal and transverse cracks. There shall not be any surface or sub-surface cracks.

3) Security clip:

a) Visual inspection: All material (100% samples) samples shall be inspected for corrosion and surface irregularities. The acceptance norm shall be as per IS:3063.

b) Dimensional check: At random check of not less than 1% sample per lot. The acceptance norm shall be dimensions as per IEC: 372/ IS: 2486(IV).

c) Resistance to bending: At random check of not less than 1 sample per lot. The acceptance norm shall be as per IEC: 372/IS: 2486(IV).

d) Operation test: At random check of not less than 1 sample per lot. The acceptance norm shall be as per IEC: 372/IS: 2486(IV).

e) Hardness test: At random check of not less than 2 samples per lot. The acceptance norm shall be hardness not less than 152 BHN for R-clip and 143 BHN for W-clip.

f) Chemical analysis: At random check of not less than 1 sample per lot. The acceptance norm shall be chemical composition confirming to AISI: 304/316 grade as per ASTM A 276.

B) Hot Dip Galvanized components:

I) Test on Raw material

1) Chemical analysis of Zinc: At random check of not less than one sample per lot. The acceptance norm shall be grade Zn98 (% of zinc > 99.95%) as per IS: 209.

II) Galvanizing checking:

1) Visual inspection: All material (100% samples) shall be visually checked as per IS: 2629. The finished surface shall be clean, smooth and shall be free from defects like discoloured patches, bare spots, unevenness of coating, spelter which is loosely attached to the steel, globules, spiky deposits, blistered surface, flaking or peeling off etc.

2) Uniformity of zinc coating: At random check of not less than 2 samples per lot. The test shall be conducted as per IS: 2633 and the samples shall withstand minimum 4 dips of 1 minute each in standard $CuSO_4$ solution without showing signs of red deposits of copper.

3) Thickness of zinc coating: At random check of not less than 1 sample per lot. The acceptance norm shall be thickness of coating not less than 610 gms/mm^2.

4) Adherence of zinc coating: At random check of not less than 2 samples per lot. There shall be no flaking or loosening when struck squarely with a chisel faced hammer.

ANNEXURE- VII

TECHNICAL SPECIFICATION FOR 0.2 ACSR "PANTHER" AND 0.4 ACSR "ZEBRA" CONDUCTOR FOR EHV TRANSMISSION SCHEMES

1.0 GENERAL

This section details on the ACSR aluminum conductors to be used for the 220 kv and 132 kv overhead transmission lines

1.1. This specification provides for design, manufacture, engineering, inspection and testing before dispatch, packing and delivery of ALUMINIUM CONDUCTOR STEEL REINFORSED (ACSR) for EHV overhead transmission purposes in Maharashtra State.

2.0 STANDARDS

2.1. Except as modified in this Specification, the conductor shall conform to the following Indian Standards, which shall mean latest revisions, amendments thereof. Equivalent International and Internationally recognized standard to which some of these standards generally correspond are also listed below:

Sr.No.	Indian Standards	Title	International Standards
1	IS:209	Specification for Zinc	BS:3436
2	IS:398 Part I to Part V as relevant	Specification for Aluminium conductors for overhead Transmission purpose.	IEC:209, BS:215(Part II).
3	IS:1778	Reels and Drums for Bare conductors.	BS:1559
4	IS:1521	Method of Tensile Testing of Steel wire.	ISO/R89
5	IS:2629	Recommended practice for Hot Dip Galvanising of Iron and Steel.	
6	IS:2633	Method of Testing of Uniformity of coating of Zinc Coated Articles	
7	IS:4826	Galvanised Coating on Round Steel Wire.	ASTM A-472 729.
8	IS:6745	Methods of Determination of weight of Zinc Coating of zinc coated Iron & Steel Articles.	Bs:443
9	IS:1841	EC grade Aluminium rod produced by rolling(Second Revision).	
10	IS:5484	EC grade Aluminium rod produced by continuous casting and rolling (First Revision).	
11	IS:7623	Specification for Lithium Soap Grease.	

3.0 PRINCIPAL PARAMETERS

3.1. The details of ACSR conductor are tabulated below:

Sr.No.	Particulars	Values For ACSR panther	Values For ACSR Zebra
(a)	Stranding and wire diameter	Aluminium: 30/3.00 mm., Steel: 7/3.00	Aluminium: 54/3.18 mm. , Steel: 7/3.18
		mm.	mm.
(b)	Number of Strands		
	(i) Steel Centre	1	1
	(ii) Ist Steel Layer	6	6
	(iii) Ist Aluminium Layer	12	12
	(iv) 2nd Aluminium Layer	18	18
			24
(c)	Sectional area of Aluminium in Sq. mm.	212.1	428.9
(d)	Sectional area of Steel in Sq. mm.	49.4	55.6
(e)	Total sectional area in Sq.mm.	261.5	484.5
(f)	Overall Diameter in mm.	21.00	28.62
(g)	Approximate weight in Kg/Km.	974	1621
(h)	Calculated D.C. Resistance at 20 degree Celsius in Ohm/Km.	0.1400	0.06915
(i)	Minimum Breaking load in KN	89.67	130.32
(j)	Modulus of Elasticity in GN/Sq.metre.	80.00	69

3.2. The details of Aluminium Strands are as below:

Sr.No.	Particulars	Values For ACSR panther	Values For ACSR Zebra
(a)	Minimum Breaking Load of Strand before stranding in KN	1.17	1.29
(b)	Minimum Breaking Load of Strand after stranding in KN.	1.11	1.23
(c)	Maximum D.C. Resistance of Strand at 20 Degree Celsius in Ohm/Km.	4.107	3.651

3.3. The details of Steel Strands are as below:

Sr.No.	Particulars	Values For ACSR	Values For ACSR Zebra	
(a)	Minimum Breaking Load of Strand before stranding in KN	9.29	10.43	
(b)	Minimum Breaking Load of Strand after stranding in KN.	8.83	9.91	
(c)	Minimum weight of Zinc Coating after stranding in Gm/Sq. Metre	260	260	

4.0 General Technical Requirement .

The conductor shall be suitable for satisfactory operation under the following tropical climatic conditions:

Sr.No.	Particulars	Values
(a)	Maximum Ambient Air Temperature	50 Degree C.
(b)	Minimum Ambient Air Temperature	3.5 Degree C.
(c)	Average Daily Ambient Air Temperature	40 Degree C.
(d)	Relative Humidity	10-100%
(e)	Maximum Rainfall yearly	1450 mm.
(f)	Maximum Altitude above Mean Sea level.	1000 metres
(g)	Maximum Wind Pressure	45 Kg/Sq.m.
(h)	Isoceraunic level	50 days/year.
Sr.No.	Particulars	Values
(a)	Maximum Ambient Air Temperature	50 Degree C.
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(c)	Average Daily Ambient Air Temperature	40 Degree C.
(d)	Relative Humidity	10-100%

(e)	Maximum Rainfall yearly	1450 mm.
(f)	Maximum Altitude above Mean Sea level.	1000 metres
(g)	Maximum Wind Pressure	45 Kg/Sq.m.
(h)	Isoceraunic level	50 days/year.

5.0 PHYSICAL CONSTANTS OF MATERIALS

5.1. Physical Constants of Hard Drawn Aluminium:

(a) Resistivity:

The resistivity of aluminium depends upon its purity and its physical condition. For the purpose of this specification the maximum value permitted is 0.02845 Ohm Sq.mm/mtr.at 20 Degree C and this value has been used for calculation of the maximum permissible value of resistance.

Note: It is not intended to check the resistivity from the measured values of resistance.

(b) Density:

At a temperature of 20 Degree C, the Density of hard drawn Aluminium has been taken as 2.703 gm/cubic cm.

(c) Constant-Mass Temperature Co-Efficient of Resistance:

5.2. PHYSICAL CONSTANTS OF MATERIALS

5.2.1. Physical Constants of Hard Drawn Aluminium:

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The resistivity of aluminium depends upon its purity and its physical condition. For the purpose of this specification the maximum value permitted is 0.02845 Ohm Sq.mm/mtr.at 20 Degree C and this value has been used for calculation of the maximum permissible value of resistance.

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At a temperature of 20 Degree C, the Density of hard drawn Aluminium has been taken as 2.703 gm/cubic cm.

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The resistivity of aluminium depends upon its purity and its physical condition. For the purpose of this specification the maximum value permitted is 0.02845 Ohm Sq.mm/mtr.at 20 Degree C and this value has been used for calculation of the maximum permissible value of resistance.

Note: It is not intended to check the resistivity from the measured values of resistance.

(b) Density:

At a temperature of 20 Degree C, the Density of hard drawn Aluminium has been taken as 2.703 gm/cubic cm.

(c) Constant-Mass Temperature Co-Efficient of Resistance:

At a temperature of 20 Degree C, the constant mass temperature co-efficient of hard drawn aluminium measures between two potential points rigidly fixed to the wire, the metal being allowed to expand freely, has been taken as 0.004 per Degree C.

(d) Co-Efficient of Linear Expansion:

The Co-Efficient of Linear Expansion of hard drawn aluminium at 0 Degree C has been taken as 23×10^{-6} per Degree C. This value holds good for all practical purposes over the range of temperature from 0 Degree C to highest safe operating temperature.

5.3.2. Physical Constants For Galvanised Steel Wires:

(a) Density:

At a temperature of 20 Degree C, the density of galvanised steel wire is to be taken 7.80 gm/cubic cm.

(b) Co-Efficient of Linear Expansion:

In order to obtain uniformity in calculations, a value of 11.5×10^{-6} per Degree C may be taken as the value for the co-efficient of Linear Expansion of galvanised steel wires used for the cores of steel re-in forced aluminium conductors.

5.4. MATERIALS

(a) The conductors shall be manufactured from EC Grade aluminium rods suitably hard-drawn on wire drawing machines. The aluminium rods used shall comply with IS: 1841 and IS:5484. The mechanical and electrical properties of aluminium wire shall comply with the requirements given in relevant standard.

(b) Galvanised steel wire shall be drawn from high carbon steel rods produced by either acidic or basic open hearth process, electric furnace process or basic oxygen process. The mechanical and electrical properties of wire shall comply with the requirements given in relevant standard. The chemical composition of high carbon steel wire is given below for guidance only:

Sr.No.	Element	Percentage Composition
1	Carbon	0.50 to 0.85
2	Manganese	0.50 to 1.10
3	Phosphorus	Not more than 0.035
4	Sulphur	Not more than 0.045
5	Silicon	0.10 to 0.35

(c) The Zinc used for galvanising shall be electrolytic high grade Zinc not less than 99.95% purity. It shall conform to and satisfy all the requirements of IS: 209.

Galvanising may be done by hot process. Neutral Grease may be applied to the core wire.

5.5. FREEDOM FROM DEFECTS

The wires shall be smooth and free from all imperfections such as spills, spilts, slag inclusion, die marks, scratches, fittings, blow-holes, projections, looseness, overlapping of strands, chipping of aluminium layers etc.and all such other defects which may hamper the mechanical and electrical properties of the conductor. Special care should be taken to keep away dirt, grit etc.during stranding.

5.6. WIRE SIZE

5.6.1. NOMINAL SIZE

The aluminium and galvanised steel wires for the stranded conductor covered by this standard shall have diameters specified in Clause 3.1.0. The diameter of the steel wires shall be measured over the zinc coating.

5.6.2. TOLERANCE ON NORMAL SIZE

(i) ALUMINIUM WIRES: A tolerance of +/- 1 % is permitted on the nominal diameter of “Panther”/ “Zebra” conductor

(ii) GALVANISED STEEL WIRES: A tolerance of +/- 2 % is permitted on the nominal diameter.

NOTE : In order to maintain the circularity of the wires, the tolerance allowed in Clause 5.5.2 shall apply to both the measurements at right angles taken at the same cross- section as per Clause 2.2 of IS:398 (Part-II, Second Revision with Amendments 1 to 30).

5.7. JOINTS IN WIRES

(i) Aluminium Wires: No joints shall be permitted in the aluminium wires in the outermost layer of the ACSR conductor. Joints in the inner layers are permitted, in addition to those made in the base rod or wire before final drawing, but no two such joints shall be less than 15 metre apart in the complete stranded conductor. Such joints shall be made by cold pressure butt- welding.

NOTE: Joints are not permitted in the outermost layer of the conductor in order to ensure a smooth conductor finish and reduce radio interference levels and corona losses on the extra high voltage.

(ii) Galvanised Steel Wires: There shall be no joints except those in the base rod or wire before final drawing, in steel wires forming the core of the steel re-in forced aluminium conductor.

NOTE: Joints have not been permitted in the steel wires after final drawing in order to avoid reduction in the breaking strength of the conductor that may occur as a result of failure of the joints.

5.8. STRANDING

(i) The wires used in the construction of galvanised steel reinforced aluminium conductor shall before stranding, satisfy all the relevant requirements of this specification.

(ii) The lay-ratio of the different layers shall be within the limit given in the following table:

LAY-RATIO OF ALUMINIUM CONDUCTORS GALVANISED STEEL REINFORCED 'PANTHER' CONDUCTOR ZEBRA conductor

(1) Number of Wire:	Aluminium: 30 Steel: 7	Aluminium: 54 Steel: 7
(2) Ratio of Diameter:	1.0	1.0
(3) Lay-Ratio for Steel Core (6 Wire Layer):	Minimum: 13 Maximum: 28	Minimum: 13 Maximum: 28
(4) Lay-Ratio for Aluminium Wires:		
(i) Out side Layer:	Minimum: 10 Maximum: 14	Minimum: 10 Maximum: 14
(ii) Layer immediately beneath outside Layer:	Minimum: 10 Maximum: 16	Minimum: 10 Maximum: 16
(iii) Innermost layer of conductor with three All Wire layers:	Minimum: 10	Maximum: 17

NOTE: For the purpose of calculation, the mean lay-ratio shall be taken as the arithmetic mean of the relevant minimum and maximum values given in the above table.

(iii) While stranding, pre forming and post forming method should be used for stranded steel core. In order to relieve the residual tension in core wire to avoid flaring of conductor.

(iv) In all constructions, the successive layers shall have opposite directions of lay, the outermost layer being right-handed. The wires in each layer shall be evenly and closely stranded.

(v) In conductors having multiple layers of aluminium wires, the lay-ratio of any aluminium layer shall not be greater than the lay-ratio of aluminium layer immediately beneath it.

5.9. LENGTH OF THE CONDUCTOR

(i) STANDARD LENGTH:

The standard length of the "Panther"/ "Zebra" conductor shall be minimum 2000/2000 metres. tolerance of +/- 5 % in standard length offered by the Concessioners shall be permitted. All length outside this limit of tolerance shall be treated as random length.

5.9.1. The Concessioner shall furnish the guaranteed technical particulars of item offered in the form enclosed at SCHEDULE "a" of this specification.

6.0 TESTS

6.1. The conductor offered in the tender should have been successfully type tested in line with the standard and technical specification within the last five years from the date of opening of tender. The Concessioner shall be required to submit 4 copies of the type test reports along with the offer in PHYSICAL FORM i.e. HARD COPY.

6.1.1. The type tests, acceptance tests, routine tests and tests during manufacture shall be carried out on the conductor. For the purpose of this clause:

(a) Type tests shall mean those tests, which are to be carried out to prove the design, process of manufacture and general conformity of the material to this specification. These tests shall be carried out on sample prior to commencement of commercial production against the order. The Concessioner shall indicate his schedule for carrying out these tests in the offer.

(b) Acceptance tests shall mean those tests, which are to be carried out on sample taken from each lot, offered for pre-despatch inspection, for the purposes of acceptance of that lot.

(c) Routine tests shall mean those tests, which are to be carried out on each strand/spool/length of the conductor to check requirements which are likely to vary during production.

(d) Tests during manufacture shall mean those tests, which are to be carried out during the process of manufacturing by the supplier, to ensure the desired quality of the end product to be supplied by him.

6.1.2. For all type tests and acceptance tests, the acceptance values shall be the values guaranteed by the Concessioner in the "Guaranteed Technical Particulars" of his proposal or the acceptance value specified in this specification, whichever is more stringent for that particular test.

6.2. DESCRIPTIONS OF TESTS

6.2.1. TYPE TESTS

The following Type Tests shall be conducted free of cost once on each sample/samples of conductor for every 1500 Kms. or part thereof of production from each manufacturing facility.

(a) <u>TEST FOR SURFACE CONDITION</u>

A sample of the finished conductor having a minimum recommended length of 5 metres with compression type dead end clamps compressed on both ends in such a manner as to permit the conductor to take its normal straight line shape, shall be subjected to a tension of 50 % of the ultimate breaking load of the conductor

The surface shall not depart from its cylindrical shape nor shall the strands move relative to each other so get out of place or disturb the longitudinal smoothness of the conductor. The measured diameter at any place shall not be less than the sum of the minimum specified diameters of the individual aluminium and steel strands.

(b)ULTIMATE TENSILE STRENGTH TEST

Circles perpendicular to the axis of the conductor shall be marked at two places on a sample conductor of minimum 5 metre length, suitably compressed with Tension Clamps at either end. Tensile load shall be applied to the sample and shall be increased at a steady rate up to 50 % of the Ultimate Tensile Strength of the conductor and held for one minute. The circles drawn, shall not be distorted due to relative movement of strands. The applied load shall then be increased at steady rate until the failing load is reached. This value shall not be less than the guaranteed breaking load of the conductor.

(c) D.C.RESISTANCE TEST

On a conductor sample of minimum 5 metres length, two contact clamps shall be fixed. The resistance shall be measured by a Ke;vin Double Bridge by placing the clamps initially zero metre and subsequently one metre apart. The test shall be repeated at least 5(five) times and the average value recorded. The value obtained shall be corrected to the value at 20 degree C as per IS: 398 (Part II).

6.2.2. ACCEPTANCE TESTS

The following acceptance tests shall be conducted on the samples in presence of the purchaser’s representative and the test values shall conform to IS:398-V.

(a) VISUAL AND DIMENSIONAL CHECK ON DRUM

The drums shall be visually and dimensionally checked to ensure that they conform to the requirements of this specification.

(b) CHECK FOR JOINTS, SCRATCHES ETC.

Conductor drums shall be rewound in the presence of Purchaser’s representative. The Purchaser’s representative shall visually check for scratches, joints etc. and that the conductor generally conforms to the requirements of this specification.

(c) DIMENSIONAL CHECK ON ALUMINIUM AND STEEL STRANDS

The individual strands shall be dimensionally checked to ensure that they conform to the requirement of this specification.

(d) LAY- RATIO TEST OF VARIOUS LAYERS

The Lay-ratios of various layers shall be checked to ensure that they conform to the requirements of this specification.

(e) ELONGATION AND TORSION TEST

The test procedure shall be as specified in IS-398 (Part-V)-1992. The material shall conform to the requirements of this specification and Clause No,9.4 & 9.5 of IS:398 (Part-V).

(f) BREAKING LOAD TEST ON INDIVIDUAL ALUMINIUM AND STEEL STRAND

For the purpose of acceptance test, this test shall be made on both aluminium and steel. The tensile test shall apply to all wires of ACSR conductors. The tensile strength of any of the wires shall not be less than the values given in the technical particulars mentioned in this specification.
When an automatic tensile testing machine is used, the load shall be applied gradually and rate of separation of the jaws of the testing machine shall not be less than 25 mm/minute and not greater than 100 mm/minute.

(g) RESISTANCE TEST

As per Clause 13.8 of IS-398-V, the measurement of resistance shall be made on strands of ACSR conductor, and shall be carried out to an accuracy of at least one part in a thousand and conform to the specified values. Certificates as to the accuracy of the apparatus shall be provided.

(h) UTS TEST ON WELDED JOINTS OF ALUMINIUM STRAND
As per procedure mentioned in IS: 398 (Part I-V)

(i) VERIFICATION OF LENGTH: By rewinding method.

(j) QUANTITY OF DRUMS TO BE VERIFIED FOR LENGTH: As per Clause-7.5.0

(k) GALVANISING TEST

The test procedure shall as specified in IS: 4826. The material shall conform to the requirement of this specification.

NOTE: All the above tests except test mentioned at (h) shall be carried out on aluminium and steel strands after stranding only.

6.2.3. ROUTINE TESTS

(a) Check to ensure that the joints are as per specification.

(b) Check that there are no cuts etc.on the strands.

(c) Check that drums are as per specifications.

(d) All acceptance tests as mentioned in Clause 6.2.0 above shall be carried out on each coil and the record of the same shall be kept by the supplier and same shall be produced at the time of Inspection.

6.2.4. TESTS DURING MANUFACTURE

(a) Chemical Analysis of Zinc Used for Galvanising:
Sample taken from the zinc ingots shall be chemically/spectrographically analyzed. The same shall be in conformity to the requirements stated in this specification
(b) Chemical Analysis of Aluminium used for making Aluminium Strands: Chemical Analysis of Aluminium samples taken from the Aluminium ingots/coils/strands shall be chemically/spectrographically analyzed. The same shall be in conformity to the requirements stated in this specification.

(c) Chemical Analysis of Steel used for making Steel Strands:
Chemical Analysis of Steel samples taken from the Steel ingots/coils/strands shall be chemically/spectrographically analyzed. The same shall be in conformity to the requirements stated in this specification.

6.3. TESTING EXPENSES:
6.3.1. The Purchaser may opt for repetition of Type Test at his own expenses prior to manufacture.
6.3.2. In case of failure in any type test, the Concessioner is either required to modify the design of the material or repeat the particular type test successfully, at his own expenses. The decision of the purchaser, in this regard shall be final and binding.
6.3.3. Concessioner shall indicate the laboratories, in which he proposes to conduct the type test. He shall ensure that the tests can be completed in these laboratories, within the time schedule, guaranteed by him, in the appropriate schedule.(in Physical Form).
6.3.4. The entire cost of testing for the acceptance tests, routine tests and tests during manufacture, specified herein, shall be treated as included in the quoted unit price of conductor, except, for the expenses of the inspector/ purchaser's representative.

6.4. ADDITIONAL TESTS:
The purchaser reserves the right of having, at his own expenses, any other test(s) of reasonable nature carried out at supplier's premises, at site, or at any other place in addition to the aforesaid type, acceptance and routine tests to satisfy himself, that the materials complies with the specification.

6.5. SAMPLE BATCH FOR TYPE TESTING
6.5.1. The supplier shall offer at least five (5) drums for selection of samples required for conducting all the type tests.
6.5.2. The Supplier is required to carry out all the acceptance tests successfully in the presence of purchaser's representative before dispatch.

6.6. TEST REPORTS (DOCUMENTS IN PHYSICAL FORM)
6.6.1. Four copies of type test reports shall be furnished to the Purchaser within one month of conducting the tests. One copy will be returned duly certified by the purchaser to the supplier within three weeks thereafter and on receipt of the same, supplier shall commence commercial production of the conductor.
6.6.2. Four copies of the acceptance test reports shall be furnished to the purchaser. One copy will be returned, duly certified by the purchaser and only thereafter, shall the conductor be dispatch.

6.6.3. All records of routine test reports shall be maintained by the supplier at his works for periodic inspection by the purchaser.

6.6.4. All test reports of tests conducted during manufacture, shall be maintained by the supplier. These shall be produced for verification as and when requested for by the purchaser.

6.7. TEST FACILITIES

6.7.1. The following additional test facilities shall be available at supplier's works:

(i) The testing equipments with Valid Calibration certificate of various testing equipments including tensile testing machine, resistance measurements facilities, burette, thermometer, barometer etc.

(ii) Standard resistance for calibration of resistance bridges.

(iii) Finished conductor shall be checked for length verification and surface finish on separate rewinding machine at reduced speed (variable from 8 to 16 metres per minute). The rewinding facilities shall have appropriate clutch system and free of vibrations, jerks etc with transverse layering facilities.

(iv) Test for Zinc Coating by volumetric method or by weight methods.

6.8. RE-TEST AND REJECTION

6.8.1. Each drum or reel selected for testing, shall be tested for compliance with the requirements of IS-398(I-V). Should any selected drum or reel not fulfill any of the test requirements, that particular drum or reel shall be withdrawn. In respect of each failure, two test pieces shall be selected from two different drums in the lot and subjected to the test under which the failure occurred. If either of the two- re-test pieces fails to pass that test, the drum or reel concerned shall be rejected.

6.8.2. All rejected drums shall be marked and segregated.

6.9. The Purchaser reserves the right to have carried out any/all type tests mentioned under Clause No 6.2.1 at his own expenses on samples of conductor selected from the lot supplied at site. The entire conductor shall be rejected if the test results are not satisfactory.

7.0 INSPECTION

7.1. The Purchaser's representative shall, at all time, be entitled to have access to the works and all places of the manufacturer, where the conductor shall be manufactured or prepared and the representative shall have full facilities for unrestricted inspection of Supplier's works, the raw materials, the manufacture of the conductor and for conducting necessary tests as detailed herein before.

7.2. The Supplier shall keep the Purchaser informed in advance of the time of starting and of the progress of manufacture of conductor in its various stages so that arrangements shall be made for Inspection.

7.3. No material shall be dispatched from its point of manufacture before it has been satisfactorily inspected and tested, unless the inspection, if waived off by the Purchaser in writing. In the later case also, the conductor shall be dispatched only after satisfactory testing for all tests specified herein has been completed.

7.4. The acceptance of any quantity of conductor shall in no way relieve the supplier of any of his responsibilities for meeting all requirements on the specification, and shall not prevent subsequent rejection if such conductor is later found to be defective.

7.5. At least 5 % of the total number of drums subject to minimum two in any lot put-up for inspection shall be selected at random to ascertain the length of conductor by following method:

" At the works of the manufacturer of the conductor, the conductor shall be transferred from one drum to another at the same time measuring its length with the help of a graduated pulley and Cyclometer. The difference in the average length thus obtained and as declare by the Supplier in the packing list shall be applied to all the drums if the conductor is found short during checking."

8.0 PACKING & FORWARDING

8.1. The conductor shall be supplied in non-returnable strong wooden drums provided with lagging of adequate strength and displacement during transit, storage and subsequent handling and stringing operation in the field. The drums shall generally conform to IS:1778-1980, amendment No.1, June 1989, except otherwise specified hereinafter. A specimen wooden drum drawing for 0.2 ACSR "Panther" Conductor, No.EEPL/WM-II/234 Dt25-03-1997 is enclosed for ready reference.

8.2. The drums shall be suitable for wheel mounting and for jetting off the conductor under a minimum controlled tension of the order of 5 KN.

8.3. The Concessioner should submit the proposed drum drawing along with the bid. However, the same shall be in line with the requirements as stated herein. After placement of the LOA, the supplier shall submit four copies of full dimensioned drawing of the drum he wished to supply, for Purchaser's approval before taking up manufacturing of Conductor. After getting approval from the Purchaser, Supplier shall submit 30 more copies of the approved drawing to Purchaser for further distribution and field use at Purchaser's end.

8.4. All wooden components shall be manufactured out of seasoned soft wood, free from defects that may materially weaken the component parts of the drums. Preventive treatment for anti-termite/anti-fungus (Aldrime/Aldruse) shall be applied to the entire drum with preservatives of a quality which is not harmful to the conductor.

8.5. The flanges shall be of two/three ply construction with each ply at right angles to the other and nailed together. The nails shall be driven from the inside face flange, punched and then clenched on the outer face. The tolerance in the thickness of each ply shall be +/- 3 mm only.

There shall be at least 3 nails per plank for ply with maximum nail spacing of 75 mm. Where a slot is cut in the flange to receive the inner end of the conductor, the entrance shall be in the line with the periphery of the barrel.

8.6. The wooden battens used for making the barrel of the conductor shall be of segmental type. These shall be nailed to the barrel supports with at least two nails. The battens shall be closely butted and shall provide a round barrel with smooth external surface. The edges of the battens shall be rounded or chamfered to avoid damage to the conductor.

8.7. Barrel studs shall be used for constructions of drums. The flanges shall be holed and the barrel supports slotted to receive them. The barrel studs shall be threaded over a length on either end, sufficient to accommodate washers, spindle plates and nuts for fixing flanges at the required spacing. Barrel studs should be tack welded with the nuts after tightening.

8.8. Normally, the nuts on the studs shall stand round of the flanges. All the nails used on the inner surface of the flanges and the drum barrel shall be countersunk. The ends of barrel shall generally be flushed with the top of the nuts.

8.9. The inner check of the flanges and drum barrel surface shall be painted with a bitumen based paint.

8.10. Before reeling, card board or double corrugated or thick bitumenised waterproof bamboo paper shall be secured to the drum barrel and inside of flanges or the drum by means of a suitable commercial adhesive material. The paper should be dried before use. Medium grade craft paper shall be used in between the layers of the conductor. After reeling the conductor, the exposed surface of the outer layer conductor shall be wrapped with thin polythene sheet across the flanges to preserve the conductor from dirt, grit and damage during transportation and handling and also to prevent ingress of rain water during storage/transport.

8.11. A minimum space of 75 mm shall be provided between the inner surface of the external protective layer and outer layer of the conductor.

8.12. Each batten shall be securely nailed across grains as far as possible to the flange edges with at least 2 nails per end. The length of the nails shall not be less than twice the thickness of the battens. The nail shall not protrude above the general surface and shall not have exposed sharp edges or allow the battens to be released due to corrosion.

8.13. Outside the protective layer, there shall be minimum of two binder consisting of hoop iron/galvanised steel wire. Each protective layer shall have two recess to accommodate the binders.

8.14. The conductor ends shall be properly sealed and secured with the help of U- nails on one side of the flanges. The end securing shall be done by taking out at least 500 mm of steel core on either ends by U- nails. The composite conductor shall be binded by use of galvanised steel wire/aluminium wire at three locations at least 75 mm apart or more covered with PVC adhesive tape so as to avoid loosening of conductor layers in transit and handling.

8.15. Only one length of conductor shall be wound on each drum.

8.16. MARKING

Each drum shall have the following information stenciled on it in indelible ink along with other essential data:

(a) Contract/Award letter number :

(b) Name and address of consignee :

(c) Manufacturer's name and address :

(d) Drum Number :

(e) Size of Conductor :

(f) Length of Conductor in metres :

(g) Gross weight of drum with Conductor:

(h) Weight of empty drum with lagging :

(i) Arrow marking for unwinding :

(j) I.S.I. Marking :

Note: The conductor offered shall bear valid ISI Certification mark. The Concessioner shall furnish copies of documentary proof to this effect along with his offer.

9.0 REQUIREMENT OF DOCUMENTS

9.1 Following information shall be furnished along with the offer in hard and soft copy

Certificate of accreditation of the testing laboratory where the type test are to be conducted.

SCHEDULE -‘a’

GUARANTEED TECHNICAL PARTICULAR OF ACSR “PANTHER”/ “ZEBRA” CONDUCTOR

(1) Code word of Conductor offered :

(2) Maker’s, address and country of

(a) Aluminium wire :

(b) Steel wire :

(c) Complete Conductor :

(3) Whether the Supplier has valid ISI Certification for the conductor offered? (Please furnish copies of documentary proof) :

(4) Details of quantities of conductor of same or higher number of strands supplied during the last five years (Please furnish copies of documentary proof). :

(5) Average annual turn over during the last five : years (Please furnish copies of documentary proof).

(6) Details of type test conducted on similar conductor during last five years (Please furnish copies of documentary proof).

(7) Stranding and wire diameter in mm.

(a) Aluminium

(b) Steel

(8) Tolerance on diameter of wires

(a) Aluminium

(b) Steel

(9) Cross Sectional area in Sq.mm.

(10) Overall Diameter of conductor in mm.
(11) Approximate weight of complete conductor

(12) Minimum breaking load in KN for

(a)Aluminium

(b) Steel :

(13) Zinc coating of steel strand

(a) Thickness of coating number and duration of dips (Precee Test) withstood :

(b) Minimum weight of coating in gms/sq.mm:

(14) Type of grease applied to the core wires :

(15) Maximum working tension at 0 degree C and 2/3 of wind pressure (Enclose sag tension chart)

(16) Weight in Kg /Km

(a) Aluminium :

(b) Steel :

(c) Complete Conductor :

(17) Resistance in ohms/Km at 20 degree C

(a) Aluminium Strand :

(b) Complete Conductor :

(18) Continuous maximum current rating of conductor in still air at 40 degree C ambient temperature in Amps.

(19) Temperature rise for the above current in degree C.

(20) Reactance/Km at 50 degree C per one metre spacing between conductors in ohms/Km, temperature rise for the above current in degree C. :

(21) Lay Ratio (Maximum & Minimum)

(a) Steel Core (i) 6 Wire layer

(b) Aluminium (i) 12 Wire layer

(ii) 18 Wire layer

(22) Whether the drum on which the conductor is wound is conforming to the specification.

(The detailed dimensional drawing shall be submitted with the offer). :

(23) Physical Constants of material/conductor

(i) Modulus of elasticity of

(a) Aluminium strand :

(b) Steel strand :

(c) Complete conductor :

(ii) Co-efficient of linear expansion per degree C: Of

(a) Aluminium strand

(b) Steel strand

(c) Complete conductor

(iii) Resistivity of Aluminium
(iv) Chemical composition of Steel

(24) Standard length of each piece in Km

(25) Tolerance, if any, on standard length

(26) No. of standard lengths in one reel

(27) Whether Concessioner is ready to supply six numbers of 2500 metres long conductor, if required

(28) Diameter of the reel in cms.
(29) Weight of the conductor in one reel in Kgs

(30) Weight of the reel in Kgs

(31) Gross weight of the reel including weight of the conductor.

(32) Standard according to which the conductor will be manufactured and tested.

(33) Whether the Concessioner has valid ISI mark for the conductor offered(Furnish documentary evidence).

(34) Whether the Concessioner has adequate facilities for performing, post forming and stranding the aluminium wire/core. :

(35) List of facilities available for testing of conductor. :

(36) Other particulars, if any

ANNEXURE - VIII

TECHNICAL SPECIFICATION FOR 7/3.15MM GALVANISED STEEL EARTH-WIRE

1.0 GENERAL

This section details about the Galvanised Steel (G.S.) earthwire, required for 220/132 KV EHV lines. The earthwire offered, shall conform to the technical requirements covered under this specification and latest Indian Standard Specifications.

2.0 SYSTEM PARTICULARS

(i) The 7/3.15mm size G.S. earthwire is required for shielding of EHV Transmissi on Lines.

(ii) (a) System : AC, 3 Phase 50 Hz.

(b)	Line Voltage	:		
	Normal	:	220 KV	132KV
	Maximum	:	245 KV	145KV
(c)	Tower Configuration	:		
i)	Single Circuit	:	Delta	Delta
ii)	Double Circuit	:	Vertical	Vertical
iii)	Bil (Impulse)	:	1050 KV (peak)	650 KV (peak)
iv)	Power Frequency withstand voltage (wet)	:	460 KV (4ms)	275KV (rms)
v)	Max. wind pressure on power conductors and groundwire in Kg/ sq.mtrs.	:	45	45
vi)	No. of conductors per phase	:	One	One
vii)	Earthing	:	Effectively earthed	Effectively earthed

3.0 TECHNICAL PARTICULARS OF EARTHWIRE SIZE 7/3.15mm

3.1 Physical properties

i)	Material	:	Heavily galvanized steel		
ii)	No. of steel wires in strand (Nos.)	:	Inner 1	Outer 6	Total 7
iii)	Normal diameter of galvanized strand wire (mm.)	:	Std. 3.15	Max. 3.25	Min. 3.07
iv)	Total sectional area (mm.sq.)	:	54.52		
v)	Approximate weight (kg/ Km)	:	426		
vi)	Minimum breaking load of strand (KN)	:	Std. 54.0	Max. 64.3	Min. 48.2
vii)	Elongation of strand after breakage shall not be less than	:	4%		
viii)	Co-efficient of linear expansion (per deg.C)	:	11.5×10^{-6}		
ix)	Modulus of elasticity (Kg/sq.mm.)	:	19×10^{3}		
x)	Permissible variation in diameter of individual zinc coated wires for a nominal diameter of 3.15mm (percent)	:	+/- 2%		
xi)	Overall diameter of earthwire (mm)	:	9.45		
xii)	Minimum weight of zinc coating (g/M sq.)	:	240 (should withstand one minute dips = 3 Nos, 1/2 minute dips =1 No.		
xiii)	Calculated D.C. resistance at 20 deg. C (ohm/km)	:	3.41		

xiv)	Strand lay and lay length (mm)	:	Minimum	:	123
			Maximum	:	265
xv)	Direction of lay of outer layer	:	Right hand		
xvi)	Density at 20 deg.C (g/cm^3)	:	7.8		

3.2 Detailed Technical Particulars

3.2.1 Material

The basic metal shall be steel made by the open heart basic oxygen or electric furnace process and of such quality and purity that when drawn to size of wire specified and coated with zinc, the finished strand and individual wires shall be of uniform quality and have the properties and characteristics as prescribed in this specification. The steel shall have following composition as per IS-12776: 2002.

Element	Composition
Carbon	0.55 Max
Manganese	0.40 to 1.10
Phosphorous	0.05 Max
Sulphur	0.05 Max
Silicon	0.15 to 0.35

3.2.1 Galvanised:

The slab zinc, when used for zinc coating, shall be of any grade of zinc conforming to ASTM specification, B-6, for zinc metal (slab Zinc) process - Hot dip.

3.2.2 Stranding

All steel strands shall be smooth, uniform and free from all imperfections such as spills and split die marks, scratches, abrasions and kinks after drawing and also after stranding. The finished material shall have minimum brittleness. Unless otherwise specified, the strand shall right hand lay. All wires shall be stranded with uniform tension. Stranding shall be sufficiently close to ensure no appreciable reduction in diameter when stressed to 10% of the specified strength. The 7 wire strand shall consist of central wire with 6 wire layer concentrically twisted over it with a uniform pitch not more than 16 times the specified nominal diameter of the strand.

3.2.3 Ductility of steel

The zinc coated wire shall not fracture when wrapped at a rate not exceeding 15 turns per minute in a close helix of at least two turns around a cylindrical mandrel. The mandrel diameter for extra high strength strand shall be equal to three times the nominal diameter of the individual wire of the strand.

3.2.4 Joints and splices

There will be no joint/splice in any of the wires of the strand in the standard length of 2750 ± 10% metre. The tenders should explicitly mention in their offers that there will be no joint in any of the wires constituting the ground wire not withstanding the provisions, otherwise, if any, in the IS.

3.2.5 Weight of coating

The weight of zinc coating gm/sq.mtre. of uncoated wire surface shall be not less than 240 gm/sq.mtr.

3.2.6 Tests of coating

The weight of the zinc coating shall be determined by stripping test in accordance with ASTM methods A90, test for weight of coating on zinc coated iron or steel articles.

3.2.7 Adherence of coating

The zinc coated wire shall be capable of being wrapped at a rate not exceeding 15 turns per minute in close helix of at least two turns round a cylindrical mantrel equal to three times the nominal diameter of the wire under test without cracking of flaking the zinc coating to such an extent that any zinc can be removed by rubbing with the bare fingers.

3.2.8 Finish

The zinc coated wire shall be free from imperfections not consistent with good commercial practice. The zinc coating shall be continuous and of reasonably uniform thickness.

3.3 Tests

All type tests and routine tests as per standard methods shall be carried out by the Concessioner. copies of the Type test certificate shall be submitted with the tender in hard and soft copies.

3.4 Standards

The Groundwire shall confirm to the provisions of the latest edition of ASTM Designation A 475-72(a) pertaining to Standard Specification for Zinc coated steel wire strand or any other authoritative standard (as amended upto date) except where specified otherwise, in the specification. The materials conforming to any international standard which ensure equal or better performance shall also be acceptable.

3.5 Sag Tension Charts

The supplier shall be required to submit six sets of stringing charts for earthwire, showing initial and final sags and tensions for various temperatures and spans. One set of chart shall be in ink on tracing cloth.

3.6 Guaranteed Technical Particulars

The Concessioner shall fill in the guaranteed technical particulars in this specification and submit the same with his tender.

4.0 TESTS

4.1. The earthwire offered in the tender should have been successfully type tested in line with the standard and technical specification within the last five years from the date of opening of tender.

4.2. The following type, acceptance and routine tests and tests during manufacture shall be carried out on the earthwire for the purpose of this clause.

4.2.1. Type tests shall mean those tests which are to be carried out to prove the process of manufacture and general conformity of the material to these specifications. These tests shall be carried out on samples prior to commencement of commercial production .

4.2.2. Acceptance tests shall mean those tests which are to be carried out on samples taken from each lot offered for pre-despatch inspection for the purpose of acceptance of that lot.

4.2.3. Routine tests shall mean those tests, which are to be carried out on each strand spool/length of the earthwire to check requirements, which are likely to vary during production.

4.2.4. Tests during manufacture shall mean those tests which are to be carried out during the process of manufacture and end inspection by the Contractor to ensure the desired quality of the end product to be supplied by him.

4.2.5. The norms and procedures of sampling for these tests will be as per the Quality Assurance Programme to be mutually agreed to, by the Contractor and Board or as per relevant IS/International Standard.

4.2.6. The standards and norms to which these tests will be carried out are listed against them. Where a particular tests is a specific requirement of this specification, the norms and procedures of these tests shall be as specified in Annexure-I or as mutually agreed by the Contractor and the Owner in the Quality Assurance Programme.

4.2.7. For all type and acceptance tests, the acceptance tests, the acceptance values shall be the values guaranteed by the Concessioner in the guaranteed technical particulars of this proposal or the acceptance value specified in these specifications, whichever is more stringent for that particular test.

4.3. Type Tests

The following tests shall be conducted once on a sample/samples of earthwire for every 500 kms of production from each manufacturing facility.

