

Gujarat Pipavav Port Limited

Tender Document **Construction of Ro-Ro Yard at** **Pipavav**

BMT-1511-GPPL-BID-001

Volume - 2

Technical Specifications

September 2023

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6 Technical specifications

6.1 Material specifications

6.1.1 M-1 Water:

Water shall not be salty or brackish and shall be clean, reasonably clear, and free from objectionable quantities of silt and traces of oil and injurious alkali salts, organic matter and other deleterious material which will either weaken the mortar or concrete or cause efflorescence or attack the steel in RCC container for transport, storage and handling of water shall be clean. Water shall conform to the standards specified in IS: 456.

If required by the Engineer-in-charge and Architects, it shall be tested by comparison with distilled water. Comparison shall be made by means of standard cement tests for soundness, time of setting and mortar strength as specified in IS: 269. Any indication of unsound change in time of setting by 30 minutes or more or decrease of more than 10 per cent in strength of mortar prepared with water sample when compared with the results obtained with mortar prepared with distilled water shall be sufficient cause for rejection of water under test.

Water for curing mortar, concrete or masonry should not be too acidic or too alkaline. It shall be free of elements which significantly affect the hydration reaction or otherwise interfere with the hardening of mortar or concrete during curing or those which produce objectionable stains or other unsightly deposits on concrete or mortar surfaces.

Hard and bitter water shall generally be found unsuitable for curing mortar or concrete.

Potable water shall be generally found suitable for curing mortar and concrete.

6.1.1.1 **Testing Standards (Chemical Analysis)**

- Sampling: Test shall be carried out only once for one particular source.
- Results:
 - TDS - 3000 mg/lit.
 - Sulphates - 5000 mg/lit.
 - pH values - 6 to 8
 - Chlorides
 - P.P.C - 2000 mg/lit.
 - R.C.C - 1000 mg/lit.
 - Carbonic contents - 200 mg/lit.
 - Non-carbonic contents - 3000 mg/lit.

6.1.2 Deleted

6.1.3 M-3 Cement

Cement shall be ordinary Portland slag cement as per IS: 269-2015 or Portland slag cement as per IS: 455-2015.

6.1.3.1 **Testing standards:**

A. Setting time:

- Sampling: From a lot of 50 tons of cement, 2% of bags shall be picked out at random, from which one sample of 15 kg, shall be taken.
 - For a lot of 50 to 100 tones - 2 samples
 - For a lot of 100 to 200 tones - 3 samples
 - For a lot of 100 to 200 tones - 3 samples
 - For a lot of 200 to 300 tones - 4 samples
 - For a lot of 300 to 500 tones - 5 samples
 - For a lot of 500 to 800 tones - 6 samples
 - For a lot of 800 to 1300 tones - 7 samples
- Results:
 - Initial setting time - not less than 30 minutes
 - Final setting time - not more than 100 minutes

B. Fineness test by sieving:

- Sampling: Using any 5 samples, made as above, one test is carried out, and using IS sieve no. 90 microns.
- Results:

90% or more should pass through the above mentioned IS sieve.

C. Fineness test by determination of specific surface:

- Sampling: Using any 5 samples, made as above, one test is carried out.
- Results:
 - For O.P.C, the surface area shall be 225 m²/kg or more (IS 269: 2015).
 - For P.P.C, the surface area shall be 300 m²/kg or more (IS 1489, Part 1).

D. Consistency test:

- Sampling: Sampling shall be as in A.

- Results:

Consistency in all samples shall be about 30%.

E. Compressive strength:

- Sampling: Sampling shall be as in A.

- Results:

- On 2nd day, compressive strength must be 160 Kg/Sq.cm., for O.P.C
- On 7th day, compressive strength must be 220 Kg/Sq.cm., for O.P.C
- On 28th day, compressive strength must be 310 Kg/Sq.cm., for O.P.C

F. Chemical composition (IS: 4032):

- Sampling: Using any 5 samples, made as above, one test is carried out.

- Results:

- Magnesium oxide - less than 6%.
- Sulphur as sulphuric anhydride - less than 2.75%.
- Loss on ignition - up to 5%.

The above is for ordinary Portland cement.

6.1.3.2 M-3A Rapid Hardening Cement (RHC):

Rapid hardening cement shall be from source like Gujarat High Tech, Ambuja, Birla or equivalent as approved by the Architect and Engineer-in-charge. It shall conform to IS: 8041-1990. Test certificates showing that the cement complies with the specifications must be submitted to the Architect, shall have strength in one day equal to that of OPC in 3 days. It shall be used for products like Hume pipes, tiles, sleepers, poles, Prestressed and precast concrete members. It shall also be used for foundations, bridges, culverts, causeways etc. where quick construction activity is required however, prior permission of the Architect and Engineer-in-charge shall be taken before use.

It shall be capable of giving required workability, final strength, and better surface finish.

6.1.3.3 M-3B Sulphate Resistant Cement (SRC):

Sulphate resistant cement shall be from source like Gujarat High Tech or equivalent as approved by the Architect and Engineer-in-charge. It shall conform to relevant IS: 12330-1988 or BS-4027 & ASTM C-150 Type-II. Test certificates showing that the cement complies with the specifications must be submitted to the Architect.

It shall be used for structures in or near sea water, where the soil conditions are aggressive, where repeated cycles of drying and wetting are occurring, and for structures which are exposed to sulphate attack & salty weather like foundations, bridges, dams, tunnels, industrial drains, sewage pipes.

It should possess low heat of hydration, more compressive strength at 3, 7 and 28 days than OPC. It should be capable of withstanding attack of aggressive substances which damage concrete structure like sulphates of sodium, magnesium, and calcium etc. It should have low co-efficient of expansion.

6.1.4 M-4 White cement :

The white cement shall conform to IS: 8042-2015.

6.1.5 M-5 Coloured cement:

Coloured cement shall be with white or grey Portland cement mixed with pigments as specified in the item of the work.

The pigments used for coloured cement shall be of approved quality and its quantity shall not exceed 10% of the cement used in the mix. The mixture of pigment and cement shall be properly ground to have a uniform colour and shade. The pigments shall have such properties as to provide for durability for colour under exposure to sunlight and weather.

The pigment shall have the property such that it is neither affected by the cement nor detrimental to it.

6.1.6 M-6 Sand:

Sand shall be used yellow sand from the Dabholi area only. Sand shall be medium/coarse natural sand, clean, well graded, hard, strong, durable, and gritty. Sand particles should be free from injurious amounts of dust, clay, Kankar nodules, soft or flaky particles of shale, alkali, salts, organic matter loam, mica or other deleterious substances and shall be got approved from the Engineer-in-charge and Architects. The sand shall not contain more than 8% of silt as determined by field test and 3% by laboratory test. If necessary, the sand shall be washed to make it clean. All sand to be used for plaster, brickwork, concrete shall be strictly sieved by 4.75 mm sieve.

6.1.6.1 **Testing standards:**

A. Silt content:

- Sampling: Test shall be carried out for every 150 m³ of sand. The sample taken for testing shall weigh 10 Kg.
- Results: Permissible content shall be 3% in laboratory test & 8 % in field test.