(a)	UTS Tests	)	MSETCL Specification
(b)	DC Resistance Test	)	Annexure-a
(c)	Surface Condition Test	)	

4.4. Acceptance Tests

a)	Visual check for joints etc.	:	MSETCL Specification Annexure-a
b)	Dimensional check on steel strands	:	- do -
c)	Check for Lay - Length of 6 wire Layer	:	- do -
d)	Wrap test on steel strands	:	- do -
e)	DC resistance test on steel strands	:	- do -
f)	Visual check on drum	:	- do -

g)	Breaking load test on steel strands	:	IS-12776:2002
h)	Elongation test on steel strand	:	- do -
i)	Torsion Test	:	- do -
j)	Galvanising tests on steel strands	:	*IS-4826-1979
k)	Length & Surface Verification by rewinding method		

*Note:
Although the tests will be as specified in IS:4826-1979, no allowance or relaxation will be given for galvanization tests done on steel wires after stranding for the purpose of acceptance of an material covered by these specifications.

4.5. Routine Tests

(a) Check to ensure that there are no joints as per specification.

(b) Check that there are no cuts, fins etc. on the strands.

(c) Check for correctness of stranding.

(d) Check that drums are as per specification.

4.6. Test During Manufacture

(a) Chemical analysis of Zinc used for galvanizing

(b) Chemical analysis of steel for making steel strands — MSETCL Specification Annexure-a

4.7. Testing Expenses

4.7.1. The purchaser may opt for repetition of Type test at his own expenses, prior to manufacture.

4.7.2. In case of failure in any type test the Concessioner is either required to modify the design of the material or repeat the particular type test successfully at his own expense. The decision of the purchaser in this regard shall be final and binding.

4.7.3. Concessioner shall indicate the laboratories in which he proposes to conduct the type tests. He shall ensure that the tests can be completed in these laboratories within the time schedule guaranteed by him in the appropriate schedule.

4.7.4. The entire cost of testing for the acceptance and routine tests and tests during manufacture specified herein shall be treated as included in the quoted unit price of conductor, except for the expenses of the inspector/purchaser's representative.

4.8. Additional Tests

The owner reserves the right of having at his own expenses any other test(s) of reasonable nature carried out at contractor's premises, at site, or any other place in addition to the aforesaid type, acceptance and routine tests to satisfy himself that the materials comply with the specification.

4.9. Sample Batch for Type Testing

4.9.1. The supplier shall offer at least five (5) drums for selection of samples required for conducting all the type tests.

4.9.2. The supplier is required to carry out all the acceptance tests successfully in the presence of purchaser's representative before dispatch.

5.0 TEST REPORTS (DOCUMENTS IN PHYSICAL FORM).

5.1. At least 3 (three) copies of type test reports should be furnished. One copy of type test reports will be returned duly certified by the Board. Only after receipt of this report, the commercial production of the said material should start.

5.2. At least 3 (three) copies of acceptance test reports shall be furnished. One copy will be returned duly certified by the owner, only after receipt of which, the materials should be dispatched.

5.3. Record of routine test reports should be maintained by the Contractor at his works for periodic inspection by the Company's representatives.

6.0 INSPECTION

6.1. The Company's representative shall at all times be entitled to have access to the works and all places of manufacture, where earthwire shall be made or prepared and the representatives shall have full facilities for unrestricted inspection of the Contractor's works, raw materials, manufacture of the earthwire and for conducting necessary tests detailed herein.

6.2. The contractor shall keep the Company informed in advance of the time of starting and of the progress of manufacture of earthwire in its various stages so that arrangements can be made for inspection.

6.3. No earthwire shall be dispatched from its point of manufacture before it has been satisfactorily inspected and tested, unless the inspection is waived off by the Company in writing. In the later case also, the earthwire shall be dispatched only after satisfactory testing for all tests specified herein have been completed.

6.4. The acceptance of any quantity of material shall in no way relieve the Contractor of any of his responsibilities for meeting all requirements of the specification and shall not prevent subsequent rejection, if such materials are later found to be defective.

7.0 PACKING

7.1. The earthwire shall be suitably packed before dispatch in strong, non-returnable wooden drums suitable for ocean/local rail and road transportation, rough handling and stringing and shall conform in all respects to the latest edition of IS 1778-1961 except as otherwise specified herein. The general construction of the drum shall be as shown in drawing enclosed.

7.2. Standard Length

The standard length of the galvanized steel earth strand shall be minimum 2750 metre. A tolerance of $\pm$ 10 % on the standard length shall be permitted.

7.3 Random Length

Random length will be accepted provided no length is less than 70% of standard length and total quantity of random lengths is not more than ten (10%) percent of the total quantity in each shipment.

7.4 Only one length of earthwire shall be wound on each drum.

7.5 Boiled linseed oil should be applied to earthwire to avoid white rust.

8.0 MARKING

8.1 Each drum shall have the following information stenciled on it in indelible ink alongwith other essential data.

(a) Contract / LOI No.
(b) Name and Address of Consignee
(c) Manufacturer's Name and Address
(d) Drum No. & Lot No.
(e) Size of Earthwire
(f) Length of Earthwire in mtrs.
(g) Gross weight of the drum with earthwire.
(h) Weight of empty drum with laggings.
(i) Arrow marking for unwinding.
(j) Position of the earthwire ends.
(k) Number of lengths on the reel/or drum.
(l) The product may be marked with the standard mark.

ANNEXURE - a
TESTS

1.0 UTS Test on Earthwire

A sample of earthwire of about 5m length will be subjected to the ultimate Tensile strength test. The earthwire shall not fail at a value less than 54 KN.

2.0 Surface Condition Test

A sample of earthwire of 5m length shall be subjected to a load of 50% of the UTS of the earthwire. Neither shall the surface depart from its cylindrical form nor the strands move relative to each other so as to get out of place or disturb the longitudinal smoothness of the earthwire.

3.0 D.C. Resistance Test

On strand of minimum 5m length, two contact clamps shall be fixed. The Resistance shall be measured by Kelvin bridge by placing the clamps initially from one end and subsequently one metre apart. The test shall be repeated at each metre length and the value recorded. The value obtained shall be corrected to the value at 20 deg.C.

4.0 Visual Check for joints/lengths

Two drums from each lot/50Km. whichever is less, shall be selected at random and rewound in the presence of the inspector and actual length of earthwire measured. The weight of the earthwire also will be measured by weighing empty drum and drum with earthwire. The inspector shall visually check for scratches, joints etc. and see that the earthwire generally conforms to the requirements of this specification. The expenditure for above measurements, if any, will be to the Concessioner's account. The firm should have separate facility for winding and unwinding for inspection purpose.

5.0 Visual Check on Drums

The drums shall be visually and dimensionally checked to ensure that they conform to these specifications.

6.0 Chemical anslysis of Zinc used for galvanising

Samples taken from the zinc ingots shall be chemically/ spectrographically analysed as per IS-209. The purity of zinc shall not be less than 99.95%.

7.0 Wrappping Test

One specimen cut from each of the samples of galvanised steel wire shall be wrapped round a mandrel of diameter equal to 4 times the wire of diameter to form a close helix of 8 turns. Six turns shall be unwrapped and again closely wrapped in the same direction as before. The wire shall not break.

8.0 Lay Length Check

The lay length shall be checked to ensure that they confirm to the requirement of the specification.

ANNEXURE - b

DRAWING CHARTS & DESIGN DATA TO BE SUBMITTED IN PHYSICAL FORM

1.0 Concessioner shall furnish full details of earthwire drum offered. The drawing shall indicate:

i) Size & weight of drum
ii) Materials used.
iii) Identification marks.
iv) Any other information which may be useful to the user.

2.0 Successful Concessioner during the execution of contract, shall submit the sag tension charts of earthwire for approval.

Sr.No	Description	Unit	Specified Values	Offered Values
1	Maker's name, address and country			
2	Percentage composition of steel wire element	**%**		
			0.55 (Max)	
	i) Carbon		0.05 (Max)	
	ii) Sulphur		0.05 (Max)	
	iii) Phosphorus		0.4to 1.1	
	iv) Manganese		0.15 to 0.35	
	v) Silicon			
3	Particulars of steel strand:			
	a) No. of strands	No	7	
	b) Diameter of strand			
	Standard	mm	3.15	
	Maximum		3.25	
	Minimum		3.07	
	c) Sectional area of strand	sq.mm		

4	Zinc coating of steel strand:		
	a) Uniformity of coating (number and duration of dips withstood) Minute duration of dips		
	i) One		3
	ii) Half	No	1
		No	
5	Standard overall diameter of steel wire	mm	9.45
6	Total area of cross section of steel wire.	sq.mm	54.52
7	Guaranteed ultimate tensile strength of steel wire	N/mm^2	1100
8	D.C. resistance in ohms per km. At 20 deg.C		3.41
9	Standard length of steel wire (minimum)	Km	2.75 $\pm$ 10 %
10	Tolerance if any on standard length	%	+ 10 %
11	Random length of steel wire	Km	
12	Random lengths in No.	No.	
13	Modulus of elasticity of steel wire	Kg/mm^2	$19x10^3$
14	Co-efficient of linear expansion	/deg.C	$11.5x10^{-6}$
15	1) Length of the lay of standard wire		
	a) Maximum	mm	265
	b) Standard	mm	
	c) Minimum	mm	123
	2) Direction of lay of outer layer	Right/Left	Righ
16	Weight of steel wire	Kg/Km	426
17	Standard length of steel wire in each drum	Metre	2750
18	Standard weight of steel wire on the drum	Kg	
19	Weight of empty drum	Kg	
20	Gross weight of the drum	Kg	
21	Dimension of the drum in cms	GWB	

22	Initial and final sags and tension and stringing charts, whether furnished	Yes/No
23	Standard according to which the steel wire will be manufactured	IS or equivalent
24	Other particulars, if any	
25	Separate winding & unwinding facilities for inspection purpose whether available	Yes/No

ANNEXURE- IX

TECHNICAL SPECIFICATION FOR OPTICAL FIBRE GROUND WIRE (OPGW)

TECHNICAL SPECIFICATION FOR SUPPLY OF OPGW CABLE & OFAC ALONG WITH ACCESSORIES

1.0 DEFINITIONS:

1.1. OPGW means an optical fibre unit embedded in the core or first layer of the ground wire, whose shield wire consists of one or more layers of Aluminium clad steel/Aluminium alloy wires.

1.2. Optical waveguide fibres means the optical fibres embedded in the OPGW/OFAC - which would serve as medium for the proposed optical communication system.

1.3. Termination joint box means outdoor box to terminate/splice the OPGW/OFAC in an organized manner. The box shall be located on the terminal gantries at each end of the lines.

1.4. Shield wire joint box means outdoor box to terminate/splice the OPGW/ OFAC in an organized manner.

1.5. The contractor means the contractor entrusted with the work of fabrication, supply and erection of OPGW system.

1.6. OFAC means Optic Fibre Approach all dielectric Cable including cables suitable for cable trench/buried duct installation, with heavy duty thermosetting jacketing and shall contain optical wave guide fibres. The approach cable shall be installed between the terminal joint boxes suitable for OPGW and Fibre Distribution Frame installed at the substation.

1.7. Distribution Rack/Termination Box means the indoor rack/box for termination of the OFAC and connection to the OLTE.

1.8. The supplier means the manufacturer of the OPGW/OFAC cable selected by the Concessioner and nominated as such in his bid.

1.9. THE CONCESSIONER MEANS THE CONTRACTOR PRIOR TO AWARD OF CONTRACT.

2.0 FIBRE OPTIC CABLING:

All optical fibre cabling including fibre itself and all associated installation hardware shall have a minimum guaranteed design life span of 25 years. Documentary evidence in support of guaranteed life span of cable and fibre shall be submitted by the contractor during detailed engineering.

3.0 REQUIRED OPTICAL FIBRE CHARACTERISTICS:

This section describes the characteristics of optical fibre to be provided under this specification.

3.1. PHYSICAL CHARACTERISTICS:

Dual-Window Single mode (DWSM), G.652D optical fibres shall be provided in the fibre optic cables. DWSM optical fibres shall meet the requirements defined in Table 1(a).

3.2. ATTENUATION

The attenuation coefficient for wavelengths between 1525nm and 1575nm shall not exceed the attenuation coefficient at 1550nm by more than 0.05dB/km. The attenuation coefficient between 1285nm and 1330nm shall not exceed the attenuation coefficient at 1310nm by more than 0.05dB/km. The attenuation of the fibre shall be distributed uniformly throughout its length such that there are no point discontinuities in excess of 0.10dB. The fibre attenuation characteristics specified in table 1(a0 below shall be "guaranteed" fibre attenuation of any & every fibre reel. The overall optical fibre path attenuation shall not be more than calculated below:

Maximum attenuation @ 1550nm: 0.21dB/km x Total km + 0.05dB/splice x No. of Splices + 0.5dB/connector x No. of Connectors

Maximum attenuation @ 1310nm: 0.35dB/km x Total km + 0.05dB/splice x No. of Splices + 0.5dB/connector x No. of Connectors

This section defines the requirements for 48 Fibers G.652D Dual-window Single mode (DWSM) telecommunications grade fibre optic cable. Concessioners shall furnish with their bids, detailed descriptions of the fibres & cable(s) proposed.

DWSM OPTICAL FIBRE CHARACTERISTICS Table 1(a)	
Fibre Description	Dual-Window Single-Mode
Mode Field Diameter	8.6 to 9.5 µm (± 0.6µm) at 1310 nm
Cladding Diameter	125.0 µm ± 1 µm
Core Field Concentricity Error	≤ 0.6 µm
Cladding Non-Circularity	≤ 1%
Cable Cutoff Wavelength, λcc	≤ 1260 nm
1550nm Loss Performance	as per G.652D
Proof Stress	≥ 0.69 Gpa
Attenuation Co-efficient	@ 1310 nm ≤ 0.35 dB/km
	@ 1550 nm ≤ 0.21dB/km
Chromatic Dispersion: Maximum	18 ps/(nm x km) @ 1550 nm
Polarization Mode Dispersion Coefficient	≤ 0.2 ps/km^½
Temperature Dependence	Induced attenuation ≤ 0.05 dB (-60°C - +85°C)
Bend Performance	@ 1310 nm (75±2 mm dia Mandrel), 100 turns;

4.0 FIBRE OPTIC CABLE CONSTRUCTION:

Overhead Fibre Optic Cables shall be OPGW (Optical Ground Wire). The OPGW cable is proposed to be installed on 220 kV & above transmission line in Maharashtra. The design of each cable type shall account for the varying operating and environmental conditions that the cable shall experience while in service. The OPGW cable to be supplied shall be designed to meet the overall requirements of the 220 kV transmission line. The normal span for 220 kV towers is 350 mtrs, however, some of the spans may be more than 350 mtrs. The exact details shall be collected by the contractor during survey. It may also be noted that part of the transmission line route may be diverted/modified during the engineering stage.

4.1. OPTICAL FIBRE CABLE LINK LENGTHS:

The estimated total optical fibre lengths are provided in BOQ/Price Schedule. However, the contractor shall supply & install the optical fibre cable as required based on detailed site survey to be carried out by the contractor during the project execution. The contractor shall prepare the drum schedule according to approved tower schedule/stringing chart and submit the same for approval. For the purpose of payment, the optical fibre link lengths are defined as transmission line route lengths from Gantry at one terminating station to the Gantry in the other terminating station. The actual cable lengths to be delivered shall take into account various factors such as sag, service loops, splicing, working lengths & wastage etc. and no additional payment shall be payable in this regard. The unit rate for FO cable quoted in the bid price schedules shall take in to account all such factors.

4.2. OPTICAL FIBRE IDENTIFICATION:

Individual optical fibres within a fibre unit and fibre units shall be identifiable in accordance with EIA/TIA 598 or IEC 60304 or Bellcore GR-20 colour-coding scheme. Colouring utilized for colour coding optical fibres shall be integrated into the fibre coating and shall be homogenous. The colour shall not bleed from one fibre to another and shall not fade during fibre preparation for termination or splicing. Each cable shall have traceability of each fibre back to the original fibre manufacturer's fibre number and parameters of the fibre. If more than the specified numbers of fibres are included in any able, the spare fibres shall be tested by the cable manufacturer and any defective fibres shall be suitably bundled, tagged and identified at the factory by the vendor.

4.3. BUFFER TUBE:

Loose tube construction shall be implemented. The individually coated optical fibre(s) shall be surrounded by a buffer for protection from physical damage during fabrication, installation and operation of the cable. The fibre coating and buffer shall be strippable for splicing and termination. Each fibre unit shall be individually identifiable utilizing colour coding. Buffer tubes shall be filled with a water-blocking gel.

4.4. OPTICAL FIBRE STRAIN & SAG-TENSION CHART:

The fibre optic cable shall be designed and installed such that the optical fibres experience no strain under all loading conditions defined in IS 802. Zero fibre strain condition shall apply even after a 25 year cable creep. For the purpose of this specification, the following definitions shall apply:

- Maximum Working Tension (MWT) is defined as the maximum cable tension at which there is no fibre strain.
- The No Fibre Strain condition is defined as fibre strain of less than or equal to 0.05%, as determined by direct measurements through IEC/ETSI (FOTP) specified optical reflectometry techniques.
- The Cable Strain Margin is defined as the maximum cable strain at which there is no fibre strain.
- The cable Maximum Allowable Tension (MAT) is defined as the maximum tension experienced by the Cable under the worst case loading condition.

- The cable Max Strain is defined as the maximum strain experienced by the Cable under the worst case loading condition.
- The cable Every Day Tension (EDT) is defined as the maximum cable tension on any span under normal conditions.
- The Ultimate /Rated Tensile Strength (UTS/RTS/Breaking Strength) is defined as the maximum tensile load applied and held constant for one minute at which the specimen shall not break.

While preparing Sag-tension charts for the OPGW cable the following conditions shall be met:

- The Max Allowable Tension (MAT)/max strain shall be less than or equal to the MWT/ Strain margin of the cable.
- The sag shall not exceed the earthwire sag in all conditions.
- The Max Allowable Tension shall also be less than or equal to 0.4 times the UTS.
- The 25 year creep at 25% of UTS (creep test as per IEEE 1138) shall be such that the 25 year creep plus the cable strain at Max Allowable Tension (MAT) is less than or equal to the cable strain margin.
- The Every Day Tension (EDT) shall not exceed 20% of the UTS for the OPGW cable.

The sag tension chart of OPGW cable indicating the maximum tension, cable strain and sag shall be calculated and submitted alongwith the bid under various conditions mentioned below:

1. 53^0 C, no wind and no ice
2. 32^0 C, no wind and no ice
3. 0^0 C, no wind and no ice
4. 32^0 C, full wind and no ice
5. 32^0 C, 75% full wind and no ice
6. 0^0 C, 2/3rd /36% of full wind (IS 802:1977/1995)

The above cases shall be considered for the spans from 100 m to 350 m or higher span length in the range of 50 m spans. Max. Vertical sag, Max. Tension and Max. Sag at 0^0C & no wind shall be considered for inline with the design parameter of transmission line. The full wind load shall be considered as the design wind load for all the transmission lines as per relevant IS 802 version and the sag tension chart shall be submitted considering the transmission lines. The contractor shall submit the stringing chart for review of employer.

4.5. CABLE MATERIALS:

The materials used for optical fibre cable construction, shall meet the following requirements:

4.5.1 Filling Materials

The interstices of the fibre optic unit and cable shall be filled with a suitable compound to prohibit any moisture ingress or any water longitudinal migration within the fibre optic unit or along the fibre optic cable. The water tightness of the cable shall meet or exceed the test performance criteria as per IEC-794-1-F-5.

The filling compound used shall be a non-toxic homogenous waterproofing compound that is free of dirt and foreign matter, non hygroscopic, electrically nonconductive and non-nutritive to fungus. The compound shall also be fully compatible with all cable components it may come in contact with and shall inhibit the generation of hydrogen within the cable.

The filling compound shall remain stable for ambient temp. between -20°C and +65°C and shall not drip, flow or leak with age or at high temperatures during short duration lightning strike and short circuit currents The filling compound shall meet the requirements of “Seepage of Filling Compound test” as per EIA/TIA 455-81 for 80°C temperature.

The waterproofing filling materials shall not affect fibre coating, colour coding, or encapsulant commonly used in splice enclosures, shall be dermatologically safe, non-staining and easily removable with a non-toxic cleaning solvent.

4.5.2 Metallic Members

When the fibre optic cable design incorporates metallic elements in its construction, all metallic elements shall be electrically continuous.

4.5.3 Marking, Packing and Shipping

This section describes the requirements for marking, packaging and shipping the overhead fibre optic cable.
a) Drum Markings: Each side of every reel of cable shall be permanently marked in white lettering with the vendor’s address, the purchaser’s destination address, cable part number and specification as to the type of cable, length, number of fibres, a unique drum number including the name of the transmission line and segment no. factory inspection stamp and date.
b) Cable Drums: All optical fibre cabling shall be supplied on strong drums provided with lagging of adequate strength, constructed to protect the cabling against all damage and displacement during transit, storage and subsequent handling during installation. Both ends of the cable shall be sealed as to prevent the escape of the filling compounds and dust & moisture ingress during shipment and handling. Spare cable caps shall be provided with each drum as required.

The spare cable shall be supplied on sturdy, corrosion resistant, steel drums suitable for long periods of storage and re-transport & handling.
There shall be no factory splices allowed within a continuous length of cable. Only one continuous cable length shall be provided on each drum. The lengths of cable to be supplied on each drum shall be determined by a “schedule” prepared by the contractor.

4.6 OPGW CABLE INSTALLATION REQUIREMENT:

The OPGW cable shall be installed at the top of tower under off line condition during construction of line. The tentative bill of quantities for off line OPGW installations have been specified in the BOQ/Price Schedule and the actual quantities shall be finalised during project execution after detailed survey.

The stringing of OPGW cable shall be carried out by contractor as per stringing chart/Procedure submitted by them and approved by employer. The splicing work shall be carried out by contractor. All hardware & fittings needed to tie the OPGW to the towers/gantries shall be provided and fitted by contractor.

Before installation, the testing (fibre loss and length measurement using OTDR) of OPGW in each drum shall be carried out by contractor in presence of employers representative. After installation of OPGW cable, the testing of each section shall be carried out again by the contractor in presence of employer's representative. In case of any damage/high loss in the fibre, the length of that particular section of OPGW cable shall be replaced by contractor at his own cost.

Contractor shall supervise the stringing at site as per the approved stringing procedure. The Supervision/Inspection work in contractor's scope shall mainly include inspection as per stringing procedure, proper location of drum site, installation of stringing blocks/pulleys, proper sagging, proper installation of hardware, proper tension as per Sag-Tension chart, provision of service loops of OPGW in jointing locations etc.

4.7 OPTICAL GROUND WIRE (OPGW):

OPGW cable construction shall comply with IEEE-1138, 2009. The cable provided shall meet both the construction and performance requirements such that the ground wire function, the optical fibre integrity and optical transmission characteristics are suitable for the intended purpose. The cable shall consist of optical fibre units as defined in this specification. There shall be no factory splices within the cable structure of a continuous cable length.

The composite fibre optic overhead groundwire shall be made up of multiple buffer tubes embedded in a water tight aluminium/aluminium alloy/stainless steel protective fibre optic unit surrounded by concentric-lay stranded metallic wires in single or multiple layers. Each buffer tube shall have maximum 12 no of fibres. All fibres in a single buffer tube or directly in central fibre optic unit is not acceptable. The dual purpose of the composite cable is to provide the electrical and physical characteristics of conventional overhead ground wire while providing the optical transmission properties of optical fibre. The Concessioner shall conduct all the type tests or shall submit the type test reports of OPGW earthwire.

4.7.1 Central Fibre Optic Unit

The central fibre optic unit shall be designed to house and protect multiple buffered optical fibre units from damage due to forces such as crushing, bending, twisting, tensile stress and moisture. The central fibre optic unit and the outer stranded metallic conductors shall serve together as an integral unit to protect the optical fibres from degradation due to vibration and galloping, wind and ice loadings, wide temperature variations, lightning and fault current, as well as environmental effects which may produce hydrogen.

The OPGW design of dissimilar materials such as stainless steel tube with aluminium or aluminium clad-steel wire strands are not allowed. Central Fibre optic unit may be of aluminium or stainless steel tube or stainless steel tube with aluminium protective coating. In case of aluminium protective coating the coating must completely cover the tubes leaving no exposed areas of tubing that can make electrical contact either directly or indirectly through moisture, contamination, protrusions etc with the surrounding stranded wires. The tube may be fabricated as a seamless tube, seam welded, or a tube without a welded seam.

4.7.2 Basic Construction

The cable construction shall conform to the applicable requirements of specification, applicable clauses of IEC 61089 related to stranded conductors and Table 2(a) OPGW Mechanical and Electrical Characteristics. In addition, the basic construction shall include bare concentric lay stranded metallic wires with the outer layer having left hand lay. The wires may be of multiple layers with a combination of various metallic wires within each layer. The direction of lay for each successive layer shall be reversed. The finished wires shall contain no joints or splices. The wires shall be so stranded that when the complete OPGW is cut, the individual wires can be readily regrouped and then held in place by one hand.

4.7.3 Breaking Strength

The rated breaking strength of the completed OPGW shall be taken as no more than 90 percent of the sum of the rated breaking strengths of the individual wires, calculated from their nominal diameter and the specified minimum tensile strength. The rated breaking strength shall not include the strength of the optical unit. The fibre optic unit shall not be considered a load bearing tension member when determining the total rated breaking strength of the composite conductor.

4.7.4 Electrical and Mechanical Requirements
Table 2(a) provides OPGW Electrical and Mechanical Requirements for the minimum performance characteristics. Additionally, the OPGW mechanical & electrical characteristics shall be similar to the electrical & mechanical characteristics of 7/3.15 GI Earthwire such that there is no or minimal consequential increase in stresses on towers.

Table2(a)

A) OPGW ELECTRICAL AND MECHANICAL REQUIREMENTS

1	Everyday Tension	≤ 20% of UTS of OPGW
2	D. C. Resistance at 20°C	< 1.0 ohm/Km
3	Short Circuit Current	≥ 6.32 kA for 1.0 second

B) TECHNICAL PARTICULARS OF OPGW EARTHWIRE

Physical properties

1	Overall diameter	11.70 mm Nominal diameter
2	Ultimate tensile strength	54 KN minimum
5	Approximate weight (kg/ Km)	400

4.7.5 Operating Conditions
Since OPGW shall be located at the top of the EHV transmission line support structure, it will be subjected to Aeolian vibration, galloping and lightning strikes. It will also carry ground fault currents. Therefore, its electrical and mechanical properties shall be the same or similar as those required of conventional ground conductors.

4.7.6 Installation

OPGW shall be installed under off line condition during construction of line. The installation shall be generally in accordance with the IEEE Guide to the Installation of Overhead Transmission Line Conductors (IEEE Standard 524 with latest revisions), with additional instructions and precautions for live line working and fibre optic cable handling. The stringing procedure and stringing chart shall be submitted prior to stringing for MSETCL’s approval.

The OPGW cable sections shall normally be terminated & spliced only on tension towers. In exceptional circumstances, and on employer specific approval, cable may be terminated on suspension towers, but in this case tower strength shall be examined to ensure that tower loads are within safe limits and if required, necessary tower strengthening shall be carried out by the contractor.

4.7.7 Installation Hardware

The scope of supply of the optical cable includes the assessment, supply and installation of all required fittings and hardware such as Tension assembly, Suspension assembly, Vibration dampers, Reinforcing rods, Earthing clamps, Downlead clamps, splice enclosure etc. The Concessioner
shall provide documentation justifying the adequacy and suitability of the hardware supplied.
The quantity of hardware & fittings to meet any eventuality during site installation min. @ 1%
shall also be provided as part of set/km. for transmission line without any additional cost to owner.
The parties shall determine the exact requirements of all accessories used to install and secure
the OPGW.

The OPGW hardware fittings and accessories shall follow the general requirements regarding design, materials, dimensions & tolerances, protection against corrosion and markings as specified in clause 4.0 of EN 61284:1997 (IEC 61284). The shear strength of all bolts shall be at least 1.5 times the maximum installation torque. The OPGW hardware & accessories drawing & Data Requirement Sheets (DRS) document shall consist of three parts: (1) A technical particulars sheet (2) An assembly drawing i.e. level 1 drawing and (3) Component level drawings i.e. level 2 & lower drawings. All component reference numbers, dimensions and tolerances, bolt tightening torque & shear strength and ratings such as UTS, slip strength etc. shall be marked on the drawings.

The fittings and accessories described herein are indicative of installation hardware typically used for OPGW installations and shall not necessarily be limited to the following:

(a) Suspension Assemblies: Preformed armour grip suspension clamps or aluminium alloy armour rods/ reinforcing rods shall be used. The supply shall include all the components of the suspension assembly including shackles, bolts, nuts, washers, split pins, P. G. clamp etc.

(b) Dead End Clamp Assemblies: All dead end clamp assemblies shall preferably be of preformed armoured grip type. The supply shall include all necessary components of the Dead end assembly for attaching the assembly to the tower strain plates including shackles, Turn buckle, bolts, nuts, washers, split pins etc..

(c)Earth Bond:__The earth bond shall be made of E.C. grade (% of Copper ≥ 99.9%) tinned flexible copper cable of size 37/7/0.417 mm with 8.757 mm diameter and copper area equivalent of 34 mm^2 confirming to IS:191(VI).

One / Two tinned copper lugs having suitable holes for 12 mm & 16 mm diameter bolts shall be press jointed at both ends for connecting it to the Suspension Clamp assembly and tower body.

For Tension Clamp assembly, one tinned copper lug having suitable hole for 16 mm diameter bolt shall be press jointed at one end for connecting it to the tower body. The other end of the copper cable shall be provided with press jointed tinned closed copper lug for fixing it in the Parallel Groove Clamp.

One 45 mm long Hot Dip galvanised Mild Steel bolt with nut and plain, spring washer (Electro Galvanised) shall also be provided. This shall be suitable for providing proper bondage between suspension / tension clamp assembly and the tower body. The pulloff load shall not be less than 300 kg.

The length of the Earth Bond shall be suitable for the Single / Double Suspension and Tension clamp assembly and shall be 750 mm minimum.

(d) Structure Attachment Clamp Assemblies: Clamp assemblies used to attach the OPGW to the structures, shall have two parallel grooves one for for the OPGW and other for copper Earth bond on either side of the connecting bolt.

(e) Vibration Dampers: Vibration dampers type 4R Stockbridge or equivalent, having four (4) different frequencies spread within the Aeolian frequency bandwidth corresponding to wind speed of 1m/s to 7 m/s shall be used for suspension and tension points in each span. The parties shall determine the exact numbers and placement of vibration dampers through a detailed vibration analysis. Vibration damper clamps shall be made of aluminium or aluminium alloy and shall support the dampers during installation.

One damper minimum on each side per OPGW cable for suspension points and two dampers minimum on each side per OPGW cable for tension points shall be used for nominal design span of 350 meters. For all other ruling spans, the number of vibration damper shall be based on vibration analysis.

The clamp of the vibration damper shall be made of high strength aluminium alloy of type LM-6. It shall be capable of supporting the damper and prevent damage or chaffing of the conductor during erection or continued operation. The clamp shall have smooth and permanent grip to keep the damper in position on the OPGW cable without damaging the strands or causing premature fatigue failure of the OPGW cable under the clamp. The clamp groove shall be in uniform contact with the OPGW cable over the entire clamping surface except for the rounded edges. The groove of the clamp body and clamp cap shall be smooth, free from projections, grit or other materials which could cause damage to the OPGW cable when the clamp is installed. Clamping bolts shall be provided with self locking nuts and designed to prevent corrosion of threads or loosening in service.

The messenger cable shall be made of high strength galvanised steel/stain less steel. It shall be of preformed and post formed quality in order to prevent subsequent droop of weight and to maintain consistent flexural stiffness of the cable in service. The messenger cable other than stainless steel shall be hot dip galvanised in accordance with the recommendation of IS:4826 for heavily coated wires.

The damper mass shall be made of hot dip galvanised mild steel/cast iron or a permanent mould cast zinc alloy. All castings shall be free from defects such as cracks, shrinkage, inclusions and blow holes etc. The surface of the damper masses shall be smooth. The damper mass shall not slip out of the messanger cable at a load less than 500 kg.

The damper clamp shall be casted over the messenger cable and offer sufficient and permanent grip on it. The messenger cable shall not slip out of the grip at a load less than the mass pull-off value of the damper. The damper masses made of material other-than zinc alloys shall be fixed to the messenger cable in a suitable manner in order to avoid excessive stress concentration on the messenger cable which shall cause premature fatigue failure of the same. The messenger cable ends shall be suitably and effectively sealed to prevent corrosion. The damper mass made of zinc alloy shall be casted over the messenger cable and have sufficient and permanent grip on the messenger cable under all service conditions.

The contractor must indicate the clamp bolt tightening torque to ensure that the slip strength of the clamp is maintained between 2.5 KN to 5 KN. The clamp when installed on the OPGW cable shall not cause excessive stress concentration on the OPGW cable leading to permanent deformation of the OPGW strands and premature fatigue failure in operation.

The technical particulars for vibration analysis and damping design of the system are as follows:

Sr.No	Description	Technical Parameters
1	Span Length in meters i) Ruling design span ii) Maximum span iii) Minimum span	 350 meters 800 meters 136 meters
2	Configuration	As per specification
3	Tensile load in each	As per sag-tension calculations
4	Armour rods used	Standard Preformed Armour Rods/AGS
5	Maximum permissible dynamic strain	+/- 150 micro strains

The damper placement chart for spans ranging from 136 m to 800 m shall be submitted by the Concessioner. Placement charts should be duly supported with relevant technical documents and sample calculations.

The damper placement charts shall include the following:-

1) Location of the dampers for various combinations of spans and line tension clearly indicating the number of dampers to be installed per OPGW cable per span.

2) Placement distances clearly identifying the extremities between which the distances are to be measured.

3) Placement recommendation depending upon type of suspension clamps (viz Free center type /Armour grip type etc.)

4) The influence of mid span compression joints, repair sleeves and armour rods (standard and AGS) in the placement of dampers.

The Concessioner shall conduct all the type tests or submit the type test reports of accessories of OPGW earthwire.

5.0 FIBRE OPTIC SPLICE ENCLOSURES (JOINT BOX):

All splices shall be encased in Fibre Optic Splice Enclosures. Suitable splice enclosures shall be provided in line with TECGR/OJC-02/02 Sept 2003 to encase the optical cable splices in protective, moisture and dust free environment. Splice enclosures shall comply to ingress protection class IP 66 or better. The splice enclosures shall be designed for the storage and protection of required no of optical fibre splices and equipped with sufficient number of splice trays for splicing all fibres in the cable. No more than 6 fibres shall be terminated in a single splice tray. They shall be filled with suitable encapsulate that is easily removable should re-entry be required into the enclosures. Splice enclosures shall be suitable for outdoor use with each of the cable types provided under this contract. Splice enclosures shall be appropriate for mounting on transmission line towers above anti-climb guard levels at about 10 meters from top of the tower and shall accommodate pass through splicing. The actual mounting height and location shall be finalised after survey. Contractor shall be responsible for splicing of fibres and installation of splice enclosures.

5.1 OPTICAL FIBRE SPLICES:

Splicing of the optical fibre cabling shall be minimized through careful contractor planning. There shall be no mid-span splices allowed. All required splices shall be planned to occur on tower structures. All optical fibre splicing shall comply with the following:

(a) All fibre splices shall be accomplished through fusion splicing.

(b) Each fibre splice shall be fitted with a splice protection sheath fitted over the final splice.

(c) All splices and bare fibre shall be neatly installed in covered splice trays. No more than six

(6) fibres shall be installed in each splice tray.

(d) For each link, bi-directional attenuation of single mode fusion splices, shall not average more than 0.05 dB and no single splice loss shall exceed 0.1 dB when measured at 1550 nm.

(e) For splicing, fibre optic cable service loops of adequate length shall be provided so that all splices occurring at tower structures can be performed at ground level.

6.0 FIBRE OPTIC APPROACH CABLES:

For purposes of this specification, a fibre optic approach cable is defined as the armoured underground fibre optic cable required to connect Overhead Fiber Optic Cable (OPGW) between the final in line splice enclosure on the gantry/tower forming the termination of the fibre cable on the power line and the Fibre Optic Distribution Panel (FODP) installed within the building. The estimated fibre optic approach cabling length shall be decided during site survey or detailed engineering. However, the Contractor shall supply & install the optical fibre approach cable as required based on detailed site survey to be carried out by the Contractor during the project execution and the Contract price shall be adjusted accordingly.

6.1 BASIC CONSTRUCTION:

The cable shall be suitable for direct burial, laying in trenches & PVC/Hume ducts, laying under false flooring and on indoor or outdoor cable raceways.

6.2 JACKET CONSTRUCTION & MATERIAL:

The Approach Cable shall be a UV resistant, rodent proof, armoured cable with metallic type of armouring. The outer cable jacket for approach cable shall consist of carbon black polyethylene resin to prevent damage from exposure to ultra-violet light, weathering and high levels of pollution. The jacket shall conform to ASTM D 1248 for density.

6.3 OPTICAL, ELECTRICAL AND MECHANICAL REQUIREMENTS:

Approach cable shall contain fibres with identical optical/ physical characteristics as those in the OPGW cables. The cable core shall comprise of tensile strength member(s), fibre support/bedding structure, core wrap/bedding, and an overall impervious jacket.

7.0 INSTALLATION OF APPROACH CABLE:

A network of cable trenches and/or ducts may exist at some sites. The parties shall make its best effort to route the cable through the existing available cable trenches. The approach cable shall be laid in the HDPE pipe in all conditions. In order to utilize the existing trenches, the approach cable may be required to be co-located with HV and LV cables. Accordingly, the approach cable shall be installed in corrosion resistant flexible conduit. Suitable provisions shall be made by the parties to ensure adequate safety earthing and insulated protection for the approach cable. All required fittings, supports, accessories, ducts, inner ducts, conduits, risers and any item not specially mentioned but required for lay and installation of approach cables shall be supplied and installed by the parties.

8.0 OPTICAL FIBRE TERMINATION AND SPLICING:

Optical fibre terminations shall be installed in Fibre Optic Distribution Panels (FODP) designed to provide protection for fibre splicing of preconnectorized pigtails and to accommodate connectorized termination and coupling of the fibre cables. The contractor shall provide rack mounted Fibre Optic Distribution Panels (FODPs) and shall terminate the fibre optic cabling upto the FODPs. The location of FODP rack shall be fixed by the Contractor, with the Employer's approval.

8.1 FIBRE OPTIC DISTRIBUTION PANELS:

At each location requiring the termination of at least one fibre within a cable, all fibres within that cable shall be connectorized and terminated in Fibre Optic Distribution Panels in a manner consistent with the following.

1) All fibre optic terminations shall be housed using FODPs provisioned with splice organizers and splice trays. All fibres within a cable shall be fusion spliced to pre-connectorized pigtails and fitted to the "Back-side" of the provided fibre optic couplings. 2) FODPs shall be suitable for use with each of the cable types provided as part of this contract. FODPs shall accommodate pass through splicing and fibre terminations.

3) FODPs for indoor use shall be supplied in suitable cabinets/racks with locking arrangement.

4) All FODPs shall be of corrosion resistant, robust construction and shall allow both top or bottom entry for access to the splice trays. Ground lugs shall be provided on all FODPs and the Contractor shall ensure that all FODPs are properly grounded. The FODP shall meet or exceed ingress protection class IP55 specifications.

5) Flexible protection shall be provided to the patch cord bunches going out from FODP to other equipment.

8.2 Optical Fibre Connectors.

Optical fibres shall be connectorised with FC-PC type connectors preferably. Alternatively connector with matching patch cord shall also be acceptable. Fibre optic coupling supplied with FODPs shall be appropriate for the fibre connectors to be supported. There shall be no adapaters.

8.3 Service Loops

For purposes of this specification, cable and fibre service loops are defined as slack (extra) cable and fibre provided for facilitating the installation, maintenance and repair of the optical fibre cable plant.

<u>Outdoor Cable Service Loops</u>: In-Line splice enclosures installed outdoors and mounted on the utility towers, shall be installed with sufficient fibre optic cable service loops such that the recommended minimum bend radius is maintained while allowing for installation or maintenance of the cable to be performed in a controlled environment at ground level.

Indoor Cable Service Loops: FODPs shall provide at least three (3) meters of cable service loop. Service loops shall be neatly secured and stored, coiled such that the minimum recommended bend radius is maintained.

Fibre Units Service Loops: For all fibre optic cable splicing, the cable shall be stripped back a sufficient length such that the fan-out of fibre units shall provide for at least one (1) meter of fibre unit service loop between the stripped cable and bare fibre fan-out.

Pigtail Service Loops: Connectorised pigtails spliced to bare fibres shall provide at least 1 meter of service loop installed in the FODP fibre organizer and at least one (1 meter) of service loop to the couplings neatly stored behind the FODP coupling panels.

Fibre Service Loops: At least 0.5 meters of bare fibre service loop shall be provided on each side of all fibre splices. The bare fibre service loops shall be neatly and safely installed inside covered splice trays.

9.0 Methodology for Installation and Termination.

All optical fibre cable termination, installation, stringing and handling plans, guides and procedures, and engineering analysis (e.g. tension, sag, vibration etc.) shall be submitted to the Employer for review and approval in the engineering/design phase of the project, prior to establishing the final cable lengths for manufacture. Installation procedures including details of personnel and time required shall be documented in detail and submitted to Employer for approval. All installation practices shall be field proven and ISO accredited.

All cable segments shall include service loops as specified in this specification. The maximum allowable stringing tension, maximum allowable torsional shear stress, crush strength and other physical parameters of the cable shall not be exceeded. The preventative measures to be taken shall be documented in detail and submitted to Employer in advance of installation.

Optical fibre attenuation shall be measured after installation and before splicing. Any increase in attenuation or step discontinuity in attenuation shall not be acceptable and shall constitute a cable segment failure. In the event of cable damage or any fibre damage, the complete section (tension location to tension location) shall be replaced as mid span joints are not acceptable.

Any or all additional steel work or modifications required to attach the fibre cabling to the overhead transmission/distribution line towers shall also be carried out by the Contractor. It shall be the Contractors responsibility to provide adequate communications among all crew members and support staff to ensure safe and successful installations.

SECTION - II

1.0 SURVEY AND ALIGNMENT

1.1 Check Survey

1.1.1 The Contractor shall finalise and submit proposal for all obligatory points within One (1) Month from the date of commencement of work at site. These obligatory points shall include all the river crossings, railway crossings, Power Line crossings or any other important crossings encountered in the transmission line route. The following schedule shall be adhered to in respect of obligatory points.

1.1.2 Route Making:

1.2 Tower Location

1.2.1 Sag Template

Sag template curve drawing and tower spotting Data shall be supplied by the owner to the successful Concessioner on award of contract. Sag template prepared based on the supplied sag template curve drawing shall only be used for tower spotting on the profiles Two nos. of the approved template prepared on rigid transparent plastic sheet, shall be provided by the Contractor to the Owner for the purpose of checking tower spotting. The templates shall be on the same scale as that of the profile.

1.2.2 Tower Spotting

With the help of approved sag template and tower spotting data, tower locations shall be marked on the profiles While locating the towers on the profile sheet, the following shall be considered.

a) Span

The number of consecutive spans between the Section points shall not exceed 10.(A section point shall be taken to comprise of a tension point with angle tower).

b) Extension

An individual span shall be as near to the normal design span as possible. In case an individual span becomes too short with normal supports on account of undulations in ground profile, one or both the supports of the span may be extended by inserting standard body extension designed for the purpose according to technical specifications.

c) Loading

There shall not be any upward force on suspension towers under normal working conditions and the suspension towers shall support at least the minimum weight span as provided in the designs. In case uplift is unavoidable, it will be examined if the same can be overcome by adding standard body extensions to the towers failing which tension towers designed for purpose shall be employed at such positions.

d) Road crossing

At all important road crossings, the towers shall be fitted with single suspension or tension or double tension insulator strings depending on the type of towers and the importance of the road being crossed but the ground clearance at the roads under maximum temperature and in still air shall be such that even with conductor broken in adjacent span, the ground clearance of the conductor from the road surface will not be less than 8.0 meters. At all national highways tension towers with double tension string shall be used. The crossing span, however, will not exceed 200 meters in any case.

e) Railway Crossing

Railway Crossing shall be supported on 15^0 ,30^0 or 60^0 type towers on either side, depending on the merits of each case and shall be constructed in confirmity with the specification laid down by the Railway Authorities. Necessary copies of tracings and prints of plan, profile etc. required for the approval of railway crossings shall be supplied by the Contractor.

f) River Crossing

In case of Major River Crossings, towers shall be of suspension type using double suspension strings and the anchor towers on either side of the man River crossing shall be 60^0 type tower with double tension string. Clearance required by navigation authority shall be provided. For non navigable rivers clearance shall be reckoned with respect to highest flood level (HFL).

g) Power Line Crossings

Where this line is to cross over another line of the same voltage or lower voltage, 2^0 type tower with suitable extensions shall be used. Provision to prevent the possibility of its coming into contact with other overhead lines shall be made in accordance with the Indian Electricity Rules, 1956. In order to reduce the height of the crossing towers, it may be advantageous to remove the ground wire of the line to be crossed (if this is possible and permitted by the Owner of the line to be crossed). All the works related to the above proposal shall be deemed to be included in the scope of the contractor without any extra cost of the Owner.

h) Telecommunication Line Crossing

The angle of crossing shall be as near to 90 Deg. as possible. However, deviation to the extent of 30^0 may be permitted under exceptionally different situations. When the angle of crossing has to be below 60^0, the matter will be referred to the authority in-charge of the telecommunication system. On a request from the Contractor the permission of the telecommunication authority will be obtained by the Owner. Also, in the crossing span, power line supports will be as near the telecommunication line as possible, to obtain increased vertical clearance between the wires.

1.2.3 Clearance from Ground Buildings, Trees etc.

Clearance from ground, buildings, trees and telephone lines shall be provided in conformity with the Indian Electricity Rules, 1956 as amended up to date.

1.2.4 Preliminary Schedule

The profile sheets, duly spotted, along with preliminary schedules indicating type of towers, type of foundations, wind span angle of deviation, river or road crossing and other details shall be submitted for the approval of the owner.

1.2.5 The detailed check survey shall be made along the alignment.

1.2.6 Preliminary line alignment and Soil resistivity measurement

During execution of the project, if due to some unavoidable reasons, the route is required to be diverted then the contractor shall have to submit the preliminary line alignment for the diverted portion to the owner for approval. The alignment shall be plotted on Survey of India maps to the scale of 1 cm=0.5 km.(1:50000). All the topographical details including all railway lines, P&T Lines, wires, canals, roads etc. up to 8 Kms. on either side of the route of the transmission line shall be drawn to the scale. After getting approval for the diverted alignment. Original tracing of the route alignment drawing shall be handed over to the Owner.

1.2.7 The soil resistivity, along the diverted line alignment, shall also be measured by the Contractor. It shall be measured by four electrodes method keeping inter-electrode spacing as 50 m. For calculating soil resistivity, the formula R=2 ar (where a = 50 m & r = Megger reading in OHMS) shall be adopted. The measurement shall be made at every 2 or 3 kms along the line route or wherever the soil characteristic changes.

1.2.8 All the expenditure on account of the above shall be deemed to be included in the bid price and no extra payment shall be made for the same.

1.3 Check Survey of Tower Location

1.3.1 The Check survey shall be conducted to make a check on detailed survey and to locate and peg mark the tower positions on ground conforming to the approved profile and tower schedule. In the process, it is necessary to have the pit centers marked according to the excavation marking charts. The levels, up or down of each pit center, with respect to the center of the tower location shall be noted and recorded for determining the amount of earthwork required to meet approved design parameters.

1.3.2 The changes desired by the Owner in the preliminary tower schedule shall be carried out by the Contractor and he shall thereafter submit a final tower schedule for the approval of the Owner. The tower schedule shall show position of all towers, "type of towers, span length, type of foundation for each towers and the deviation at all angles as set out with other details.

1.3.3 Excavation work must not be started until the approved tower schedule and profile has been given by the Owner.

1.3.4 The Owner may get certain tower foundations constructed by other agencies. However, the Contractor shall be responsible for check survey, location marking on the ground and stub setting work.

1.4 Way Leaves and Trees Cutting

1.4.1 Any way leave which may be required shall be arranged by the Contractor, after submission of the final alignment. Necessary help if required for establishing way leave and right of way shall given by the representatives of the MSETCL. However the tree cutting required for way leave, approach road and tower location shall be carried out by the contractor with the prior permission from Forest/ Local authorities. The payment for compensation of way leave and plantation shall be made by the successful Concessioner.

1.4.2 The Owner shall not be held responsible for any claim on account of damage done by the contractor or his gangs to trees, crops or other property without specific consent from the Owner.

ANNEXURE - X

GUARANTEED WEIGHTS OF TOWERS

Sr. No.	Type of Tower	Unit Weight (MT)	
		Steel Structure	Nuts & Bolts
C)	220 KV D/C		
1)	DA (2^0)		
a)	Stub	0.179	0.002
b)	Superstructure	3.889	0.132
c)	+ 3 mtr. extn.	0.524	0.025
d)	+ 6 mtr. extn.	0.963	0.032
e)	+ 9 mtr. extn.	1.712	0.057
2)	DAM (2^0)		
a)	Stub	0.199	0.002
b)	Superstructure	4.091	0.141
c)	+ 3 mtr. extn.	0.549	0.025
d)	+ 6 mtr. extn.	1.029	0.034
e)	+ 9 mtr. extn.	1.819	0.060
3)	DB (150)		
a)	Stub	0.243	0.002
b)	Superstructure	5.174	0.234
c)	+ 3 mtr. extn.	0.941	0.036
d)	+ 6 mtr. extn.	1.960	0.072
e)	+ 9 mtr. extn.	2.704	0.097
4)	DC (300)		
a)	Stub	0.305	0.002
b)	Superstructure	5.799	0.195
c)	+ 3 mtr. extn.	1.321	0.052
d)	+ 6 mtr. extn.	1.964	0.044
e)	+ 9 mtr. extn.	3.662	0.115
5)	DD (600)		
a)	Stub	0.419	0.002
b)	Superstructure	7.474	0.288
c)	+ 3 mtr. extn.	1.649	0.037
d)	+ 6 mtr. extn.	2.623	0.064
e)	+ 9 mtr. extn.	2.978	0.097
6)	SH (300)		
a)	Stub	0.079	0.002
b)	Superstructure	1.685	0.103
7)	SD (600)		
a)	Stub	0.212	0.002
b)	Superstructure	2.420	0.150
8)	DAM(20) + 12		
a)	Stub	0.198	0.002
b)	Superstructure	7.375	0.258
9)	DAM(20) + 15		
a)	Stub	0.243	0.003
b)	Superstructure	8.116	0.277
10)	DC(300) + 12		
a)	Stub	0.430	0.003

b)	Superstructure	10.500	0.309
11)	DD(600) + 12		
a)	Stub	0.596	0.007
b)	Superstructure	17.070	0.450
D)	220 KV M/C		
1)	MA (2^0)		
a)	Stub	0.419	0.002
b)	Superstructure	11.526	0.352
c)	+ 3 mtr. extn.	1.634	0.034
d)	+ 6 mtr. extn.	2.870	0.052
2)	MB (15^0)		
a)	Stub	0.718	0.002
b)	Superstructure	16.405	0.476
c)	+ 3 mtr. extn.	2.495	0.078
d)	+ 6 mtr. extn.	3.986	0.103
3)	MC (30^0)		
a)	Stub	0.907	0.002
b)	Superstructure	19.168	0.504
c)	+ 3 mtr. extn.	3.208	0.145
d)	+ 6 mtr. extn.	5.112	0.155
4)	MD (60^0)		
a)	Stub	0.968	0.002
b)	Superstructure	25.538	0.854
c)	+ 3 mtr. extn.	4.958	0.135
d)	+ 6 mtr. extn.	7.300	0.162
E)	132 KV M/C		
1)	MP (2^0)		
a)	Stub	0.314	0.006
b)	Superstructure	7.018	0.264
c)	+ 3 mtr. extn.	1.060	0.030
d)	+ 6 mtr. extn.	1.535	0.032
2)	MQ (15^0)		
a)	Stub	0.413	0.003
b)	Superstructure	9.330	0.350
c)	+ 3 mtr. extn.	1.501	0.034
d)	+ 6 mtr. extn.	2.234	0.050
3)	MR (30^0)		
a)	Stub	0.548	0.003
b)	Superstructure	11.298	0.430
c)	+ 3 mtr. extn.	1.858	0.046
d)	+ 6 mtr. extn.	2.978	0.079
4)	MS (60^0)		
a)	Stub	0.750	0.003
b)	Superstructure	14.700	0.502
c)	+ 3 mtr. extn.	2.588	0.091
d)	+ 6 mtr. extn.	3.753	0.101

ANNEXURE - XI

Guaranteed Excavation volumes, Concrete volumes and Reinforcement for 220kV DC & Horizantal Towers

Sr.	Tower Type	NORMAL FOUNDATION		
No.		Concrete	Excavation	Reinforcement
		Vol. (M^3)	Vol. (M^3)	(Kg)
		1:1.5:3		
I)	2^0 DA mkd. 'A'			
	(M/s. KEC)			
1)	A	1.707	17.81	63
2)	A + 3	1.707	17.81	63
3)	A + 6	1.707	17.81	63
4)	A + 9	1.768	18.68	63
II)	2^0 DAM mkd. 'AM'			
	(M/s. KEC)			
1)	AM	2.100	13.76	68
2)	AM + 3	2.100	13.76	68
3)	AM + 6	2.100	13.76	68
4)	AM + 9	2.200	14.67	68
III)	15^0 DB mkd. 'B'			
	(M/s. JYOTI)			
1)	B	3.170	34.27	74
2)	B + 3	3.170	34.27	74
3)	B + 6	3.170	34.27	74
4)	B + 9	3.170	34.27	74
IV)	30^0 DC mkd. 'C'			
	(M/s. TPC)			
1)	C	3.0248	20.909	75
2)	C + 3	3.0248	20.909	75
3)	C + 6	3.0248	20.909	75
4)	C + 9	3.0248	20.909	75
	(M/s. KPTL)			
1)	C + 12	7.300	24.66	189
V)	60^0 DD mkd. 'D'			
	(M/s. SAE)			
1)	D	7.820	87.48	440
2)	D + 3	7.820	87.48	440
3)	D + 6	7.820	87.48	440
4)	D + 9	7.820	87.48	440
	(M/s. SAE)			

1)	D + 12	--	--	--
	(M/s. TEL)			
1)	SH (300)	1.308	11.645	--
	(M/s. TEL)			
1)	SD (600)	4.674	39.2	--

Sr.	Tower Type	B.C./SUBMERGED FOUNDATION			
No.		Concrete	Lean Concrete	Excavation	Reinforcement
		Vol. (M^3)	(M^3)	Vol. (M^3)	(Kg)
		1:1.5:3	1:3:6		
I)	2^0 DA mkd. 'A'				
	(M/s. KEC)				
1)	A	12.723	2.112	140.19	528
2)	A + 3	12.723	2.112	140.19	528
3)	A + 6	12.723	2.112	140.19	528
4)	A + 9	13.084	2.178	150.34	550
II)	2^0 DAM mkd. 'AM'				
	(M/s. KEC)				
1)	AM	15.200	2.55	179.72	776
2)	AM + 3	15.200	2.55	179.72	776
3)	AM + 6	15.200	2.55	179.72	776
4)	AM + 9	15.752	2.65	186.28	857
III)	15^0 DB mkd. 'B'				
	(M/s. JYOTI)				
1)	B	27.66	3.53	221.88	827
2)	B + 3	27.66	3.53	221.88	827
3)	B + 6	27.66	3.53	221.88	827
4)	B + 9	27.66	3.53	221.88	827
IV)	30^0 DC mkd. 'C'				
	(M/s. TPC)				
1)	C	21.302	3.445	237.63	1232
2)	C + 3	21.302	3.445	237.63	1232
3)	C + 6	21.302	3.445	237.63	1232
4)	C + 9	21.302	3.445	237.63	1232
	(M/s.				
1)	C + 12	52.55	8.01	527.48	3044
V)	600 DD				
	(M/s.				
1)	D	30.15	5.41	369.05	2070

2)	D + 3	30.15	5.41	369.05	2070
3)	D + 6	30.15	5.41	369.05	2070
4)	D + 9	30.15	5.41	369.05	2070
	(M/s.				
1)	D + 12	53.62	--	206.67	--
	(M/s.				
1)	SH (300)	12.892	--	81.225	166
	(M/s.				
1)	SD (600)	14.730	--	139	1439

Sr.	Tower Type	HARD ROCK FOUNDATION		
No.		Concrete	Excavation	Reinforcement
		Vol. (M^3)	Vol. (M^3)	(Kg)
		1:1.5:3		
I)	2^0 DA mkd. 'A'			
	(M/s. KEC)			
1)	A	1.453	1.372	18
2)	A + 3	1.453	1.372	18
3)	A + 6	1.453	1.372	18
4)	A + 9	1.453	1.372	18
II)	2^0 DAM mkd. 'AM'			
	(M/s. KEC)			
1)	AM	1.458	1.372	18
2)	AM + 3	1.458	1.372	18
3)	AM + 6	1.458	1.372	18
4)	AM + 9	1.458	1.372	18
III)	15^0 DB mkd. 'B'			
	(M/s. JYOTI)			
1)	B	1.57	1.48	16
2)	B + 3	1.57	1.48	16
3)	B + 6	1.57	1.48	16
4)	B + 9	1.57	1.48	16
IV)	300 DC mkd. 'C'			
	(M/s. TPC)			
1)	C	1.581	1.483	19

2)	C + 3	1.581	1.483	19
3)	C + 6	1.581	1.483	19
4)	C + 9	1.581	1.483	19
	(M/s. KPTL)			
1)	C + 12	5.31	5.2	234
V)	600 DD mkd. 'D'			
	(M/s. SAE)			
1)	D	5.01	4.91	135
2)	D + 3	5.01	4.91	135
3)	D + 6	5.01	4.91	135
4)	D + 9	5.01	4.91	135
	(M/s. SAE)			
1)	D + 12	--	--	--
	(M/s. TEL)			
1)	SH (300)	0.856	0.777	--
	(M/s. TEL)			
1)	SD (600)	2.146	2.048	--

Sr.	Tower Type	FISSURED ROCK FOUNDATION		
No.		Concrete	Excavation	Reinforcement
		Vol. (M^3)	Vol. (M^3)	(Kg)
		1:1.5:3		
I)	2^0 DA mkd. 'A'			

	(M/s. KEC)			
1)	A	3.611	18.00	289
2)	A + 3	3.611	18.00	289
3)	A + 6	3.611	18.00	289
4)	A + 9	--	--	--
II)	20 DAM			
	(M/s. KEC)			
1)	AM	4.215	24.35	480
2)	AM + 3	4.215	24.35	480
3)	AM + 6	4.215	24.35	480
4)	AM + 9	--	--	--
III)	150 DB			
	(M/s.			
1)	B	12.7	35.57	188
2)	B + 3	12.7	35.57	188
3)	B + 6	12.7	35.57	188
4)	B + 9	12.7	35.57	188
IV)	300 DC			
	(M/s. TPC)			
1)	C	20.29	46.63	169
2)	C + 3	20.29	46.63	169
3)	C + 6	20.29	46.63	169
4)	C + 9	20.29	46.63	169
	(M/s. KPTL)			
1)	C + 12	13.48	51.08	190
V)	600 DD			
	(M/s. SAE)			
1)	D	28.39	92.973	346
2)	D + 3	28.39	92.973	346
3)	D + 6	28.39	92.973	346
4)	D + 9	28.39	92.973	346
	(M/s. SAE)			
1)	D + 12	--	--	--
	(M/s. TEL)			
1)	SH (300)	2.209	7.252	76
	(M/s. TEL)			
1)	SD (600)	9.07	33.89	113

GUARANTEED EXCAVATION, CONCRETE VOLUME AND STEEL REINFORCEMENT FOR 220 KV M/C TOWERS

Sr.	Tower Type	NORMAL DRY FOUNDATION		
No.		Concrete	Excavation	Reinforcement
		Vol. (M^3)	Vol. (M^3)	(Kg)
		1:1.5:3		
I)	2^0 MA mkd. 'MA'			
	(M/s. KEC)			
1)	MA	6.814	59.74	98
2)	MA + 3	6.814	59.74	98
3)	MA + 6	6.814	59.74	98
II)	15^0 MB mkd. 'MB'			
	(M/s. KEC)			
1)	MB	24.556	143.73	164
2)	MB + 3	24.556	143.73	164
3)	MB + 6	24.556	143.73	164
III)	30^0 MC mkd. 'MC'			
	(M/s. KEC)			
1)	MC	34.623	179.478	190
2)	MC + 3	34.623	179.478	190
3)	MC + 6	34.623	179.478	190
IV)	60^0 MD mkd. 'MD'			
	(M/s. SAE)			
1)	MD	35.56	256.13	1858
2)	MD + 3	35.56	256.13	1858
3)	MD + 6	35.56	256.13	1858

Sr.	Tower Type	B.C./SUBMERGED FOUNDATION			
No.		Concrete	Lean Concrete	Excavation	Reinforcement
		Vol. (M^3)	(M^3)	Vol. (M^3)	(Kg)
		1:1.5:3	1:3:6		
I)	2^0 MA mkd. 'MA'				
	(M/s. KEC)				
1)	MA	28.934	4.513	306.03	1450
2)	MA + 3	28.934	4.513	306.03	1450
3)	MA + 6	28.934	4.513	306.03	1450
II)	15^0 MB mkd. 'MB'				
	(M/s. KEC)				

1)	**MB**	**54.07**	**8.179**	**537.876**	**3346**
2)	**MB + 3**	**54.07**	**8.179**	**537.876**	**3346**
3)	**MB + 6**	**54.07**	**8.179**	**537.876**	**3346**
III)	300 MC mkd. 'MC'				
	(M/s. KEC)				
1)	MC	66.016	9.744	635.98	4999
2)	MC + 3	66.016	9.744	635.98	4999
3)	MC + 6	66.016	9.744	635.98	4999
IV)	600 MD mkd. 'MD'				
	(M/s. SAE)				
1)	MD	83.225	11.765	774.96	6743
2)	MD + 3	83.225	11.765	774.96	6743
3)	MD + 6	83.225	11.765	774.96	6743

Sr.	Tower Type	HARD ROCK FOUNDATION		
No.		Concrete	Excavation	Reinforcement
		Vol. (M^3)	Vol. (M^3)	(Kg)
		1:1.5:3		
I)	2^0 MA mkd. 'MA'			
	(M/s. KEC)			
1)	MA	2.535	2.425	22
2)	MA + 3	2.535	2.425	22
3)	MA + 6	2.535	2.425	22
II)	15^0 MB mkd. 'MB'			
	(M/s. KEC)			
1)	MB	6.087	5.977	31
2)	MB + 3	6.087	5.977	31
3)	MB + 6	6.087	5.977	31
III)	30^0 MC mkd. 'MC'			
	(M/s. KEC)			
1)	MC	6.915	6.771	32
2)	MC + 3	6.915	6.771	32
3)	MC + 6	6.915	6.771	32

IV)	60^0 MD mkd. 'MD'			
	(M/s. SAE)			
1)	MD	16.44	16.18	345
2)	MD + 3	16.44	16.18	345
3)	MD + 6	16.44	16.18	345

Sr.	Tower Type	FISSURED ROCK FOUNDATION			
No.		Concrete	Excavation	Lean Concrete	Reinforcement
		Vol. (M^3)	Vol. (M^3)	(M^3)	(Kg)
		1:1.5:3		1:4:8	
I)	2^0 MA mkd. 'MA'				
	(M/s. KEC)				
1)	MA	8.1061	37.437	0.9074	586
2)	MA + 3	8.1061	37.437	0.9074	586
3)	MA + 6	8.1061	37.437	0.9074	586
II)	15^0 MB mkd. 'MB'				
	(M/s. KEC)				
1)	MB	12.0063	80.001	1.5235	1092
2)	MB + 3	12.0063	80.001	1.5235	1092
3)	MB + 6	12.0063	80.001	1.5235	1092
III)	30^0 MC mkd. 'MC'				
	(M/s. KEC)				
1)	MC	15.0124	112.1386	2.048	1597
2)	MC + 3	15.0124	112.1386	2.048	1597
3)	MC + 6	15.0124	112.1386	2.048	1597
IV)	60^0 MD mkd. 'MD'				
	(M/s. SAE)				
1)	MD	23.884	169.53	2.9645	1938
2)	MD + 3	23.884	169.53	2.9645	1938
3)	MD + 6	23.884	169.53	2.9645	1938

SECTION – F – GIS SUBSTATION SPECIFICATIONS

Contents

TECHNICAL SPECIFICATION OF 132 OR 220kV GAS INSULATED SWITCHGEAR

1.1 SPECIFICATION OF 132 OR 132 OR 220kV GAS INSULATED SWITCHGEAR

1.1.1. SCOPE OF WORK

The scope of work comprises of design, manufacture, testing, supply, delivery at site, installation, testing and commissioning of 3-phase, 132 OR 220 kV, 3150 A, 50kA for 1 sec Gas insulated indoor type sub-station.

132 OR 220kV GIS shall be supplied from GIS manufacturer who has established manufacturing facility, service setup in India & have manufactured & supplied 132 OR 220kV or above higher rating GIS of minimum 10 bays from their Indian manufacturing unit and same should be in satisfactory operation in India for minimum two year as on date of submission of bid.

1.1.1.1. The **supply** will include all supporting structures, auxiliary equipment, mechanical linkages, hydraulic piping for control devices with pumps, SF6 gas piping, auxiliary circuits wiring, interlocking devices, current and voltage transformers, cable end boxes and SF6 bus ducts. Necessary sub-assemblies must be assembled in the supplier's plan, accounting for the transportation condition. The scope of work includes the following but not limited to

1.1.1.2. Each Incomer Bay - 2 Nos. consisting of;

Circuit Breaker - 1 No.

Current Transformer - 1 No. (as per SLD) Maintenance Earth Switch - 1 No.

Line Disconnector - 1 No.

Line Earth Switch (Fast acting) - 1 no.

Voltage Transformer with manually operated isolation device of rated insulation- 1 no.

Bus Disconnector Switch - 2 Nos.

Bus end Maintenance Earth Switch - 1 No.

Indoor lightning arrestor - 1 no.

1.1.1.3. Each Transformer Feeder Bay - 2 Nos. consisting of;

Circuit Breaker - 1 No.

Current Transformer - 1 No. (as per SLD)

Maintenance Earth Switch (Tr. Side) - 1 no. Maintenance Earth Switch (Bus Side) - 1 No.

Bus Disconnectors - 2 Nos.

Line Disconnector - 1 No.

Line Earth Switch (Fast acting) - 1 no.

Other items as required for connection to bus bars, cables etc. and for completing the intent of work

1.1.1.4. Each Bus Coupler Bay- 1 No. consisting of;

Circuit Breaker - 1 No.

Current Transformer - 2 Nos.

Bus Disconnectors & Earth Switch - 2 Nos.

Other items as required for connection to bus bars, cables etc. and for completing the intent of work

1.1.1.5. Each Bus VT Module - 2 Nos. consisting of;

Voltage Transformer with manual isolating link - 1 No.

Bus Earthing Switch - 1 No.

1.1.1.6. Bus bars for double bus arrangement.

1.1.1.6.1. New Gas charging equipment with gas cylinders for each set of the newly constructed GIS substation covered in the scope of work. After commissioning this will become property of Employer. The contractor would be required to hand over them in proper working condition with 10% gas.

1.1.1.6.2. EOT crane with VVVF drive for continuous operation for GIS equipment handling during installation, commissioning and maintenance etc. Crane lifting capacity shall be adequate to handle the heaviest package of GIS but shall not be less than 10 ton capacity.

1.1.1.6.3. Supply, erection, testing and commissioning of all items of work required to make the HV bays (132 OR 220kV) fully functional.

1.1.1.7. Main Feature required :

1.1.1.7.1. The 132 OR 220 kV equipment shall be built according to the SF6 gas insulation technology. The equipment shall be indoor type, and shall be installed building.

1.1.1.7.2. 132 OR 220kV GIS as offered should be fully type tested as per latest IEC standards at the time of submitting the bid. The bidder would be required to submit the detailed type test reports as per latest IEC standards in the event of an order. GIS manufacturer need to submit type test from their present subsidiary unit or principle/collaborator/group units.

1.1.1.7.3. The equipment installed shall offer all necessary facilities for equipping and connecting the equipment sections to follow, without entailing any shut down of equipment already in service as possible as per the manufacturer's recommendation.

1.1.1.7.4. In the event of arcing in a compartment, the arc should not extend to the neighboring compartment. Any failure to the enclosure of the compartment shall not lead to damages in the neighboring compartments. In view of this, continuous busbar without gas segregation is not acceptable.

1.1.1.7.5. Suitable means of expansions should be provided in the metal enclosure and pipelines to absorb the actual thermal expansion and contraction of the SF6 equipment and to facilitate the alignment of switchgear assembly.

1.1.1.7.6. The metal enclosures for the SF6 gas insulated equipment modules shall be made from aluminum alloy.

1.1.1.7.7. GIS should be of modular design, and it should be possible to add feeder bays. The layout of GIS equipment should show space earmarked for the future provision.

1.1.1.7.8. The incoming 3 phase 132 OR 220kV single core cable feeders shall be of minimum size of 800/1000 sq.mm Copper and shall be verified by the contractor. The terminations at transformers shall be of normal Indoor type with suitable cable connection from the GIS.

1.1.1.7.9. The Disconnectors and earthing switches shall be electrically interlocked against maloperation. Feeder earthing switch shall be fast acting type and isolated from earthed enclosures and shall permit testing of switchgear. It shall also be possible to carryout high voltage testing of cable cores (provision for applying maximum 10kV AC/1 min test voltage) without having to open the breaker assembly or SF6 chamber without disconnecting the cables. For other routine maintenance also, dismantling of switchgear should be required.

1.1.1.7.10. Conductors/Busbars shall be made of Aluminium alloy, suitable for the specified voltage and current ratings. The electrical connections between the various gas sections shall be made by means of multiple contact connectors (plug-in type) so that electrical connection is automatically achieved when fixing one section to another. Field welding of the conductor is not acceptable. The surface of the contacts shall be silver- plated.

1.1.1.7.11. All fixtures or nuts or instruments whose maintenance / opening would leak the SF6 gas should be clearly ear marked and distinctly identifiable.

1.1.1.7.12. All gas sampling shall be possible during normal operation and without loss of gas.

1.1.1.7.13. Loss of gas per annum shall not exceed 0.5 % by weight in each compartment.

1.1.1.7.14. Adequate burden capacity shall be available in instrument transformers to permit provision of additional test, protection on measuring instruments. CT cores will be as per SLD.

1.1.1.7.15. Clear visual indication of isolator and earthing switch, switch blade position, whether open or closed shall be provided.

1.1.1.7.16. Each component shall be modular and complete with ancillary equipment.

1.1.1.7.17. Circuit breaker shall be of single pressure interrupter. The moving and fixed contacts shall be housed in the same interrupter chamber without any split so as not to affect the synchronism of three phases. The Operating Mechanism for the circuit breaker shall be Spring/Spring or Hydro mechanical Spring to give highest reliability to the system, following loss of supply voltage the operating mechanism shall have local storage sufficiency for a duty cycle of O-CO without the need for recharging. No other equipment of GIS shall be part of CB gas compartment. Bidder need to demonstrate this with gas schematic diagram submitted with bid.

1.1.1.7.18. The isolators shall be fitted with a suitable actuation system operating simultaneously on all three poles, backed up by an emergency manual actuation in case of malfunction of the former. The isolators shall not change of position under the effect of electro dynamic loads.

1.1.1.7.19. In case of any internal arc fault/flashover - regardless whether it occurs in a bus bar section, a busbar isolator or the circuit breaker-repair works should be possible without shutting down the substation; at least one busbar and the undisturbed feeder should remain in operation. It should be possible to remove and replace a circuit breaker interrupter without interfering the operation of the adjacent feeder. All circuit breakers should be interchangeable.

1.1.1.7.20. The GIS equipment shall be arranged in such a manner that in case of maintenance work on any of the equipment, at least one bus bar should be available for operation.

1.1.1.7.21. Each bay shall be segregated from its neighboring bays by means of gas tight barrier insulators to ensure that in case of an internal arc the fault will be restricted to the concerned bay.

1.1.1.7.22. The Local Control Cubicles shall be integrated with the GIS.

1.1.1.7.23. Following accessories shall be provided for each compartment.

a) Pressure relief devices.

b) Provision of desiccants.

c) Gas Valve

1.1.1.7.24. Monitoring of Gas in the enclosure:

Each gas compartment should have its own SF6 pressure monitoring facilities as well as static filters. Pressure relief devices shall be designed to limit maximum pressurize below the busting level of the enclosure and barrier insulation. Instrument shall be provided to continuously monitor the Gas density. The Gas density meter should be provided with Scale.

Each Single phase module shall have separate Gas Density monitors. Combined gas density monitors for multiple modules shall not be acceptable in any case.

The GIS shall be equipped with the remote online GAS monitoring system. The gas pressure of each compartment shall be able to be monitored remotely from SCADA. The system shall have the facility to pinpoint the exact gas module in the bay where gas leakage problem is there.

1.1.1.7.25. The protection devices for this equipment shall ensure permanent monitoring of gas pressure inside each compartment by means of temperature compensated monitoring devices triggering a dual alarm threshold annunciation system in the event of gas pressure drops:

Stage 1: Performance of the station is unaffected, in particular cut-off capabilities remain intact. Immediate intervention by the specialist is not necessary but recommended.

Stage 2: The dielectric properties of the station in the presence of occurring over voltage shall be such that all the necessary isolating operations still remain possible without any danger nor any accident taking place. The concerned breaker should trip and / block.

1.1.1.7.26. The inter bay width shall be sufficient to allow access to all drive mechanisms and other termination boxes without the need of dismantling other apparatuses.

1.1.1.7.27. The design of the cable termination shall allow plugging and unplugging the HV cable without need of opening the GIS and without any gas work or minimum work.

1.1.1.7.28. The GIS shall be provided with the inspection windows at the disconnector and maintenance earth switch positions to have visual check on switch contact conditions and positions.

1.1.1.8. STANDARD SPECIFICATIONS

The switchgear conforms to the following IEC standards:

1.1.1.8.1. SWITCHGEAR, GENERAL:

IEC 62271-1 :	High-voltage switchgear and control gear Part 1: Common specifications
IEC 62271-203:	High-voltage switchgear and control gear Part 203: Gas-insulated metal enclosed switchgear for rated voltages above 52 kV Circuit-breakers:
IEC 62271-100:	High-voltage switchgear and control gear Part 100: Alternating-current c Circuit-breakers
IEC 62271-303:	High-voltage switchgear and control gear - Use and handling of sulphur hexafluoride (SF6)
IEC 61000:	Electromagnetic compatibility (EMC) IEC 60060 High voltage test techniques
IEC 60255:	Electrical relays
IEC 6026:	High voltage switches
IEC 60270:	High-voltage test techniques - Partial discharge measurements
IEC 60376	Specification and acceptance of new Sulphur hexafluoride
IEC 60480	Guide to checking of Sulphur hexafluoride (SF6)
IEC 60529:	Degrees of protection provided by enclosures (IP Code)
IEC 60815:	Guide for the selection of insulators in respect of polluted conditions
IEC 61869	Instrument transformers
IEC 60364 / 60479 / 60621 / IEEE std. 80	Standards for station rounding CENELEC/SVDB Pressure vessel codes.

1.1.1.8.2. CABLE CONNECTIONS:

IEC 62271-209: High-voltage switchgear and control gear Part 209: Cable connections for gas-insulated metal-enclosed switchgear for rated voltages above 52 kV - Fluid-filled and dry- type cable-terminations.

1.1.1.8.3. OUTDOOR BUSHINGS:

IEC 60137: Insulated bushings for alternating voltages above 1000 V Transformer direct connection:

IEC 61639 62271-211: Direct connection between power transformers and gas-insulated metal-enclosed switchgear for rated voltages of 72.5 kV and above.

1.1.1.8.4. LOCAL CONTROL CUBICLES:

IEC 61439 -1: Low-voltage switchgear and control gear assemblies Part 1: General rules EMC.

IEC 62271-1: High-voltage switchgear and control gear Part 1: Common specifications

1.1.1.8.5. ENCLOSURE

CENELEC standard or other equivalent mentioned above

1.1.1.8.6. MODULAR DESIGN

Housings and expansion joints together form the pressure-resistant enclosure of the switchgear. The housings are made of cast or welded aluminum, the expansion joints of high-grade steel and the covers of steel or aluminum. The switchgear modules are singlephase or three-phase encapsulated.

The manufacturing and testing of the housings are state-of-the-art technology. Each housing is subject to a pressure and gas tightness test and complies with the requirements of the relevant CENELEC or equivalent standard.

Paint Shade

Paint Shade: Indoor RAL 7038 (Agate grey)/ RAL 7035 Outdoor RAL 9010 (Pure white)

1.1.1.8.7. GAS

Gas compartments, monitoring of gas compartments:
SF6 serves as insulation for the enclosure of several separately-sealed gas compartments static filters in all gas compartments - with single-phase encapsulation for each phase for single phase encapsulation design - absorb moisture and decomposition products; the filter material is placed in filter bags which are supplied In airtight cans

All gas compartments are equipped with rupture diaphragms and, if necessary, with gas diverter nozzles; these nozzles are arranged in a way that, if the rupture diaphragm bursts, the gas flow is guided away in a direction not unnecessary hazardous to either personnel or equipment the modules of circuit-breakers, voltage transformers, cable connection module form separate gas compartments.

1.2 132 OR 220kV GAS INSULATED SWITCHGEAR

1.2.1. GENERAL SPECIFICATION

The intent of this specification is to provide the work enumerated to be fully complete in every detail for the function designated. It is hereby required that the BIDDER, in accepting the contract, agrees to furnish all apparatus, appliances, material not herein specifically mentioned or included, but which may be found necessary to complete, perfect or test any portion of the apparatus or equipment herein specified in a substantial manner, and in compliance with the requirements implied in this specifica tion and without extra cost to the PURCHASER/OWNER.

The GIS manufacturer must have

(1) manufacturing facility and prompt after sale service support in India as on date of bid

(2) having HV 703 testing kit &

(3) provide supporting documents for the same.

1.2.2. ELECTRICAL RATINGS:

The GIS equipment shall be provided with one enclosure per phase or three phase for all gas compartments. The apparatus shall have the following basic electrical and design characteristics: 132 OR 220kV

i)	Phase design		1-ph / 3-ph
ii)	Rated voltage	kV	132 OR 220
iii)	Rated lightning impulse withstand voltage (peak)		
	Phase to earth	kV	1050
	Across open contacts	kV	1050+206
iv)	Power frequency 1 minute (r.m.s.)		
	Phase to earth	KV	460
	Across open contact	kV	460+145
v)	Rated frequency	Hz	50
vi)	Rated current (bus bars) [At 40°C]	A	3150A

vii)	Rated short-time current (r.m.s) (1s)	kA	50kA
viii)	Rated making current (peak)	kA	135
ix)	Rated short circuit breaking current	kA	50kA
x)	Partial discharge level, complete bay	pC	< 5

1.2.3. EQUIPMENT SPECIFICATION

It is understood that each manufacturer has their own particular GIS design concept and it is not the purpose of this specification to impose any unreasonable restrictions. However, in the interest of safety, reliability and maintainability, the switchgear offered shall meet the following minimum requirements stipulated herein.

1.2.3.1. General

The GIS shall be made of tubular Aluminum alloy and filled with SF6 gas for insulation. Enclosures shall be of 1-phase / 3-phase encapsulation for 245kV both the bus bars and the feeder section bays. The switchgear shall be modular in design. Future extensions shall be easily accomplished by adding extra feeders without dismantling any major parts of the equipment. As much as possible the parts shall be of standard manufacture with similar parts and assemblies being interchangeable. The tenderer is encouraged to offer an optimized physical layout regarding minimized space requirem ents and maintainability.

Shipping sections which are tested in the factory shall be jointed in the field by using bolted and sealed flange connections only. Field welding of enclosures is not acceptable. The size of the per-assembled shipping sections shall be as big as practical for transportation. Complete 3-Phase GIS assembly in the factory for testing purpose is mandatory. All routine & FAT test should be performed in factory on completely assembled GIS bays at the factory

The flanged connections shall have gas seals between the flange surfaces. Connections including bolts and nuts shall be adequately protected from corrosion and easy accessible with the proper tools.

Bus Potential Transformer (PT) shall be provided with manual isolating link switch as shown in the Single Line diagram.

1.2.3.1.1. SECTIONALIZATION

The switchgear must be sectionalized, with gas tight barriers between sections or compartments. The sections shall be designed

i. To minimize operational shut down when the gas pressure is reduced due to Leakage or for maintenance purposes.
ii. To minimize the quantity of gas that has to be evacuated and recharged before and after maintaining any item of equipment.

Continuous bus bar lengths without gas segregation shall not be acceptable under any circumstances. Service continuity concept shall be maintained as per IEC 62271-203, Annexure-F; Point F.3 to achieve the requirements of this specification. During maintenance of any feeder module in the GIS, at least one bus bar shall remain in service and any other feeder, except the feeder to be maintained, shall not be affected/ shall not be required to take shut down.

Each section shall be provided with necessary valves to allow evacuation and refill of gas without evacuation of any other section.

For the purpose of gas monitoring and maintenance, the GIS shall be provided with gas density monitoring device along with temperature compensated gas density switch having two stage contacts in each gas compartment. Each Single phase module shall have separate Gas Density monitors. Combined gas density monitors for multiple modules shall not be acceptable in any case.

Online Gas Pressure monitoring facility shall be provided. This system shall provide the facility to monitor the gas density levels of each gas module in the bay separately on remote HMI. Pressure relief devices shall be used where ever required.

1.2.3.1.2. CONDUCTOR TYPE AND CONTACTS

Conductors shall be made of Aluminum suitable for the specified voltage and current ratings. The electrical connections between the various gas sections shall be made by means of multiple contact connectors (plug-in type) so that electrical connection is automatically achieved when bolting one section to another. Field welding of the conductor is not acceptable. The surface of the connector fingers and conductor tubes on such connections shall be silver plated.

1.2.3.1.3. SUPPORT INSULATORS AND SECTION BARRIERS

Support insulators shall be used to maintain the conductors and enclosure in proper relation. Barrier insulators which are employed to isolate gas compartments as well as support insulators shall be manufactured from high quality epoxy resin, free of all voids and be designed to reduce the electrical stress on the insulators to a minimum. The support insulator shall have holes on both sides for proper flow of gas. The mechanical strength must be sufficient to ensure the conductor’s space requirements and clearances when short circuit faults occur.