B. Fineness Modulus:

- Sampling: Sampling shall be as in A.
- Results:
 - Fine sand : 2.2 to 2.6 shall be used as earth filling in plinth, zari, etc.
 - Medium sand : 2.6 to 2.9 shall be used for brickwork and plaster.
 - Coarse sand : 2.9 to 3.2 shall be used for concrete.

In general, the fineness modulus of sand shall not be less than 2.5 and shall not exceed 3.0. A sand having a fineness modulus more than 3.2 will be unsuitable for making satisfactory concrete.

C. The sieve analysis of sand shall be as under

Table 6-1: Sieve analysis of sand

IS sieve designation	% By weight passive sieve	IS sieve designation	% By weight passive sieve
4.75 mm	100	600 Micron	30 - 100
2.36 mm	90 – 100	300 Micron	5 - 70
1.18 mm	70 - 100	150 Micron	0 - 50

6.1.7 Deleted

6.1.8 M-8 Stone grit :

Grit shall consist of crushed or broken black trap stone and be hard, strong, dense, durable clean of proper gradation and free from skin or coating likely to prevent proper adhesion of mortar. Grit shall generally be cubical in shape and as far as possible flaky elongated pieces shall be avoided. It shall generally comply with the provisions of IS: 383-2016. Unless special stone of particular quarries is mentioned, grit shall be obtained from the best black trap or equivalent hard stone as approved by the Engineer-in-charge and Architects. The grit shall have no deleterious reaction with cement.

Table 6-2: Gradation for stone grit

IS sieve designation	% By weight passive sieve	IS sieve designation	% By weight passive sieve
12.50 mm	100	4.75 mm	0 – 20
10.00 mm	85 – 100	2.36 mm	0 - 5

The crushing strength of grit will be such as to allow the concrete in which it is used to build up the specified strength of concrete.

The necessary tests for grit shall be carried out as per the requirements of IS: 2386 (parts I to VIII), as per instructions of the Engineer-in-charge and Architect. The necessity of test will be decided by the Engineer-in-charge and Architect.

6.1.9 Deleted

6.1.10 Deleted

6.1.11 M-11 Cement mortar :

Water shall conform to M-1. Cement shall conform to M-3. Sand shall conform to M-6.

- **Proportion of mix:**

Cement and sand shall be mixed to specified proportion sand being measured by measuring boxes. The proportion of cement will be by volume on the basis of 50Kg / Bag of cement being equal to 0.0342 m³. The mortar may be hand mixed or machine mixed as directed (only for small works).

- **Proportion of mortar:**

In hand mixed mortar, cement and sand in the specified proportions shall be thoroughly mixed dry on a clean impervious platform by turning over at least 3 times or more till a homogeneous mixture of uniform colour is obtained. Mixing platform shall be so arranged that no deleterious extraneous material shall get mixed with mortar or mortar shall flow out. While mixing, the water shall be gradually added and thoroughly mixed to form a stiff plastic mass of uniform colour so that each particle of sand shall be completely covered with a film of wet cement. The water cement ratio shall be adopted as directed.

The mortar so prepared shall be used within 30 minutes of adding water. Only such quantity of mortar shall be prepared as can be used within 30 minutes.

6.1.12

M-12 Stone coarse aggregate for nominal mix concrete :

Coarse aggregate shall be of machine crushed stone of black trap and be hard, strong, dense, durable, clean, and free from skin and coating likely to proper adhesion of mortar.

The aggregate shall generally be cubical / round in shape. Unless special stones of particular quarries are mentioned aggregates shall be machine crushed from the black trap or equivalent black hard stone as approved. Aggregate shall have no deleterious reaction with cement. The size of the coarse aggregate for plain cement concrete and ordinary reinforced cement concrete shall generally be as per the table given below. However, in case of reinforced cement concrete, the maximum limit may be restricted to 6 mm. less than the minimum lateral clear distance between bars or 6 mm. less the cover, whichever is smaller.

Table 6-3: Stone coarse aggregate for nominal mix concrete

IS sieve designation	% passing for single size aggregates of Nominal size			IS sieve designation	% By weight passive sieve		
	40 mm	20 mm	16 mm		40 mm	20 mm	16 mm
80 mm	-	-	-	12.5 mm	-	-	-
63 mm	100	-	-	10 mm	0 - 5	0 - 20	0 - 30
40 mm	100	100	-	4.75 mm	-	0 - 5	0 - 5
20 mm	0 - 20	85 - 100	100	2.35 mm	-	-	-
16 mm	-	-	85 - 100	-	-	-	-

Note: This percentage may be varied somewhat by the Engineer-in-charge when considered necessary for obtaining better density and strength of concrete.

The grading test shall be taken in the beginning and at the change of source of materials. The necessary tests indicated in IS: 383-2016 and IS: 456-2000 shall have to be carried out to ensure the acceptability. The aggregate shall be stored separately and handled in such a manner as to prevent the intermixing of different aggregates. If the aggregates are covered with dust, they shall be washed with water to make them clean.

6.1.12.1 Testing standards:

A). Flakiness index:

- Sampling: For every 200 m³ of aggregates, one test shall be carried out.
- Results:
 - The Flakiness index is taken as the total weight of the aggregates passing through the various thickness gauges, expressed as a percentage of the total weight of the sample taken.
 - Permissible is not more than 35% for aggregates used in concrete for wearing surfaces.

B). Impact value:

- Sampling: For every 100 m³ of aggregates, one test shall be carried out.
- Results:
 - The impact value shall not be more than 45% by weight for aggregates used for concrete other than wearing surfaces.
 - For aggregates used for concrete to be used as wearing surface, the impact value shall not be more than 30%, by weight.

C). Abrasion Value:

- Sampling: Sampling shall be as in B.
- Results: The percentage of wear shall not be more than 35%.

6.1.13 M-13 Black trap or equivalent hard stone coarse aggregates for design mix concrete :

Coarse aggregate shall be machine crushed stone of black trap or equivalent hard stone and hard, strong, dense, durable, clean, and free from skin and coating likely to prevent proper adhesion of mortar.

The aggregates shall generally be cubical in shape. Unless special stones of particular quarried are mentioned, aggregates shall be machine crushed from the best black trap or equivalent hard stones as approved. Aggregates shall have no deleterious reaction with cement.

The necessary tests indicated in IS: 383-2016 and IS: 456-2000 shall have to be carried out to ensure the acceptability of the material.

If the aggregates are covered with dust, they shall be washed with water to make them clean.

6.1.14 Deleted

6.1.15 M-15 Bricks :

The bricks shall be of first quality hand or machine moulded and made from suitable soils and kiln burnt. They shall be free from cracks, flaws, and modules of free lime. They shall have smooth rectangular faces with sharp corners and shall be of uniform in colour. The bricks shall be moulded with a frog of size 100 mm. x 40 mm. and 10 mm. to 20 mm. deep on one of its flat sides. The bricks shall not break when thrown on the ground from a height of 1 m.

The size of modular bricks shall be 190 mm. x 90 mm. x 90 mm. and the size of the conventional bricks shall be (9" x 4.5" x 3") 230 mm. x 110 mm. x 76.5 mm.

Only bricks of one standard size shall be used on a particular work site. The following tolerances shall be permitted in the conventional size adopted in a particular work site.