1.2.3.1.4. GAS SYSTEM

The GIS shall be furnished with sufficient sulfur hexa-fluoride (SF6) gas to pressurize the complete system in a sequential approach, one zone or compartment at a time to the rated nominal density. During commissioning the dew point of SF6 gas shall be measured and documented. Maximum water content of SF6 -gas in GIS, within guarantee period:

CB ≤ 150 PPM (volume) Others ≤ 500 PPM (volume)

The Gas loss of the switchgear shall be in no case higher than 0.5% per year (as per IEC62271-203).

1.2.3.1.5. GAS SEALS

All gas seals shall be designed to ensure that leakage rates are kept to an absolute minimum under all normal pressure, temperature, electrical load and fault conditions. All gas seals located in the flanges of the equipment enclosures shall be of the O-ring type. The material and method of sealing used shall be stated in the tender.

1.2.3.1.6. GAS FILTERS / TREATMENT

Each gas compartment shall be fitted with gas filters, driers or desiccants for the absorption of moisture and the gaseous products of switching. The filter shall be effective for the duration of time between major overhaul. It shall be possible to replace the active material of the filter without extensive dismantling. The absorbent shall be located in an easy accessible location. The tenderer shall indicate the detail and type of filters used in the various gas sections

1.2.3.1.7. SF6 GAS QUALITY

The GIS shall be designed for use with SF6. All SF6 gas supplied as part of the tender shall comply with the requirements of IEC 60376 at a minimum.

1.2.3.1.8. GAS MONITORING DEVICES

Temperature-compensated gas density monitoring devices shall be provided for each gas compartment. The monitoring device shall have two alarm settings. These shall be set so that:

First stage: Advanced warning can be given that the gas density is approaching an unacceptably low level

Second stage: The relevant CB can be tripped/blocked.

1.2.3.1.9. GAS LOSS

Maximum guaranteed gas leakage loss of the switchgear shall be in no case be more than 0.5% per year.

1.2.3.1.10. SF6 GAS TREATMENT

Under normal operating conditions it shall not be necessary to treat the insulating SF6 gas between major overhauls. Normally closed valve shall be provided to facilitate filling and recharging. In all gas compartments permanent efficient filters and drying agent shall be at least effective for the duration of time between major overhauls. The filters shall be capable of absorbing the by-products of SF6 gas during interruption.

1.2.3.1.11. SUPPLY OF SF6 GAS

The tender shall include the supply of all SF6 gas necessary for filling and putting in commercial operation the complete switchgear installation with recommended extra quantity (minimum 10% extra).

1.2.3.1.12. PRESSURE RELIEF

Automatic external pressure relief devices shall be incorporated in the basic design as a precaution against bursting of enclosure. Internal pressure relief devices shall not be acceptable. The bursting pressure of the relief device shall be effectively coordinated with the rated gas pressure and the pressure rise due to arcing to avoid any mal-operation in normal operating conditions. Deflection devices shall be installed to ensure that personnel will not be endangered. Pressure relief shall be by means of a metallic bursting disc system with a preset opening pressure. For better gas tightness, bursting discs made of graphite or non-metallic material shall be avoided.

1.2.3.1.13. SWITCHGEAR ENCLOSURES

The metal enclosures for the GIS equipment modules shall be made from Aluminum alloy and tubular in construction. The tenderer shall state the material used for his particular design. All flanges shall be directly bolted together with good metallic contact to make enclosures equipotential.

Enclosures shall withstand normal and transient pressure in operation. They shall be designed and manufactured according to the related standards to guarantee safety and reliability of material, construction, welding technology and testing.

Enclosures shall be designed to withstand any internal arc specified in IEC 62271-203.

The gas-filled enclosures shall comply to the pressure vessel code applied in the country of manufacturer and shall be suitable for purchaser’s environmental condition.

1.2.3.1.14. EXPANSION JOINTS AND FLEXIBLE CONNECTION

Expansion and installation alignment shall be considered in the design of the bus and enclosure. The continuity of service during thermal expansion / contraction and vibrations shall be ensured. The switchgear shall be fixed to the floor with minimum requirement on floor preparation. If required, expansion joints shall be provided with compensator for the enclosure and sliding plug-in contacts for the conductors. Expansion joints and flexible connections shall be considered in the design of the bus and enclosure to take care of thermal expansion / contraction and vibrations during service and to absorb the relative movement between the switchgear equipment and its fixing structure / floor. The position of expansion joints or flexible connections are to be considered by the manufacturer to ensure that the complete installation will not be subject to expansion stresses which could lead to distortion or failure of any piece of the SF6 equipment, support structures or foundations. These expansion joints shall be provided with each bay, which will provide maximum tolerance and the flexibility during the installation & maintenance.

Also, expansion joints, flexible connections and adjustable mountings shall be provided to compensate for reasonable manufacturing and construction tolerances in the associated equipment to which the GIS may be connected. This is to ensure that unreasonably excessive accuracy is not required when installing such equipment and constructing the associated foundations or support structures, e.g. transformers or the interconnection of isolated sections of switchgear by means of long GIS bus bar or duct installations. Flexible joints may also be provided to allow more efficient maintenance and future extensions of the GIS.

1.2.3.1.15. FINISH OF SURFACE AND CLEANING

The finish of interior surfaces of the GIS enclosures shall facilitate cleaning and inspection. Any paints or other coatings that may be used shall not deteriorate when exposed to the SF6 gas and arc products, etc., that may be present in the enclosures. They shall not contain any substances which could contaminate the enclosed SF6 gas or affect its insulating properties over a period of time.

The equipment shall be manufactured and assembled at the manufacturer’s works under conditions of the utmost cleanliness. Before factory tests and packing for shipment, interior surfaces, insulators, barriers etc., must be thoroughly cleaned.

1.2.3.1.16. SUPPORTING STRUCTURES

All supporting structures necessary for the support of the GIS equipment including associated parts such as anchor bolts, beams etc. shall be supplied.

Access has to be considered in the design of the structures to all equipment of the GIS. It has to be possible to surround the GIS with the gas cart.

The specified stresses for outdoor equipment like wind, earthquake, snow, ice and thermal expansion due to current and sun radiation have to be considered.

Proper surface treatment for all parts especially in outdoor situation has to be considered. All steel members have to be hot-dipped galvanized according to DIN standards for heavily polluted environment.

1.2.3.1.17. FUTURE EXTENSION

For any type of bus bar configuration, it shall be possible to extend the switchgear by adding future feeders as decided by the owner with at least one of the bus bar systems service continuously and the existing feeders remaining in service continuously. The Vendor is required to demonstrate clearly in his submitted documents the suitability of the switchgear design in this respect.

1.2.3.1.18. REPAIR

In case of the repair works on CB interrupter of a particular bay, repair works must be possible with both the busbars in service. Whenever one busbar disconnector is out of service for repair/maintenance, at least one busbar should always be available and adjacent feeder will also remain available.

1.2.3.1.19. REMOVAL OF COMPONENTS

The GIS shall be designed so that any component of the GIS can be easily removed. As minimum flexibility in the layout arrangement, it shall be possible to remove the circuit breaker interrupter with both bus bar remaining in service.

1.2.3.1.20. EARTHING OF THE SWITCHGEAR

(a) EARTHING OF MAIN CIRCUITS

To ensure safety during maintenance work all parts of the main circuit, to which access is required, shall be provided with facilities for connecting removable earthing device, after opening the enclosure, on the circuit element which is previously earthed via main earth switch.

(b) EARTHING OF ENCLOSURE

The enclosure shall be connected to earth. All metal parts other than main and auxiliary circuits shall be earthed.

Separate earthing strips to short circuit flanges and earth switches are not allowed. Earthing switches shall be connected to earth through enclosures. Individual earth leads for the earth Switches are not recommended.

The continuity of the earthing circuits shall be ensured taking into account thermal and electrical stresses caused by the current they have to carry.

Each of the earthing strips shall be connected to the main earthing mesh installed below the GIS, at two ends.

(c) EARTHING OF GIS

The earthing system shall be based on a multi-point design ensuring the protection in case of indirect contact (Touch or step voltages, in case of system fault) and transient phenomena in case of lightning or switching operations.

Earthing conductors shall allow fault with short circuit current for at least 1 sec. Separate ground strips to short circuit flanges and earthing switches are not allowed. Grounding switches shall be connected to ground through the enclosure. Individual ground leads for the ground switches are not allowed.

1.2.3.1.21. AUXILIARY CONTACTS

Each equipment shall be furnished with adequate number of electrically independent contacts at user's disposal. They shall be wired to terminals located in the local control cabinet of the circuit breaker bay. Installation of auxiliary relays (contact multiplication) may be used to meet the overall control and protection requirements.

1.2.3.2. TECHNICAL SPECIFICATION OF THE HIGH VOLTAGE COMPONENTS OF GIS

1.2.3.2.1. CIRCUIT BREAKER

1.2.3.2.1.1. General

The GIS circuit breakers shall comply with the following general requirements for circuit breakers and the latest revisions of the relevant IEC specifications.

The breaker shall be Self-Blast / auto Puffer type principle and consist of one interrupting arcing chambers. Circuit breaker must be in the independent gas compartment and no other equipment (CT / DS / ES) shall be accommodated inside the CB compartment.

Each circuit-breaker including the drive mechanism shall be completely factory assembled, adjusted and tested. The breaker shall include a suitable operating mechanism to assure proper opening and closing, and shall permit checking adjustments and opening characteristics. Each mechanism shall include dual trip coils in redundant design. The mechanism shall be capable of re-closing within the range specified in the applicable standards. The breakers are to be re-strike-free. The Circuit breaker shall be C2 class type.

Breaker disposition must be horizontal to provide higher mechanical stability and ease in maintenance. The operating principle of the breaker shall ensure minimized dynamic floor loading. Low reaction forces on foundations especially dynamically, are favorable and considered
in the evaluation.

1.2.3.2.1.2. Technical Particulars

Description	Unit	Rating
Nominal operating Voltage	kV	132 OR 220
Highest system Voltage	kV	245
Nominal operating current (at 40°C)	A	3150
System earthing		Solidly earthed

Rated withstand voltage with respect to		
Earth Lightning	kV	1050
Power frequency	kV	460
Rated short-circuit breaking current	kA	50(r.m.s.), 3sRated making current (peak): kA 135
Rated break time	ms	As per IEC-62271-100
Rated opening time	ms	As per IEC-62271-100
Rated closing time	ms	As per IEC-62271-100
Close-open time	ms	As per IEC-62271-100
Rated cable and line charging breaking Current	A	250 & 125 (132 OR 220kV)
Number of breaks per pole	Nos.	1
First pole to clear factor		1.3
Operating mechanism:		Spring-charged or Hydro mechanical Spring
Rated operating sequence		O-0.3s-CO-3 min-CO /CO-15sec-CO
Type		Spring-charged or or Hydro mechanical Spring
Number of trip coils		2 in each pole
Number of closing coils		1 in each pole
Rated control voltage (DC)	V	110 DC

1.2.3.2.1.3. Auxiliary electrical equipment shall be suitable for operation on the following supply system.

a. Power Devices like drive Motors of rating maximum 1 kW 415V, 3 phase 4 wire/230V 50Hz, neutral grounded AC supply.

b. Lighting, space heaters and Fractional kW motors. 240V, single phase, 50Hz neutral grounded AC supply.

c. Alarm, control and Protective devices. 110V DC, 2 wire

Technical Particulars

Description	Unit	Rating
Rated Voltage	kV	245
- Lightning impulse withstand voltage (across open disconnector)	kV	1050+206
- Power frequency withstand voltage (across open disconnector)	kV	460+145
Nominal operating current (at 40°C)	A	3150
Rated short-circuit withstand current (r.m.s.), 1 sec	kA	40
Type of operating mechanism		Motor
Number of drives per 3 phase		1
Control voltage (DC)	V	110/132 OR 220V DC

For emergency situations manual operation shall be possible. Handles or hand cranks shall be provided. Manual operation shall be prevented if the interlocking conditions have not been satisfied. The auxiliary energy shall be electrically uncoupled from the motor when the switch is operated manually.

The mechanisms shall be arranged for locking in the open and in the closed position. Facilities shall be available to allow the switch to be padlocked in any position.

1.2.3.2.1.4. Position indicating

External mechanically connected position indicators shall be provided showing either open or close position.

1.2.3.2.2. DISCONNECTOR

1 General

The GIS dis connectors shall comply with the following general and the latest revision of the relevant IEC standards. Dis connectors shall be three pole, group operated, no-load break, with one motor operated mechanism per three-pole. They shall also have facilities for emergency manual operation and the necessary operating handles or hand cranks shall be supplied. Dis connector shall be interlocked to prevent the earthing switch from closing on a energized bus section.

All main contacts shall either be silver plated or shall have silver inserts. Each dis connector shall open or close only due to motor-driven or manual operation. The switch contact shall not move due to gravity or other means, even if a part fails. Once initiated, the motor mechanism shall complete an open or close operation without requiring the initiating contact to be held closed. The dis connectors shall be located as shown in single line diagram.

2 Technical Particulars

Rated Voltage	kV	245
- Lightning	kV	1050+206
- Power frequency	kV	460+145
Nominal operating current(at 40°C)	A	3150
Rated short-circuit withstand current (r.m.s.),	kA	50 for 3s
Type of operating mechanism		Motor
Number of drives per 3 phase		1
Control voltage (DC)	V	132 OR 220 DC

Electric motor for the driving mechanism shall be DC operated. Mechanisms shall be arranged (mechanically ganged) so that all three phases of any particular disconnect switch operate simultaneously. All mechanisms shall be suitable for electrical motor operation to achieve a fully automatic operation in an unmanned substation.

For emergency situations manual operation shall be possible. Handles or hand cranks shall be provided. Manual operation shall be prevented if the interlocking conditions have not been satisfied. The auxiliary energy shall be electrically uncoupled from the motor when the switch is operated manually.

The mechanisms shall be arranged for locking in the open and in the closed position. Facilities shall be available to allow the switch to be padlocked in any position.

3. Position indicating

External mechanically connected position indicators shall be provided showing either open or close position

1.2.3.2.3. MAINTENANCE EARTHING SWITCH

1.2.3.2.3.1. General

The GIS earthing switches shall comply with the general requirements and the latest revision of the relevant IEC standards. Maintenance earthing switches shall be three pole, group operated, no-load break, with one motor operated mechanism per three-pole. They shall also have facilities for emergency manual operation and the necessary operating handles or hand cranks shall be supplied.

Maintenance earthing switches shall be electrically interlocked to prevent the earthing switch from closing on an energized bus section. The common point of the two bus bars along with earth switch shall be designed and housed in a separate compartment so as to avoid complete shutdown of the system in case of maintenance required in any disconnector.

All main contacts shall either be silver plated or shall have silver inserts. Each earthing switch shall open or close only due to motor-driven or manual operation. The switch contact shall not move due to gravity or other means, even if a part fails. Once initiated, the motor mechanism shall complete an open or close operation without requiring the initiating contact to be held closed.

The maintenance earthing switches shall be located as shown in the single line diagram.

1.2.3.2.3.2. Technical Particulars

Description	Unit	Rating
Rated Voltage	kV	245
-Lightning impulse withstand voltage (across isolating distance)	kV	1050+206
-Power frequency with stand voltage (across isolating distance)	kV	460+145
Nominal operating current (at 40°C)	A	3150
Rated short-circuit withstand current (r.m.s.), 1sec	kA	40 /50
Type of operating mechanism		Motor
Number of drives per 3 phase		1
Control voltage (DC)	V	110 DC

1.2.3.2.3.3. Operating mechanism

Electric motor for the driving mechanism shall be DC operated. Mechanisms shall be arranged (mechanically ganged) so that all three phases of any particular earthing switch operate simultaneously.

All mechanisms shall be suitable for electrical motor operation to achieve a fully automatic operation in an unmanned substation. For emergency situations manual operation shall be possible. The manual operation of earthing switch shall be possible from the front of of the switchgear.

Handles or hand cranks shall be provided.

Manual operation shall be prevented if the interlocking system does not allow the operation of the switch.

The auxiliary energy shall be electrically uncoupled from the motor when the switch is operated manually.

The mechanisms shall be arranged for locking in the open and in the closed position. Facilities shall be available to allow the switch to be padlocked in any position.

1.2.3.2.3.4. Position indicating devices

External mechanically connected position indicators shall be provided showing either open or close position.

1.2.3.2.4. FAST ACTING EARTHING SWITCH

1.2.3.2.4.1. General

Fast acting earthing switches shall be located at all external HV connections of feeders (like HV cable). The switching capability shall be class B (Earthing switches designated to be used in circuits having relatively long lines or high coupling to adjacent energized circuits) as per IEC 62271-102 Annex C standard. Furthermore, it shall withstand the full making capability.

The fast-acting earthing switches shall comply with the general requirements of fast acting earthing switches and the latest revision of the relevant IEC specifications.

Fast acting earthing switches shall be three pole group operated, with one motor operated mechanism for three phase. They shall also have facilities for emergency manual operation and the necessary operating handles or hand cranks shall be supplied.

Fast acting earthing switches shall be electrically interlocked to prevent the fast-acting earthing switch from closing on an energized bus section.

All main contacts, male and female, shall either be silver plated or shall have silver inserts.

Each fast-acting earthing switch shall open or close only due to motor-driven or manual operation. The switch contact shall not move due to gravity or other means, even if a part fails. Once initiated, the motor mechanism shall complete an open or close operation without requiring the initiating contact to be held closed.

1.2.3.2.4.2. Technical Particulars

Description	Unit	Rating
Rated Voltage	kV	245
Rated short-circuit withstand current 1s, (r.m.s.):	kA	40 /50
Inductive current switching capability	A, kV	As per IEC standard
Capacitive current switching capability	A, kV	As per IEC standard
Type of Mechanism		Motor

No. of drives per three phase Nos. 1

Closing time ms As per manufacturer standard

Control voltage V 110 DC

1.2.3.2.4.3. Operating mechanism

Electric motor for the driving mechanism shall be DC operated. Mechanisms shall be arranged (mechanically ganged) so that all three phases of any particular fast acting earthing switch operate simultaneously.

All mechanisms shall be equipped with a motor suitable for operation from the auxiliary supply, and a set of springs for energy storage and closing. Motors shall be suitable for operation at any voltage between 85% and 110% of the rated auxiliary voltage.
For emergency situations manual operation shall be possible. Handles or hand cranks shall be provided, together with all necessary operation rods and rod guides. The auxiliary energy shall be electrically uncoupled from the motor when the switch is operated manually. The mechanisms shall be arranged for locking in the open and in the closed position.

1.2.3.2.4.4. Auxiliary switches

Each fast-acting earthing switch shall be furnished with adequate number of electrically independent contacts at user's disposal. The auxiliary switches shall indicate the position of the switch contacts and shall be independent of the motor operation.

1.2.3.2.4.5. Position indicating devices

External mechanically connected position indicators shall also be provided.

1.2.3.2.5. CURRENT TRANSFORMERS

1.2.3.2.5.1. General

The current transformers shall be supplied in accordance with the general requirements and the latest revisions of the relevant IEC standards.

Each current transformer shall be outside the gas compartment and shall be so arranged so that the enclosure current does not affect the accuracy or the ratio of the device or the conductor current being measured.

Current transformer secondary cores shall be terminated to shorting terminal blocks.

It shall be possible to test each current transformer without the removal of gas through the insulated grounding switches.

1.2.3.2.5.2. Position of the Current Transformers and Cores, Ratios and Characteristics.

The CT cores may be distributed on both sides of the CB.

The rating, ratio, accuracy class etc. for the individual current transformer secondary cores shall be as specified. Where multi-ratio current transformers are required, the various ratios shall be obtained by changing the effective number of turns on the secondary winding.

However, CT ratio shall be finalized during detailed engineering.

1.2.3.2.5.3. Rating and Diagram Plates

Rating and diagram plates shall be as specified in the IEC specification incorporating the year of manufacture.

The rated extended current rating voltage and rated thermal current shall also be marked on the name plate.

The diagram plates shall show the terminal markings and the relative physical arrangement of the current transformer cores with respect to the primary terminals (P1 & P2). The position of each primary terminal in the current transformer SF6 gas section shall be clearly marked by two plates fixed to the enclosure at each end of the current transformer.

1.2.3.2.5.4. Constructional Details:

The current transformers incorporated into the GIS will be used for protective relaying and metering and shall be of metal enclosed type. The secondary windings shall be air insulated/Gas insulated with terminals brought out for secondary connection.

All the current transformers shall have effective electromagnetic shields to protect against high frequency transients.

Each current transformer shall be equipped with a marshalling box with terminals for the secondary circuits, which are connected to the local control cubicle or CT secondary terminals shall be directly terminated to the local control cubicle to avoid open circuiting in marshalling box. The star/ delta configuration and the inter connection to the line protection panels will be done at the CT terminal block located in the local control cubicle.

Current transformers guaranteed burdens and accuracy class are to be intended as simultaneous for all cores.

The wiring diagram, for the interconnections of the three single phase CTs shall be provided inside the marshalling box.

The current transformers shall be suitable for high speed auto re-closing. Provisions shall be made for primary injection testing either within CT or outside.

1.2.3.2.5.5. Technical Particulars

Description Unit Rating

Core number per phase Nos. 5-Core

Accuracy

- Metering - 0.2

-Protection - 5P20, PS

Rating Primary A	400-200 (Incoming feeder & Bus CT)	
	300-100 (Transformer Feeder)	
Rated secondary current	A	1
Continuous Thermal rating	%	120

All parameters shall be valid at the highest tap.

1.2.3.2.6. POTENTIAL TRANSFORMERS (PT): Bus PT

1.2.3.2.6.1. General

The voltage transformers shall be supplied in accordance with the general requirements and the latest revisions of the relevant IEC.

Each voltage transformer shall be an electromagnetic, dry type SF6 -enclosed three-phase unit with the specified ratings.

The voltage transformers are to be connected as shown in the attached single line diagram.

Voltage transformers shall be attached to the gas-insulated system in such a manner that they can be readily disconnected from the system if required for dielectric testing. The metal housing of the voltage transformer shall be connected to the metal enclosure of the GIS with a flanged, bolted and gasketed joint so that the transformer housing is thoroughly grounded to the GIS enclosure. Adequate measures shall be provided to prevent any unacceptable impact on the secondary control and protection circuits which might result from very fast transients (VFT) or ferro-resonance.

1.2.3.2.6.2. Ratios and Characteristics

The rating, ratio, accuracy class, connection, etc. for the voltage transformers shall be as specified below.

This shall be (132 OR 220kV)/ (sqrt3)/110V/(sqrt(3)/110V(sqrt(3) accuracy class 0.2/3P, connection Y/Y-Y. The voltage transformers shall have 2 secondary windings, each winding with one tap.

1.2.3.2.6.3. Rating and diagram plates

Rating and diagram plate shall be provided complying with the requirements of the IEC specification incorporating the year of manufacture and including turns ratio, voltage ratio, burden, connection diagram etc.

1.2.3.2.6.4. Secondary Terminals, Earthing, MCB's and Fuses

The beginning and end of each secondary winding and all secondary taps shall be wired to suitable terminals accommodated in the local control cabinet for the feeder bay. Fuses / MCBs shall be also located in the local control cabinet.

All terminals shall be stamped or otherwise marked to correspond with the marking on the diagram plate. Secondary terminals shall have permanent marking as identification of polarity, in accordance with IEC. Provision shall be made for earthing of the secondary windings inside the terminal box.

The transformer shall be able to sustain full line to line voltage without saturation of transformer. The accuracy class will be at highest tap.

1.2.3.2.6.5. Constructional Details of Potential Transformers:

The potential transformers shall be located in a separate bay module on the bus and will be connected phase to ground and shall be used for protection, metering and synchronization.

The potential transformers shall be of inductive type, nonresistant and shall be contained in their own-SF6 compartment, separated from other parts of installation. The potential transformers shall be effectively shielded against high frequency electromagn etic transients. The voltage transformers shall have two secondary windings

Potential transformers secondary shall be protected by fuses for all the windings. In addition, fuses shall be provided for the protection and metering windings for fuse monitoring scheme. The secondary terminals of the PT‟s shall be terminated to the non-disconnecting terminal blocks in the secondary boxes via the fuse.

The potential transformer should be thermally and dielectrically safe when the secondary terminals are loaded with the guaranteed thermal burdens.

The diagram for the interconnection of the VTs shall be provided inside the marshalling box.

1.2.3.2.6.6. Technical Particulars

Description	Unit	Rating
Rated voltage	kV	245
Primary winding	kV	(132 OR 220)/√3
Secondary winding	V	110/√3
No of secondary windings	Nos.	2
Accuracy of secondary winding		
class		0.2 /3P
Burden*		20 / 20

Partial discharge level at 1.5 U//3	pC	As per IEC

*Burden shall be finalized during detailed engineering.

1.2.3.2.7. SF6/AIR BUSHINGS (if applicable)

1.2.3.2.7.1. General

Outdoor SF6 to air bushings, for the connection between the GIS or conventional air insulated equipment shall be furnished where specified.

Bushings shall comply with the relevant IEC standards.
Bushings with porcelain insulators is acceptable.

The internal insulation of the bushings should be with SF6-gas. The internal and external electrical field of the bushings can be controlled by a capacitive grading body or by grading shields.

Bushings with composite insulators can be pressurized with the normal service gas-pressure of the GIS.

Insulation levels and creepage distances:

1.2.3.2.7.2. Insulation levels and creep age distances:

The insulation levels are applicable to normal sea level atmospheric conditions. The creep age distance over the external surface of outdoor bushings shall not be less than 25 mm/kV.

1.2.3.2.7.3. Mechanical forces on bushing terminals:

Outdoor bushings must be capable of withstanding a cantilever force as per IEC standard

1.2.3.2.7.4. Interface definition

The flange and conductor connection between bushing and GIS component shall be the standard of the GIS supplier.

1.2.3.2.8. 132 OR 220kV POWER CABLE CONNECTION

1.2.3.2.8.1. General

The design of the cable end box shall fully comply with the IEC 62271-209 standard.

The cable end unit design shall include a facility for high voltage AC testing of the connected power cable on site. Removable bolted links or similar connections will be accepted. The design of the link and connections shall ensure that when removed the resulting gap can withstand the power frequency test voltages applicable to the switchgear and the cable high voltage AC test voltage.

1.2.3.2.8.2. Interface definition

Dimensions and division of work shall fully comply with IEC 62271-209 standard.

1.2.3.2.9. LOCAL CONTROL CUBICLE

1.2.3.2.9.1. General

One local control cabinet (LCC) shall be supplied for the local control and operation of each circuit breaker bay. Each LCC shall contain the local control, interlocking, operation and indication devices for the associated GIS feeder bay.

The LCC shall operate as a link between GIS and Control, protection and DPCS in Control Room LCC shall generally include:

- mimic showing the single line diagram showing the position of CB, Dis, FAES, MES etc.
- Position indicators of CB, Dis, FAES, MES etc.
- Discrepancy type control switches for breaker, disconnector and earthing switch
- Local / remote selections
- Aux. relays or other devices as required by the design.

For easy overview, the LCC's should be integrated in the switchgear in front of the related circuit breaker bay. A general arrangement drawing showing the installation position shall be submitted with the quotation.

The LCC"s shall be installed indoors. The LCC"s shall also be dust and vermin proof and shall be Integrated with GIS modules.

The control and operation circuits shall be well shielded and with safety measures to protect operator from touching energized parts. Power frequency withstand of control circuits shall be 2 kV for 1 minute. The LCC shall be factory tested and shipped together with the bay as one transport unit.

1.2.3.2.9.2. DC Supplies and Circuits

DC supplies shall be provided by the tenderer for all control, interlocking, alarm, indication and power supply circuits. The normal maximum and minimum voltage levels that will occur on the supply are specified.

The design of all circuits must be such that separately fused or sub fused circuits are always kept electrically separate.

1.2.3.2.9.3. A.C. Supplies and Circuits

A.C. power for heaters and other auxiliary loads will be provided by the tenderer by two 240 V, 50 Hz, 3-phase circuits.

The normal maximum and minimum voltages that will occur in the supply are as specified. All equipment supplied shall be capable of running continuously or switching the AC current within the range of the normal maximum and minimum voltages specified.

1.2.3.2.9.4. Cable connections within the GIS and their LCC’s

All cable connections between the various GIS modules and the LCC shall be made by 1.1 KV XLPE Insulation ,UV resistant, Anti rodent ,Black, Polyurethena sheathing (Zero halogen) control cable with multi-point plug-in connections on both ends. PT and CT shall be hard wired.

All cables shall be Annealed bare copper(Class 5), multi-stranded tinned copper braid and adequate for their application (indoor / outdoor).

Space Heater: Each panel shall be provided with a space heater rated for 240V, single phase, 50 Hz Ac supply for the internal heating of the panel.

1.2.3.2.10. SPARE PARTS

The following spares shall be supplied at a minimum:
Quantity

(a) Maintenance earthing switch module 1 no

(b) Fast acting earthing switch module 1 no

(c) Disconnector module 1 no

(e) Density monitors for gas compartments 3 no

(f) Drive for circuit breaker 1 no

(g) Drive for dis connector & Maintenance earthing switch 1 no each

(h) Drive for fast acting earthing switch 1 no

(i) Closing Coil and tripping Coil 1 no each

1.2.3.2.11. TESTING & COMMISSIONING:

(a) TYPE TEST:

Type tests shall be according to the IEC 62271-203 and other relevant IEC standards. These type tests should have been conducted in a Recognized independent institution / Laboratory. The type test reports of the manufacturer or its principal (holding/group company) shall be acceptable, if the manufacturer is of international repute.

(b) ROUTINE TESTS:

Routine tests shall be as per the IEC 62271-203 and other relevant standards. The manufacturer shall provide all the testing equipment required for the site tests.

(c) COMMISSIONING TESTS/ON SITE TESTS AFTER ERECTION:

After erection, and before putting into service, the gas-insulated metal enclosed Switchgear shall be tested as per the IEC 62271-203 for the correct operation and dielectric strength of the equipment.

These tests and verifications shall comprise:

(1) Tests to be conducted on the circuit breaker at site at all required operating sequences

- Measurement of operating time
- Checking of wiring and connections and dielectric checks Indications, alarms and interlocks,auxiliary contacts
- Operation at minimum and maximum control supply voltage/pressure Operation of anti-pumping device.

(2) Test to be conducted on the Disconnectors at site

- Checking of wiring and connections and dielectric checks
- Indications, alarms and interlocks, auxiliary contacts
- Operation at minimum and maximum control supply voltage/pressure

(3) Other Tests at Site

- Dielectric tests on auxiliary circuits
- Measurement of the resistance of the main circuit
- Measurement of gas condition
- Gas tightness tests
- General verifications

(4) Power Frequency Test: on site testing of GIS

- Power frequency tests for the completed GIS at site shall be complied as per IEC 62271-203 The power frequency test voltage at site shall be 80% of the factory test voltage for 1 min at 50Hz.
- Voltage tests on main circuits at reduced voltage (80% p.f.) comprising:

50 Hz A.C. voltage test for 1 min

Housing Specification -Prefabricated Substations & E House

1 Environment and Utility Data

Ambient air temperature

-	Maximum temperature	°C	<=45*
-	Minimum temperature	°C	>= -35**
-	Daily average temperature	°C	<=+35

Ambient humidity

-	Daily mean relative humidity	95% and below
-	Monthly mean relative humidity	90% and below

Altitude of the installation site m 1,000 and below (or on request)

Wind pressure Pa =700 (equivalent to a wind speed of 34 m/s)

Seismic intensity Not exceeding magnitude 8

Horizontal acceleration	g	0.5
Vertical acceleration	g	0.5
Safety factor		=1.67 (simultaneous action)

The modular E-House for the Plant facility will be designed in accordance with the following conditions:

- Installation: Outdoor
- Minimum ambient temperature 40° F /(4.44°C)
- Maximum ambient temperature: 122° F / (50°C)
- Wet bulb temperature 93°F / (34°C)
- Design relative humidity tbc
- Rainfall (in 24 hours) tbc
- Maximum wind velocity
- Wind direction 100 miles per hour
  North East (Predominantly)
- Site elevation (above sea level): 100 meter
- Seismic zone: Zone 2A
- Ground acceleration 0.2g (meter/sec square).
- Electricity
  - 400Volts, 60Hz
  - 480Volts, 60Hz
  - 12kV, 60Hz

2 Products

2.1 General

- The prefabricated E-houses shall be self-framing type buildings fully in compliance with codes, standards and related specifications as specified in this document.
- The prefabricated modular E-House are to be installed in non-hazardous area.
- BIDDER will assist in providing all necessary documentation for the fabrication and installation of the EHouse.
- For this project, BIDDER shall provide detailed section plan during tendering indicating each split section dimensions and site assembly information in brief.
- The following equipment shall be supplied by BIDDER /customer as applicable, which are required to be installed completely in accordance with relevant standards completely assembled, interconnected, tested
    a. HVAC system (Optional)
    b. Fire safety system
    c. SCADA system
    d. Power transformer installed in separate house
    e. HV switchgear
    f. MV Switchgear
    g. LV Switchgear and MCC
    h. AC UPS system with charged batteries
    i. DC UPS system with charged batteries
    j. Relay panel for DCS, ESD system auto start/stop signals end customer free issued item-PLC panels.

Any other system specified by BIDDER during technical review of RFQ.

- The HVAC system for the building shall provide both temperature and humidity control as mentioned in the specification and datasheet. Outdoor conditions are specified in the specification in relevant section of site conditions already.
- It is the responsibility of the supplier to design, calculate and select the method of roof and exterior wall insulation considering the design criteria for internal and external environmental conditions assuring optimum performance of an economically designed system.
- The Prefabricated E-house shall be suitable for industrial and/or utility service. The Equipment and E House shall be designed and constructed for continuous operation for a minimum service life of 25years with complete operation time of 8760 hours for E-House and 8400 Hours for Equipment
- The Modular E-House shall be suitable for ready installation either at ground or elevated level.

- BIDDER shall followed the attached specification for color coding and pipe marking wherever applicable
- BIDDER has followed the attached specification for painting and coating of piping and equipment wherever applicable.

2.2 Materials

- All material, equipment and components furnished shall be brand new, of premium quality and essentially standard heavy duty design, either meeting or exceeding the requirements of this specification or standards.
- All equipment, component and materials shall be of recent manufacture and design, for which replacement parts and service is readily available in the jobsite area and which may be manufactured worldwide to the extent possible.

2.3 Design Requirements

2.3.1. Modular E-House:

- All interior modular E-House material including finish, insulation and acoustical treatments shall have aflame spread index of class-2 in accordance with BS 5588-11.
- As described above necessary strength shall be maintained to meet all the mechanical and loading requirements for base and other structures.
- Required spacing shall be provided to accommodate the external equipment, alarm indicators and signage(s) as specified
- In general, all the exterior walls, roof and under floor shall be suitably insulated. The base shall be undercoated with material as per customer requirement.
- All electrical equipment and installations shall be in accordance with applicable sections of IEC or GB standards.
- All structural bolts and fasteners shall be grade 8 electroplated or stainless steel and brackets shall be stainless steel or aluminum for harsh environment. No cadmium plated or steel hardware shall be used unless approved by the buyer.
- The structure shall be securely bolted or welded and all walls and floor openings shall be framed to maintain the structure integrity.
- All external nonstructural bolts, fasteners and modular E-house hardware shall be type 400 series stainless steel.
- Bidder shall pay utmost attention to maintain aesthetic look of the building both from inside and outside.
- All wall and floor opening must be hermetically sealed in order to maintain the integrity of house structure and protection class as IP54 when room is air- conditioned and IP 33 when using forced ventilation.
- Supplier shall provide the load of product, if need distribution calculation surcharge, for the floor and roof and shall ensure strengthening is provided wherever required based on installed equipment mechanical data and requirement.

- All Structural members must be designed and reinforced to meet or exceed the static and dynamic loads.
- Supplier shall ensure all the structural members are coordinated with the equipment inside to provide maximum access for cables while maintaining required mechanical support.
- The layout drawing showing equipment layout and dimensions, door locations and E-House size shall be provided during tendering clearly showing the open spaces, aisles and clearances.
- All external cables to and from the bottom shall be sealed with approved multi cable transit (MCT) or cable glands and gland plates
- Supplier shall ensure floor is welded to the structure fully and is sized as per the standard thickness as mentioned elsewhere in the specifications.
- Maximum dimensions of the modular E-House shall be in accordance with the local transportation codes for the mode of transportation. The maximum modular transportation dimensions are 15m x 4m x 3.6m(LxWxH).
- Inside height of ceiling to finished floor shall be minimum 2.9m taking into consideration the height of HVAC ducting, switchgear arc plenums if required cable trays, minimum cable bending radius and above electrical equipment or indicated in the layout drawing.
- Working space around equipment shall be in accordance with the equipment Manufacturer's recommendations but shall in any case be not less than as indicated in IEC for specified voltages.
- Provision for future extension shall be provided as specified in the layout drawings
- Supplier shall ensure the maximum allowed designed defection under lift shall not exceed L/240 for floor.
- The floor shall be designed for a 6.35mm maximum deflection on a 3.05m span if moving removable equipment elements.
- The design shall meet all load combinations. Structural steel base shall be designed to withstand all transporting and erection loads in addition to normal and live loads.
- Structural steel members shall be rigidly braced with structural steel cross members for installation on concrete slabs
- Lifting eyes should be removable if the transportation width exceeds 3.6m.
- The modular E-House or each transporting assembly with complete equipment installed shall be designed for a maximum 4-point bottom lift for assemblies shorter than 12m.
- Supplier shall provide one set of lifting spreader bar and associated accessories shall be provided for each type of section (if different lifting arrangement required) with sketch and calculations.
- The bearing surfaces of lifting eyes, spreader bars and other means shall be free from sharp edges.
- Supplier shall follow the seismic requirements as mentioned in specifications.

2.3.2. Walls, columns and doors

- Doors & walls are a double-layer structure, plug welded with galvanized 1.2 mm inner sheet and 2.0 mm outer sheet, sandwiching 44.8 mm thick. This design features a validated structural integrity fire rating of180 min. Total thickness for both doors and walls are 48 mm and both use the thermal bridge design which enhances thermal insulation performance.
- Doors can be equipped with appropriate locks, door closers, or push bars depending on customer's request, standard products don't have door closers.
- Doors are pre-assembled into a welded steel frame. Hinges shall be stainless steel, and the door shall be positioned in the frame with a gasket to provide an effective seal against wind-driven rain when closed.
- All doors shall swing a maximum of 100º, and open outward.
- Columns are bent with Q235 2.5 mm galvanized steel sheet and welded onto the base. Same
solution isused for the lintels between columns. Stiffening columns are plug welded together with columns.

2.3.3. Roof

Roof is framed and welded by angle steel:

- Top sheet - 2.0 mm galvanized steel
- Base sheet - 0.5 mm PPGI sheet
- Sandwiching nonflammable foam in the middle.

Another feature for the roof is the removability; its eyebolts connect the top sheet and structure together, which enables equipment to be lifted in or out of the modular substation with relative ease after the roof removed.

2.3.4. Floor

Floor shall be 6.35mm minimum steel thickness, welded to all perimeter channels and cross beams to produce a flat surface fully free from any exposed seams, ripples or irregularities.

Floor shall be antistatic with insulation matt for electrical switchgear and control room.

2.3.5. Door

- The modular E-House shall have standard doors on both exits with padlock and standard lockable features. The door size shall be minimum 90cm wide fully gasketed to facilitate egress and to prevent entrapment of personnel.
- One of these doors shall be designated as equipment door for equipment loading and lifting. An equipment loading door shall be minimum 90 cm wide and 2. San high. The 2. San height can include removable transom panel and standard height door.
- The equipment door shall be of adequate size to insert/remove largest equipment section in the E-House.

- The equipment doors shall be designed with adequate sealing and drip shields to avoid any dust air, contaminations or water leakage and shall not affect the required insulation of the building. (Door flush at the top). All such items shall be compatible with building material color.
- A rain canopy shall be provided over each personnel entry door extending minimum of 90cm from structure and extending 15cm on each side of door opening.
- The door material shall be same color as the main building and all doors shall open outward.
- The door material shall be 1.98 mm steel minimum.
- The equipment door shall have, stainless steel bearing hinges with easy opening and closing provisions.
- Door shall be insulated and made of double wall construction with integral frame.
- Inside panic hardware design shall be provided to override all locks.
- Common keyed locks shall be provided on all doors with minimum of 5 keys with each modular E-house.
- Doors shall be provided with fire rated glazing or wire glass vision panel in top half of door if specified in datasheet.
- Door closer(if application) hardware shall can hold the door in fully open position and can keep the door closed automatically.
- Adequate provisions for maintaining the room enclosure as IP54 with high quality material shall be provided for personnel door.
- Emergency door shall be provided in each room.
- Equipment doors shall be double doors and personnel doors shall be single door type.
- Doors shall swing a minimum of 110 degrees outwards.
- Panic bar assembly and pneumatic door closer with hold open feature shall be furnished on the interior of personnel doors.
- All doors shall be provided with mechanical locking hardware on the exterior side and the personnel doors must be capable of opening from inside regardless of being locked from external entry.
- Dust seal material shall be supplied on all doors all around.
- Doors shall be supplied with" Danger high volt" signage in English and one more language to be specified during Engineering.
- Self-powered side equipment access panels behind equipment shall be provided if shown on the layout drawing.
- Panels shall be capable of opening with Equipment in place
- Panels shall be weatherproof, insulated and gasketed, full height and hinged. Panels shall have 3-point latching mechanism with pad lockable handle
- Panels shall have mechanical interlocking to prevent opening when equipment is energized.
- Panel shall be 2.78mm at a minimum.

- If indicated on the layout drawing, side entrance fire rated framed bulkhead openings or other Principal approved methods shall be provided.
- If bottom entrance is indicated on layout drawing for cable entry, removable non- ferrous metal plates shall be provided to facilitate drilling for cable openings.