Length: + 1/8"(3.0 mm.). Width: + 1/6" (1.50 mm.). Height: + 1/6"(1.50 mm.).

The crushing strength of the bricks shall not be less than 50 Kg / cm², no unburned / over burnt bricks shall be used for any structure. The bricks should have dimensional stability as per IS standards. The average water absorption shall not be more than 20% by weight. Necessary tests for crushing strength and water absorption etc. shall be carried out as per IS: 3495 (Part I to IV).

6.1.15.1 **Testing standards:**

A). Efflorescence:

- Sampling: Test of 20 bricks is carried out from a stock of 20,000 bricks.
- Results: Moderate.

B). Water absorption:

- Sampling: Test of 32 bricks is carried out from a stock of 35,000 bricks.
- Results: Absorption shall not be more than 20%.

C). Compressive strength:

- Sampling: Test of 50 bricks is carried out from a stock of 1,00,000 (1 Lac) bricks.
- Results: On average the compressive strength shall not be less than 50 Kg/Sq.cm. And every result shall not be less than 20% of the IS standards.

6.1.15.2 M-15A First class bricks for exposed brickwork:

First class bricks are those which strictly conform to the standard size of modular bricks, i.e., 19 cm. x 19 cm. x 9 cm. actual size, such that ten layers of brick laid in mortar shall form masonry of 1 m. height. Conventional bricks should have quality standard as per modular brick except size.

These bricks are manufactured from good quality plastic earth, which is free from saline deposits. They are of good uniform colour. They are well burnt, giving a hard ringing sound when two bricks are struck together.

They should have straight edges and even surfaces. They are free from cracks, chips, flaws, and modules of lime.

When immersed in water for an hour, they do not absorb water more than 1/6th of their weight. On drying, these bricks do not show any sign of efflorescence.

6.1.15.3 M-15B Calcium silicate bricks:

The bricks shall be machine moulded and made from good quality and clean siliceous sand, lime, and fly ash (maximum content up to 30% in raw material composition). They shall be free from cracks, flaws, clay, and free lime. They shall have smooth rectangular faces with sharp corners and shall be uniform in size, colour, and shape.

The size of bricks shall be 228 mm. x 110 mm. x 72 mm. or as approved by the Architect. The compressive strength of bricks shall be minimum 150 kg / m². and the bricks shall have very high strength to weight ratio. The bricks shall have very good resistant capacity to atmospheric conditions, optimum building properties in relation to heat insulation, sound insulation, absorption of water and fire protection.

Calcium silicate products shall conform to the appropriate IS standards and there shall be no change required in civil application techniques while using such products in the place of traditional clay bricks.

6.1.15.4 M-15C Glass brick:

It shall be from Imperial or equivalent as approved by the Architect and Engineer-in-Charge.

It shall be free from any defects like, cracks, air bubbles, uneven surface, breaks etc. During handling and laying, its edges shall not be damaged. All edges and corners of all faces shall be sharp and well-shaped. It shall be of size and colour as specified in the item or as approved by the Architect. The glass bricks shall be of uniform size and tolerance of +2 mm. shall only be allowed in dimensions of glass brick. Spots of colour other than that of bricks or in bricks shall not be allowed. The weight of each brick shall be about 2.75 kg.

The transmission of direct light through brick shall not be less than 40%. The glass brick shall have good thermal insulation. It shall be sound proof and vibration absorber having adequate compressive strength. If bricks with groove or projections shall be used, the groove or projections shall be uniform and regular in size & shape.

6.1.16 Deleted

6.1.17 Deleted

6.1.18 M-18 Mild steel bars :

Mild steel bars reinforcement for RCC work shall conform to IS: 432-1982 and shall be of tested quality. It shall also comply with relevant part of IS: 456-2000.

All the reinforcement shall be clean and free from dirt, paint, grease, mill scale or loose or thick rust, at the time of placing.

For the purpose of payment, the bar shall be measured correct up to 10 mm. length and weight payable worked out at the rate specified below:

I.	6 mm.	0.22 Kg/m.	ix.	20 mm.	2.47 Kg/m.
II.	8 mm.	0.39 Kg/m.	x.	22 mm.	2.98 Kg/m.
III.	10 mm.	0.62 Kg/m.	xi.	25 mm.	3.85 Kg/m.
IV.	12 mm.	0.89 Kg/m.	xii.	28 mm.	4.83 Kg/m.
V.	14 mm.	1.21 Kg/m.	xiii.	32 mm.	6.31 Kg/m.
VI.	16 mm.	1.58 Kg/m.	xiv.	36 mm.	7.99 Kg/m.
VII.	18 mm.	2.00 Kg/m.	xv.	40 mm.	9.86 Kg/m.

Procurement of Steel should be from authorised / approved rolling mills and test certificates should be submitted with each lot.

6.1.18.1 Testing standards:

- Sampling: For every 40 tonnes of steel, at least one test shall be done.
- Results:

Table 6-4: Sampling results for mild steel bars

Thickness	Ultimate tensile strength	Chilled state	% Elongation
0 – 20 mm	42 Kg/Sq.cm	26 Kg/Sq.cm	23
20 – 40 mm	42 Kg/Sq.cm	24 Kg/Sq.cm	23
40 mm & above	42 Kg/Sq.cm	24 Kg/Sq.cm	23

6.1.19 M-19 High Yield Strength Steel Deforms bars:

High strength deformed steel bars and wires for concrete reinforcement shall conform to IS 1786: 2008.

Other provision and requirements shall conform to M-18 for Mild steel bars.

6.1.19.1 M-19 A. Thermo-mechanically Treated Bars (TMT)

TMT bars shall conform to IS: 1786

Procurement of steel should be from approved manufacturer and test certificates should be submitted with each lot.

6.1.19.2 M-19 B. Corrosion Resisting Steel (CRS)

CRS bars shall conform to IS: 1786

Procurement of steel should be from approved manufacturer and test certificates should be submitted with each lot.

6.1.20 Deleted

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6.1.26 M-26 Shuttering :

6.1.26.1 M-26A Timber/wooden planking:

The shuttering shall be either of wooden planking of 30 mm. minimum thickness with or without steel lining or steel plates stiffened by steel angles. The shuttering shall be supported on battens and beams and props of vertical ballies properly cross braced together, so as to make the centering rigid. In place of ballie props, brick pillar of adequate section built in mud mortar may be used.

The form work shall be sufficiently strong and shall have camber, so that it assumes correct shape after deposition of the concrete and shall be able to resist forces caused by vibration, live load of men working over it and other incidental loads associated with it. The shuttering shall have smooth and even surface and its joints shall not permit leakage of cement grout.

If at any stage of work, during or after placing concrete in the structure, the form work sags or bulges out beyond the required shape of the structure, the concrete shall be removed, and work redone with fresh concrete and adequately rigid form work. The complete form work shall be got inspected by and got approved from the Engineer-in-charge and Architect before the reinforcement bars are placed in position.

The props shall consist of ballies having 100 mm. minimum diameter, measured at mid-length and 80 mm. at thin end and shall be placed as per design requirement. These

shall rest squarely on wooden sole plate 40 mm. thick and minimum bearing area of 0.10 m². laid on sufficiently hard base.

Double wedges shall further be provided between the sole plate and the wooden props so as to facilitate tightening and easing of shuttering without jerking the concrete.

The timber used in shuttering shall not be so dry as to absorb water from concrete and swell or bulge nor so green or wet as to shrink after erection. The timber shall be properly sawn and planned on the sides and surface coming in contact with concrete. Wooden form work with metal sheet lining or steel plates stiffened by steel angles shall be permitted.

As far as possible, clamps shall be used to hold the forms together and use of nails and spikes shall be avoided.

The surface of timber shuttering that would come on contact with concrete shall be well wetted and coated with soap solution before the concreting is done. Alternatively coat of raw linseed oil or oil of approved manufacture may be applied in place of soap solution. In case of steel shuttering, either soap solution or raw linseed oil shall be applied after thoroughly cleaning the surface. Under no circumstances, black or burnt oil shall be permitted.

The shuttering for beams and slabs shall have camber of 4 mm. per meter (1 in 250) or as directed by Engineer-in-charge and Architect, so as to offset the subsequent deflection. For cantilevers, the camber at free end shall be 1/50 of the project length or as directed by the Engineer-in-charge and Architect.

6.1.26.2 M-26B Concrete shuttering plywood:

It shall be made from strong and selected hard woods. It shall be bonded with high quality Phenol Formaldehyde synthetic resin adhesive, hot pressed and then shall be further treated with a permanent type of preservative by vacuum-cum-pressure impregnation.

Due to the bonding with Phenol Formaldehyde, it shall be moisture and weatherproof. The use of selected hard-woods renders hard and wear-resistant faces and thereby it shall be reusable several times. It shall be highly resistant to rot, termites, and other wood inhabiting insects. Due to complete penetration of the preservative, it shall be exceedingly durable.

It shall have high impact strength and therefore shall be used successfully in place of timber planks and steel sheets. It shall protect the concrete from rapid temperature changes and shall provide optimum conditions for setting of the concrete. As it shall possess remarkable design flexibility, it shall be ideal for curved formwork.

Besides it shall be used as centering, shuttering and formwork of concrete columns, beams, slabs, walls, tanks, bridges, flyovers, silos etc. It shall also be used for structural applications like external walling, roofing, flooring, curtain walls, work-site offices, in cabins of trucks, rail coaches etc.

6.1.26.3 **M-26C Steel sheeting and steel plates:**

Steel sheeting and steel plates should be free from clinks, twists, offsets, warps, etc. Their surface should be neat, clean, and smooth. Before placing concrete, steel forms shall be thoroughly cleaned off of all rust, dust and loose materials. Colourless oil or grease of approved quality shall be applied before placing steel.

The size of angles used for framing and bracing of steel plates should be sufficient to withstand the weight of concrete without forming clinks, twists, offsets, warps, etc. in the steel plates. Also, the gauge of steel sheeting used should not be higher than 14 G.

Minimum two bracing angles should be provided along with angle framing while making the steel plates. It should be riveted or welded to suit the requirement of finish concrete surface. Minimum two rivets should be provided at all Four Corners and at junction of angle framing and bracing.

If the plates are to be welded, steel sheet and angle framing/bracing should be welded from sides and at back. Welding on sides should be buffed to make the sides smooth. Also, intermittent welding should be done to keep steel sheet and angle framing/bracing in one plane.

6.2 **Earthworks**

6.2.1 **General**

Earthworks shall include all operations necessary for excavating, filling, compacting, and protecting any material above level mentioned in drawings to the dimensions, lines, levels and profiles required in the Works.

The Contractor shall take and be responsible for any necessary measures to protect faces of excavation of fill which are exposed during construction.

6.2.2 **Product**

6.2.2.1 **Definition of earthworks materials**

The following definitions of earthworks materials shall apply to this and other clauses of the specification in which reference is made to the defined materials:

- 'Suitable material' shall comprise all that which is acceptable in accordance with the requirement of the project and as approved by Engineer-in-charge.
- 'Unsuitable material' shall mean other than suitable material and shall comprise:
 - Refused and man-made materials
 - Vegetation, shrub / bushes, and perishable materials.
 - Materials susceptible to spontaneous combustion.
 - Clay of liquid limit exceeding 90 and/or plasticity indexes exceeding 65 both determined in accordance with IS 2720: part 5.
 - Materials having a moisture content greater than the maximum permitted for such materials in the contract, unless otherwise permitted by the Owner.

- Materials containing chlorides, sulphates or other chemicals in quantities which will be injurious to the Permanent Works.
- ‘rock’ shall mean geological strata or deposits so described in the contract and any hard natural or artificial material requiring the use of blasting or approved pneumatic tools for its removal but excluding individual masses less than 0.25m³ in excavations having a width less than 2 meters or less than 1.0m³ in general excavation.
- ‘Artificially hard material’ shall mean placed material such as foundation bases and buried previous Works encountered, requiring the use of blasting, or approved pneumatic tools for its removal but excluding individual masses less than 0.25m³.
- ‘backfilling’ or ‘structural filling’ shall mean screened earthen material used to create a strong and stable base for construction.
- ‘Soil compaction’ shall mean the specified method of mechanically increasing the density of soil in accordance with the requirement of the project and relevant standards.

6.2.3 Execution

6.2.3.1 **Record surveys**

Before commencing excavating or filling the Contractor and the Owner shall jointly survey and agree the ground levels on the Site as specified. The levels shall be recorded by the Contractor on the survey drawings.

6.2.3.2 **Site clearance**

Before commencing any excavation or filling the Contractor shall clear the ground in accordance to the satisfaction of the Owner.

6.2.3.3 **Earthworks to be kept free of water**

The Contractor shall arrange for the rapid dispersal of water shed onto the earthworks or completed formation, or which enters the earthworks from any source.

6.2.3.4 **Excavation**

6.2.3.4.1 Extent of excavation

Excavation shall be taken out in all material by whatever means necessary to the lines and levels shown on the drawings, or as ordered by the Owner. Slopes and formation surfaces shall be trimmed true to the required profiles.

All excavation beyond the contract limits, as shown on the drawings, or the limits otherwise ordered by the Owner shall be made good with concrete mix of approved grade by the Owner or with compacted approved suitable material from excavations as ordered by the Owner.

6.2.3.4.2 Stockpiles

Stockpiles of approved suitable materials from excavations shall be formed at locations and in a manner agreed by the Owner. Stockpile Sites shall be cleaned up after use and restored to their original condition.

6.2.3.4.3 Removal from site

All excavated unsuitable material shall be removed from the Site and disposed off at an agreed Site between the Contractor and the Owner. All excavated suitable material, which is surplus to the requirements of re-use in the Works, shall be transported to an agreed Site stockpile.

No excavated suitable material, other than that surplus to the requirements of the contract, shall be removed from the Site, unless otherwise authorised or directed by the Owner. Should the Contractor be permitted to remove suitable material from the Site to suit his operational procedure, then he shall make good from his own resources any consequential deficit of fill with sufficient suitable fill material to occupy, after full compaction, a volume corresponding to that which the excavated suitable material occupied.