2.3.6. Steps, Handrail and Platforms(If application)

- Access Steps and platforms with integral handrails shall be provided for each exterior door.
- Treads shall be minimum 3.18mm Galvanized steel with open grip grating.
- The Step unit shall have a 20cm maximum rise and 28cm minimum depth treads and 91cm minimum width
- Removable handrails shall be provided on platforms and on both side of steps.
- Platform at each door shall be of sufficient dimensions to allow full opening of doors and a minimum of 71cm wide clearance between door and handrails with door open and allow the equipment to get through for maintenance etc.,
- Anticorrosion provision of Supporting structure, Steps handrails and platform shall comply to manufacturers standard.

2.3.7. Insulation

- The modular E-House shall be insulated for the climatic conditions as described in the specifications, earlier.
- Insulation shall have minimum flame spread
- Bottom underside of the E-house shall be insulated except at the removable plates used for bottom entry.
- Roof insulation shall be secured between roof and ceiling panels.

2.3.8. Building Services

- Normal interior light shall be rapid start, high power factor, high efficiency, industrial type fluorescent fixtures with lamps.
- Supply voltage for lighting, receptacles and equipment accessories for modular E-house substation utilities shall comply with the requirements stated in earlier sections.
- A minimum of one power and lighting board shall be provided with integral main breaker, bolton industrial type branch circuit breakers, neutral bus and ground bus.
- Branch circuit breakers shall be determined by modular E-house loads. All such branch circuit breakers shall be minimum 20amp with provision for padlocking in OFF position.
- A minimum of one circuit shall be provided for lighting, one for receptacles and one each for space heaters, one for HVAC if required from each panelboard.
- Minimum of four (4) spare circuits shall be provided for customer use.
- All receptacles shall be protected with 30mA residual circuit breaker (RCCB)
- A minimum of two (2) receptacles shall be provided inside and outside the E-House. Additional receptacles maybe required for buildings with transporting splits.

- Receptacles shall be wired to the E-house Panel-board. Inside E-house the receptacles shall be placed every 3 meters if possible.
- Lighting, receptacles and HVAC units shall be split into two panel boards if multiple panelboards are provided.
- A typed circuit directory shall be provided on the inside door of distribution board.
- Fixtures shall be attached to ceilings and shall be located to obtain illuminations as uniform as possible and to avoid objectionable shadows and glare. Front of equipment shall be well lighted. Lighting shall be designed to provide a minimum in-service lighting level of 200 lux on the floor level with 150 lux on vertical face of each equipment line up.
- 25% of the lighting shall be self-contained, integral battery supplied
- LED emergency with 90 minutes back up shall be provided in adequate quantity.
- Each personnel door shall have self-illuminating EXIT signage
- The modular E-house shall be furnished completely with factory installed, instant restart,230V, SOW minimum high intensity discharge fixtures.
- Fixtures shall be provided with integral photo control and shall be adjacent to each doorway and connected to E-house panel-boards.
- Exterior lighting shall be enclosed and gasketed with globe and guard. Interior lighting shall have wire guards.
- Electrical matting shall be installed in each E-house to effectively cover 1 meter in front of the switchgear.

  Electrical matting shall be 6.35mm thick and rated for maximum voltage present in the E-house. Matting shall be rolled up and stored for final installation at site.

2.3.9. Fire protection and alarm system

- Modular substation should set automatic fire alarm system and the system shall comply with the requirement of NFPA72 and API RP 555.
- All materials used in the construction of E-house shall be noncombustible.
- The fire alarm is to discover, notify the fire and take the methods to control and suppress the fire to minimize the losses. The automatic fire alarm system shall alarm the fire in earliest stage.
- The fire system configuration shall be divided into following parts:

  a. Regional alarm controller

  b. Manual alarm push button(Optional)

  c. Audible and visual alarm

  d. Intelligent smoke detector(Optional)

  e. Thermostatic heat detector

  f. Gas detector in air inlet.

- Regional alarm controller should be installed in cabinet room and the alarm signal should be transmitted to central control room.
- Intelligent smoke detector should be installed in cabinet room of modular E-house.
- Thermostatic heat detector shall be installed in MV switchgear room, LV switchgear room and power transformer room.
- Dry contacts to be provided for alarm.
- Fire extinguishers, addressable smoke detector(Optional), call point, outdoor fire Siren & Beacon, indoor fire Siren & Beacon, interlocking with HVAC (shut down fresh air inlet via fire signal) and central control room shall be considered in the design and detailed offer shall be provided.

2.3.10. HVAC/Air-conditioning system (Option)

- HVAC should be heavy duty industrial grade with n+1 redundancy.
- HVAC shall be wall mounted/roof mounted design thermostatically controlled from with the E-House
- E-house shall be airtight design with slightly positive inside pressure by HVAC to prevent dust ingress.
- Bidder shall provide supporting calculations to determine heating and air-conditioning loads
- HVAC shall be capable of maintaining 70°C at the maximum ambient temperature
- An enclosed safety disconnect switch with provisions for padlock in “OFF" position, approved for area classification shall be provided on or mounted adjacent to outdoor unit to provide isolation of HVAC. Source of power shall be identified on the disconnect switch.
- Replaceable filters shall be accessible from within the modular substation.
- HVAC location shall be arranged in such a way that the condensate does not drip or collect round doorways
- Drip pans and piping to remove condensation shall be provided for all building mounted HVAC. Drip pans shall not be mounted over Electrical equipment.
- HVAC duct shall not be mounted over major Electrical equipment.
- HVAC design shall include detailed calculation of heat gain and loss, sensible and latent, airflow volume, freshair intake and nose of fresh air change.
- Psychometrics charts and room state such as temperature and relative humidity shall be produced for summer and winter.

2.3.11. Grounding / Earthing

- Earthing shall be in accordance with IEC 60364 requirements.
- An interior earthing loop shall be provided and connected to the exterior ground pads. Interior loop shall consist of 50mm x 6mm copper bus bar located around the bottom of modula substation and all equipment shall be bounded to this bus-bar. Each interior equipment earthing loop shall be connected at each end to theE-house earthling loop.

- All exposed non-current carrying metal parts including additions such as steps etc., shall be electrically bonded to the earthling loop.
- The Earthing system shall provide separate system and equipment earthling for all Electrical and instrumentation equipment and Packages E-house frame.
- Every lighting panel, HVAC unit, panel board, switchgear and MCC and their associated loads shall be supplied with equipment grounding conductor.
- The conductor shall be sized by the allowable current-carrying capability by a series of rules in the NEC.
- Stranded Copper or stainless steel two-hole ground pads shall be at each corner or opposite corners of the exterior of the modular E-house for earth connection to plant earth grid.
- Power transformer star point shall be directly earthed and connected with interior earth bus-bar 2.3.12 Cable Sizing
- All cables sizing for the installation shall be considered by required de- ratings, voltage drop, ambient temperature etc. in accordance with the standards.
- All cables of power supply system use cross-linked polyethylene insulation and retardant cable with a different color and the independent insulating layer and the jacket layer, which can work for a long duration at temperatures above 90°C and the rated insulation shall be higher than the actual voltage insulation requirement.
- Cross-sectional area of neutral cable and ground cable shall be larger than phase cable. The minimum cross sectional area of the phase shall be larger than 4squaremillimeters,and the cross-sectional area of lighting and power supply socket cable is greater than 2.5square millimeter.
- The technical performance, identification, security, wiring methods of power distribution box shall be in full compliance with the most stringent requirements of clause in standards.

2.3.12. Stairs and platforms(Optional)

- Stairs shall be made by galvanized steel and are anchored to the Pre-Fabricated Switch room base.
- Stairs shall be 100mm wider than the personnel door.

2.3.13. Painting

- The manufacturer unless given written instruction shall comply to all the requirement without any exception.
- All structure family members shall be cleaned to nearly white metal. Use of chemical or solvent cleaning of structural steel is not permitted.
- After cleaning one shop quote of epoxy primer (75pm minimum dry thickness shall be applied.)
- Floor surface shall be finished with a durable scuff resistant non-skid epoxy or enamel coating.

- All modular E-house seems outside shall be sealed with 25-year life span silicon sealant to preclude crevice corrosion and to assure integrity of the E-house against blowing rain, dust/dirt or sand.
- All interior/exterior exposed metal surfaces shall receive factory paint quotes to meet or exceed 1,000 hours of salt spray test.
- Panels of any component shall not show any evidence of blistering, peeling or chipping.
- Panels shall not show surface chalking.
- Panels after cleaning shall show no color change more than seven units when measured.
- Exterior wall panels and trims should be painted as per MSETCL specified color.
- All structural members under the flooring shall be coated with additional 0.5mm to 0.6mm of bit mastic or equivalent undercoating to eliminate base rusting and subsequent potential corrosion.
- Two one liter cans of touch up paint shall be supplied per equipment assembly for each color used.

2.3.14. Cable / Wire support

- All wiring methods, raceways and cable systems shall be in accordance with IEC
- All control wiring and safety system wiring shall be provided in PVC conduit pipes, (hot dip galvanized steel conduit pipes as an optional), cable trays or cable ladder if applicable will be installed on wall. Light fittings switches and socket outlets shall also be installed properly.

2.3.15. Cable / Wire

- Bidder shall provide interconnection of the installed equipment includes those between Buyer supplied equipment and those between Buyer and vendor supplied equipment.
- For buyer furnished material we shall provide connection requirement prior to the engineering design phase, and all connection cables for the customer's equipment should be supplied by the customer.
- Bidder shall provide all control, alarm, lighting and facility power wiring with a minimum 12kV/1KV insulation ,stranded copper conductor with insulation and wire sizes as follows:
  Lighting and facility power- 2.5mm² min.
  Control and alarm- 1.5mm²
- Bidder shall provide identification of both ends of interconnection using sleeve type heat shrink wire markers with appropriate wire numbers in accordance with the electrical equipment wiring diagram. Where appropriate terminate both ends of each wire with a ring type terminal, properly sized for both the wire and terminals to which they connect.

2.3.16. Specific Project requirements:

- Smoke alarms with a dry contact outputs for remote alarm indication shall be provided.
- Smoke detectors and other safeguarding devices shall not be mounted directly above arc resistant equipment where access is required for maintenance.
- Space shall be provided for PPE cabinet. Space to be defined in principle layout.

- A key diagram of the electrical system with a clear indication of associated switchgear showing the normal position, open or closed, of the switches incomers, sectionalizes, bus couplers and distribution circuits should be clearly visible on a wall in main MV Substation.
- A notice should be posted on each E-House containing instructions for the resuscitation of persons exposed to electrical shock.
- Approved means of removing persons still in contact with live electrical equipment should be available
- Caution notice, danger sign boards and earth notices shall be provided adequately.
- All equipment shall be provided with tag numbers in accordance with project standards.
- Modular E-house tags shall be of laminated plastic with black lettering on white background and permanently attached with stainless steel hardware to each piece of equipment.
- Device markers and shrink sleeve markers shall be provided to identify all circuits and equipment.
- Nameplates shall be provided for all panel-boards, transformers, specialty equipment and exterior access panels not otherwise covered by equipment specifications.
- Lighting fixtures, receptacles, HVAC and other such electrical equipment shall be identified with power source. (Panel name and circuit number).
- Access panels shall also be identified with appropriate circuit and cubicle number.
- Access panels shall have warning label-EXPOSED ENERGISED PARTS WHEN DOOR IS OPEN.
- Languages of all labels shall be Chinese above and English below.
- When layout of 2 cabinets is face to face, the minimum passageway for operation, maintenance and escape shall be 2x cabinet door width + 800 mm.
- When layout of 2 cabinets is staggered face to face, the minimum passageway for operation, maintenance and escape shall be such that in the process of two parallel open doors, spacing shall not be less than800mm.
- When layout of 2 cabinets is back to face, the minimum passageway for operation, maintenance and escape shall be 1x cabinet door width + 800 mm
- When layout of 2 cabinets is back to face, the minimum passageway for operation, maintenance and escape shall be such that in the process of two parallel open doors any spacing should not be less than800 mm.
- When layout of equipment is in single row, the minimum passageway for operation, maintenance and escape between walls shall be 1x cabinet door width+800 mm.
- Distance between wall and cabinet wall shall not be less than 800 mm except installed against wall.
- Distance between wall and cabinet flank shall not be less than 800 mm except installed against wall.
- Distance between cabinet flanks shall not be less than 800 mm except tied installed.

- All switchgear shall be free standing and no maintenance from back side(or optional maintenance from back).

2.3.17. Routine test and checkouts:

- The supplier shall furnish a list of tests to be performed on the equipment under supplier's scope.
- Buyer shall conduct functional test of the complete system and supplier shall provide all necessary support and manpower to conduct the same. Required power supply and other logistic arrangement shall also be in suppliers scope
- Following tests shall be carried out after completion of assembly:
- Wet spray for water leaks
- Continuity checks for wiring installed by supplier
- Earthing of equipment and continuity of earthling
- Checking of lighting panel and distribution boards to identify circuits are operational and properly identified.
- Ensure raceways and covers are properly tightened.
- Ensure pipe fittings are properly installed and have a good aesthetic looks
- Lighting fixtures are firmly mounted and operational.
- Verifying operation of HVAC and room integrity to maintain design temperature and confirm positive room pressure
- Air conditioning unit operation and interlocks
- Fire system operation and interlocks
- Cable and connections for proper spacing, supports, insulation, bolt sizes, bolt torques etc.,
- Mechanical operation of doors and interlocks
- Conduct dielectric potential and insulation of power and control wiring
- Overall workmanship
- Quality of paint and fabrication
- Provide certified test reports documenting all individual test results carried out by supplier.

2.3.18. Factory acceptance testing:

- The completed E-House will be completely tested at supplier's location. This will include testing the operation of all equipment with in the room and outside as per scope including the free issued items. Free issued items shall only be tested in presence of buyer's representative who shall solely direct the functional testing and the same shall be carried out by qualified personnel from supplier's side.
- Complete functional test shall be carried out on the whole system and supplier shall make preplanned arrangement for conducting the full factory acceptance test of the E-house supplier shall work out a complete FAT plan with buyer during engineering and conduct the tests based on approved protocol sheets and procedure.
- All tests must be documented by completion of protocol test forms to verify completion of each step and the corresponding results.

2.3.19. Aftersales Service

- During customs declaration and product inspection, the supplier should, in accordance with related rules and requirements of the buyer, provide goods documents, certificates and other documentations and coordinate with the buyer in customs declaration and product inspection.
- The supplier (manufacturer) should provide adequate spare parts and technical services all around the clock.
- When the equipment fails, or cannot satisfy requirements of the owner or EPSC contractor, the supplier should eliminate the failure according to demands of the owner or EPSC contractor to satisfaction is agreed upon.
- During the warranty period, when equipment requires maintenance or parts replacement, the supplier should assign the experienced engineers to the site to provide technical support to the demand of the owner or contractor.
- When the owner or contractor requires services provided by the supplier, the latter should reply within 12 hours after reception of the information. Overseas staff assignment should not exceed 15 days.
- Within the warranty period, the supplier is responsible for making clear reply to the questions raised by the owner or contractor on quality of product in written form. For quality issue, the supplier should take protective measures in time and be responsible for product replacement for free. Moreover, the quality guarantee period should be prolonged accordingly.
- Within service life of the product, the supplier should ensure supply of all spare parts
- Overseas distribution period of spare parts provided by the supplier should not exceed 30 days.

2.3.20. Packing and Shipping

- Provide adequate temporary bracing for the roof, walls and all equipment to prevent damage during transportation.
- The packing shall be suitable for International transportation by sea transport.
- Necessary certifications, fumigation etc. as required shall be in suppliers scope as per international standard and as required.
- Supplier is solely responsible for safe loading of the E-house on buyers trucks/trailers including necessary lifting and handling equipment.
- Supplier shall provide at least 8 weeks ahead of delivery with complete loading plan details of center of gravity and transportation plan to buyer
- Final as built shall be provided within 2 weeks following shipment.

2.3.21. Vendor Data Requirement List

The documentation requirements in table shall be included by the manufacturer/supplier in the deliverables.

Table documentation requirements

- DESCRIPTION

– Detailed bill of materials

– General layout of equipment, showing all dimensions, locations, and outline drawings, showing the final assembled configuration Connection wiring diagrams and schematics

– Assembly, inspection, and testing guide

– Three-line and control schematic diagrams

– Structural drawings shall include complete dimensions, arrangemen,plans and elevation views, support locations and weight on each support,conduit and bus duct entrance locations, lifting and jacking locations, earthing connections, estimated weight of each piece of equipment, total weight and center of gravity of modular substation.

– HVAC drawings and reports shall include heat loss and gain calculations, pressurization calculations, and equipment selection calculations, arrangement and plan, elevation views, purchased

– HVAC equipment air changes calculation sheets showing capacities and physical data and all maintenance, testing, and operations manuals Heat Loss Data on Components

– Lighting and cable tray plans/details

– Certified test reports including test equipment calibration information Installation, operation, and maintenance manual

– Recommended spares parts list

– Inspection and Testing Plan with “hold point” for Principal approved

These documents shall be provided with proposal.

These documents shall be provided for the Contractor's review and authorization to proceed before fabrication.

These documents shall be provided as part of the final certified document submittal.
One additional set of installation, operation, and maintenance manuals shall be included with the equipment when shipped.

The final as-built shall be provided within 2 weeks following shipment.

2.3.22. Drawing and Data Requirements

Two reproducible set of drawings shall be provided plus two hardcopies of all documentation and operating manuals.

Drawing format shall be Adobe Acrobat searchable portable document format (pdf) and convertible format (such as PDF, DWG), unless the contractor approves otherwise.
In addition to the hardcopies referenced above, documentation and operating manuals shall be provided electronically in pdf format.

1 Purpose and Basic Description

This document provides the general specifications and technical attributes for containerized switchgear housings for prefabricated substations.

1.1 Scope

This document covers the specification for the following equipment:

- Containerized housing including base frame
- HVA/C
- LV Small power and internal lighting
- Accessories

2 General Technical Specifications

2.1 Technical data

Type of Installation: Outdoor - non-hazardous area Housing type:

Single- or split/multiple housing units Application: Utility

and/or industrial - permanent installation Type of operation:

Continuous

Expected lifetime -housing: 40 years

Housing specification - dimensions
Unit 01

Dimensions (L x W x H)	….. x …… x …… (mm)
Weight (with auxiliaries but without main equipment)	………….. kg
Number of units	…….

Unit 02

Dimensions (L x W x H)	….. x …… x …… (mm)
Weight (with auxiliaries but without main equipment)	………….. kg
Number of units	…….

Ambient Conditions

Maximum wind load	40 m/s
Snow load	NA N/m2

Ice load	NA N/m2
Housing specification - mechanical	
Fireproof classification	EI0
Ingress protection	IP54
Seismic classification	0.5g : 0.5g : 0.5g (acceleration x : y : z, in one direction)
Surface treatment acc.	C4M
Container color (outside)	RAL9010
Color coating thickness (outside)	180 μm

Housing specification - electrical	
Voltage level AC	240 V AC, 3Ph, 50 Hz
Voltage level DC	2 x 125 V
Illumination level 200 mm above floor	350 lux
Applicable Standards	
Permissible sun radiation levels	ISO 12831
Fireproof classification acc.	EN ISO 13501-2
Ingress protection acc.	DIN EN 60529:2014-09
Seismic classification acc.	IEC 62271-207
Building components and building elements — Thermal resistance	EN ISO 6946
Electrical standard for low voltage equipment	UL/CSA
Steel coatings	EN ISO 12944-2

2.2 Containerized Housing

The container consists of a baseframe and a top housing. In general, all the exterior walls, roof and floor shall be suitably insulated. The structure shall be securely bolted or welded and all walls and floor openings shall be framed to maintain the structure integrity.

All structural members must be designed and reinforced to meet or exceed the static and dynamic loads.

2.2.1. Base frame

The base frame provides the structural stability required by the installed main electrical equipment for transportation and operation.

The floor is covered with slip-proof halogen-free material.
Beams in the double floor have openings with minimum dimensions of 300 x 80 mm where the LV control cables can transit.

Edges of these openings are protected to avoid scratches on the cable isolation.

In some layouts there are high voltage cables entering through the base frame. The openings shall have the following inner dimensions L x W (L, W in direction of container length L and width W): 700 x 750 mm. The openings must be positioned according to the layout drawing.

2.2.2. Substructure

The housing is prepared for installation onto the following substructures:

- Steel framework or concrete pillars
- No substructure: Direct placement on concrete slab or strip foundation

The fixation of the housing units onto substructures is done by means of anchor bolts.

2.2.3. Layout and Dimensions

Maximum external transportation dimensions L x W x H (mm): 15 000 x 4 000 x 3 600
All as-built dimensions are the same as in design drawings. Deviations as described in DIN ISO 2768-1 are tolerable.

Dimensions shall be chosen to suit maximum transportation dimensions.

The sizing of material shall be in accordance with DIN EN ISO regulations (metric standard sizes), if nothing else is specified.

All screws on the outside are made of stainless steel (A4 quality) or hot-dip galvanized depending on the size and purpose. Screws on the inside shall be made of galvanized steel or higher quality. Nuts and washers shall be made of stainless steel (A4 quality). Stud bolts shall be hot-dip galvanized. No screws, bolts or other fasteners shall be painted.

No sealing of doors, openings etc. shall be painted.

Provision for future extension shall be provided if specified in the layout drawings.

2.3 Outer painting and surface treatment

The painting fulfills the requirements of class C4M according to DIN EN ISO 12944, especially regarding corrosion protection, UV resistance and scratch resistance. Measurements according to DIN 50982 are performed to ensure the coat thickness. The paint can be water-based.

2.3.1. Stairs

For elevated housing units, stairs shall be provided either in front of the doors or the access areas. The stairs are slip-proof, have handrails on both sides, and have holes so snow can fall through.

Stairs shall be minimum 1000 mm wide and the distance between each step shall be 200 mm.

2.3.2. Steel frame lifting lugs

The container shall be possible to lift with installed equipment with crane lugs on the edges of the roof of the container housing. All crane lugs shall allow fixation of crane hooks and transport fixation.

All container units shall be fitted with 4 lifting rings at the roof edge.

The units can be lifted with a cross-bar fitted to the crane or with a single hook: The slings fitted to the lifting points shall have the following minimum angles (v):

Single hook: **v = 60□** cross-bar: **v = 45□**

Lifting eyes should be removable if the transportation dimensions are exceeded.

2.3.3. Walls, roof and doors

The roof shall be stable enough to allow two persons to perform installation works on top of the container (250kg/m²). The design of the walls, roof, and doors shall provide the necessary thermal insulation. The heat transfer coefficient shall be below 1 W/m²K.

Door frame and door cases are made of aluminium or steel profiles and are equipped with a double strength sealing system. Each door shall have a safety lock. For each container, 3 master keys are provided. As an option, doors with panic push bars instead of normal doors can be offered.

Doors and openings can optionally be fitted with electrical contacts for connection to a supervision system (SCADA)

In case of multiple container installations, each container shall be transported separately, where temporary packing cover the openings in the walls with proper sealings. These shall be removable as the containers are installed on site. In multiple container installations, a suspension point for a chain hoist shall be fitted above any equipment requiring connections at the split between containers according to the layout drawing.

2.3.4. Roof openings

Above some equipment, maintenance openings shall be furnished. These shall be tightly sealed and easily removable by two persons without a crane.

The inner dimensions shall be specified on the layout drawing.

Pressure relief flaps shall be installed at suitable locations of the housing enclosure which shall open in case of overpressure. This over-pressure may occur in the unlikely event of an internal arc-fault in the electrical equipment. This will trigger the rupture discs and cause an internal release of gas into the container causing an over-pressure. The pressure-relief flap is a means to avoid severe damage of the container. They may consist e.g. of hinged flaps which are secured by plastic screws or similar that tear apart in case of overpressure. In addition, they are secured with a chain or similar to avoid the flap flying off and causing personal injury.

2.3.5. Wall openings

In order to enable access to components which are not accessible from inside the container, wall openings shall enable access from the outside. The positioning of all openings shall be according to the layout drawing.

In certain layouts, there are GIS ducts or high voltage cables transits through the wall.

2.3.6. Sealing of openings for HV Cables (in base frame or wall)

Openings for HV cables shall be sealed by e.g. aluminium split plate and a sealing compound, ensuring specified ingress protection class.

2.3.7. Sealing of maintenance openings (in roof or wall)

Maintenance openings in the wall and roof are sealed by sealing tape and/or sealing compound and rain guards to ensure sufficient ingress protection.

2.3.8. Control Cables of electrical equipment

All cables shall be halogen free and flame retardant.

Substation service power, control and communication cables are routed through the floor or the inside wall of the housing unit.

GIS cabling shall be routed along the GIS enclosure or through the floor.
External cables may be routed through the double floor as well.

2.3.9. Auxiliary equipment

All auxiliary equipment shall be fixed to the walls or to the ceiling.
All auxiliary equipment shall have IP41 ingress protection level.

2.3.10. Low voltage distribution panel

The distribution panel shall be equipped with the following equipment:

- Automatic fuses
- Rail mounted miniature circuit breakers and switches
- HVA/C control unit

The distribution panel shall feed all electrical equipment installed inside the container. If additional equipment will be installed inside the container, e.g. provided by customer, the required loads shall be provided within the base design phase.

The following in- and output voltages shall be fulfilled:

1. AC: 240 V AC, 3Ph, 60 Hz + 2 x 125 V DC

2. DC: 2 x 125 V

A socket for low voltage input power shall be installed on the container outside. The socket inlet is lockable.

2.3.11. Lighting

Indoor: Each container contains long-life lights ensuring 350 lux measured 200 mm above floor level. The lights are positioned at least in front of the door(s), and in front of cubicles. An on-off switch is placed at every exit door.

2.4 Heating, Ventilation and Air-conditioning

(HVA/C)

For ambient temperatures out of the ranges of operating temperatures specified an HVA/C system shall ensure the required temperature during operation. As an option, the HVA/C system shall ensure the required ambient temperature during transport and storage (with external power supply). Apart from temperature ranges, the HVA/C system shall ensure that condensation is avoided.

2.4.1. Air conditioning

The offer may contain different variants of optional air-conditioning units suited for different thermal loads and ambient conditions.

The HVA/C unit shall have the operation modes: ventilation, cooling, and (passive) dehumidification.

2.5 Scope of Supply: Services

2.5.1. Routine Tests

The housing units shall be routinely tested before proceeding to the Factory Acceptance Test (FAT).

2.5.2. Container routine test

Prior to the assembly of the main equipment in the container, all individual components of the container shall be routinely tested to guarantee the highest quality, as follows:

- Check of welding: Vt-reports \
- Mechanical Inspection: check report

The mechanical inspection of the container consists of a visual, dimensional and color code inspection. Therefore, the number, design, dimensions and quality state of the container's openings, floor and auxiliaries are accordingly checked. Furthermore, a function test of moving units like doors and lockers finalizes the mechanical inspection.

- Electrical Inspection: CE - Declaration, Inspection Record E-Installation (1000V~/50Hz)

The electrical inspection checks that the container's electrical installation fulfills operational needs, by testing power sources, sockets, lighting…

- Electrical equipment test

The functionality of all optional electrical equipment of the container like air conditioning and fire detection is checked.

- Painting Corrosion Protection Test Report

2.5.3. Rain test **for** ingress protection verification

A water spray test to confirm the ingress protection class shall be offered as an option. Containers shall be possible to verify prior to delivery on end-customer's request.

2.5.4. Foundation load calculation

All interfaces between the main equipment and the container shall be possible to analysis for the purpose of load dimensioning. Furthermore, a permissible roof load shall be stated, as well as maximal loads of container lifting points.

2.6 Earthing

2.6.1. Potential earthing

The housing shall be connected to the earthing of the base frame on at least two points for example by means of a copper bar or braids.

The base frame shall be electrically conductive and connected to the external earthing grid by one of the two main earthing connection points, each one located at each container’s long end and properly marked with an earthing sticker according to DIN EN ISO 7010. Adjacent base frames for multiple housing unit installations shall also be conductively connected.

The container connection to the main earth grid shall be possible on each corner by a copper conductor with a cross-section of 240 mm² (acc. IEC 60364-5-54:2011-03). The connection to the base frame is minimum a M12 threaded bolt.
The steel structure must be continuously connected to build up an earthing grid.
Doors shall be earthed as well (e.g. by means of copper braid).

The potential bonding of the primary electrical equipment inside the housing units shall be possible by solid connections to the steel beams in the base frame.

A component drawing provided by the main electrical equipment manufacturer shall show the designated equipment earthing plates with all required specifications and dimensions for equipment earthing and required earthing connections.

2.6.2. Short circuit earthing

The base frame shall have a main earth rail consisting of an isolated copper bar with a cross-section of at least 240 mm² positioned transversally across all container units. The connection between short circuit earthing of main electrical equipment and this main earth rail shall be possible.

The main earth rail shall extend to the outside through a penetration at the short edge of the base frame (the same opening as for low voltage cabling may be used), covered with a non-conducting sealed plate, and protrude at the sides by 100 mm (but without exceeding the defined outer length of the skid/container) providing a connection point to the ground earthing grid.

The main earth rail must always be connected to the earthing grid in the shortest way possible.

2.6.3. Earthing of the container enclosure

The container enclosure shall be earthed with a copper cable providing the earthing connection of the container (standard case: drilled holes in the ISO-corners of the base frame / skid) to the outer ends of main earth rail.

PRINCIPLE TECHNICAL PARAMETERS FOR COLUMNS, BEAMS, PEAKS AND SUPPORT STRUCTURES

1 GENERAL REQUIREMENTS :

a) The equipment to be supplied against this specification shall be as per relevant drawing (will be provided to successful bidder). In case the bidder desires to supply the material with slightly varying design, the same shall be subject to purchaser's specific approval. The heights of various support structures indicated in the relevant drawings are typical and indicative. It may be necessary to carry out slight variations in the height to match the bus height in relation to the sub-station land contours/ equipment dimensions. Such changes shall be bidder's responsibility.

b) The quantity of various items to be supplied shall be as per the Bill of Materials (Annexure-I) and also as per the scope indicated in the sub station layout plans furnished. Supply of complete quantity of steel members along with accessories required shall be in the bidder's scope.

c) Unit rates shall be quoted by the bidder for various types of structures and shall be on tonnage basis.

d) All columns, beams, and peaks as also the various types of support structures shall be on tonnage basis.

e) All the columns, beams, and peaks as also the various types of support structures and lighting masts/ lighting cum lightning masts shall be of lattice type design as shown in the relevant drawings.

f) Shearing, Punching, Bevel cutting and bending of steel members shall be done accurately so that during assembly there will not be any drifting or reaming of holes. All bevel cutting shall be accurate, and any variation of more than 1.5 mm may be liable for rejection. Punching shall be done with the use of gauge (or by other methods acceptable to the purchaser) to ensure accuracy. Bending shall be moderately sharp and true to the details shown on the shop drawing. Bends may be done either hot or cold.

g) Identical pieces of structures bearing the same erection mark must be interchangeable in their relative positions in all structures of which they form a part. Leg ends, bearing on each other or resting on bases, shall be milled true to bear and ensure good bearing and perfect alignment. Finished members, without ends finished for contact bearing, may have tolerance (+) 1.5 mm for a member upto 3 M long. For longer members, 1 mm per additional 3 M length will be allowed subject to maximum of 3 mm.

h) Welding where necessary shall be carried out before galvanizing and shall conform to relevant Indian Standard Specifications. Caution shall be exercised to obtain full penetration of the weld when welding light members to heavy members.

i) After all shop works are complete, all structural members shall be punched with "Erection Mark" and be treated suitably for through cleaning. The duly treated steel members shall be hot dip galvanized. The galvanization shall be done as per relevant IS, and shall be capable of withstanding minimum four one-minute dips in copper sulphate solution. Galvanizing of each member shall be carried out in one complete immersion.

j) The equipment support structures for wavetrap, Coupling capacitor, Isolator with and without earth blade shall be supplied with the equipment. The same shall be as per foundation plan specified for the structure.

k) The Gantry and equipment support structures shall be fabricated as per MSETCL's standard structural drawing/approved drawings for the particular structure. The equipments should match with the standard structural drawing.

l) Bolts, Nuts and washers of makes approved by MSETCL shall only be supplied. All bolts, nuts and washers shall be hot dip galvanised conforming to IS 5358. Spring washers shall be galvanised in accordance with IS 1573 service condition IV. Excess spelter from bolts, nuts, etc. shall be removed by centrifugal spinning. Rethreading of bolts after galvanising, shall not be permitted. Nuts however, may be tapped, but this should not cause appreciable recking of the nuts on the bolts.

2 STEEL SECTIONS:

a) The steel angle sections used for fabrication shall be Mild Steel or High Tensile steel, as indicated in structural drawing, having yield strength as specified below conforming to IS-2062 and IS-8500 & EN-10025 JR & JO with revision thereof.

Designation	Section (Min.) thickness	Yield Strength (N/mm^2)
Mild Steel		
Fe 410 WA/WB	< 20 mm	250
	20-40 mm	240
	> 40 mm	230
High tensile Steel		
Fe 490/B	< 16 mm	350
	16-40 mm	330
	41-63 mm	320

3 PROTOASSEMBLY:

a) The manufacturer shall fabricate and offer protoassembly of each type of structure for purchaser's inspection and approval (alongwith relevant shop floor drawings at his works) prior to taking up mass fabrication. The fabrication of protoassembly of particular structure/s shall be exempted if the manufacturer has in past fabricated and got approved the proto assembly and supplied the same.

b) The checking and approval of prototassembly by purchaser shall not relieve manufacturer from the responsibility of correctness of engineering, workmanship, fitting of parts, details, materials supplied and errors or omissions if any. Purchaser's approval shall only constitute approval of the sizes of members, dimensions and fitting arrangement but shall not constitute approval of the connection between members and other details shown on the shop drawings which shall be responsibility of supplier. Purchaser's approval shall not invalidate any claim for damages of any kind for incorrectly fabricated steel. The cost of assembly and dismantling of each prototype shall be borne by the supplier.

4 DRAWINGS AND BILL OF MATERIALS:

a) The manufacturer shall furnish to the purchaser 2 sets of final and approved versions of the drawings and bills of materials alongwith 1 set of reproducibles / soft copy to C.E.(Tr. Proj.) within two weeks after final approval. The drawing shall be preferably in A-3 size paper & B.O.M shall be in A-4 size paper. The Bills of Material should indicate on each page the type of structure, its identification mark, the KV rating , reference of structural drawing etc. The supplier shall ensure that the packing list and Bill Of Material (BOM) are approved by the purchaser before offering the material for pre- dispatch inspection. A copy of approved BOM and a computer CD shall also be dispatched with the consignment to each consignee.

b) Structural/Erection drawings of structures shall show each individual member with its identification mark. Locations and position of the outstanding leg of angle, length of connecting bolts and their diameter etc.

5 MARKING:

a) Each individual structure member shall be marked with its respective identification mark given to it on the erection drawings/BOM. The marking shall be stamped with a metal die before galvanising with figure at least 2 cms high in such a manner and to such optimum depth as to be clearly visible after galvanising.

The erection mark shall be A-BB-CC-DDD where-

AA - Manufacturers name code (Alphabet).
BB - Manufacturers order reference (Numerical)
CCC - Type of Structure (Alphabet)
DDD - Mark Number (Alpha-Numeric)

b) The marking shall be on the outer surface of all angle sections and near one end but clear of bolt holes. For other members such as channels, flates, gusset plates etc. the markings shall be so stamped that they are easily discernible when sorting out members.

c) Marking on like pieces shall be in identical locations. Members having lengths 3 meters or more shall be stamped with markings at each end.

d) After galvanising, marks shall be circled or bracketed with black paint.

6 GALVANISING:

a) After all shop work is complete, all structural members shall be punched with the Erection Mark and be hot dip galvanised in conformity with IS:2629, IS:4759 and IS:2633. Before galvanisation, the steel section shall be thoroughly cleaned of any paint, grease, rust, scale, acid or alkali or such other foreign matters as are likely to interfere with the galvanising process or with the quality and durability of the zinc coating. Pickling shall be very carefully done and shall be proper.

b) The galvanizing bath shall be of adequate dimensions for facilitating galvanizing of structural parts in one dip.

c) The zinc used for galvanising shall be of grade Zn98 as per IS:209. The mass of zinc coating shall be as follows:

Sr. No.	Thickness of steel article	Mass of zinc coating	Thickness of zinc coating
1)	5 mm and above	610 gm/m^2	86 microns
2)	Below 5 mm	460 gm/m^2	64 microns
3)	Fasteners	300 gm/m^2	42 microns
4)	Spring washers	272 gm/m^2	38 microns

1 gm/m^2 = 0.14 Microns

d) The galvanised surface shall consist of continuous and uniformly thick coating of zinc, firmly adhering to the surface of steel. The finished surface shall be clean and smooth and shall be free from defects like discolored patches, bare spots, unevenness of coating, spelter which is loosely attached to the steel, globules, spiky deposits, blistered surface, flaking or peeling off etc. The presence of any of these defects noticed on visual or microscopic inspection shall render the material liable to rejection.

e) There shall be no flaking or loosening when struck squarely with a chisel faced hammer. The galvanising on steel member shall withstand minimum four one minute dips in standard copper sulphate solution as per IS:2633.

f) Galvanising of each member shall be carried out in one complete immersion. Double dipping shall not be permitted. When the steel section is removed from the galvanising kettle, excess spelter shall be removed by 'bumping'. The process known as 'wiping' or 'scraping' shall not be used for this purpose.

g) Defects in certain members indicating presence of impurities in the galvanising bath in quantities larger than that permitted by the specifications, or lack of quality control in any manner in the galvanising plant, shall render the entire production in the relevant shift liable to rejection.

7 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 a moderate amount of reeming shall be classified as defective workmanship. All charges required to be incurred in rectification of defective workmanship, shall be deducted from the amount due to the contractor against any bill under payment.

8 ACCEPTANCE TESTS:

The following acceptance tests, as per procedure stipulated in IS, shall be carried out by the supplier in presence of purchaser's representative.

a)	Verification of dimensions	: IS:2062/IS:8500/IS:808/IS:1730
b)	Tensile test	: IS:2062/IS:8500
c)	Bend test	: IS:2062/IS:8500
d)	Preece test	: IS:2633/IS:2629
e)	Adhesion test	: IS:2629
f)	Strip test	: IS:6745/IS:4759

SECTION – G – PROJECT MANAGEMENT REQUIREMENTS

Contents

SPECIFICATIONS

PART 1 – GENERAL

1.1 Introduction

1.2 Location of works

1.3 Scope of Work

The Scope of work mainly comprises the following:

1.4 Specific Requirements

1.4.1 General

The work sites is e located in NMMC area outside Navi Mumbai and in the rural area. The Tenderer shall take into consideration certain major factors while executing the Works, such as availability of limited area on the surface for working, restrictions on free working especially in the night shift due to objections from near by people for nuisance caused by noise of construction equipment or trucks, tippers etc., restricted time during disposal of muck etc.
Contractor will be allowed to construct garage for machinery, vehicles within Corporation's land to the extent available. For labour camp the Contractor may have to obtain land from private owners at his own cost.

There is no surplus power with NMMC hence Contractor have to depend on Diesel Generating sets for Power Supply. The Contractor will be allowed to use Corporation's roads as available, but Contractor will be responsible for maintenance of the Corporation's service roads. Contractor will be responsible for removal of unused muck to a safe site at his own cost, following existing rules and regulations.

The Tenderer shall take these factors into consideration for meeting the stipulated schedule and to quote his rates accordingly for various items of work.
The Contractor shall follow certain conditions for protecting the environment.

1.4.2 Insurance and Indemnity

The Contractor shall indemnify the Corporation and save it harmless from any claims for loss or damage to person or property as required under the tender stipulations, arising out of any risk due to driving of the tunnels by drilling and blasting or by TBMs, excavations in the shafts by drilling and blasting, pipe laying or associated civil works covered within the scope of the Contract.

Besides normal workman's compensation insurance cover, the Contractor shall take an "All Risk Insurance Policy" for the contract period. All insurance policies shall necessarily be taken from the Director of Insurance, Maharashtra Insurance Fund of Government of Maharashtra only.

1.4.2 Mucking and Disposal of Muck

The Contractor shall arrange for safe and sturdy head frames for hoisting and tipping arrangements as per INDIAN MINE RULES. Capacity of the head frames shall be such that the disposal of muck does not impede the progress of the excavation work. Also, it shall be noted by the Contractor that disposal of the muck overland would be subject to coordination with forest / police department who could impose restrictions on movement of transport. It is the Contractor’s responsibility to check and get confirmation of the transportation hours from the forest / police department. Hence, the above restrictions will have to be taken into consideration while planning and executing the work to meet the required schedule.

1.4.3 Connection to Existing Pipeline

The pipelines to be laid under the Contract shall be connected to the running pipeline and for this purpose, NMMC will arrange for an outage for a period allotted by the City Engineering department ’s (H.E.) department. Since the existing pipes are in service, the period of outage will be limited and hence the Contractor shall plan, schedule and adopt such methodologies to ensure that the entire work of connection of pipes is completed well within the outage period. The Contractor shall carry out all works connected within the items like, road breaking, excavation, diverting road where necessary, breaking of concrete / gunite cover of the existing pipe, cutting, preparing ‘V’, grinding, filling, introducing specials, appurtenances, major/minor fixtures, laying pipeline, welding, concreting, backfilling and consolidating, restoring the road /pavement, removing diversion etc. and any other connected items required for this though not specifically mentioned herein. The Contractor shall arrange all construction equipment, tools, tackles, cranes, diesel generators and/or diesel driven equipment and standby equipment to ensure meeting the scheduled programme. The Contractor shall prepare his programme for this work and submit it for the Engineer’s review and approval.