6.2.3.4.4 Excavation for trenches pits etc.

When excavating pits and trenches the Contractor shall provide all necessary timbering, sheet piles or other support, and shall shore the sides of excavation, trenches, pits, etc. in such a way as to prevent any movement of the sides of the excavation or damage to adjacent structures.

Unless shown otherwise or approved by the Owner, the sides of excavations shall not be battered. The soil from deep excavations shall be deposited at a safe distance from the edge of the excavation.

6.2.3.4.5 Pipe and cable trenches

Trenches for pipes and cables shall be set out in straight lines and to uniform falls between inter-sections. Sight rails shall be set-up at all inter-sections. Trenches for pipes and cables shall be so excavated as to allow the pipes or cable to be properly laid, jointed, inspected and tested. In areas of filling, trenches for pipes and cables shall be dug after the fill material has been fully compacted and approved by the Owner.

The method of supporting the excavations must be such that disturbance to the bedding below the pipes and cables is minimized.

The trench bottom shall be hand finished to correct levels and free from unsuitable material, stones or other sharp objects. Unsuitable material in trench inverts shall be removed and replaced by approved bedding or suitable material. The trench bottom shall be compacted by approved means to a density of not less than that of the undisturbed ground.

Where pipes are not required to be bedded on concrete or bedding material, the trench bottom shall be formed so that each pipe is properly supported throughout its length with recesses taken out at joints.

No pipes, cables or bedding material shall be placed in trenches until the trench bottom has been approved.

6.2.3.4.6 Bottom of pits and trenches

In excavations for foundations, rock surfaces shall be thoroughly cleaned until sound rock is exposed over the whole area. In material other than rock the last 150mm of excavation shall be carried out by hand, and only when concrete blinding is about to be placed. Before blinding is placed, the material in the bottom of the excavation shall be compacted by approved means to a density of not less than that of the undisturbed ground.

Any pockets of soft soil or loose rock in the bottom of pits and trenches shall be removed, and the resulting cavities and any large fissures filled with suitable material or with concrete mix as directed by the Owner. After placing of any blinding concrete, no trimming of the side faces shall be carried out for 24 hours.

The Contractor shall notify the Owner when excavations are ready for inspection. The placing of blinding concrete or any new Work shall not commence without the prior written consent of the Owner. Blinding shall be placed in the bottom of excavations as soon as consent is given, so that the bottom does not soften or become unsuitable.

If the Contractor allows the bottom to become unsuitable due to flooding or other causes, the Contractor shall remove the unsuitable material at or below the bottom of the excavation and make good with suitable material or concrete mix as directed by the Owner, at his own expense.

6.2.3.4.7 Minimum pipe trench widths

Excavation for pipe trenches shall be carried out to give a minimum clear width of 150 mm on each side of the pipe, or of the extent of bedding and hunching material where this is specified. Additional excavation to give ample space for making pipe joints shall be carried out as necessary.

6.2.3.4.8 Maximum pipe trench widths

Excavation for pipe trenches shall not exceed the width used in the structural design of the pipeline. Where the width exceeds the maximum permissible value, it shall be made up in concrete mix up to the level of the crown of the pipe as directed by the Owner.

6.2.3.4.9 Minimum cable trench widths

The side of any excavated cable trench shall be a minimum of 150mm from the side of the cable.

6.2.3.4.10 Excavation near existing utilities

- Prior to commencement of excavation, the Contractor shall determine the number and location of underground utilities in the immediate proximity of the work.
- Whenever necessary, the Contractor shall excavate test pits to determine the exact locations of existing utilities. It shall be the responsibility of the Contractor to make

such explorations sufficiently in advance of construction to enable the Owner to approve modifications, if any, to be made to any pipeline, structure or conflicting utility.

- Re-filling and compaction shall be completed as soon as practicable after the necessary information has been obtained. No extra payment will be made for the excavation and refilling of test pits.
- As excavation approaches existing pipes, conduits, cables and other underground facilities, excavation machinery shall be discontinued, and hand tools shall be used. The contractor shall provide temporary support for the existing utilities to prevent damages during his operations.
- Notwithstanding the foregoing provisions, if damages to existing utilities results from the Contractor's operations, such damages shall be repaired without delay by the Contractor or some other agency as determined by the Owner, and the cost of such repairs shall be borne by the Contractor.
- If damage to existing utilities causes disruption of the Contractor's schedule of work by delaying work in the area of such damage, the Contractor shall readjust his schedule, method of working and resources so that critical dates in the schedule for the completion of the Contract is not affected.

6.2.3.4.11 Supporting excavation

- The Contractor shall provide adequate sheeting, bracing, shoring and other supports to the sides and ends of all excavations to provide for the safety of all personnel and to prevent the occurrence of falls or runs from any portion of the ground outside the excavation or settlement or damage to previously constructed structures adjacent to the excavation.
- Previously constructed structures and facilities included both structures and facilities existing when this Contract began, and structures and facilities already provided under these specifications.
- The lateral distance from the edge of the excavation to the adjacent structure's foundation shall be equal or greater than the distance between the bottom of the footing and the bottom of the trench, unless otherwise approved by the Owner.
- Sheeting, bracing, and shoring shall be designed and built to withstand all loads that might be caused by earth movement or possible surcharge loads from equipment used in the work.
- Trenches less than 1.5m deep need not be shored. Trenches more than 1.5m in depth shall be shored unless the Contractor can provide soils data that ensures its stability. Alternatively, the Contractor may slope the sides of the trench at the angle of repose of the excavated material.
- The Contractor shall furnish and install additional shoring as directed by the Owner where, in the opinion of the Owner, sufficient or proper shoring has not been provided. Neither complying with such directives, nor failure of the Owner to make such directives, shall relieve the Contractor of his responsibility for providing adequate supports.

- Any extra excavation necessary to provide space for such support or other working space shall be held to be support, any excavations give way or damage occurs to adjacent structures, the necessary repairs shall be carried out by the Contractor or by other agency approved by the Owner and the cost of such repairs or construction shall be borne by the Contractor.
- The Contractor may elect to form excavations with sloping faces (other than sloping excavations shown on the Contract Drawings or required as permanent features of the work) without shoring contingent of the Owner's approval. The excavated faces shall have stable slopes and heights and any resulting extra excavation shall be held to be excess structural excavation.

6.2.3.4.12 Excavation for roadways and embankments

- When road embankment is to be made and compacted on natural or previously constructed fill slopes, such slopes shall be cut into for a minimum of 2m horizontally as the work is brought up in layers.
- Material thus cut out shall, if suitable fill material, be compacted along with the new road embankment material. Material cut out which is unsuitable fill material shall be disposed of as specified therein.

6.2.3.4.13 Tolerances

- No point on excavation slopes shall vary from the plane of the design slope by more than the 100mm measured at right angles to the slope except that where excavation is in rock, no point shall vary more than 500mm.
- In no case shall the excavation slope encroach on the roadbed.
- No point on the completed embankment slope within 1m below shoulder grade shall vary from plane of the design slope by more than 10mm measured at right angle to the slope. Slopes more than 1m below shoulder grade shall not vary from the plane of the design slope by more than 200mm measured at right angles to the slope.