1.5 Drawings

Specification Drawings are included in the tender document. These drawings are meant for the Tenderer’s guidance only. ‘Released for Construction’ drawings, broadly conforming to the basic scheme, will be progressively issued to the Contractor by the Engineer during the course of work. ‘Released for Construction’ drawings may be revised and revised copies will be issued to the Contractor from time to time by the Engineer.

The Contractor shall carefully scrutinize the “Released for Construction” drawings and shall be responsible to point out discrepancies, if any, to the Engineer before execution of any part of the Works affected thereby.

1.6 Specifications

The Specifications are intended for general description of quality and workmanship of materials and finished work. They are not intended to cover minute details. The work shall be executed in accordance with the best modern practices using special techniques and conforming to relevant IS codes.

1.7 Issue and Return of Contract Documents

In addition to the two certified true copies of the Contract Document (including drawings) to be supplied to the Contractor, the Contractor will be supplied with two copies of the Specifications and Bill of quantities and two copies of all further “Released for Construction” drawings, which may be issued.

The documents and drawings issued as above remain the property of the Corporation and shall be returned to the Engineer’s Representative not later than the end of the Defects Liability Period.

1.8 Not used

1.9 Programme of Works

1.9.1 The works to be carried out under the Contract form an important part of Navi Mumbai Water Supply Project and satisfactory progress of this Project as a whole will depend on the timely completion of the Works. For this reason, great importance is placed on the proper programming of the Works with adequate provision to guard against all delays normally encountered in this type of work. The work shall be carried out in two shifts, on 6 days a week basis. However, between 6.00 a.m. and 11.00 p.m., the Contractor may not be permitted to carry out certain activities which cause a noise level of more than 85 dbA 10 meters from the source of noise. For working after the sunset, the Contractor shall make necessary lighting arrangements at his own cost subject to approval from the Engineer.

1.9.2 Notwithstanding the provision of Clause 8(L) of SGCC, no extension of time will be granted by the Engineer in respect of inclement weather or its effects (such as floods or drought), fire or industrial disputes unless such events could not have been reasonably foreseen by an experienced Contractor. All allowances to guard against such delay shall be clearly indicated in his programme.

1.9.3 As soon as practicable, within 30 days from the date of commencement of works, the Contractor shall submit for the Engineer’s approval a detailed Programme of Works in the form of CPM/PERT network and bar chart together with a description of his proposed methods of working. This post award Programme shall be reviewed / approved by the Engineer and will subsequently be used for monitoring of progress on the Contract.

1.9.4 The Contractor shall regularly review his programme in the light of the progress actually achieved and shall submit for approval updated bar charts at intervals to be agreed by the Engineer’s Representative. If progress falls behind that needed to ensure timely completion of the various parts of the Works, the Contractor shall submit proposals for improving his methods and place of working to the satisfaction of the Engineer’s Representative and shall carry out such measures as are needed to ensure that the works are completed on time. No additional payment to the Contractor shall be made on this account.

1.10 Time for Completion

The time limit for the Contract inclusive of monsoon periods is 10 months for Section.

The Contractor shall commence the Works on the date of receipt of the order of commencement of works issued by the Engineer and shall proceed with the Works with due expedition and without delay except as may be expressly sanctioned or ordered by the Engineer or be wholly beyond the Contractor’s control.

The whole of the Works shall be completed and the site cleared of the Contractor's equipment, establishment at site and debris within the above-stipulated period.

1.11 Taking-Over Certificate

If the Engineer issues a Taking-Over Certificate for the works pursuant to Clause 5(af) of SGCC, the Contractor shall, so far as practicable, finish all outstanding work during the Defects Liability Period. The Taking-Over Certificate shall not relieve the Contractor of any of his obligations in connection with other Contractors whose work is carried out after the issue of such a certificate.

The Contractor may apply for a Taking-Over Certificate for the works when the Works are completed in accordance with Clause 5(af) of SGCC.

1.12 Construction Materials

All construction materials including cement, reinforcing steel, structural steel, mild steel plates, sand, aggregates shall be procured by the Contractor from approved sources. The material so procured shall conform to the Specifications laid down in the Contract. The Contractor's responsibilities for construction materials shall be as set out in Clause 7of SGCC.

1.13 The Site

In accordance with Clause 5(h) of SGCC, the Corporation will make available to the Contractor the areas in possession of the Corporation. The Corporation will afford the Contractor possession of these areas. The Contractor shall be deemed to have inspected the work sites before submitting his tender.

The Corporation will not be in a position to make available any land for the Contractor's camp for labour or staff. The Contractor will have to negotiate separately with private parties for such camping ground for his use in the vicinity of the work sites at his own cost. For this purpose, the Corporation will only issue a recommendatory letter on specific request from the Contractor to facilitate obtaining necessary permission from the private parties.

1.14 Geological Information

Borehole log results from the site investigation are shown on Specification Drawings. The Corporation accepts no responsibility whatsoever for inferences drawn from these drawings, or from inspection of the borehole logs and the Contractor is deemed to have satisfied himself on his own responsibility as to the extent to which this information represents the conditions to be encountered. For further details, refer to part 3 of the Specifications.

1.15 Temporary Works

A reasonable time (in any case not less than 14 days) before the Contractor intends to commence construction of any temporary works; he shall submit full particulars including drawings of the same for the approval of the Engineer's Representative. Submission to and approval by the Engineer's Representative of any such particulars shall not relieve the Contractor of any of his responsibilities under the Contract.

1.16 Amenities to be preserved

The Contractor shall cause the least possible interference with the exiting amenities, whether natural or manmade. No tree shall be felled without the permission of the Engineer's Representative and clearance of the site shall generally be kept to the minimum necessary for the Works and temporary works.

Trees designated by the Engineer shall be protected from damage during the course of the work and earth level within one meter of each such tree shall not be changed. Where necessary, such trees shall be protected with temporary fencing. If retention of trees and protection thereof is found quite impossible due to site clearance requirements, the tress shall be removed wholly and replanted as directed by the Engineer. When trees are felled, they shall be cut into transportable pieces and carried to the stacking yard or Municipal store, all as directed by the Engineer.

1.17 Works to be kept clear of water

The Contractor shall keep the Works well drained until the Engineer certifies that the whole of the Works is substantially complete and shall ensure that so far as is practicable all work is carried out in the dry. Excavated areas shall be kept well drained and free from standing water.

The Contractor shall construct, operate and maintain all temporary works including pumping arrangements that may be necessary to exclude water from the Works while they are in progress and till they are handed over to the Corporation. No separate payment will be made for such dewatering works/measures. Unit rates quoted by the Contractor will be deemed to have covered expenses for such dewatering works/measures. Such temporary works shall not be removed without the approval of the Engineer's Representative.

Notwithstanding any approval by the Engineer's Representative of the Contractor's arrangement for the exclusion of water, the Contractor shall be responsible for sufficiency thereof and for keeping the Works safe at all times, particularly during any floods and for making good at his own expense any damage to the Works, including any that may be attributable to floods. Any loss of production or additional costs of any kind that may result from floods shall be at the Contractor's own risk and cost.

1.18 Discharge of Water into existing watercourse

The Contractor shall make provision for the discharge or disposal from the Works and temporary works of all water and waste products howsoever arising and the method of disposal shall be to the satisfaction of the Engineer's Representative and of any Authority or person having an interest in any land or watercourse in which waste may be so discharged. In the event there being no municipal storm water drains adjacent to the Work Site, the Contractor shall provide for drains to the point of disposal of pumped discharges to the satisfaction of the Engineer. The Contractor shall make his own arrangements for trapping of the silt before leading the water into drains or watercourse. The treatment of water from shafts should be as per Maharashtra Pollution Control Board (MPCB) norms.

All the necessary expenses for such arrangements shall be deemed to be included in the quoted prices. The requirements of this clause shall not limit any of the Contractor's obligations or liabilities under the Contract.

1.19 Prevention of Pollution

The Contractor shall ensure that at all times during construction of the Works all reasonable precautions are taken to the satisfaction of the Engineer's Representative to prevent pollution of the Site and of the environment. In particular, the Contractor shall prevent pollution arising from the disposal or spilling of sewage, diesel, fuel oil, liquid mud or from the disturbance of natural dust, aggregate dust or cement dust. The Contractor shall take all reasonable precautions to control the noise levels generated by construction equipment and mobile vehicles used for muck handling and disposal, below 85 dbA.

Selection of ventilation fans shall be subject to the approval of the Engineer's Representative and the same shall be provided with proper acoustics and/or silencers so as to maintain the noise level below 85 dbA at a distance of 10 metres from the source of noise. Muck handling trucks shall be provided with rubber mats. Crane hoisting system shall be hydraulically operable.

Dust generation at the site shall be suppressed by suitable methods such as periodic water spray to the satisfaction of the Engineer's representative. Trucks carrying excavated muck shall be adequately covered to prevent any spillage of muck on the roads while transporting the same to the locations of disposal.

Adequate toilet facilities with proper arrangement for discharge of treated effluent shall be made by the Contractor.

1.20 Effects of Weather

The Contractor shall ensure that no damage occurs to the Works during construction by arranging adequate protection for each work or building work against the effects of any natural cause such as drought, sunshine, wind or rainfall (including erosion and flooding). No work shall be performed when in the opinion of the Engineer' Representative such work is liable to be injuriously affected by the weather. The Contractor shall have no claim against the Corporation on account of loss alleged to have been sustained directly or indirectly by reason of the Engineer's Representative declining to permit such work to start or continue, or ordering any work damaged by the weather to be made good or removed and re-executed.

1.21 Site to be kept tidy

The Contractor shall keep the Site and all working areas in a tidy and workmanlike condition and free from rubbish and waste materials. Any temporary works, construction equipment, materials or other things which for the time being are not required for use by the Contractor may, with the consent of the Engineer's Representative, be removed from the Site but otherwise shall be dispersed about the Site in an orderly fashion and shall be properly and securely stored thereon.

1.22 Safety Measures and Services

The Contractor shall be responsible for the safety of all workmen and other persons entering or in the works and shall take all measures necessary to ensure their safety to the approval of the Engineer's Representative. Reference in these respects shall be made to the SGCC 5(u) as also to the following:

a) provision of proper safety and emergency regulations; fire, gas and electric shock precautions, stretchers and first aid box together with rescue facilities generally for each place of working;

b) provision of efficient safety helmets and gumboots for all personnel including the Engineer’s Representative and each of his staff and any authorized visitors to the Site;

c) safe control of water whenever required including provision of ample standby generating and pumping plant;

d) provision and maintenance of suitable lighting to provide adequate illumination of works with appropriate spares and standby equipment;

e) provision and maintenance of safe, sound mechanical equipment, each item of plant having an update testing certificate;

f) provision and maintenance of safe, sound ropes, slings, pulleys, and other lifting tackle, each appliance having an upto date test certificate where appropriate;

g) provision of notices 1.0 m x 1.5 m size written in bold letters in English, Hindi and Marathi to be erected at points of access likely to be used by the public, which shall warn the public of the existence of the Works. These notices shall be in addition to any statutory requirements demanded of the Contractor.

The Contractor shall submit for approval of the Engineer’s Representative detailed proposals under (a) above. When the regulations have been approved and before the work is started, the Contract shall distribute copies in English or in other languages as appropriate to all his employees and to the Engineer’s Representative.

The Contractor shall ensure that all his employees are fully conversant with the regulations, emergency and rescue procedures, etc., and the Contractor shall enforce the rule that any employee committing a serious breach of such regulations shall be instantly dismissed and shall not be re-employed.

No separate payments shall be made for observing any safety measures and services.

1.23 Water Supply and Sanitation

Untreated water will be made available to the Contractor from nearby pipeline. The Contractor shall make suitable arrangements, at his own cost, for conveyance and distribution of water for the construction of the Works and provide a satisfactory arrangement for supply of potable water for drinking, washing, sanitation and cleaning.

The Contractor shall have to make his own arrangement to store adequate quantities of water and convey it to the Work Site. The Contractor will be responsible for all the costs, where applicable, of connection, pumping, water consumed, disconnection and the laying, maintenance and ultimate removal of any distribution system around the Site in pursuance of Clause 5(i) of SGCC.

The Contractor shall provide lavatories and urinals for the use of site personnel at no charge. The Contractor shall also make necessary arrangements for disposal of wastes from lavatories and urinals to the satisfaction of the Engineer at no extra cost.

1.24 Electricity

The Contractor shall be responsible for installation of suitable size of D G power generating units along with indoor/outdoor substation together with supply of necessary outdoor/indoor equipment and accessories such as but not limited to D G sets, transformers, switchgears, cables, control / protection / metering / earthing etc; and, operation, maintenance and subsequent removal of temporary supplies of electricity, which the Contractor may require in connection with construction of the Works at each of the Sites and for adequate illumination on the Sites and approach roads and at the camps.

Suitable provision shall be made in the bid price for doing the needful in respect of the above and also for carrying out any civil works together with supply of necessary materials. No separate / extra payment shall be considered for this item on any account. The contents in the following paragraphs are only for the guidance of the Tenderer.

Immediately after the award of the Contract, the Contractor shall apply as per the required procedure to Maharashtra State Electricity Board/Torrent Power/TATA Power or any available source of power supply as applicable, for temporary supply at the respective sites at appropriate times to suit the construction schedule. All the expenses towards laying / Strengthening the line if any, connection charges and deposit etc., shall be borne by the contractor and shall be deemed to be included in the quoted prices. The

Employer will not reimburse any of the expenses by the contractor towards power supply.

Provision in the bid price shall, however, be made to make power supply available at each Site through suitably sized DG sets, in the event there is a delay in obtaining power from supply authorities or to continue the works during long periods of failure of normal power supply. Any delay in obtaining electricity supply from the supply authorities shall not constitute grounds for an extension of time or extra payment under the Contract.

1.25 Claims for Damage to Persons or Property

Any claim received by the Corporation or the Engineer’s Representative in respect of matters in which the Contractor is required under the Contract to indemnify the Corporation will be passed on to the Contractor who shall likewise inform the Corporation and the Engineer’s Representative of any such claim which is submitted directly to him by a claimant. The Contractor shall do everything necessary, including notifying the insurers of claims received, to ensure that all claims are settled properly and expeditiously and shall keep the Corporation and the Engineer’s Representative informed as to the progress made towards settlement, failing which the Corporation shall be entitled to make direct payment to claimants of all outstanding amounts due to them and deduct the same by way of offset, the amounts so paid from any sums due or which become due from the Corporation to the Contractor.

If the Contractor receives a claim which he considers to be in respect of matter in which he is indemnified by the Corporation under the Contract, he shall immediately pass such claim to the Corporation.

1.26 Testing of Materials

The Contractor shall be permitted, by arrangement with the Corporation, to use on terms and charges fixed by the Commissioner such equipment and facilities for testing as may be available in the Corporation’s Laboratories in Navi Mumbai.

1.27 NMMC's Office

Notwithstanding the contents of Clause 5(c) of SGCC, temporary offices shall be provided by the Contractor shall be a two A.C. containers. These offices will be provided with furniture and amenities as described hereinafter.

Each office shall be furnished with the following Godrej furniture and shall be taken back by the Contractor at the end of the Contract:

a) Four table, Twelve chairs with arms, Three cupboard, two filing cabinet (2-tier).

b) The Contractor shall clean and maintain these offices and demolish the same at the end of the Defects Liability Period or when ordered so by the Engineer.

c) All stationary, materials etc. required at sites for Engineer's use will be supplied by the Contractor at his own cost.

d) the Contractor shall supply a photocopier machine (color & black) of Canon laser, Latest model or approved equivalent. The contract shall also arrange for the installation of the telephone line for facsimile transmission.

e) The Contractor shall also provide a computer satisfying the following requirements:

i) I-3, 2.4 GHz of HP or approved equivalent along with the following :

- Keyboard 105
- 17 inch Monitor TFT
- Hard disc drive-1TB
- Logitech mouse with 3 buttons
- 4GB DDR3 RAM

i) Operating System – WINDOWS -10
ii) Softwares to be preloaded :

- MS OFFICE 2013
- AutoCAD (Latest Version)

iii) Lesar printer of Hewlett Packard or approved equivalent

The Contractor shall arrange for maintenance of the photocopier machine, and the computer till the end of the Contract. The photocopier, printer and Computer will be operated by the Engineer's office staff.

The Contractor shall note that the above machines and the computer along with their peripherals will be the property of the Corporation and the rest of the furniture and amenities will be the Contractor's property.

v) Adequate printing / photocopier stationary shall be provided by the Contractor.
No separate payment shall be made for expenses incurred under this clause.

1.28 Assistance for the NMMC's Staff

The Contractor shall provide all necessary assistance to the Engineer's Representative and his staff in carrying out their duties of checking the setting-out, inspecting and measuring the Works. The Contractor shall provide chainmen, staff men, office attendants and labourers as may be needed from time to time by the Engineer.

The Contractor shall provide for the Engineer and his staff such protective clothing, safety helmets and rubber boots of suitable sizes, hand lamps and the like as may be reasonably required by them. These articles shall remain the property of the Contractor. No separate payment shall be made on this account.
The Contractor shall provide immediately on commencement of contract, for the Engineer supervising staff, the following:-

i) The Contractor shall provide telephone connection at site, exclusively for the use of NMMC's staff. Monthly bills / expenses on account of this shall be borne by the Contractor.
ii) Two seven seater cars/Geep with drivers shall be provided for use of employer's staff. This shall be provided during Construction Works Period and until one year from Commercial Operation Date and shall provide for monthly average 3000 K.m. per vehicle. Fuel and maintenance of cars shall be responsibility of the contractor.

1.29 Instruments to be provided

The Contractor for shall provide, for the exclusive use at the Site, all survey equipment and measuring instruments of approved make and of every kind necessary for the execution of the Works, all to the approval of the Engineer's Representative, including:

(a) Total Stations with least count of one second, displaying the survey co-ordinates of objects and stations on screen;

(b) one automatic surveyor's levels with horizontal 360^0 circles, tripods and carrying cases;

(c) two leveling staffs 6.2 m long, with attached bubbles, graduated in meters and tenths and hundredths of a meter;

(d) reflector prisms;

(e) one set of prism holder and adapter to fit in tribranch and pogo stick;

(f) battery chargers for the batteries provided with the above instruments;

(g) two surveyor's steel bands of which one shall be 100m long and approximately 20 mm wide, and one shall be at least 30 m long and approximately 12 mm wide, each fully divided, complete with tape thermometers and tension handles and wound on an open plastic cross;

(h) an adequate number of ranging rods, steel and linen tapes, string lines, pegs, lines, spirit levels, survey umbrellas, light batteries, stores and tools) extensometer for measurement of tunnel diameter after boring.

The instruments mentioned above shall be for the exclusive use of the Engineer and shall remain at office in the custody of the Engineer till the Works are completed.

The Contractor shall be solely responsible for all such instruments and equipment and shall ensure that they are at all times in good repair and adjustment and shall make good any loss or damage howsoever caused.

No separate payment shall be made on this account.

1.30 Publicity Notice Board

The contractor shall provide, maintain and remove at the end of the Defects Liability Period a publicity notice board according to the requirements of the Corporation.

1.31 Progress Photographs and Video Films

The Contractor shall take coloured slides and / or coloured photographs as ordered by the Engineer's Representative every month or as directed by the Engineer. Four unmounted prints not less than 165 mm x 215 mm on glossy paper shall be provided along with negatives for each coloured photograph. The required number of albums of size 45 cms x 30 cms and of approved quality shall be provided to paste and maintain the photographs. Four colored slides shall be provided for each slide photograph. All negatives, prints and slides shall become the property of the Corporation and the Contractor shall not make use of them for his own purposes unless specifically permitted by the Corporation. The photographs should be also provided in soft copies on CDs/Pen drive.

The Contractor shall also arrange for video filming of important events during the progress of the Works, starting from commencement and including periodic achievement of milestones in commissioning and when ordered by the Engineer's Representative or as directed by the Engineer. The film shall be for about 1hours duration. The Contractor shall provide four copies of the film after proper editing and incorporating suitable audio. All original and copies of the video film shall become the property of the Corporation and the Contractor shall not make any use of them for his own purpose unless specifically permitted by the Corporation. The video film to be also provided in DVDs.

1.32 Clearing of Site on completion

On completion of the Works, the Contractor shall clear away and remove from the Sites all construction equipment, surplus materials, rubbish, temporary works of every kind including any sheds, site offices etc. constructed by the earlier Contractor and leave the whole of the Site and the Works clean and in a workmanlike condition to the satisfaction of the Engineer.

The Contractor shall comply with the above requirement before the start of the Defects Liability Period and by the end of that period shall clear, regrade, terrace, level topsoil and grass all his working areas as instructed by the Engineer. No separate payment shall be made on this account.

1.33 Forms of Monthly Statements

Statements pursuant to Clause 12(b) of SGCC for record and measurements shall be submitted in the manner set out hereinafter on Forms 1.35Aand 1.35B to be provided by the Contractor. Such forms shall be printed or duplicated to the approval of the Engineer's Representative as soon as practicable after the order of commencement of works has been issued. Each statement shall be submitted to the Engineer's Representative, interim statements being in eight copies and the final statement being in nine copies. No separate payment shall be made on this account.

1.34 Pipelines and Services

The Contractor shall not permit his construction equipment to pass over buried pipelines other than at places designed for such loading, as identified by the Engineer.

1.35 Sub-Contracts

Successful Contractors will be permitted to engage any approved Sub-Contractor. However, the responsibility of execution of the work, will be of the Main or Prime Contractor.
Attention of Tenderers / The Contractor is also invited to Clause 3(b) ofSGCC.

1.36 Sale of Excavated Material

If the Contractor requires any of the materials for execution of the Works under the Contract, he shall apply to the Engineer in writing and the materials may be sold to him after taking joint measurements. Measurement shall be taken either by forming depots or by any other method approved by the Engineer, there being no deductions for voids. The cost of material to be sold to the Contractor is indicated below and is inclusive of royalty. However, the cost is exclusive of supervision charges which will be charged extra at 10%.

i	Stone rubble of good quality	Rs. 650 per Cu. M.
ii	Stone rubble of inferior quality	Rs. 600 per Cu. M.
iii	Excavated earth, murrum, quarry spalls (up to size of 150 mm)	Rs. 400 per Cu. M

If surplus materials from any other work is available, it will also be released to the Contractor for work under the Contract at the same rates as above on the same terms and conditions at the engineer's discretion. For this purposes, the Contractor shall have to sort out the material in separate stacks and transport the same to the site of work at his cost. The Contractor shall note that the cost of this excavated material along with the supervision charges will be deducted from the total value of Work.

1.37 Special precautions to be taken in view of cement mortar lining to the associated pipelines

Attention of the Contractor is specially invited to the fact that the pipelines will be provided with cement mortar lining, and it is therefore very necessary that the pipes remain circular during the laying operations and thereafter till they are mortar lined. The diametric variation shall be kept within ± 2%. To achieve this, the Contractor shall provide suitable strutting arrangement to the pipes from inside to the satisfaction of the Engineer. They shall be of adjustable type and shall normally be provided at intervals of not more than 1.8 metres or as directed by the Engineer. These struts shall be removed only after the refilling is done to the full height or after the concrete encasing is set.
If the diametric variation is found to be more than permissible, the section of such pipe line shall be removed and relaid by the Contractor at his full risk and cost.

1.38 Housing Accommodation

There is no spare housing accommodation belonging to NMMC near and around the site of work. The Contractor will have to provide the same for his staff at his cost.

The Contractor shall make his own arrangements to secure private land for this purpose and pay all the taxes and fees that may be claimed by the Assessment of any other Department of the Corporation or by State Government Local Authority in respect of ground, sheds, offices, etc., constructed on such private land.

The contractor shall maintain his camps and staff quarters in perfect sanitary conditions to the entire satisfaction of the Engineer. Under no circumstances, shedsfor residential purposes will be allowed to be constructed along any of the public roads near the work site.
Attention of the Tenderers / the Contractor is invited to Clause 6(b)SGCC in this regard.

1.39 Forest Reserve

The Contractor shall ensure that his employees and Sub-Contractors shall not fetch firewood from the forest around the site. The Contractor shall be liable for penalties levied by the forest authorities for infringement of this regulation.

1.40 Deleted

1.41 Interpretation of Documents

Tenderers shall carefully examine the Tender Documents and fully inform themselves as to all the conditions and matters which may any way affect the work or the cost thereof. Should a Tenderer find discrepancies in or omissions from the Specification or other documents or should he be in doubt as to their meaning, he should at once address a query to the City Engineer (City Engineering department). Any resulting interpretation of the Tender Documents will be issued to all the Tenderers as an addendum. Verbal clarification and /or information given by the City Engineer (City Engineering department) shall not be binding on the Corporation.

1.42 Errors and Discrepancies in Tenders

Should the Bill of Quantities submitted with the Tender be found to contain errors such as adding mistakes, incorrect transferences and discrepancies between rates and amounts, the Engineer will advise the Tenderer of any errors and discrepancies as aforesaid which may have been found in the Bill of quantities and after discussion with the Tenderer, will make such amendments (and no others) as are proper to resolve the errors and discrepancies as aforesaid and will re-total the Bill of Quantities.
In General the quoted unit price in the original Tender will apply when discrepancies arise with the extended price.

1.43 Commissioning

On satisfactory completion of the Works before filling up the pipeline, the Contractor shall clean the Works to satisfaction of the Engineer. The Contractor shall gradually fill the pipeline in a manner directed by the Engineer.

On substantial completion of the Works, the Contractor shall issue a notice to the Engineer as set out in. The net volume of water required for filling up and commissioning shall be provided free of charge by the Corporation. However, it shall be the responsibility of the Contractor to make all necessary arrangements by way of labour and construction equipment incidental to commissioning.

No separate payment shall be made for commissioning and the expenses shall be deemed to have been included in the rates quoted for other items of work.

1.44 Royalty

Notwithstanding the provisions of clause5(ab) ofSGCC, if and when royalty becomes payable to the Government Authority on excavated material as per statutory requirements, the payment shall be made by the Contractor and no reimburment.

1.45 Special Condition for Operating the provisional Sum

1) Bidder not have to quote the rate for Provisional Sum
2) Under provisional sum is for reimbursement towards check/verify of design and drawing

1.46 Provisional sum

Use of Provisional **Sums and Production of Vouchers, etc.**
Provisional sums set out in the bill of quantities which shall be stated to be provisional or for contingencies shall be used only at the direction and discretion of Engineer and if not used, either wholly or in part shall, as to the amount not used, be deducted from the Contract Price.

The Contractor shall when required by the Engineer produce all quotations, invoices, vouchers and accounts or receipts in connection with expenditure in respect of provisional sums for reimbursement. The reimbursement will not be added with any overheads and profits.

2.1 MILD STEEL PIPELINE

2.1.1. SCOPE

This specification along with Section 5 of the Specifications covers supply, fabrication, testing, delivery at site, laying, erecting and jointing of Mild Steel buried pipelines, vertical pipe work in the shafts, specials and steel liner in the tunnels.

The sections below specifically cover fabrication of pipes, specials, testing, painting, transporting to Site as well as laying of buried pipelines. The erection of pipe work in shaft and pipes in tunnel (also called liners) are covered in Part 5.

2.1.2. APPLICABLE CODES & SPECIFICATIONS

The following specifications, standards and codes are made a part of the specification. All standards, tentative specifications, codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions.

In case of discrepancy between this specification and, those referred to herein, this specification shall govern.

1.	IS	:	2062	-	Structural steel (Fusion welding Quality).
2.	IS	:	808	-	Rolled steel Beam, channel and Angie Sections.
3.	IS	:	814	-	Specifications for covered Electrodes for Metal Arc Welding for Mild Steel.
4.	BS	:	639	-	Covered electrodes for manual metal are welding of Mild steel and medium tensile steel.
5.	AWS	:	A-5.1	-	Specification for mild steel covered are welding electrodes.
6.	IS	:	3613	-	Acceptance tests for wire flux combinations for submerged are welding.
7.	AWS	:	A-5.17	-	Specification for bare mild steel electrodes and fluxed for Submerged are welding.
8.	IS	:	1367	-	Technical Supply Conditions for Threaded Fasteners.
9.	IS	:	2016	-	Plain Washers.
10.	IS	:	2074	-	Ready Mixed Paint, Red Oxide Zinc Chrome and Priming.
11.	IS	:	102	-	Ready Mixed Paint, Brushing, Red Lead, Nonsetting, Priming.
12.	IS	:	1786	-	Specification for Cold Twisted Steel bars for concrete reinforcement.
13.	IS	:	432 (Part-1)	-	Specification for Mild Steel Medium Tensile bars and hard drawn steel wire for concrete reinforcement : Tensile steel Bars.

14.	IS	:	432 - (Part-II)	Specification for mild steel Medium Tensile steel bars and hard drawn steel wires for concrete reinforcement : Hard Drawn steel wire.
15.	IS	:	269 -	Specification for ordinary and Low heat Portland cement.
16.	IS	:	8041 -	Specification for Rapid hardening Portland Cement.
17.	IS	:	383 -	Specification for coarse and fine aggregate from natural Source for concrete.
18.	IS	:	12330 -	Specification for Sulphate Resisting Portland Cement.
19.	IS	:	456 -	Code for practice for plain and reinforced concrete.
20.	IS	:	800 -	Code of practice for general construction in Steel.
21.	IS	:	816 -	Code of practice for use of Metal Arc Welding for General Construction.
22.	IS	:	4353 -	Recommendation for Submerged Arc Welding of Mild Steel & Low Alloy Steels.
23.	IS	:	817 -	Code of practice for Training and Testing of Metal Are Welders
24.	IS	:	1182 -	Recommended practice for Radiographic examination of Fusion-Welded Butt Joints in steel plants.
25.	IS	:	2095 -	Code of Practice for radio-graphic Testing.
26.	IS	:	3658 -	Code of Practice for Liquid Penetrant Flaw Detection.
27.	IS	:	5334 -	Code of practice of Magnetic Particle Flaw Detection of Welding
28.	ASTM	:	E-94 -	Recommended Practice for Radiographic Testing.
29.	ASTM	:	E-109 -	Dry Powder Magnetic Particle Inspection.
30.	ASTM	:	E-138 -	Wet Magnetic Particle inspection.
31.	ASTM	:	E-165 -	Liquid Penetrant Inspection.
32.	IS	:	3600 -	Code of Procedure for Testing of Fusion Welded Joints And weld-metal in steel.
33.	IS	:	4853 -	Recommended Practice for Radiographic Examination Of Fusion Welded Circumferential Joints In Steel Pipes.
34.	IS	:	3589 -	Specification for Electrically welded steel pipes for Water Gas and Sewage (150 to 2000 mm Nominal size)
35.	IS	:	6631 -	Steel pipes for Hydraulic Purposes.
36.	IS	:	7343 -	Code of practice for ultrasonic Testing of Ferrous Welded Pipes and Tubular Products.
37.	IS	:	2548 -	Safety Code for Industrial Radiographic Practice.
38.	IS	:	5822 -	Code of Practice for Laying of Welded steel pipes for water supply
39.	IS	:	1566 -	Specification for plain hard drawn steel wire fabric for Concrete reinforcement.
40.	IS	:	5878 - (Part VI)	Code of practice for construction of tunnels. Steel lining.
41.	IS	:	2002 -	Steel Plates for Pressure Vessels for Intermediate and High Temperature Service Including Boilers – Specifications

2.1.3. MATERIALS

a) Steel Plates – The steel plates for pipes, liners, fittings, specials and stiffeners shall be of mild steel grade Fe410 conforming to IS : 226 or IS : 2062. Only SAIL & TATA STEEL M.S.Plate shall be preferred.

b) Welding Consumables – such as electrodes, filler rods and wires shall conform to IS : 814, IS : 3613, IS : 6419 and IS : 7280.

c) Cement – The cement used shall be of one of the following :
   i) Ordinary Portland Cement conforming to IS:269
   ii) Sulphate Resisting Portland Cement Conforming to IS : 12330

d) Aggregate – The aggregates shall conform to IS: 383

e) Water – The water used in preparation of concrete mix shall conform to the requirements of mixing water given in IS:456

f) Steel for Reinforcement shall conform to IS : 1786

g) Before fabrication of pipes and specials / fittings is commenced, the copies of the mill sheets and the manufacturer's test certificates for plates and other materials for the fabrication, shall be submitted by the Contractor to the Engineer for his approval.

   When requested by the Engineer, the Contractor shall supply free of charge to the Employer, for testing in approved laboratory, suitable sample of the materials to be used / in the works. The cost of such tests shall be borne by the Contractor and shall be included in his item rates.

   The contractors shall provide sufficient separate stacking yard for the steel materials, fabricated pipes, and specials scrap in their factory as per the requirements. Size of plates will be measured in millimeters.

   The Contractor shall procure MS plates and other structural steel required for fabricating pipes / specials considering the wastage / scrap etc. and rate quoted shall be inclusive of wastage / scrap etc. The contractor should note that no claim will be considered on account of scrap wastage / scrap etc.

2.1.4. INSPECTION

All works and material under specification will be rigidly inspected during all phases of manufacture and testing and such inspection shall not relieve the Contractor of his responsibility to furnish materials and perform work in accordance with this specification.

The Contractor shall notify the Engineer, in advance the production of materials and fabrication thereof, in order that the employer may arrange for mill and shop inspection.

The engineer may reject any or all materials or work that do not meet with any of the requirements of this specification. The Contractor shall rectify or replace such rejected material / performed work at his own cost, to the satisfaction of the Engineer.

The Engineer shall have free access to those parts of all plants or any other premises and sites that are concerned with the furnishing of materials or the performance of work under this specification.

The Contractor shall furnish to the Employer's inspector reasonable facilities and space without charge for inspection, testing and obtaining of any information he desires in respect of the character of material used and the progress and manner of the work.

The Contractor shall supply free of cost required specimen of materials for testing by the owner at any time during the progress of work and shall bear the cost of all such tests or re-tests to the satisfaction of Engineer.

2.1.5. MANUFACTURE OF M.S. PIPE

2.1.5.1. General

All pipes and specials shall be manufactured out of mild steel plates which shall be free from any cracks, surface flaws, laminations, excessive pitting or any other defects. The pipes shall be truly cylindrical and straight in axis. The ends shall be accurately cut and prepared for field welding. The external circumference of the pipe pieces which are to be fixed adjacent to flange adapter/dismantling joint with fixed outer diameter shall not deviate from theoretical one by more than 1 mm. To obtain the accuracy the pipe shall be rolled several times, if necessary, as pipe pieces should be truly cylindrical. The external longitudinal welding of this pipe shall be ground smooth flush with surface to the satisfaction of the Engineer. No extra cost shall be charged by the Contractor for this grinding work.
Minor repair by welding or otherwise shall be permitted at the discretion of the Engineer, but such repairs shall be done only after obtaining the previous permission of the Engineer. Any pipe or part thereof, which develops injurious defects during shop welding or other operations, shall be rejected.

Provision for lodging, boarding & transport for staff deputed for inspection in fabrication shop.

2.1.5.2. Fabrication of Pipe / Liner

The Contractor shall get the fabrication work done in a duly valid licensed factory of his own or that of an approved, nominated sub contractor. This factory meant for fabrication pipes, specials etc. shall also be involved with testing etc., machining as well as painting.

The factory should have valid ISI License and it should be ISO certified. For completing the work under the present contract within the contract period, the factory shall be equipped with adequate number of following equipment and plant but not restricted to

i) Plate bending machines for rolling of pipe drums

ii) Automatic welding machines (suitable for circumferential as well as longitudinal welding)

iii) Hydraulic Testing Machines

iv) Travelling gantry or crane of capacity 10 Tonnes or above.

v) Mobile cranes for loading/unloading of plates, pipes etc. 15 tonnes capacity each.

vi) Lathe for machining of the flanges rings, plates etc.

vii) Equipment for sand blasting and applying paint by spray gun.

viii) Equipment for cold pressing of plates upto 25 mm thick to the required curvature (domes, plug plates, M.H.cover etc.)

ix) Any other, considered necessary for carrying out the work covered in scope.

The factory shall have adequate area, and shall also have stacking yard for the stacking of plates, structurals, fabricated pipes etc. and the scrap.

The Bidder shall furnish with his bid the MOU with the factory where he intends to get the fabrication done, such as it's location and the equipment, plant and other facilities available in the factory for the manufacture of M.S. Pipes and specials required under this contract.

2.1.5.3. Cutting Plates to Size

The plates shall be indented in such length as to have minimum wastage and so as to make the pipe as far as possible with one longitudinal joint.

Before cutting, all the edges of the plates shall be cleaned by brushing/grinding on both the sides.

After the plates are cut, the edges shall be made smooth and even by polishing with an electrical or pneumatic grinder to remove all inequalities. Care shall be taken to see that the cut edges of the plate are perfectly straight. Jigs to be used for this purpose shall depend upon the types of cutting machine used. The plates cut to the required shape shall be checked for correctness before they are rolled into pipe drums. If any corrections are required, the Contractor shall do the same by re-cutting, if necessary. If any plate or flat is found to be warped, to have ierrugations, the defects shall be removed by putting the plate or flat into a roller press, and no extra payment for this rectification work shall be made. The laminated or heavily corroded plate shall not be used in the manufacturing of the pipe.

2.1.5.4. Rolling of Plates

The plates cut to the exact size shall be put into a rolling machine to form a pipe of the required diameter. The Contractor shall adjust the rolling machine so as to give a, uniform curvature to the pipe throughout its circumference. The curvature obtained shall be checked by the Contractor's foreman during the process of rolling and if proper curvature is not obtained at any place including the ends, the rolling operation shall be repeated at this stage or even after the longitudinal welding of the drum where directed. Heating of plates to obtain the desired curvature shall not be permitted.

2.1.5.5. Tacking the Drums

The rolled drums shall be kept on an assembly platform for tacking, care being taken to ensure that the tacked drums have their end faces at right angles to the axis of the pipe. While tacking the drum, a gap of 2 mm to 4 mm shall be maintained, where hand welding is permitted. However, where the welding is to be done on automatic welding machine, there is no need of maintaining such gap depending on the penetration through complete thickness of the welding required. To achieve this objective, clamp spiders, tightening rings and or any other approved gadgets shall be used. Each such drum, before being taken to the assembly platform, shall be numbered on the inside with oil paint, stating the plate thickness as well.

2.1.5.6. Assembly of Drums into Pipes

The tacked drums shall then be transported to an assembly platform where they shall be tack-welded together to form suitable pipe-lengths. Plate shall be bent in the maximum possible width to reduce the number of circumferential joints.

The longitudinal joints shall be staggered at 90^0. The drums when tacked together shall have no circumferential gap when the welding is done on automatic welding machine. But when hand welding is adopted as gap of 2 mm to 4 mm shall be maintain, to obtain a god butt welded joint.

The assembly shall be truly cylindrical and without any kinks. The faces shall be at right angles to the axis of the cylinder. A suitable arrangement for testing the correctness of the face shall be provided by the Contractor at the assembly platform.

2.1.5.7. Welding

All components of a standard shell, either straight or bent etc. shall be welded, wherever possible by use of automatic are welding machine by metallic shielded are process with alternating current. Hand welding shall not be permitted except for sealing runs and such other minor works at the discretion of the Engineer. The strength of the joint shall be at least equal to that of the parent material.

The Contractor shall use electrodes of approved make and size, the size depending on the thickness of plate and the type of joint. It shall also use with standard current and are voltage required for the machine in use with such modifications as may be found necessary after experimental welding. For this purpose, samples of welded joints shall be prepared and tested in the presence of the Engineer. The values once determined shall be maintained throughout the work and if any modifications are to be made, a written permission of the Engineer of the Engineer shall be obtained. In the case of thin sheets, electric are welding may not give satisfactory results and gas welding shall be resorted to. Gas welding shall be subject to the same specifications and tests as those for electric welds.

All the shop and field joints shall be welded, all welding shall conform to the requirements of IS 823 and IS 4353.

All longitudinal and circumferential joints shall be double welded butt joints. Due to non-accessibility of both side welding, field girth joints shall be accomplished using back up plates.

All circumferential welds involving plates of unequal thickness shall be so kept that the inside surfaces of plates match to provide stream lined joints without alteration in the internal diameter. As far as practicable, welding of dissimilar thickness of shells shall be carried out in the shops.
The welding shall be of the best workmanship free from, flaws, burns etc. and the Contractor shall provide for his own, electrodes and equipment, ovens to keep the electrodes at the desired temperatures and dry. In order to maintain a good standard in welding, welders shall be tested by the Contractor before they arc entrusted with the job. Qualification standard for welding procedures, welders and welding operation shall conform to the requirements of IS: 7307 and IS: 7310 (latest). Periodical tests as regards their efficiency shall also be taken at intervals and those found inefficient shall be removed from the job; only those who pass the test shall be posted on the job. If an incompetent welder has already welded some pipes all welding done by him previously shall be fully, checked by X-ray in addition to the regular X-

ray inspections. The defects if any, shall be set right to the satisfaction of the Engineer. All such check tests and rectification of defects shall be entirely at the cost of the Contractor. No pipes or steel sections shall be erected unless the work of the welder concerned has been proved to be satisfactory. Site welds shall be done by specially selected welders.

A record shall be maintained showing the names of welders and operators who have worked on each individual joints Hand-welding shall preferably be carried cut by a pair of welders so that, by observing proper sequence, distortion can be avoided. A joint entrusted to a particular individual or a pair shall be as far as possible, completed by them in all respects, including sealing run. No helper or other unauthorized person shall be, permitted to do any welding whatsoever, in case of infringements of above, the persons shall be punished as directed by the Engineer.

The welded joint after welding should not become brittle or sensitive to blows and there should be no loss of toughness due to welding or heat treatment. The material after welding and heat treatment is to be tougher than the base metal, and is to retain its original ductility. No allowance will be made for thinning of weld and the weld should in no point be less than the nominal thickness of plate.