6.2.3.5 **Filling**

6.2.3.5.1 General

No fill material shall be placed until all concrete placement and all construction are completed below the elevation of finished grades; the surface of the subsoil to receive fill has been cleaned and prepared as specified; all formwork, trash and debris shall be removed from the excavation; the area is free of standing or running water and has been accepted by the Owner.

6.2.3.5.2 Approval to commence filling

The areas on which fill material is to be placed shall be cleared and no fill shall be placed until the Owner has given written approval for filling to begin.

6.2.3.5.3 Fill material

Except where otherwise indicated, in the drawings or instructed by the Owner fill material used anywhere in the Works shall be suitable material obtained from the excavations on

the Site. Where suitable materials from the excavations are insufficient for the required filling the requirement shall be made up with imported materials which shall be supplied / sourced to an approved location. The quality of all fill material shall be to the approval of the Owner.

6.2.3.5.4 Method statement

At least 7 days before starting the earthworks, the Contractor shall submit to the Owner his method statement for placing and compacting the fill material without segregation for approval.

6.2.3.5.5 Mechanically placed fill and compaction

Fill material shall be placed evenly in layers not exceeding 250mm compacted thickness. Each layer shall occupy the full width of the area to be filled including any side slopes and shall be compacted in a regular pattern so that all parts of the area receive the full amount of compaction specified. The spreading of a layer pattern so that all parts of the area receive the full amount of compaction specified. The spreading of a layer shall be carried out as soon as practicable after the previous layer has reached the degree of compaction specified. The fill material shall be compacted at its optimum moisture content to a tolerance as agreed by the Owner. The in-situ density shall be determined and the dry density in accordance with IS 2720: Part 38 in accordance with IS 2720: Part 28 & IS 2720: Part 29.

Fill placed in the dry shall when necessary be watered by spraying, but the Contractor shall arrange his operations so as to make the best use of the natural moisture content of the fill material to obtain the maximum in-situ density.

Any side slopes of filled areas shall be slightly overfilled when placing and compacting, and afterwards trimmed back to the correct profile in such a manner that fully compacted material extends out to the face.

6.2.3.5.6 Fill near structures

The soluble sulphate content of any fill material used within 500mm of concrete structures shall not exceed 1.9g of sulphate (expressed as SO₄) per litre, when tested in accordance with IS 2720: Part 27.

The total sulphate content (expressed as SO₄) of any fill material used within 500mm of metallic items forming part of the Permanent Works shall not exceed 0.5% by mass when tested in accordance with relevant IS code or equivalent international code.

When placing fill material adjacent to structures, the surface level of the fill material around the perimeter shall at no stage vary by more than 0.5m. The fill material shall be carefully compacted right up to the structure, using a vibrating plate compactor or other suitable compactors in places where the main equipment cannot operate.

6.2.3.5.7 Compacting near formation level

The in-situ density of all fills placed under this contract shall exceed 95% of the maximum dry density.

A series of 5 in-situ density tests shall be carried out daily, or for each 250m³ of fill material placed or at such other intervals as the Owner may determine. At least 9 out of the 10 test results shall be not less than the specified density, and no result shall be less than 92% of the maximum dry density. If such tests disclose an insufficient degree of compaction, the Contractor shall take all suitable measures to achieve the required compaction and shall, if necessary, excavate the fill material in the defective areas and replace it so that the specified compaction is achieved, or carry out such other remedial action as the Owner may instruct.

6.2.3.5.8 Filling and compaction in trenches and pits

Unless a particular surround and backfilling sequence is specified for a pipe, back fill to pipe trenches shall be carefully deposited and thoroughly consolidated by ramming in layers not exceeding 150 mm thick around and over the pipes up to a height of 300mm over the pipes using suitable material. Thereafter the fill shall be returned to the trench and thoroughly consolidated by vibrating plate compactor in layers not exceeding 150mm.

Backfilling in pits and trenches other than pipe trenches shall be in suitable material and consolidated by vibrating plate compactor or power operated rammer in layers not exceeding 150mm.

In pipe trenches the sheeting within the depth of the bedding must be carefully withdrawn clear of the bedding (and concrete arch) before backfilling is commenced and must be further withdrawn in stages as the backfilling is carried out. At no time during the withdrawal of the sheeting shall the pipe be allowed to settle below the required level and every care shall be taken to ensure the even distribution of the bedding into the void left by the removal of the sheeting.

6.2.3.5.9 Fill, backfill and compaction for roadways and embankments

6.2.3.5.9.1 *Fill and backfill*

Subbase course

- Place subbase course material on approved subgrade in layers of uniform thickness, conforming to indicated cross-section and thickness.
- Maintain optimum moisture content of $\pm 2\%$ for compacting subbase material during placement operations.

Shoulder

- Place shoulders along edges of subbase course. Construct shoulders of acceptable soil materials; place such quantity to compact to thickness of each subbase course layer.
- Compact and roll at least a 300mm width of shoulder simultaneously with compacting and rolling of each layer of subbase course.
- Compact each layer of subbase to 100% of maximum dry density and field tested as determined in accordance with IS:2720.

Finish tolerances

- Shape surfaces of areas under pavement to line, grade cross-section with finished surface not more than 20mm above or below the required subgrade elevation for pavement thickness over 250mm and 10mm for pavement having thickness less than 250mm.

Clearances

- When pipes, conduits, culverts or ducts are required within road embankment areas, embankment shall either be constructed and essentially completed in advance of such work, or the embankment shall be constructed to a subgrade height at least 600mm or higher above the top of pipe, conduit, culvert or duct.

Settlement period

- Where a settlement period is shown on the Contract Drawings or otherwise specified, the permanent fill shall be constructed to full height and to the other limits shown or specified and shall remain in place for the required settlement period before commencing construction of foundations or placing other layers of materials on the fill surface.
- Where a settlement period for a surcharged permanent fill is shown on the Contract Drawings or otherwise specified, the surcharge fill shall be constructed to the height and to the limit shown or specified. The surcharge fill shall remain in place until the end of the settlement period shown or specified.
- Where settlement periods are required, permanent fill and surcharge fill shall not encroach upon travelled ways or upon existing improvements that are subject to damage and, if necessary, the Contractor shall furnish and install bulkheads or whatever means may be necessary to retain the fill material in place.

6.2.3.5.9.2 Compaction

Cut areas and natural ground (where construction is to be accomplished)

- Scarify and compact the top 150mm of cut roadway to 95% dry maximum density or 75% relative density.

Under pavements and shoulders

- Compact top 300mm of subgrade and each 200mm loose layer of base course fill and each layer of subgrade fill to 100% maximum dry density or 78% relative density.

Compact of stone surfacing

- Stone surfacing, where required, shall be spread over the prepared subgrade to required thickness to conform to lines and elevations shown on the Contract Drawings.
- The final surface shall be rolled until stone is thoroughly interlocked and creeping of the stone layer ahead of the roller is not visible.

6.2.3.5.10 Settlement

The Contractor shall make good and compact surface in an approved manner with fill material or other suitable material as approved by the Owner, all settlement that may

occur defects in the Permanent Works due to settlement shall be made good by the Contractor.