Upon receipt of the order and prior to the start of fabrication, the Contractor shall submit to the Engineer for his approval the "welding procedure" he intends to use in the shop work. Similarly, prior to the start of the field welding, procedure for the field welding must be submitted to the Engineer for his approval. Manual welding shall be adopted only when machine welding is not possible.

2.1.5.8. Fabricating of Specials in Fabrication Shop

Specials, such as tees, Y-Pieces, bends, tapers, dished ends shall necessarily be in steel and shall be manufactured as per standards and tested :n the same manner as the pipe. Small branches, single piece bends, etc. may be fabricated at site, care being taken to ensure that the fabricated fittings have the same strength as the pipeline to which they are to he joined.

2.1.5.9. Pre-heating of Plates

The metal adjacent to weld shall be preheated where thickness of plate-exceeds 32 mm but less than 38 mm so as to reduce the cooling rate of welding, to obtain tough deposit of metal and to prevent development of cracks.

2.1.5.10. Thermal Stress Relieving

All heavy and rigid parts, specials such as shell piece with manholes, when the nominal thickness of the plates is more than 38 mm and when the welded joints connect plates of different thickness they shall be thermally stress relieved as per requirements of IS : 5878 (Part VI). Stress relieving shall be done in a suitable furnace. No stress relieving for joints in steel pipes is required where thickness of plates is 32 mm or less. Stress relieving shall be done by resorting to the following process and the chart shall be submitted in proof of this process.

2.1.5.11. Tolerance

The shell in the completed work shall be substantially round. The difference between maximum and minimum inside diameters at any cross section shall not exceed 1% of the nominal diameter of the cross section under consideration subject to a maximum of 10 mm.The diameter of pipe mentioned in this tender is the inner diameter.

Machined parts shall be within the following limits :

a) For mitred finished surface = ±20 minutes of arc

b) For elbow angles = ± 20 minutes of arc

c) For length of elbow pieces = ± 6 mm

Straight pipes shall have their faces perpendicular to th; axis of the section with a maximum deviation of 2 mm on either side of the plane.

2.1.5.12. Shop Testing

After fabrication, but before application of protective coatings all pipes and specials shall be subjected to a shop hydraulic test. Standard lengths of pipes shall be directly subjected to test and non-standard pipe and elbows can be tested as standard pipe before being cut to size.

The test pressure shall ensure that the plate material is stressed to 80% of the minimum yield strength and at least 150 m pressure as specified by the Engineer.

Each pipe shall be filled with water and the pressure slowly and uniformly increased until the required test pressure is reached.

The pipe to be tested shall be given a serial no. which shall be painted on its inside together with details such as pipe No. Shell thickness, diameter, length etc. as directed. It shall be entered in the register to be maintained by the Contractor.

Prior to testing, the pipe shall be inspected thoroughly and all the apparent defects in welding such as jumps, porosity etc. shall be repaired by gouging and re-welding.

The hydraulic test shall be carried out under cover at the fabrication shop, in the presence of and to the satisfaction of the Engineer or the inspection agency appointed by the Employer.

For indicating the pressure inside the pipe an accurate pressure gauge of approved make duly tested and calibrated for the accuracy of readings shall be mounted on one of the closures, which close the pipe ends.

The pressures shall be applied gradually by approved means and shall be maintained for at least 10 minutes or till the inspection of all welded joints is done during which time the pipe shall be hammered throughout its length with sharp blows, by means of a 1 kg. hand hammer.

The pipe shall withstand the test without showing any sign of weakness, leakage, oozing or sweating. If any leak or sweating is observed in the welded joints, the same shall be repaired by gouging and re-welding after dewatering the pipe. The repaired pipe shall be retested to conform to the specified pressure.

If any leak or sweating is observed in pipe shell the pipe under test shall be rejected temporarily. The Contractor shall stack such rejected pipes separately in his yard. The Engineer, shall inspect the same and after taking cuts if necessary, shall determine the nature of repairs to be carried out thereon and shall then decide as to how and where they shall be used. No payment shall be made for handling or carrying out repairs, but, payment for the fabrication and hydraulic testing of the pipe shall be released only after acceptance of the pipe with necessary repairs and subsequent testing etc. are carried out by the Contractor to the satisfaction of the Engineer. The Engineer shall be supplied with two copies of the results of all the tests carried out.

2.1.5.13. Submission of Daily Progress Report

The Contractor shall submit to the Engineer a daily progress report in the pro forma approved by the Engineer, wherein all the details of the work carried out in the factory shall be fully recorded. Similarly, works done in the various units in the factory shall be separately mentioned. The Contractor shall maintain a register of all the finished materials giving dates of carrying out important operations such as testing, transport, etc. The register shall be presented at least once a week to the Engineer, who shall initial the entries after verification.

2.1.6. TRANSPORTATION OF PIPES. SPECIALS ETC.

All pipes and specials fabricated in the factory and temporarily stacked in the Contractor's yard shall be transported to the site of laying after cleaning them internally etc. The item of transport covers the cost of loading in the factory, transporting to the factory transporting to the site of laying or to stacking yard selected by the Engineer in its vicinity and unloading and sticking item carefully in such a manner that the material so kept is not easily disturbed or rolled away from the place of stacking The loading in the factory, shall be carried out by means of either a crane, gantry or shear legs, so as not to cause any damage to the finished material. Similarly, while unloading and stacking, great care shall be taken to ensure that the material is not damaged or dented. The contrivances to be used for unloading will be different in different situations and in each case the one approved by the Engineer shall be adopted. The material stacked at shall be jointly inspected by the Engineer and the c contractor and defect or damage noticed shall be repaired to the satisfaction of the Engineer before payment is made.

Props of approved designs shall be fixed to the pipes during transit to avoid undue sagging and consequent distortion. After the pipes are carefully stacked, props may be removed and re-used for subsequent operations. The stacking ground, both in the Contractor's yard and at the site of laying shall be selected in such a way as not to get waterlogged during monsoon, if this cannot be done, the pipes shall be supported on sleepers to avoid contact with wet earth and subsequent rusting. In order to prevent sagging during transit, savings of steel plates can be utilized by cutting to the required length and tacking the same to the pipe ends, in place of props, if approved by the Engineer.
As explained in earlier paragraphs, materials such as pipes, tapers, etc. may be transported to the site of laying as soon as the material is finished in all respects with the permission of the Engineer to avoid congestion in the Contractor's yard. However, materials such as T branches and other complicated items, shall be stacked in the Contractor's yard until they are required for laying in the field. In view of this, the work of fabrication of such materials shall be properly synchronised as far as possible with the laying operations.

2.1.7. PROCEDURE FOR RECEIVING STEEL PIPES. SPECIALS ETC.

2.1.7.1. General

To ensure that the work of erecting pipes is not held up at any stage and place, the Contractor shall maintain an adequate stock of standard specials, flange rings, plug plates, manhole covers, etc. and short length of smaller diameter pipelines, etc. at site in his field stores, in consultation with the Engineer. Wherever possible, the Contractor shall arrange one full month's requirement of pipes, specials, etc. stacked along the alignment.

2.1.7.2. Stacking of pipes etc. and inspection

The Contractor shall keep in each section a responsible representative to take delivery of the pipes, specials and appurtenances, etc. transported from the fabricating stockyard or received from any other work site to the site of laying and to stack along the route on timber skids. Padding shall be provided between coated pipes and timber skids to avoid damage to the coating. Suitable gaps in the pipes stacked shall be left at intervals to permit access from one side to the other. The pipes, Specials, appurtenances so received on site shall be jointly inspected and defects recorded, if any, such as protrusions, grooves, dents, notches, damage to the internal coating etc. shall be pointed out immediately to the Engineer at the site and in the acknowledgment challans. Such defects shall be rectified or repaired to the satisfaction of the Engineer entirely at the Contractor's risk and cost.

2.1.7.3. Hurdling of pipes, specials

It is essential to avoid damage to the pipes, fittings and specials, etc. or their coatings at all stages during handling. The pipes and specials shall be handled in such a manner as not to distort their circularity or cause any damage to their surface treatment. Pipes shall not be thrown down from the trucks nor shall they be dragged or rolled along hard surfaces. Slings of canvas or equally nun-abrasive materials of suitable width of special attachment shaped to fit the pipe ends shall be used to lift and lower coated pipes to prevent damage to the coating.

Great care shall be taken in handling the pipe right from the first operation of manufacture until they are laid and jointed. The Contractor will provide temporary props in order to prevent any sagging of the pipes while they are stacked in their yard and while transporting to the site of delivery, i.e. laying. The props shall be retained until the pipes are laid. If at any time these props are found to be dislodged or disturbed, the Contractor shall immediately reinstate them in such a way that the true shape of the pipe shell or specials is maintained to the satisfaction of' the Engineer. No defective or damaged pipe or special shall be allowed to be used in the work without rectification to the satisfaction of the Engineer. Any damage to the coating shall be repaired by the Contractor at his own cost to the satisfaction of the Engineer.

2.1.7.4. Dents

Whenever any dent, i.e. a significant alteration of the curvature of the pipe shell is noticed, the depth of the dent shall lie measured between the lowest point of the dent and the pipe shell curvature line. All dents exceeding 2 percent of the outer diameter of the pipe shall be removed by cutting out a cylindrical portion of the pipe and replacing the same by an undamaged piece of the pipe. The Engineer may permit insert patching if the diameter of the patch is less than 25 percent of the nominal diameter of the pipe. Repairs by hammering with or without heating shall not be permitted. Any damage to the coating shall also be carefully examined and rectified.

2.1.7.5. Marking

The component parts of the pipes shall be carefully marked for identification in the field. The marking shall be on the side, which will be the inside of the pipe after bonding.

The marking operation shall be conducted with full size rulers and templates. Only blunt nose punches should be used.

The plates used for fabrication of pipes shall be laid out in such a way that when the shells are completed one set of original identification markings for the material will be plainly visible. In case these markings are unavoidably cut out, they shall be accurately transferred by the Contractor to a location where these markings will be visible on the completed work.

After the hydraulic tests on the specials and other items, the number of the shell in the line as it will be erected and the direction of flow shall be stamped in a prominent manner on each piece. A register shall be maintained in- suitable proforma giving the following information for each shell tested:

a)	Serial No.	b)	Shell No.
c)	Date of test	d)	Thickness and specification of steel
e)	Weight of shell tested	f)	Maximum test pressure
g)	Details of test performance	h)	Details of radiographic examination of welds
i)	Name of Engineers representative witnessing tests		

A copy of these details shall be furnished to the owner free of cost.

No separate payments will he made for these markings and the rates for the items concerned shall be deemed to include the cost of such markings.

2.1.7.6. <u>Extra Cutting and Welding</u>

In course of work, the Contractor may be called upon to either cut steel Plates, pipes and specials etc. or carry out certain welding jobs, which are not covered by other fabrication items of the Bill of Quantities. <u>Such special jobs shall be paid forseparately, under relevant items.</u>
After cutting the edges shall be made smooth and even by the use of electrical or pneumatic grinders so as to remove all inequalities. Care shall be taken to see that the shape of the materials cut, is not deformed in any way at the time of cutting.

Welding may be done either by electric arc welding or by gas welding and payment shall be per meter of pipe length welded. The Engineer shall specify the leg length in case of lap joints required for each job as well as the gauge of the electrodes to be used. The rate for welding shall also include the cost of assembling, the steel pieces to be welded and holding them in correct position (without distortion) during the process of welding. Cleaning of pipes shall be as given earlier.

2.1.7.7. <u>Gas Cutting</u>

In the course of the work, the Contractor may be called upon to cut steel pipes, specials, etc. on site. Gas cutting shall be adopted for preparing on site, distance pieces, straps, etc. cutting out holes in the pipeline laid for manholes, scour valves, air valves and other appurtenances, holes required for blast cleaning operation, cutting of pipe faces to form kinks or bends, holes required for bye-pass arrangement.
The rate for gas cutting shall include chamfering for forming ‘V’ or square cut, cost of aligning, holding member in position, etc., and shall cover thickness upto 25 mm.

After cutting, the edges shall be made smooth and even, by using electrical or pneumatic grinder so as to remove all inequalities. Care shall be taken to see that the item is not deformed in any way at the time of cutting. The ends of the pipe shall have bevel edges or 'V' edges to facilitate hand welding. As field welding is to be carried out from inside in the case of pipes of diameter 1200 mm and above, the bevel shall be from inside. For pipes of smaller diameter, as field welding has to be done from outside cnly, the edges of pipes shali have bevels to suit the above.

2.1.8.Radiograph of Welded Joints

2.1.8.1. General

Shop welds in pipes, specials shall be radiographed as per requirements mentioned below :

As soon as practicable, after welding is done minimum 15% (fifteen percent) length of the weld at random for each pipe shall be radiographed to detect welding defects as per the requirement of IS:5878 and as directed by the Engineer. This 15% sampling will be at random but ensure 100% coverage of junctions of longitudinal and circumferential joints. If the results of such radiography fail to conform to the requirements, the Contractor shall carry out as directed additional 100 percent radiography test for the pipe at the Contractor's cost to the satisfaction of Engineer.

The weld ripples or weld surface irregularities, on both inside and outside shall be removed by any suitable mechanical process to a degree such that resulting radiographic contact due to any remaining irregularities cannot mark or be confused with that of objectionable defect. The radiograph shall be made in strict accordance with the latest requirements and as per the latest and most efficient technique either with X-ray or gamma ray equipment.

The photographs are to be marked in such a way that the corresponding portion of the welded scam can be readily identified. All radiographs will be reviewed by the Engineer to identity the defect and determine those which must be removed. Defects that are not acceptable shall be removed by chipping; machining or flame gouging to sound metal and the resulting cavities shall be welded. After rectification, the joint is to be radiographed again to prove the quality of the repair. The radiographs will be judged as acceptable or unacceptable by the Engineer based on the latest standards prescribed by Indian Standard specification.

All X-ray shall be made with equipment and by personnel furnished by the Contractor. Films shall be developed within 24 hours of exposure and be readily accessible at all times for inspection by the Engineer. The Contractor shall provide for the use of the Engineer suitable X-ray viewing equipment. X-ray films shall be properly maintained by the contractor and shall be handed over to the department on completion of the Contract. All films shall be identified by the No. and chart prepared indicating location of the joint each X-ray photo represents, In the event of additional radiographic inspections required of any work associated with the pipe erection, such inspection shall be performed by the Radiographer at the discretion of the Engineer.

2.1.8.2. Radiographic Inspection of welded joints

All welded joints to be radiographed shall be examined in accordance with

IS :	2595	-	Code of Practice for Radiographic Testing.
IS :	4853	-	Recommended Practice for Radiographic Examination of Fusion Welded

			Circumferential joints Steel Pipes.
IS :	1182	-	Recommended Practice for Radiographic Examination of Fusion Welded Butt-joints.
IS :	2598	-	Safety Code for Industrial Radiographic Practice.

The reinforcement on each side of all butt welded joints shall not exceed 1.5 mm.

A complete set of radiographs and records as descried in IS: 2595 Clause 14, for each job shall be retained by the Contractor and kept in file for a period of at lest five years.

Radiographers performing radiograph shall be qualified in accordance with SNT-TC-1A. Supplements and Appendices "Recommended Practice for Nondestructive Testing Personnel Qualification and Certification" published by the American Society for Nondestructive Testing as applicable for the technique and methods used.

Final acceptance of radiographs shall be based on the ability to see the prescribed penetrameter image and the specified hole.

Sections of welds that are shown by radiography to have any of the following types of imperfections shall be judged unacceptable and shall be repaired.

(a) any type of crack, or zone of incomplete fusion or penetration,

(b) any elongated slag inclusion which has length greater than 6 mm,

(c) any group of slag inclusion in "line that have an aggregate length greater than thickness in a length of 12 times thickness, except when the distance between the successive imperfections exceeds 6L where L is the length of the longest imperfection in the group,

(d) rounded indications in excess of that specified by the acceptance standards given earlier.

2.1.9. CEMENT MORTAR LINING FOR INTERNAL SURFACE OF PIPELINE

2.1.9.1. Scope

This Specifications covers the requirements of providing materials and application of in-situ cement mortar lining by mechanical and/or hand application to the internal surfaces of pipeline at surface, in shaft and in tunnel to be installed under this contract. However, owing to limited pipework, the cement mortar application may be hand applied. After completion of field hydraulic test of the pipeline, the Contractor shall take up the in-situ cement mortar lining to the internal surface of the pipeline. The work shall be started only after obtaining the written approval of the Engineer in this respect.

2.1.9.2. Applicable Codes and Specifications

The following specifications, standards and codes in addition to those listed in Clause 2.7.2 of this specification are made a part of this specification. All standards, specifications, codes of practices referred to herein shall be the latest edition including all applicable official amendments and revisions. In case of discrepancy between this specification and those referred to herein, this specification shall govern.

1) AWWAC602-76	-	American Water Works Association (AWWA) Standard for Cement Mortar Lining of Water Pipelines - 4 in. and larger - In Place.

2) IS-3696	-	Safety code for scaffolds and ladders (Part 1 &II)
3) ASTM - C40	-	Test for organicImpuritiesin Sands for Concrete.

2.1.9.3. General

Engineer shall have the right to inspect the source/s of material/s, the operation of procurement and storage of material, Cement mortar batching ad mixing equipment and the quality control system. Such an inspection shall be arranged and the Engineer's approval obtained prior to starting of lining work.

2.1.9.4. Method of Application

All lining work shall be done by machine/hand application.. If there are areas where the lining can be done by machine but cannot perform finishing, then the bidder in his bid shall indicate such areas. By prior approval, of Engineer, these areas may be machine sprayed and hand troweled.

2.1.9.5. Workmanship

All works shall be performed in a thorough and workmanlike manner by trained personnel with previous experience under the supervision of experienced men skilled in the in-situ application of cement-mortar lining to pipelines and pipes laid in underground works such as tunnel, shaft.

2.1.9.6. Programme of Lining And Plant And Equipment :

The plant and equipment Proposed by the Contractor for Carrying out the cement mortar lining application shall be furnished along with the Bid. The contractor shall also furnish the methods he proposes to adopt.

2.1.9.7. Materials of Construction

a) Cement

Cement required for mortar lining shall be "Portland Cement" conforming to IS-269.

b) Admixture

To improve workability, density and strength of the mortar, admixtures as approved by the Engineer may be used by the Contractor at his own cost. No admixtures shall be used that would have a deleterious effect on water flowing in the pipe, which is required for drinking Proposes.

c) Sand

Sand shall consist of inert granular material. The grains shall be strong, durable, and uncoated The sand shall be well graded and shall pass a 1.18 mm mesh screen (ASTM

No. 16) with not more than 5% passing 150 micron sieve (ASTM No.100). Same shall be free from injurious amounts of dust, clay, lumps, shale, soft or flaky particles mica, loam, oil, alkali, and other deleterious substance. The total weight of such substances shall not exceed 3 percent of the combined weight of the substances and the sand that contained them. Limitations shall apply to specific substances as follows :

Substances	Maximum allowable Percentage by weight
Shale	1
Clay lumps	1
Mica and deleterious Substances other than Shale and clay lumps	2

Organic impurities - Sand shall not show a color value darker than the reference standard color solution prepared as required by ASTM 6.40 "Test for organic Impurities in Sands for Concrete "

d) Water

Water for mixing mortar shall be clean and free from injurious amounts of mud, oil, organic material or other deleterious substances.

2.1.9.8. Design of Mortar Lining

a) General

Composition of mortar for the lining shall be composed of cement, sand and water mixed to such consistency as to produce a dense, homogenous lining that will adhere firmly to the pipe surface. Bidder should indicate in his bid the details of the admixtures he proposes to use.

b) Proportion

Proportions of cement and sand shall be i part of cement to 1½ parts of sand by volume. Slight modifications in composition could be made at site to suit the characteristics of the sand used. Each bad of cement shall be weighed and converted into volume for its use. Admixtures, if permitted, shall be used in strict

accordance with the manufacturers recommendations. The minimum cement content shall be 1000 Kg / m^3 and water cement ratio of between 0.3 : 1 and 0.45:1 by mass

c) Water Content:

Water content shall be the minimum that is required to produce a workable mix, with full allowance made for water collecting on the interior of pipe surface.

d) Mixing :

Mortar shall be well mixed and of proper consistency to obtain a dense, homogenous lining. Where premixed mortar is used, it shall be done so before initial set.

e) Thickness of Lining

Cement mortar lining shall be minimum 12.5 mm thickness v/ith a maximum plus tolerance of 3 mm.

2.1.9.9. Method of Construction

f) Access Openings

Only such openings as indicated by the Tenderer in his bid and approved by Engineer shall be provided in the pipelines. After lining is completed, closure pieces will be welded 10 the pipe. Mortar lining of closure pieces and adjacent area shall be included in the rates quoted for the mortar lining work.

g) Preparation of Pipe Surface
The interior surface of pipe to be lined shall be cleaned to remove all rust, chemical or other deposits, loose and deteriorated remains of old coating materials, oil, grease, and all accumulations of water, dirt, and debris. The cleaning of the surface shall be carried out by the use of suitable chemical or mechanical means with the approval of Engineer. The extent of cleaning shall be to the satisfaction of the Engineer.

All loose mill scale, dirt, rust, and accumulation of construction debris shall be removed from the interior off the steel pipeline. The pipeline shall be cleaned by use of a power driven cleaner incorporating revolving brushes on rotating arms. After this cleaning the pipe shall be flushed with potable water and all standing water removed.

Surfaces applied with cement wash shall be cleaned with wire brush manually to the satisfaction of the Engineer.

c) Machine Application of Mortar Lining Clean Up Ahead of Machine
Immediately prior to the travel of the lining machine through the pipeline, all foreign material shall be removed. This includes sand and loose mortar that might have accumulated since the work of preparation of surface was completed.

d) Lining Procedure

The lining shall be placed by centrifugal method in one course by a machine traveling through the pipe and discharging the mortar at a high velocity over all pipe sections and long radius bends. The discharge shall be from the rear of the machine so that the freshly applied mortar will not be marked. The rate of travel of the machine and the rate of mortar discharge shall be mechanically regulated so as to produce uniform thickness throughout. The mortar must be densely packed and shall adhere the pipe wherever applied.

2.1.9.10. Surface Finish

Mortar lining shall be mechanically trowelled except for the places where hand trowelling is expressly permitted by the Employee.

a) Trowelling Lining

The lining machine shall be provided with attachments for mechanically trowelling the mortar. Both the application and trowelling of ths mortar shall take place at the rear of the machine so that the freshly placed and trowelled mortar will not be damaged. The trowel attachment shall be such that the pressure applied to the pipe will be uniform and produce a lining of unifonn thickness with a smooth and even finished surface free of spiral shoulders. The finished surface of machine placed and trowelled linings in pipe shall be examined according to the procedures in clause 2.7.9.10.b.

b) Examination Procedure

In the stretch of pipe that has been lined and trowelled in each day's ran, ten places shall be selected in straight sections of the pipe by the Engineer. In each of the ten places the thickness of the lining shall be measured as directed by the Engineer. Thickness of lining shall be ascertained frequently during placing of mortar and trowelling. Hair cracks or cracks upto 0.25 mm width in saturated linings and not over 300 mm in length are acceptable.

c) Untrollwed Lining

The finished surface shall be smooth and regular except that it may exhibit a slightly dimpled appearance. Edges or uneven build up caused by irregularity in the travel route of the machine will not be allowed.

2.1.9.11. Hand Application of Mortal Lining

Handplaced mortar shall have a uniform and smooth surface with smooth transitions to adjacent machine placed linings.

Cement mortar lining of bends, specials, areas closely adjacent to valves and other such places where machine placing may not be practical shall be performed by hand. The Engineer may order the correction for any defect by hand application.

Cement mortar for handwork shall be of the same materials at the mortar for machine placed lining.
The areas to be lined shall be thoroughly cleaned as specified earlier and, If necessary, shall be moistened with water immediately prior to placing the hand-applied mortar.

Steel finishing trowels shall be used for the hand application of cement mortar, except at bends the outer edges of hand trowelled areas may be brushed in order to reduce the abutting offset.

All hand finishing work in a section of the pipeline shall be completed within 24 hours after completion of the machine application of mortar lining to that section. If necessary, application of mortar lining by machine shall be delayed or stooped to assure compliance with this schedule.

2.1.9.12. Special requirements at Laterals and Service connections

Laterals and connections to the pipe that is being lined shall not be left obstructed by the lining operations.

Before the lining is placed, the openings in the pipeline leading to air valves, blowoff, manholes and appurtenances, as well as to laterals and connections that transmit pressure or carry water from the pipeline, shall be temporarily covered or plugged with suitable devices. These shall be removed later without damaging the cement-mortar.

2.1.9.13. Curing

Curing shall commence immediately after completion of the mortar lining and hand finishing of a section of pipeline. This shall, however, not be later than 8-hours after mixing of mortar. The lining shall be kept continuously in moist condition for a period of 14 days. During the operations of lining, finishing and curing, exterior surface of the pipe exposed to sunlight shall be sprinkled with enough water to keep the pipe cool. Open ends of pipes shall be suitably closed so as to maintain a moist atmosphere and prevent draught. Curing of mortar lining and simultaneous cooling of the pipeline externally shall be continued even beyond the period of 14 days as directed by the Engineer.

2.1.9.14. Tests of Cement Mortar used for Lining

Test blocks of the same material as used for the lining shall be made in 150 mm cube moulds and subjected to Works cube crushing tests. Each block shall be removed from its mould as soon as practicable and cured under the conditions of temperature and humidity identical with those in which the lining of the pipe is cured. The number of tests shall be at least 4 cubes for each age and each water cement ratio. The works cube strength of the test cube shall not be less than 300 Kg/cm^2 after 28 days of curing or 170 Kg/CM^2 of 7 days of curing. The density of the test cube shall not be less than 2300 Kg/m^3

2.1.9.15. Inspection

a) Responsibility of Engineer and Contractor

The entire procedure of applying cement mortar lining shall be subject to continuous inspection by the Engineer but such inspection shall not relieve the Contractor of his responsibility to furnish material and perform work in accordance with this specifications.

b) Defective Lining

Defects in lining including but not restricted to sand pockets, voids, oversanded areas, blisters, cracked and dummy areas, and thin spots shall be removed, and the area shall be repaired by hand application to the full required thickness of the mortar lining. Defective areas encompassing the full diameter of the pipe shall be replaced by machine wherever practical. Defective lining rejected at the time of lining shall be removed before initial set of the mortar. Defective lining rejected after initial set shall be replaced or repaired by the most practical method as determined by the Engineer.

c) Guarantee

If on examination by the Engineer of the cement-mortar lining work within a period of two years after final completion and acceptance of the Contract Work reveals evidence of defective materials or workmanship as defined in this specification but not limited to the same, then the Contractor shall perform the remedial work at his own expense in a manner acceptable to the Engineer.

2.1.10. CLEANING AND PAINTING OF PIPES AND SPECIALS

2.1.10.1. General

The fabricated pipes arid specials shall be painted externally with Primer, one coat of red oxide of iron paint and covering coat of Grey graphite where they will be exposed after erection. But those pipe surfaces, which are to be embedded in concrete shall be provided with cement wash in the shop on their exterior surface. Internal surface of all pipes shall be provided with cement wash.

2.1.10.2. Material

Zinc rich epoxy primer and Heavy Duty bitumen paint (Inertol 49W or equivalent) conforming to the following specification shall be used for painting. Each lot of the paint supplied shall be accompanied by the certified copies of the results of the tests carried out by the manufacturer.

If any sample of the Paint and/or primer is not conforming to the specification, the entire consignment to which the sample way pertains shall be rejected. Only those primers and painting materials that have been approved by the Engineer / Owner in writing shall be used for this work.

2.1.10.3. Primer

The primer shall be of Zinc Rich Epoxy type conforming to the specifications Given below:

a) Specification for Zinc Rich Epoxy Primer

1)	Description	Two pack Zinc Rich consisting of-
	i) Base	Fine Zinc Dust ground in Epoxy Resin Solution, supplied in paste form.
	ii) Catalyst	Abduct Type - The non-volatile portion of the material (mixed) should consist of 92% Zinc Dust and 8-10% Resin and curing agent.
2)	Shade	Grey
3)	Characteristics	The paint shall provide a complete rust inhibitive barrier coating of high mechanical and abrasion resistance. The film shall be compatible for fusion and spot weld.
4)	Pot Life	4-6 Hours
5)	Covering	8-10 sq.m/litre per coat giving a film capacity thickness of one mil.
6)	Mixing Ratio	The proportion of mixing base and hardener should be as specified by the Manufacturer by weight and volume.
7)	Viscosity of ready Mixed Paint	15-22 in Fort Cup No.4 at: 30° C
8)	Drying Time	i) Dust Free -10-15 minutes ii) Chamber curing - 24-48 hours.
9)	Procedure	Blaser steel surface of the pipes shall be cleaned of ductand grit and shall be primed immediately followingcleaning. The surface shall be dry at the time the primeris applied during rain or fog unless protected frompermission of the Engineer. The primer shall be appliedby hand spraying and shall be in accordance with themanufacturers. The Priming

coat shall be uniform andfree from floods, runs, sags, drips or bare spots, Anybare spots shall be recoated with an additionalapplication of the primer. All runs, sag, floods or dripsshall be removed or all such defects shall be remediedby reblasting and repriming at the discretion of the
Engineer and at the cost of the Contractor.

b) Application of Zinc Rich Primer

The primer shall be Prepared as follows:

The primer shall be prepared in the manner and proportion as specified by the manufacturers. The mix of Zinc Rich Epoxy primer shall be prepared 15 minutes before applying on the Works site.

One coat of Zinc Rich Epoxy primer shall be applied by spray right up to the edge of the pipe giving a film thickness of approximately 1 mil.

No thinner should be added to the ready mix paint without the previous written approval of the Engineer. Though the priming coats become dust free dry in 10-15 minutes, the finishing coats shall on be applied after allowing the film to cure at least for 48 hours.
Shade after application : Grey.

2.1.10.4. Specifications for Red Oxide of Iron Paint

1. Composition

(a) Mixed Pigment	-	55% ±2% Dry
(b) Volatile	-	Not more than 5%
(c) Drier	-	These may be added when necessary and order that the paint may conform requirements. Such drier shall not contain volatile matter other than turpentine or white sprit. The drier shall be linoleat or napthenate. Tesinate drier shall not be used.
(d) Linseed oil	-	The remainder.

2. **Pigment :**The red oxide of iron shall contain not less than 70% of Ferric Oxide (Fe_2O_3) and shall be free from acid, water soluble salts and all other impurities.

3. **Linseed Oil :**The linseed oil shall be of genuine quality prepared from

linseed, free from turbidity in water. It shall be of such quality so as to become dry within 8 hours and form a film free from being sticky.

4. **Thinners :**The thinners used shall either be turpentine or white spirit ofstandard quality as approved by the Engineer.

5. Weight: The minimum, weight in kg/10 litres of paint shall be 15.5 kgwithin ±3%.

2.1.10.5. Specification for Covering Coat (Graphite paint)

1. Composition :

(a) Mixed Pigment - Not less than 45% Dry
(b) Volatile - Not less than 10%
(c) Drier - These shall be linoleat or napthonate and shall not contain any volatile matter other than turpentine or white sprit. Resinate drier shall not be used.
(d) Linseed oil - The remainder.

2. Pigment : The pigmsni shall contain not less than 50% of white lead and 40% of graphite as per IS' 62/50, the balance being barytcs (Pure graphite being 24% min.)

3. Linseed Oil : The linseed oil shall be of genuine quality prepared from linseed, free from turbidity, sediments undissolved in water. It shall have a specific gravity between 0.981 and 0.942 at 30°C. It shall be of such quality so as to become dry within 8 hours and form a film free from being sticky.

4. Thinners : The thinners used shall either be tuipentine or white spirit of standard quality as approved by the Engineer.

5. Weight : The weight of one litre of paint shall not be less than 1.5 kg and not more than 2.1 kg.

6 Color :According to Indian Standard Specifications Shade No. 671.

7. Remaining Clauses shall be as per the General specifications as stated above.

2.1.10.6. Inspection and .Testing of Zinc Rich Epoxy primer/ Red Oxide of Iron Paint and Grey Graphite

(a) Primer

i) Each lot of primer and heavy duty paint supplied shall be accompanied by certified copies of the results of the tests carried out by manufacturers.

ii) The entire procedure of applying the paint as specified shall be rigidly inspected right from blast cleaning stage to the application of the final coat. If, at any time, it is found that the procedure of applying the paint is not as per the standard laid down, all such painting work shall be rejected.

iii) Samples of the paint brought by the Contractor shall be sent to the Testing Laboratory, as directed by the Engineer, for testing .as specified. If any sample as found to be not conforming to the specifications, the entire consignment to which the sample may pertain shall be rejected. Samples shall be taken at intervals at the option of the Engineer. All the cost incidental to such testing, such as the cost of the paint, cost of prescribed testing charges and cost of the transport, etc., shall be deemed to be included in the rates quoted by the Contractor foi painting.

(b) Red Oxide of iron Paint. Grey Graphite

One sample from each consignment of paint consisting of 50 drums or less shall be taken by the Engineer and got tested in an approved Laboratory. If the test is satisfactory, the consignment shall be passed for use. If it fails, two more samples from two other separate drums shall be taken for test and the consignment shall be accepted for use provided both samples are found satisfactory. In case one or both of the later two samples fail in the test, the whole consignment of the paint shall be rejected and all the rejected tins of paint shall be marked "Rejected" on the lids with paint. The Contractor shall remove the entire consignment of the rejected paint from his works within three days of such intimation from the Engineer. If the rejected consignment is not so removed within the specified time, the Engineer may remove the same to any Municipal Stores in Greater Navi Mumbai at the Contractor's risk and cost, and the Corporation shall not be held responsible for its safe custody thereafter.

The entire cost in connection with testing of all the samples of paints, whether satisfactory or otherwise shall be deemed 10 be included in the rates quoted by the Contractor.

2.1.10.7. Painting

a) General

Except with the permission of the engineer, nothing but ready mixed paints of an approved make and brand shall he used. Thinning or heating of paints will not he permitted except with specific approval and in accordance with instructions. Any warming of paint shall be performed by means c fa hot water bath and paint shall not be heated to temperature higher than 40 C All paint shall be in thoroughl y mixed condition at the lime of application. On completion of the work, the contractor shall remove any oil stains or paint spots, leaving the structures and equipment in a clean and acceptable condition.

Paint shall be applied only to dry, freshly cleaned surfaces, free from dust, rust, scale, grease or other substances which might affect the adhesion or the durability of the coating. In no case shall paint be applied to surfaces that are not to be applied during rainy or misty weather, unless unavoidable, in which case the work shall have suitable and satisfactory protection and such protection shall be maintain until the paint has dried.

All paint shall be applied by skilled workmen in workmanship manner and the average coverage shall be equal to that recommended for first class work with the type of paint and on the kind of surface being painted

b) Preparation of Surface for Painting

i) General

All oil and grease shall be removed from surface to be painted by washing with a suitable solvent and by wiping with rags until completely clean. After removal of all oil and greases, surfaces of metal work required to be painted shall be cleaned by removing all rust, loose scale and dirt by sandblasting, grit blasting or other effective means. Surface which will be permanently or intermittently submerged or subjected to moisture from spray or excessive condensation shall be cleaned to clean metals by sand or grid blasting. After cleaning, all surfaces shall be maintained free from oil, greases, rust, dirt and other contaminations until they have received the final coat of paint.

Surface of stainless steel and bronze and machined surfaces which are attached or adjacent to metal work that is being cleaned or painted shall be protected by adhesive tape or other suitable means during the cleaning and painting operation.

ii) Sand Blasting

The surface of the steel pipes and specials painted shall be thoroughly cleaned by sand or shot blast cleaning process to SA 2.5 finish, to remove all rust mill scale etc. Cil and grease shall be removed by applying a suitable cleaning solution and wiping with clean rags. All foreign matter which cannot be removed by blasting process shall be removed as directed by the Engineer/Owner.

Blasting should be done at a pressure of 5.62 kg/sq.cm. (80 p.s.i.) at the compressor end and at 4.93 kg/sq. cm. (70 p.s.i.) at nozzle end. This pressure should be maintained during the entire blasting operations. Improper joining of hose pipes; and resultant reduction in pressure at nozzle end shall be checked and avoided.

The blast cleaned surface shall be primed immediately after blasting is over. The sequence and the programme of blast cleaning application of Zinc Rich Epoxy primer shall be arranged in such a way that the blast cleaned surface shall not remain uncovered with Zinc Rich Epoxy primer for more than 2 hours.

Any deviation from above shall require approval of the Engineer / Employer.

iii) Manual Cleaning .

Wherever manual cleaning is approved by the Engineer the surface of pipes and specials shall be thoroughly cleaned by using scrapers and wire brushes to remove all rust, mill scale etc. to give a shining metallic (SA 2.5) surface. The surface so cleaned shall be washed with water and allowed to dry. A metal cleaning solution of approved make shall then be applied over it. After it is dry, the surface shall be again washed with water, crapping wire brushes simultaneously. A copious use of water is necessary at this state to ensure that the metal cleaning solution is completely removed. The primer coat shall be applied immediately after the surface has become dry.

c) Application of Primer

No primer shall be applied without Prior approval of the Engineer / Owner. During rain or fog, shells of the pipes and specials shall be protected from weather by suitable housing.

The proportion of mixing of base and hardener shall be as specified by the manufacturer by weight and volume. The mix of Zinc Rich Epoxy primer shall be prepared at the work site / yard not earlier than 15 minutes before applying the same on pipe and specials surfaces.

One coat of primer shall0 be applied by spray giving a film thickness of approximately one mil.

No thinner shall be added to the ready mix paint without previous approval of the Engineer/Owner, and the finishing coats on top of the primer coat, shall only be applied after allowing the film to cure for at least 48 hours.

The priming coat shall be uniform in thickness and free from floods, runs, rags, drips, or bare spots. Any bare spots shall be recoated with an additional application of the primer. All runs, sags, floods or drips shall be removed or all such defects shall be remedied by repriming as per the instruction of the Engineer/Owner.

d) Field Painting

The Contractor shall take proper care during loading/ unloading and transport of the pipes and specials from the shop to the site of erection to preserve the shop paint in the best practicable condition.

After erection of the pipeline on installation all rust spots, damaged areas and site welded portion of the pipeline shall be cleaned to metal and shall be painted with one coat of red oxide of iron paint and covering coat of Grey graphite.

After lapse of 48 hours of application of repairing coats specified above a finish coat of heavy duty bitumen paint shall be applied to exterior surface of the entire pipeline care being taken to clean the surface with duster prior to application of the said finish coat.

2.1.10.8. Inspection

The entire procedure of applying the paint as specified will be rigidly inspected right form the cleaning stage to the application of final coat by the Engineer/Owner. If, at any time, it is found that the procedure of applying the paint is not as per the standards laid down, all such painting work done shall be rejected and shall be rectified by the Contractor at his own cost, as directly by the Engineer/Employer.

2.1.10.9. Application of Cement Wash

Where the pipeline is to be cement mortar lines, it shall be given a coating of cement wash internally. Also where the pipeline is to be encased in concrete anchor blocks or encasement, it shall be given a coating of cement wash externally.

The pipe shall be first be cleaned manually as specified in Clause 2.7.10.7 (b) to the Engineer's satisfaction. Immediately after a short stretch of the pipe is blast cleaned, the Contractor shall commence coating of the pipe with cement wash.
Before painting is started, the inner surface of the pipe shall be thoroughly scrapped by using scrapers, wire brushes to get rid of rust, mill scale etc. and washed with water. A suitable metal cleaning solution of approved make shall be applied over it. After it has dried, the surface shall again be washed with water and scrapped with brushes simultaneously and allowed to dry.

The rate quoted for cement wash shall also include for blast cleaning.

2.1.10.10. Internal Cleaning of Pipeline.

Wherever directed by the Engineer, internal surfaces of pipes, specials etc. of all size shall be thoroughly cleaned by repeated hosing of water and simultaneous rubbing with gunny cloth.

Further, when a section of pipeline has been laid and all the work inside it has been completed to the satisfaction of the Engineer, its internal shall be cleaned of all dirt, debris, dust or other deposits.

Pipelines larger than 900 mm diameter shall be cleaned by repeated hosing of copious quantities of water on the pipe surface and simultaneously rubbing the surface with gunny cloth. Cleaning with metal cleaning solution, acid, wire brushed, scrappers or sand paper will not be permitted.

For 900 mm and smaller diameters cleaning of laid pipelines will be restricted to cleansing and scraping out of debris and dirt only.

Cleaning shall be done to the satisfaction of the Engineer. The section of the pipeline once cleaned shall not be entered into for any purpose later. Sufficient precaution shall be taken to prevent the ingress of any dirt, debris, or dust inside the section. Failing this the section shall be cleaned again at the discretion of the Engineer.

In the case of above ground pipeline, the length of the section to be taken up for cleaning shall be decided in consultation with the Engineer from the point of view of ventilation etc.

In case of buried pipeline a section shall be taken up for cleaning after the work of back filling around and over the pipeline is completed and the spiders have been removed from inside.

During the pipe laying operation in the adjoining section, the Contractor shall take all precautions to prevent ingress of water, muck, debris, dirt, dust etc. in the cleaned section, failing which the section shall be cleaned again at the discretion of the Engineer. Where deemed necessary by the Engineer suitable closures shall be provided at the open end or the ends of the cleaned sections. Payment will be made for the work under the relevant items of the Bill of Quantities.

At die end of a season's work, closure shall invariably be provided at all the open ends to protect the Pipeline from ingress of sub-soil water, mud, muck, etc.