6.2.4 Codes and references

Standards and other codes referred to in this section are as follows:

- IS 2720: – Method of test for soils.
 - : Part 3 (Sec-2) Determination of specific gravity of fine, medium & coarse-grained soil
 - : Part 8 Determination of water content-dry density relation using heavy compaction.
 - : Part 5 Determination of Liquid & Plastic Limit
 - : Part 27 Determination of total soluble sulphate
 - : Part 28 Determination of Dry Density of Soils in place by soil replacement method
 - : Part 29 Determination of Dry Density of Soils in place by core cutter method
 - : Part 38 Compaction control test.
- Specifications for road and bridge works by Ministry of Road Transport & Highways (MORTH)
- IRC:36 – Recommended practice for construction of earth embankments and subgrade of road works

6.3 Precast Interlocking Concrete Blocks Pavement

The precast interlocking Concrete Block Pavement shall be conforming to IRC SP 63.

6.3.1 Materials

6.3.1.1 General

The quality of materials, cement concrete strength, durability, and dimensional tolerances, etc. are of great importance for the satisfactory performance of block pavements. These aspects and the block manufacturing process itself, which immensely influences the quality of paving blocks, are broadly outlined in the subsequent paragraphs. The desired engineering properties of bedding / jointing and layer beneath the block, the base course and sub-base materials are also described.

6.3.1.2 Salient Mix Design Aspects

The commonly used processes for the manufacture of pre-cast cement concrete paving units require dry, low-slump mixes. The desired characteristics of the mix are as under:

Water/cement ratio: 0.34 to 0.38

Water content of the mix: 5 to 7% of total mix

Quantity of cement in mix: Generally, not less than 380 kg/m³ depending on the equipment being used for block making. Upper limit of cement shall not be more than 425 kg/m³ Fly ash also can be used in the mix, replacing Ordinary Portland Cement to an extent of 35 per cent. The above values are for general guidance only. The actual mix design has to be made to suit each individual requirement.

Aggregate/cement ratio: 3:1 to 6:1

Aggregates: Should be sound and free from soft or honeycombed pieces. The proportion of coarse aggregate in the mix is typically 40 per cent and the fine aggregate (sand) 60 per cent. The size of coarse aggregate should lie between 6 mm and 12 mm and the gradation should be in the recommended range for cement concrete mixes in general.

Strength: In general terms, the paving block must have adequate strength to withstand handling, construction stresses and effects of traffic, though the strength as such is not considered a vital factor in the satisfactory performance of a block pavement. However, it is suggested that the minimum compressive strength of a single block should be above 50MPa.

Addition of Pigments: To provide the desired colour to paving blocks, appropriate type and amount of pigments are added during mixing, in the form of powder or slurry. Although organic pigments render brighter colours than inorganic pigments, the former are adversely affected by the alkaline environment of concrete and do deteriorate with time. Inorganic pigments, mostly metal oxides, are more durable and hence preferred for consistency and purity. Saturation of colour takes place with a pigment volume of around 5 to 9 per cent of cement content. Pigments should be finer than cement (fineness value between 2 and 15 m²/gm). For the same slump, addition of pigments requires increase in mixing water, which in some cases may lead to lowering of flexural and compressive

strength of concrete; therefore, suitable adjustments in mix proportions may become necessary.

Other Additives: Under special circumstances, super-plasticizers at around 0.4 per cent of cement by weight may be added for high early strength. Water repellent admixtures of calcium stearate are sometimes used to reduce water absorption. Air entraining agents, when added to the mix, cause some reduction in the needed amount of cement. Further reduction is achieved by substituting part of the cement with blast-furnace slag or pozzolanas like fly ash; besides reducing cost, these also control "efflorescence" (surface deposition of salts as a result of water movement upwards).

6.3.1.3 Manufacture of Paving Blocks

The method of manufacture of paving blocks has an important bearing on the quality, durability, and level of finish - dimensional tolerance, etc. all of which reflect on the ultimate performance of the block pavement during service. At the very outset, therefore, it is to be emphasized that hand-casted concrete blocks are unacceptable for use and that an appropriate plant should be used which would make it possible to apply high pressure together with controlled vibration. Adaptation of production facilities designed for high quality hollow masonry blocks, though feasible, is not as economical and as efficient as the use of purpose designed machinery for paving block manufacture. Essentially, the manufacturing process involves compacting concrete, in a steel mould clamped to a vibrating table, by hydraulic pressure.

Concrete is fed into the mould from a hopper by a drawer - if a second hopper is added, a block can be made of two kinds of concrete having "backing" and "facing" surfaces. In the "facing" of the block, the top 5 mm has greater amounts of cement and sand to make it more durable and skid resistant and extra pigment is added for the coloured face vis-a-vis the rest of the block. In the first stage of compaction, pre-vibration is affected by running the vibrators attached to the vibratory table, the frequency generally being in the range of 50 to 100 Hz. In the second stage of compaction, compression pressure is applied to the tamper heads, also fitted with vibrators for a high level of surface finish. Blocks are extruded from mould by forcing down the tamper heads, after the vibrating table is disengaged from the mould. The blocks thus prepared are stacked either in a single layer or multiple layers for curing, depending on the plant used being single layer or multi-layer.

6.3.1.4 Dimensional and other Requirements of Paving Blocks

For normal paving work, the length of a paving block should ordinarily be not greater than twice the mean width; the thickness is a minimum of 60 mm; the maximum length generally not exceeding 280 mm; the width generally is in the range 75 to 140 mm with a maximum chamfer of 10 mm (preferably chamfer should be in the range 3-5 mm). The sides of the block should be perpendicular to the top and bottom faces except that the top edge may be chamfered. The blocks should have the following dimensional tolerances:

Plan dimensions: ± 2 mm

Thickness: ± 3 mm

To ensure durability, the average water absorption in a block should not exceed 5 per cent; and for cold regions in a standard freeze-thaw durability test, the weight loss should not exceed 1 per cent.

In situations, where parts of blocks are to be used e.g., around manholes, the block should be purpose-cut at site.

It is to be recognized that variations in the thickness of blocks used for a paving job can be a major cause for the loss of surface profile. In the interest of maintaining a good surface profile, the block thickness should be controlled carefully; this can be done to advantage by adopting multi-layer method of manufacture of paving blocks, which reduces the variation in block thickness.

6.3.1.5 Bedding Sand

It is well established that if proper attention is not paid to the quality of bedding sand, and if the thickness of the bedding sand layer is not uniform enough, serious irregularities in surface profile can result; excessive differential deformation and rutting can occur early in service life of the block pavement. The desired gradation of bedding sand should be as per mentioned in Sec. 6.3.4.2.

Care should be taken to see that single-sized or gap graded sands or sands with excessive amount of fines or plastic fines should not be used. The shape of sand particles should preferably be sharp rather than rounded since the sharp sands possess higher strength and resist the migration of sand from under the block to less frequently trafficked areas. Even though sharp sands are relatively more difficult to compact than rounded sands, the use of sharp sands should be preferred for the more heavily trafficked pavements. The bedding sand should be free of deleterious materials.

6.3.1.6 Joint Filling Sand

The gaps in between two paving blocks (typically about 2-3 mm wide) need to be filled by sand relatively finer than the bedding sand. The desired gradation for the joint filling sand is as per mentioned in Sec. 6.3.4.2.