No separate payment will be made for the work of cleaning and providing closures. The rates quoted for the laying the pipes, painting etc. shall include the cost thereof.

2.1.10.11. Testing of Pipeline

After the work of laying of pipeline is completed and before putting it into commission, the pipeline shall be tested in the field, if so directed by the Engineer, both for its strength and leakage. The procedure for the test shall be as follows:

For the purpose of Pressure testing, the pipeline shall be divided into sections as defined by the Engineer.

Before pressure testing is started, the Contractor shall recheck pipes and valves for cleanliness and shall ensure the operation of all valves. The "open" ends of the pipeline (or sections thereof) shall normally be stopped off by blank flanges or cap ends additionally secured where necessary by temporary struts and wedges. All anchor and thrust blocks shall have been completed and all pipes straps and other devices intended to prevent the movement of pipes shall have been securely fastened. The Contractor shall clean out the whole pipeline and flush it with water, so as to remove dirt, dust and any foreign matter lying in the pipeline. No separate payment for the work of cleaning will be made and the rates under the various items of work shall included the cost thereof.

Each valve section of the pipeline be subjected to a hydraulic test in full length or in part as may be necessary. For this test, the pipe shall be slowly filled with clean water by opening cross connections with existing mains or otherwise as directed and all air shall be expelled form the pipeline through hydrants, air valves and blowoff fixed on the pipeline. Once the pipe is full, the cross connections shall be closed. The pressure in the line should then be raised and maintained by means of suitable approved pumps, to the specified test pressure based on the elevation of the lowest point on the line or section under test. The test pressure shall be not less than the static head pressure or 1.5 times the working pressure whichever is higher.

No section shall be tested unless anchor blocks have been provided at either end, all appurtenances, etc. have been fixed in position, arrangements for cross connections have been made with existing mains. Before starting the pressure test, the expansion joints shall be tightened. The test Pressure shall be maintained for at least 24 hours. The drop in pressure shall not exceed 0.7 kg/sq. cm (10 Ibs. per sq. inch) within aperiod of 2 hours after the full test pressure is built up. Under the pressure, no leak or sweating shall be visible at the welded joints.

During the test, the pipe shall be-struck sharp blows with a 4 Ib. Hammer. Water shall not spout, ooze, or sweat through any part. In case of leakage anywhere in the factory joints, whether welded or bolted., the same shall be prepared entirely contractor's cost, which shall included repairs to welding, and coating repainting etc. The repaired joint shall be subjected to a retest. No section shall be accepted put in a perfectly water tight conditions and retested satisfactorily. The entire cost of testing, retesting etc. shall be paid under the relevant items of Bill of Quantities. The Contractor shall make all arrangement for all labour, pumps, pressure gauges equipment, etc. No main valve or cross connections either on the new or existing main shall be operated by the Contractor, and only the City Engineering department 's or Project Department staff shall operate the same. The Contractor shall arrange for labour required for operating the air valves, etc., Municipallabour employed for the test shall be charged to the Contractor.

The hydraulic testing of the water main will be carried out fully, or partly as per the site conditions. If any leakages are observed during the defects liability period due to defective workmanship, the same will be rectified through City Engineering department 's Department as the work on live water main is done by City Engineering department 's department only. The charges of repair will be recovered from the amount of retention money. Repairs on live water mains are to be carried out immediately to avoid wastage of water and other problems such as disruption of water supply, traffic etc. In view of this, it will be very difficult to give prior intimation to the Contractor. As such, the cost of repairs as per City Engineering department 's Department's bill will be recovered from the retention money withheld in deposits without giving any prior intimation. The Contractor shall not challenge or claim any extra for such action on the part of Municipal Corporation.

2.1.11. UNDERGROUND PIPELINE-LAYING

2.1.11.1. Handling of pipes and Specials

Coated pipes and specials that are to be stored on supports shall bear on the uncoated ends only. If bearing on coating is employed the supports shall be not less than 20 cm (8 inches) wide and so arranged to prevent damage to the coating.

During handling of the pipes and fittings, coating shall be protected not less than 20 cm wide and placing strips of heavy belting or other approved sheet materials not less than, 20 cm wide under all ropes or fastening.

2.1.11.2. Bedding

Bedding for the pipeline shall be of two different classes depending on the soil strata and as per drawings and as per the direction of the Employer’s Representative.

When soil strata in the trench is soil (other than soft or hard rock), the trench shall be properly compacted and no extra bedding shall be provided. The bottom of the trench shall be prepared in such a way that profile of the pipe shall touch the bottom of the trench at 120 degree from the center of the pipe. This profile of pipe at the bottom of trench for uniform support shall not be made more than 2 days prior to actual laying of pipe.

When soil strata in the trench is rocky, or consists of any unsuitable material which is likely in the opinion of the Employer’s Representative to cause damage to the pipe, then sand bedding shall be provided. The sand used for bedding shall be clean, well graded and free from topsoil, clay or vegetable matter and to the approval of the Employer’s Representative. If the sand supplied is unclean it shall be washed. In no case shall sand containing more than 3.5% by dry volume or 5% by wet volume of clay, loam or silt be accepted. Tests specified for determining silt in sand and organic impurities as described in IS 383 shall apply.

The bedding shall be done as under:

- The filling and compaction shall be done up to appropriate depth.
- The bedding shall be compacted, at optimum moisture content and by mechanical equipment with suitably shaped tamping feet/ plate, to 90% modified proctor density.
- The compacted fill shall be re-excavated in a profile to match the pipe profile to form a “cradle” which will provide a 120 degree uniform support to the pipe.
- The appropriate depth is such that after re-excavating the fill minimum 150 mm of sand bedding material shall remain below the bottom center of the pipe.

The profile of pipe in compacted fill for uniform support shall not be made more than 2 days prior to actual laying of pipe.

2.1.11.3. Lowering and Jointing

The pipe shall he lowered into the trenches by removing only one or two struts at a time. It shall be seen that no part of the shoring is disturbed or damaged and, if necessary additional temporary struts may be fixed during the lowering operations. It shall also be necessary to see that the gunite coating of pipe is not damaged in anyway during the lowering and assembling. After the pipe is lowered into the trench, it shall be laid in correct line and level by using the levelling instruments, sight rails, theodolite, etc. care shall be taken to see that the longitudinal joints of two consecutive pipes at each circumferential joints are staggered by 90°. While assembling the pipes, the ends shall have to be brought close enough to leave a uniform gap not exceeding 4 mm. If necessary, a marginal cut may be taken to ensure a close fit of the pipe faces. For this purpose, only experienced cutters who can make uniform and straight cuts, shall be permitted to cut the faces of the pipes. No extra payment shall be made for such marginal cutting. There shall be no lateral displacement between the pipe faces to be joined. If necessary, spiders from inside and tightening rings from outside shall be used to bring the two ends contact and alignment. I t may also be necessary to for this purpose. In no case shall hammering or longitudinal slitting be permitted. When the pipe is properly assembled and checked for correct line and level, it shall be finally supported on wooden beams and wedges and tack welded. Some portion of the trench may be refilled at this stage so as to prevent the pipeline from losing its alignment. The tack welded circumferential joints shall then be welded fully. Only experienced welders, who shall be tested from time to time shall be permitted to carry out the welding work. For welding, refer to clause 2.7.11.7.

On completion of the pipe jointing and external protection, the trench and the welding pits shall be cleaned of guniting rebound. The welding pits shall be filled and compacted in 150 mm layers with the bedding material.
Backfilling shall be carried out as detailed in clause 2.7. 11.6.

2.1.11.4. <u>Providing Steel Props Inside The Pipeline (Dia. 1200 mm and above)</u>

In order to effectively provide cement mortar lining to the inside of the pipes and to avoid difficulties during the work, it is necessary that the roundness of the pipes is maintained circular till the lining work is taken up. To achieve the same, steel adjustable screw type props of screw or similar approved make consisting of minimum six legs shall be fixed inside the pipe. The deflection of the Pipe should be limited to 2% of the average diameter. In no case shall the limit be exceeded, even under the full load, in case of pipes laid underground. The design and drawings of the props that the contractor intends to use should be got approved by the Engineer before starting the work. While laying the pipes underground, the Contractor shall provide this propping arrangement from inside to maintain circularity. These props shall be fixed vertically and at intervals of no more than 1.8 metres or as directed by the Engineer. In case the Engineer finds it necessary, they will have to be fixed in any position. The props should be kept in position at least for three days after the encasing of the pipe in that section is completed or till refilling is done to the full eight of fill over the pipe in case he pipes are not encased. The props shall be removed only after obtaining permission from the Engineer. The height of earth fill over the pipe top shall normally be such as to avoid floatation under submerged condition and to have a minimum earth cushion of about 1.25 metres over the pipe whichever is greater. It is also necessary that, in case of buried pipe, adequate side supports from the backfilled materials is developed to keep the diametral deflection within the specified limits. Backfilling of the excavated trenches, particularly below the pipe and along the sides shall, therefore, have to be done with proper care and compaction as desired.

2.1.11.5. <u>Precautions against Floatation</u>

When the pipeline laid underground or above ground in a long narrow cutting gets submerged in water collected in the trench of cutting it is subjected to an uplift pressure due to buoyancy and is likely to float if completely or partly empty. In the design of pipelines, provision is made to safeguard against floatation providing sufficient overburden or by providing sufficient dead weight by means of blocks, etc.

In the case of works extending over one or more monsoon seasons, however special care and precautions are necessary during the progress of work on this account. The Contractor shall close down pipe laying operations well in time for the monsoon. The work of providing blocks, refilling the earth to the required level, compacting the same, etc. shall always be done as soon as the pipeline in the cutting has been laid.

The Contractor shall see that the water shall not be allowed, to accumulate in open trenches. Where work is in an incomplete stage, precautionary work, such as blankflanging in the open ends of the pipeline and filling the pipeline with water etc. shall be taken up as directed by the Engineer.

Such works shall be to the Contractor's account and no separate payment shall be made for the same. The Contractor's rate for pipe laying shall be deemed to include such precautionary measures against floatation.

Protection of the pipeline against floatation during the Contract Period shall be the responsibility of the Contractor. Should any section of the pipeline float due to hisnegligence, etc. the entire cost of laying it again to .the correct line and level shall be to his account.

2.1.11.6. Refilling of Trenches

On completion of the pipe laying operations in any section, for a length of about 100 m and while further work is still in progress, backfilling of trenches shall be started by the Contractor with a view to restricting the length of open trenches.

All backfill material shall be free from cinders, ashes, slag, refuse, rubbish, vegetable or organic materials, lumpy or frozen material, boulders, rocks or stones or other material which in the opinion of the Employer’s Representative is unsuitable or deleterious.

Unless otherwise specified or permitted by the Employer’s Representative, all backfill material shall be compacted by mechanical means using equipment with suitably shaped feet/ plates. At the time of placing the backfill, the Contractor will be responsible to ensure that the optimum moisture content is achieved so that the required degree of compaction is achieved. If necessary, the Contractor will be required to add water to the backfill material in such a manner so that the moisture content is uniform throughout each layer during compaction.

Backfilling shall be done with fine grained soils with less than 25% sand content placed in layers of 150 mm. The back filling material shall be deposited in the trench for its full width of each side of the pipe, fittings and appurtenances simultaneously. The column of backfill along the sides of the pipe shall be compacted by mechanical means up to 90% modified proctor density. Care shall be taken to ensure that mechanical compacting equipment is not used from the top of the pipe up to 300 mm above the crown of the pipe.

If suitable material for refilling is not available from already excavated material the Contractor shall import material of approved quality as directed by the Employer’s Representative.

Care shall be taken during backfilling not to injure or disturb the pipes, joints or coating. Filling shall be carried out simultaneously on both sides of the pipes so that unequal pressure does not occur.

The Contractor will be responsible to ensure that the water content of the soil shall be kept as near the optimum moisture content as possible. Regular measurement of the field dry density shall be taken by the Contractor at various levels in the backfilling as required by specifications and the Employer's Representative. Any backfill which fails to achieve the required degree of compaction shall be re-excavated, replaced and re-compacted to the required density, all at the Contractor's cost.

Only mechanical compaction shall be done unless otherwise specified or approved by the Employer's Representative. No mechanical plant other than approved compacting equipment shall run over or operate within the trench until backfilling has reached its final level or the approval for the Employer's Representative has been obtained.

Walking or working on the completed pipeline shall not be permitted unless the trench has been filled with the specified bedding and backfilling up to height of atleast 300 mm over the top of the pipe except as may be necessary for tamping, etc., during backfilling work.
The trench shall be refilled so as to build up to the original ground level, keeping due allowance for subsequent settlement likely to take place. The surface of the refilled excavations shall be left slightly higher than the adjacent ground and shall be maintained by the Contractor to a smooth even slope.

Should any subsidence take place either in the filling of the trenches or near about it during the works the Contractor shall make good the same at his own cost. All the surplus excavated stuff (including rock) will be the Contractor's property and he will be responsible to make proper arrangement for disposal of the same.

2.1.11.7. Welding Joints

As regards the welding work, the following points shall be borne in mind by the Contractor :

(a) The Contractor shall use approved make of standard electrodes depending on the thickness of plate and type of joint. He shall also use standard current and arc voltage required for the machine in use as per manufacturer's directions. Welding electrodes shall conform to I.S. 814 - "Specifications for covered electrodes for metal arc welding of mild steel (Latest Revision).

(b) Welded joints (other than for closing lengths) shall be of the butt welded type with an internal circumferential weld. However, pipes 900 mm and below in diameter shall be jointed with external welds and pipes larger in size will be circumferentially welded both internally and externally. All fillet welds shall have a throat thickness not less than 0.7 times the thickness of the pipe to be welded.
All parts to be welded shall have loose scale, slag, rust, paint and other foreign matter removed by means of a wire brush and shall be left clean and dry. All scale and slag shall be removed from each weld when it is completed.

(c) Gauging
M.S. pipes larger in size, i.e. more than 900 mm diameter shall be welded internally and externally. At the time of internal welding, a 'V' cut is made from inside of the pipes and after completing the internal welding with the required number of runs, the external welding (sealing run) is incumbent. Before starting the external welding (sealing run), the internally welded material in the joint will have to be cleaned by Gouging with Gas Flame, Gouging shall be done before starting the external welding (sealing run) the rate of welding shall include the cost of gouging also." Gouging will also be carried out before rectifying the defective welding wherever necessary as directed by the Engineer.

(d) Procedure

The welding of large pipes in the field shall comply with I.S. 816 and I.S. 823 (Latest Revisions). No field welding shall be permitted if there is rain or high wind.
Openings in the laid pipeline in the form of manholes made at suitable distances, for access into the pipeline for the work of cleaning, painting and repairs to the welds, etc. shall be closed by welding a new patch on the opening.

Such manholes should, as far as possible, be provided at the sides of pipelines; cutting at the crown of the pipe should be avoided. The following procedure should be strictly adopted while plugging the manholes by patch plating:

(i) The manholes shall be plugged by providing a patch plate cut from a separate strake of pipe of the same diameter. The old plate cut from the pipeline shall not be used for this purpose.

(ii) The edges of the new patch plate shall be properly shaped and the plate-inserted in the opening by keeping a gap of 1.5 to 2.5 mm and tacked.

(iii) The welding of the patch should be done in segments with proper sequence conforming to I.S. 823.

(e) Testing of Welding Joints

(i) The welded joints shall be tested in accordance with the procedure laid down in I.S. 3600 "Code of Procedure for testing of fusion welded joints and weld metals in steel". One test specimen shall be taken from at least one field joint out of any ten and shall be subjected to test.

(ii) The test pieces shall be taken out from the positions pointed out by the Engineer without any delay. They shall be machined and tested in a week's time.

(iii)The shape of the test pieces removed from the pipes shall be such that it will give a specimen of the required dimensions and, at the same time, leave a hole in the pipe with rounded corners. This hole shall be patched up by inserting and welding suitable size plates. Great care should be taken in preparing these plates so as to get a good butt weld. Procedure given in Clause 2.7.11.7 (d) shall be followed.

(iv) After the jointing is completed, all protruding portions shall be chipped off and ground smooth and the unpainted portion of the pipeline near the field joint shall be thoroughly scraped and cleaned. Internal and external surface treatment shall be done as per the instructions of the Engineer.

(v) The entire cost of the test, including taking out test samples, machining the test pieces, transport to and from the laboratory and testing them in a laboratory, the cost of patching up the test piece hole in the pipe, payment of all testing fees, cleaning and painting the same, shall be borne by the Contractor. The tests shall be carried out in some Government or Semi-Government institute approved by the Engineer. This shall be arranged by the Engineer entirely at the Contractor's cost.

(vi) The following tests shall be made :

1. **Tensile Test,** : The test specimen taken across the weld shall be shapedin accordance with I.S 823. The specimen shall be taken from the end ofthe pipe or at any field joint in the pipe as directed by the Engineer and shall be cut such that the weld lies

approximately in the middle of the specimen length. The specimen shall be machined. The protruding welded portion from both inside and outside shall be removed by machining or grinding before the specimen is tested.

2 At least one field joint out of every ten shall be subjected to test by taking out a specimen. If a test specimen shows defective machining or develops flaws not associated with welding, it may be discarded and another specimen substituted. The welding joint shall show a strength not less than the minimum tensile strength specified for the plate

3. **Bend Test,** : The bend test specimen shall be prepared in the same wayas that for tensile test and tested in the presence of the Engineer. The specimen shall withstand being bent cold through 180º around a pin, the diameter of which is equal to 4 & 1/2 times the thickness of the plate, without developing cracks. In making the bend test, the side of the specimen representing the inside of the pipe shall be placed touching the pin.

4. **Re-test,** : If the results of the tensile or band test of any lot do notconform to the requirements specified, retests of two additional specimens from the same section shall be made, each of which shall conform to the required specifications. In case of failure of one or both, extensive gouging (scooping out) and repairing shall be carried out as directed by the Engineer before the lot can be accepted.

(vii) The welder / operator shall be held responsible for any failure of the joint. Since factors such as current, arc voltage, quality of electrodes, etc. are already determined and controlled, the failure is due only to the carelessness and negligence of the welder. For the first failure, the welder/operator shall be warned and for the second failure, he shall be removed from the work and replaced by another approved welder / operator. The joints or a portion thereof shall be gouged and repaired to the satisfaction of the Engineer. In order to maintain a good standard in welding, all welders shall be tested before they are entrusted with any job. Further, they shall be periodically tested at intervals of six months.

(viii) A complete record shall be maintained by the Contractor showing the names of welders and operators working on each individual joint. The work shall preferably be carried out by a pair of welders so that, by observing proper sequence, distortion can be avoided. A joint entrusted to a particular individual or pair shall be as far as possible completed by them in all respects, including the sealing run. No helper or other unauthorized unqualified person shall be permitted to do any welding work whatsoever. In case of any infringement, the person concerned shall be penalised as directed by the Engineer.

2.1.12. CLEANING, DISINFECTING AND COMMISSIONING OF THE PIPELINE

Upon completion of a newly laid main, the main shall be disinfected as directed by the Engineer.

The main shall be flushed prior to disinfection except when the tablet method is used. After initial flushing, the hypochlorite solution shall be applied to the water main with mechanically or electrically powered chemical feed pump designed for feeding chlorine solutions. For small applications, the solution may be fed with a hand pump.

In the case of main of large diameter, water from the existing distribution system or other approved source of supply shall be made to flow at a constant measured-rate into the newly laid pipe line. The water shall receive a dose of chlorine also fed at a constant measured rate. The two rates shall be proportioned so that the concentration in the water entering the pipe line is maintained at no less than 300 mg/1. The chlorine shall be applied continuously and for a sufficient period to develop a solid column of 'slug' of chlorinated water that will as it passes along the line expose all Interior surfaces to a concentration of at least 300 mg/1 for atleast 3 hours. As the chlorinated water flows past tees and crosses related valves and hydrants shall be operated so as to disinfect the appurtenances.

In the case of newly laid mains in which scrupulous cleanliness has been exercised the tablet method can be adopted and in this method, the initial flushing is dispensed with. The calcium hypochlorite tablets are placed in each section of pipe and also in hydrants, hydrant branches and other appurtenances. The tablets shall he attached by an adhesive and must be at the top of the main. The main shall then be filled with water and the water shall remain in the pipe for atleast 24 hours.

After the applicable retention period, the heavily chlorinated water shall be flushed from the main until the chlorine concentration in the water leaving the mains is not higher than that generally prevailing in the system or less than 1 mg /I.

After final flushing and before the water main is placed in service, a sample or samples of water shall be collected from the end of the line and tested for bacteriological quality and shall show the absence of coliform organisms. If the initial disinfection fails to produce satisfactory samples, disinfection shall be repeated until satisfactory samples are obtained before the main is placed in service.

The Contractor is expected to carry out the disinfection work as a part of laying the pipes and his rates for laying the pipes should include the disinfection and other connected works till the main is placed in service, unless otherwise specified in the schedule.

2.1.13. MEASUREMENT

The measurement for pipes shall be on running metres of net length along the centre line of the pipe as laid excluding the length of specials and appurtenances. Specials shall be paid separately on the basis of net weight of fabricated specials without the weight of mortar lining and guniting. For the payment purpose, flanges shall be either included in or excluded from the weight of the specials as described in the Bill of Quantities. However weight of the jointing materials such as nuts, bolts and washers, etc. shall not be considered for the payment. The Bidder / Contractor shall include their cost in the item rates of specials and appurtenances Appurtenances shall be paid per number basis. Painting shall be paid on area basis.

ANNEXURE A

ENVIRONMENTAL CONDITIONS

TO BE COMPLIED BY THE CONTRACTORS APPOINTED FOR PUBLIC CONSTRUCTION WORKS

I. PERLIMINERY CONDITIONS OF ENVIRONMENT

In case of plot development works :

1) The contractor shall provide G.I. sheet cladding of 16-20 feet height all around the boundary of construction site and it should be maintained till completion work. (In case of road and pipe line laying works the height of G.I Cladding shall be 6-10 feet.)

2) The contractor shall construct internal roads/pavements in asphalt or cement concrete as per standard specifications with proper slope, camber and gradient for movement of vehicles. These roads/pavements should be maintained in all respect at all time, the vehicles should move on these roads only. No other constructions activity should start before constructions of these roads/pavements.

3) Raised platform in C.C. with necessary drainage arrangement all around shall be constructed near exit gate for washing tires of vehicles.

4) Covered storage bins shall be constructed for storage of raw material.

5) The Contractor shall submit ambient air and noise level survey report to ensure non-working pollution level.

II. GENERAL CONDITIONS :

1) The contractor shall hold valid Water/Air consent and Letter of Authorization for disposal of hazardous waste from M.P.C.B. and shall comply with the terms and conditions stated therein.

2) The construction activity shall not cause nuisance due to smoke, heat, noise, vibration, particulate matters, dust, waste water, fluff, odour or any other cause and should take suitable / additional measures in case of nuisance with prior approval of this office, so as not to cause nuisance to surrounding area /inhabitants.

3) Excavated earth/ debris shall not be piled up above 6 feet height to avoid air pollution nuisance.

4) In case of existing residential/commercial within radius of 50 metres, pressure piling by hammering method will not be allowed. Developer should go for bored piling, so as to reduce noise and vibration nuisance. If at all pressure piling is necessary on some technical ground, the contractor should submit reasons for the same from their Structural Engineer.

5) As far as possible fabrication activity must be avoided on site.

6) Loading/unloading of raw material at site such as steel, pipes, rubble, wood, metal, machinery shall be restricted in day hours only.

7) Mechanical machinery such as vibrators, lifts, JCBs, pock lains, trolleys, tractors, pneumatic compressors, pumps, D. G. sets, vehicles shall be of good quality and shall not cause any noise nuisance. For all types of machineries the serviceable life will be considered as 8 years and that for vehicles 15 years. Old machineries beyond this will not be allowed at site.

8) Any kind of permissible site work will be allowed between 7.00 a.m. to 7.00 p.m. only.

9) The raw material storage bins shall be covered and the contractor shall maintain good house-keeping and take adequate measures for prevention and control of pollution from all sources.

10) The contractor shall submit Ambient air, Waste water & Noise level survey report to this office as and when required.

11) No activity causing noise nuisance will be permitted in ‘Silence Zones.’

12) The debris management plan shall be as per conditions of the N.O.C. issued by the Zonal Ex. Engineer (S.W.M.) (Env.)

13) The contractor shall stop is activity in case of any accidents or break down occur from environmental aspects.

14) The contractor shall ensure that fugitive emission from the activity are controlled, so as to maintain clean and safe environment in and around the construction site.

15) As far as possible storing, lifting and conveyance of Cement shall be carried out through closed system only and will not cause dust emission.

16) No activity of crushing the metal into finer size shall be allowed at site.
17) Repair to transit mixers/vehicles shall not be allowed at site.

18) In case of any one environmental control systems are not operating in proper manner, the contractor shall immediately stop its operations till necessary rectification is carried out.

19) The solid waste generated shall be disposed of in an approved manner.

20) In case of bonafide complaint of pollution is received by this office or any sort of nuisance is noticed, the contractor shall take further measures in consultation with this office for abatement of nuisance.

21) It is responsibility of the contractor to obtain NOC/clearance from other Mun. Deptt/Statutory/ Govt. deptt’s as may be necessary.

22) The contractor shall install a comprehensive control system consisting of control equipments as is warranted with prior approval of NMMC/MPCB and with reference to generation of emissions and operate and maintain the same continuously so as to achieve level of pollutants below the limiting standards.

23) M.C.G.M. reserve the right to change /alter/add/delete these terms and conditions.

24) In case of plot development work thick and tall tree plantation all along the boundary of plot shall be provided.

25) Violation of any one of above conditions may result in issuing Stop Work notice and other legal actions.

26) The contractor shall scrupulously follow the General and specific conditions stated in the 'Environmental Clearance' issued by MoEF, Govt. of India, if applicable.

27) All activities shall be in resonance with the provisions of Indian Forest Act, 1927 (16 of 1927), Forest (Conservation) Act, 1980 (69 of 1980) and wildlife (Protection) Act, 1972 (53 of 1972) CRZ notification and all the Environmental Statutes and Instruments.

28) No quarrying activities shall be commenced in the area unless appropriate permissions are obtained for a limited quarrying material required for construction of local residential housing and traditional road maintenance work, provided that such quarrying is not done on Forest Lands and the material is not exported to the outside area.

29) Extraction of Ground water for the construction activity shall require prior permission of the State Ground Authority or other relevant authorities, as applicable.

30) Near the activities that are related to water (like activity of water parks, water sports) and /or in the vicinity of lake, Dissolved Oxygen shall not be less than 5 mg/liter.

31) The contractor shall obtain separate NOC/permission from the Dy. Ch.Eng. (Civil) Environment of NMMC for RMC/STP/ETP/ Comprehensive kitchen exhaust systems, filtration plant for swimming pool after submitting relevant information/documents to the office of the Dy. Ch. Eng.(Civil) Environment and should obtain Completion Certificate for the same after completion.

III <u>CONDITIONS RELATED TO AIR ACT</u>

a) The applicant may install diesel generating sets (DG sets) as per approval of competent authority as a stand by power source, of required capacity and shall be equipped with comprehensive control system as is warranted with reference to generations of emissions and operate and maintain the same continuously so as to achieve the level of pollutants with National Ambient Air Quality Standard:-

i) The applicant shall erect the Chimney(s) of the following specifications

No.	Chimney attached to	Height above roof level
1	D G Set	4.5 meters

ii) The applicant shall provide ports in the chimney and facilities such as ladder, platform etc. for use of the Board's staff. The chimney shall be numbered as S-1, S-2 etc. and these shall be painted/displayed to facilitate identification.

iii) Conditions for D. G. Sets (as a stand by arrangement)

a) The location of the D. G. Sets proposed to be installed shall be got approved from this office.

b) The developer should obtain permission from competent authority for installation of D. G. Sets.

c) Noise from DG sets shall be controlled by providing acoustic enclosure or by treating the room acoustically.

d) Applicant should provide acoustic enclosure for control of noise. The acoustic enclosure/ acoustic treatment of the room shall be designed for minimum 25 dB (A) insertion loss or for meeting the ambient noise standards, whichever is on higher side. A suitable exhaust muffler with insertion loss of 25 dB (A) shall also be provided. The measurement of insertion loss shall be done at different points at 0.5 meters from acoustic enclosure/room and then average.

e) The applicant should make efforts to bring down noise level due to DG set, outside the premises, with ambient noise level requirements by proper setting and control measures.

f) Installation of DG set must be strictly in compliance with recommendations of DG set manufacturer.

g) A proper routine and preventive maintenance procedure for DG set shall be set and followed in consultation with the DG manufacturers, which would help to prevent noise levels of DG sets from deteriorating with use.

h) The DG set shall be operated only in case of power failure. The contractor shall make arrangement for regular electrical power.

i) The applicant shall not cause any nuisance in the surrounding area due to operation of DG sets.

j) In case of problems, the DG set shall not be operated until it is set back to satisfactory position.

iv) Water spraying in controlled manner shall be done on ground to avoid fugitive emission.

v) Constriction material shall be carried in enclosed vehicles during construction activities.

PERMISSIBLE AMBIENT AIR QUALITY

C. P. C. B. Standards				
Parameter	Exposure Period	Industrial Area	Residential, Rural & other Area	Sensitive Area
SO2	Annual avg.	80 µg/m^3	60 µg/m^3	15 µg/m^3
	24 Hrs avg. II	120 µg/m^3	80 µg/m^3	30 µg/m^3
	Annual avg.	80 µg/m^3	60 µg/m^3	15 µg/m^3
	24 Hrs avg. II	120 µg/m^3	80 µg/m^3	30 µg/m^3
Nh3	Annual avg.	100 µg/m^3	100 µg/m^3	100 µg/m^3
	24 Hrs avg. II	400 µg/m^3	400 µg/m^3	400 µg/m^3
SPM	Annual avg.	360 µg/m^3	140 µg/m^3	70 µg/m^3
	24 Hrs avg. II	500 µg/m^3	200 µg/m^3	100 µg/m^3
Respirable particulate matter	Annual avg	120 µ g/m^3	60 µg/m^3	50 µg/m^3
	24 Hrs avg. II	150 µg/m^3	100 µg/m^3	75 µg/m^3
Lead	Annual avg	1.0 µg/m^3	0.75 µg/m^3	0.50 µg/m^3
	24 Hrs avg. II	1.5 µg/m^3	1.0 µg/m^3	0.75 µg/m^3
Carbon Monoxide	8 Hrs.	5.0 mg/m^3	2.0 mg/m^3	1.0 mg/m^3
	1 Hr.	10.0 mg/m^3	4.0 mg/m^3	2.0 mg/m^3

PERMISSIBLE NOISELEVELS

Sr. No.	Area	C. P. C. Standard	
		Day dB/A	Night dB/A
1	Residential	55	45
2	Commercial	65	55
3	Traffic	65	55
4	Air Port Area	65	55
5	Silence Zone	50	40
6	Industrial	75	70

IV CONDITIONS RELATED TO WATER ACT

i) No waste water containing cement slurry etc. shall be let off within the premises, outside the premises and in municipal S. W. Drain.

ii) Proper network for disposal of waste water shall be provided.

iii) Sewage effluent Disposal (Recycling)

Domestic treated effluent shall be disposed of on land for gardening/irrigation/lawns/ tree-plantations within own premises. Excess treated sewage effluent shall be disposed into to underground drainage scheme provided by local body. In no case, effluent shall find its way to any water body directly/indirectly at any time.

V CONDITIONS RELATED TO (M & H) & AMENDMENT RULES 2003

The contractor shall not generate or handle any hazardous waste

SECTION – H – PREFERED VENDOR LIST

1. HYDRO ELECTRIC POWER PLANT		
S. NO.	**EQUIPMENT**	**VENDORS**
1.	OPU / Power packing	REXROTH / YUKEN / PARKER / HYDAC
2.	Generator	BHEL / CGL / KEC / TDPS / WEG / JYOTI
3.	Power Transformer	CGL / KEC / SIEMENS / BHARAT BIJLI / ALSTOM / VOLTAMP / EMCO / ECE / SOUTHERN / AREVA
4.	HV Outdoor circuit breaker	ABB / CGL / ALSTOM / AREVA/ SIEMENS / S & S
5.	HV Outdoor CT	MEHRU / INSTRANS / SILKANS / EI
6.	HV Outdoor PT	MEHRU / INSTRANS / SILKANS / EI
7.	HV Outdoor Lightning Arrestors	WS / IGE / OBLUM / CGL / ELPRO / LAMCO
8.	HV Outdoor isolator	ELPRO / DANKE / ELECTROLYTE / RAMA ENGG. / PACTIL
9.	Cables	FORT GLOSTER / UNIVERSAL / ASIAN (RPG) / KEI / POLYCAB / LAPP
10.	Battery Charger	CHHABI / MASSTECH / SABNIFE / UNIVERSAL
11.	Battery	EXIDE / AMCO
12.	Switchgear Panels with Control, Metering & Protection	CONTRONICS / AREVA
13.	Switchgear Components	L & T / GE CONTROLS / SIEMENS
14.	Control & Protection Panels	CONTRONICS
15.	Auxiliary distribution board	CONTRONICS / AREVA
16.	Metering	CONTRONICS / AE. CO. / IMP / MECO / RISHABH
17.	Valves / Gates	AUDCO VALVES / LEADER / KRILOSKAR / FOURESS/ VAG/ L &T/ IVC / JASH
18.	Hydro Power Equipments	ANDRITZ Hydro Private Limited **/** MECAMIDI HPP INDIA PRIVATE LIMITED. (Formerly - HPP Energy (India) Private Limited.) / B FOURESS (P) LIMITED / KIRLOSKAR BROTHERS LIMITED / VOITH HYDRO PRIVATE LIMITED / PENTAFLO HYDRO PVT. LTD. / FLOVEL ENERGY PRIVATE LTD. /

		TPSC(I) PRIVATE LIMITED (Wholly owned subsidiary of Toshiba Plant Systems & Services Corporation, Tokyo, Japan) / APE POWER PRIVATE LIMITED / JYOTI LTD. / SCHIMMER ENERGY PVT. LTD. / BHARAT HEAVY ELECTRICALS LTD. / BOOM SYSTEMS PRIVATE LIMITED.
19	HYDRO-MECHNICAL EQUIPMENTS (Gates & Lifts)	Nepal Hydro & Electric Limited. / M/s Pilot Engineering Works / M/s Indo Asiatic Engineers Pvt. Ltd. / M/s Rockwell Hoisto Cranes Pvt. Ltd. / M/s General Mechanical Works Pvt. Ltd. / M/s P & R Engineering Services (Pvt.) Ltd / M/s INTOP Projects / M/s Aarti Infra Projects Pvt. Ltd./ M/s Anju Industries / PM Infra Projects India Pvt.Ltd.

2. SCADA And Automation		
S. NO.	**EQUIPMENT**	**VENDORS**
1.	SCADA software	Schneider Electric, Siemens, Mitsubishi, GE, ABB, Rockwell
2	PLC	Schneider Electric, Siemens, Mitsubishi, GE, ABB, Rockwell
3	PLC Panel	Rittal,
4	Server Rack	Rittal,
5	Server	IBM, DELL, HP, LENEVO,
6	Workstation	IBM, DELL, HP, LENEVO,
7	Firewall	Cisco, Fatigate, Cyberroam
8	KVM LED Console	IBM, DELL, HP, LENEVO, Raritan
9	Ethernet Switch	D-Link , Cisco, HP, Netgear , Schneider, Siemens
10	LTO Backup Drive	IBM, DELL, HP, Quantum
11	VPN GPRS Moden	Maestro, cyberroam, Inhand
12	MFM Printer	HP, Canon, Sharp
13	Colour Printer	HP, Canon, Sharp
14	SMPS	Phoenix contact, Meanwell, Hirshman or PLC OEM
15	UPS / Invertors	Aplab, Schneider Electric (APC), Emerson Network Power, Delta, Hirel, Eaton, Kiroskar
16	Batteries	Excide, Amara Raja (Amron), Chloride India, Globa Yusa, Slandered , TATA
17	Pressure transmitter	ABB, Siemens, Emerson, Yokogava, WTW
18	Lighting Protection Unit	Erico, MTL Instruments, OBO Betterman, Peppelar and fuchs, Rittimeyer
19	Digital Pressure indicator, Digital flow indicator & integrator	ABB, Eurotherm DEL, Masibus, Radix Electrosystem, Yokogawa Bluestar
20	Instrument cable	Asian cable, LAPP, Polycab , Finolex
NOTE : All accessories shall be preferably from OEM of PLC hardware Manufacturer		
Bidder shall propose only one vendor's software and execute project with same vendor's software proposed , if awarded contract. Bidder cannot change software proposed in bid after award of contract.		

3. SOLAR POWER PLANT		
S. No.	**EQUIPMENT**	**VENDORS**
1.	SPV Module	TATA POWER SOLAR / BHEL / EMMVEE /WARE/ VIKRAM SOLAR / CANADIAN SOLAR / JINKO SOLAR / KYOCEAR / TRINA SOLAR / JA SOALR /SUN POWER / RISEN / ALESUN / CSUN / DAQO / ADANI / SOVA SOLAR / WEBSOL
2.	POWER CONDITION UNIT / STING INERTER	SMA , GERMANY / ABB FINDLAND , BANGLORE , AEG / SCHENDER/ GE HITACHI - HIREL
3	STRING MONITORING UNIT	WEILMULLER, GERMANY/ SOCOMEC , GERMANY, HENSEL , USA / CAPA , ELECTRIC / TRINITY TOUCH /SMA / L&T / ABB
4.	POWER TRANSFORMER (OIL FILLED TYPE)	BHEL /ALSTOM /SCHNIDER / ABB / CGL / EMCO /KANOHAR
5.	INVERTER DUTY TRANSFORMER (IDT) or SOLAR POWER TRANSFORMET (STP)	BHEL /ALSTOM /SCHNIDER / ABB / CGL / EMCO /KANOHAR
6.	Circuit Breakers SF6 /VCB	SIEMENS / ABB / CGL/BHEL / ALSTOM / L& T / SCHNEIDER
7.	ISOLATOR (Outdoor Type)	HIVELAM / ABB / CGL / ALSTOM / L& T / SCHNEIDER / ELPRO / SIEMENS
8.	CVT	ABB / CGL / ALSTOM / BHEL
9.	CT (Oil Filled Ttpe)	BHEL /ALSTOM /SCHNIDER / ABB / CGL / KAPPA / PRAGATI /PRAYOG
10	MV SWITCHGEAR	BHEL /ALSTOM /SCHNIDER / ABB / CGL / SIEMENS
11	LT Switchgear Panel / Control Panel / DCDB / Annunciation Panel	L& T / ABB / SIEMENS / GE /BHEL /ALSTOME
12.	C &R PANEL	BHEL /ALSTOM /SCHNIDER / ABB / GE / SIEMENS
13	HT/ MV CABLES	UNIVERSAL CABLES / TORRENT CABLE / POLYCAB / KEI / HAVELLS /KEC
14	DC CABLES	SIECHEM / LAPP / STRUDER, GERMANY , LEONI , RADOX / PRYSMIAN
15	LT AC POWER CABLES & CONTROL CABLES	UNIVERSAL CABLES / TORRENT CABLE / POLYCAB / KEI / HAVELLS /KEC / UCL /CCI
16	INSTRUMENT CABLE	UNIVERSAL CABLES / / POLYCAB / KEI / HAVELLS /KEC / UCL /CCI
17	BATTERY CHARGER	AMARA RAJA / BHL NIFE / CHHABI ELECTRICAL / CHLORIDE POWER / STATCON / DUBAS ENGG
18	FIRE ALARM PANEL (MCROPROCESSOR BASED)	AUTONICA , NORWAY / EDWARD, USA/ NOTIFIER, USA/ SCHRACK, AUSTRIA / HONEYWELL ,

4. POWER EVACUATION SYSTEM		
S. NO.	**EQUIPMENT**	**VENDORS**
1	TOWERS	M/s. Unitech Power Transmission Ltd., Gurgaon / M/s. Bajaj Electricals Ltd., Ranjangaon / M/s. Jyoti Structures Ltd., Nasik / M/s. Kalpataru Power Transmission Ltd., Gandhinagar /M/s. EMCO, Vadodara / M/s. KEC International Ltd.,Navi Mumbai / M/s. B.G.Shirke Construction Technology Ltd., Pune /M/s. Associated Transrail Structures Ltd, Vadodara
2	INSULATOR HARDWARES & CONDUCTOR AND EARTHWIRE ACCESSORIES	M/s. EMI Transmission Ltd., Thane/ M/s. IAC Electricals Pvt. Ltd., Kolkatta/ M/s. International Transmission Products Pvt. Ltd.,Bhandup / M/s. Modern Malleables Ltd.,Kolkatta / M/s. Asbesco(I) Pvt. Ltd., Kolkatta / M/s. Rashtraudyog Pvt. Ltd., Kolkatta
3	CONDUCTORS ACSR ZEBRA/ PANTHER	STERLILTE /APAR /GALADA / DURGA / SARASWATI / PENNAR M.P OVERHEAD / DIMOND
4	G.S EARTHWIRE	BHARATH WIRE / GEEKAY WIRE / BHILAI WIRE / BEDMITHA SINNER / MOHATTA & HECKEL
5	INSULATORS	
	PORCELAIN DISC	M/s ADITYA BIRLA INSULATORS , Rishra / M/s BHEL, BANGALORE JAGDISHPUR / M/s WSI(I) LTD. CHENNAI
	POECELAIN LONG ROD	M/s MODERN INSULATORS LTD, / M/s SARAWANA GLOBLE ENERGY LTD, CUDDALORE

5. **GIS Equipment’s**

- Abb
- Siemens
- GE
- Hyosung
- Toshiba