It is necessary to restrict the fines (silt and/or clay) to 10% since excessive fines make joint filling very difficult. Similarly, it is not advisable to use cement in the joint filling sand which will not only make it difficult to completely fill the joints but would also adversely affect the desired flexibility characteristics of the paving block layer. The joint filling sand should be as dry as possible; otherwise, complete filling of joints will be difficult. To overcome the problem of efflorescence on the surface of paving block layer, the joint filling sand should be washed to remove soluble salts.

6.3.2 Construction

6.3.2.1 Deleted

6.3.2.2 Preparation of Subgrade

This is the foundation layer on which the block pavement is constructed. Like in conventional pavements the water table should be at a minimum depth of 600 mm below the subgrade. Subgrade should be compacted in layers of 150 mm or 100 mm thickness

as per IRC:36-2010. The prepared subgrade should be graded and trimmed to a tolerance of ± 20 mm of the design levels, and its surface evenness should have a tolerance of within 15 mm under a 3 m straight edge. Compact top 300mm of subgrade and each layer of subgrade fill to 97% maximum dry density.

6.3.2.3 Base and Sub-base Course

Base and sub-base courses are constructed in accordance with standard procedures contained in the relevant IRC Specifications, like, IRC:37-2018, IRC:50-1973, IRC:51-1993, IRC:63-1976, IRC:19-2005. When cement bound base are proposed it may be constructed using rolled lean concrete as per IRC: SP:49-2014. The quality control specified in IRC: SP:11-1984 shall apply. Constructing the layers to proper level and grade is very essential to maintain the level and surface regularity of the block pavement.

6.3.2.4 Placing and Screeding of Bedding Sand

The thickness of the sand bed after compaction should be in the range of 20-40 mm, whereas, in the loose form it can be 25 to 50 mm. It is preferable to restrict the compacted thickness to 20-25 mm to reduce the risk of any localized pre-compaction, which would affect the final block surface level. Bedding sand should not be used to fill-up local depressions on the surface of a base or subbase. The depressions should be repaired in advance before placing sand.

Sand to be used should be uniformly in loose condition and should have a uniform moisture content. Best moisture content is that when sand is neither too wet nor too dry and have a value of 6 to 8%. Requirement of sand for a day's work should be prepared and stored in advance and covered with tarpaulin or polythene sheets.

The processed sand is spread with the help of screed boards to the required thickness. The screed boards are provided with nails at 2-3 m apart which when dragged gives the desired thickness. The length of nail should take into account the surcharge to be provided in the uncompacted thickness. Alternatively, the screed can be dragged on edge strips kept on both sides as guide. Asphalt paver can be employed in large projects.

The sand is subsequently compacted with plate vibrators weighing 0.6 tonnes or more. Level checks shall be carried out on a grid pattern to establish that the desired level is achieved. Local correction can be done either by removing or adding extra sand followed by levelling and compacting the layer. There will be some settlement of sand after the blocks are placed and compacted, which must be allowed for, while fixing the level of sand bed.

6.3.2.5 Laying of Blocks

Blocks can be laid generally by manual labour but mechanical aids like hand-pushed trolleys can expedite the work.

Normally, laying should commence from the edge strip and proceed towards the inner side. When dentated blocks are used, the laying done at two fronts will create problem for matching joints in the middle. Hence, as far as possible, laying should proceed in one direction only, along the entire width of the area to be paved.

While locating the starting line, the following should be considered:

- On a sloping site, start from the lowest point and proceed uphill on a continuous basis, to avoid downhill creep in incomplete areas.
- In case of irregular shaped edge restraints or strip, it is better to start from straight, string line.
- Influence of alignment of edge restraints on achieving and maintaining laying bond.

6.3.2.6 Bonds or Patterns of Laying Blocks

The blocks can be placed to different bonds or patterns depending upon requirement. Some popular bonds commonly adopted for block paving are:

- Stretcher or running bond
- Herringbone bond
- Basket weave or parquet bond

6.3.2.7 Establishing the Laying Pattern

In relation to the starting line, the blocks should be placed at the correct angle to achieve the final orientation as required by the laying pattern. If the edge restraint is straight and suitably oriented, the first row of blocks can abut it. For irregular-shaped and unfavourably oriented edge restraints, a string line should be established a few rows away to position the first row.

With the help of gauges, the joint width specification (2 to 4 mm) should be checked in the first few square metres, where it should be ensured that the block alignment is correct. The laying patterns and face should be established to permit fast and easy laying without the necessity of forcing a block between previously positioned blocks. To start with, full blocks should be used; only subsequently, cutting and in-filling at edges be permitted. Under no circumstances should the blocks be forced or hammered into the bedding sand at this stage of laying. For cutting paving blocks, hydraulic or mechanical block cutters, or power saws are used. Cut units less than 50 mm minimum dimension should not be used, as these are difficult to cut accurately and can be dislodged under traffic. Where space does not permit use of a larger segment, use premixed concrete or a sand-cement mortar instead. The control over alignment, laying pattern and joint widths can be maintained by the use of chalked string lines, at about 5 m intervals.

6.3.2.8 Methods of Construction of Block Pavement

6.3.2.8.1 Mechanised Methods

Mechanised laying requires the use of specialised equipment for transporting and placing clusters of paving blocks. The size of paving block cluster suitable for paving, is usually 0.3 to 0.5 m² in area for hand-operated equipment; for fully mechanised equipment, the cluster surface area can be up to about 1.2 m². These clusters are designed to maintain a joint space of about 3 mm between blocks, when clamped together.

Since the blocks are placed in separate clusters, there exists the possibility of damage if joints between adjacent clusters run uninterrupted throughout the pavement. To overcome this problem, clusters may be arranged so that the joints are periodically

staggered both along and across the cluster axis or link blocks are installed by hand across these joints.

Mechanised laying must be coordinated with the manufacturer, so that the blocks are delivered stacked on pallets in the required pattern; in some cases, spacing ribs may be cast on the sides of blocks to preserve the required joint spacings.

6.3.2.8.2 Compaction

For compaction of the bedding sand and the blocks laid over it, vibratory plate compactors are used over the laid paving units; at least two passes of the vibratory plate compactor are needed. Such vibratory compaction should be continued till the top of each paving block is level with its adjacent blocks. It is not good practice to leave compaction till end of the day, as some blocks may move under construction traffic, resulting in the widening of joints and corner contact of blocks, which may cause spalling or cracking of blocks. There should be minimal delay in compaction after laying of the paving blocks to achieve uniformity of compaction and retention of the pattern of laying; however, compaction should not proceed closer than 1 m from the lying face, except after completion of the pavement.

During vibratory compaction of the laid blocks, some amount of bedding sand will work its way into the joints between them; the extent of sand getting worked up into the joints will depend on the degree of pre-compaction of sand and the force applied by the block compactor. Standard compactors may have a weight of about 90 kg, plate area of about 0.3 m² and apply a centrifugal force of about 15 kN, while heavy duty compactors may weigh 300-600 kg, have a plate area of about 0.5-0.6 m² and apply a centrifugal force of 30-65 kN. Where the bedding sand has been pre-compacted and for heavily trafficked block pavements, heavy duty compactors should be used. After compaction by vibratory plate compactors, some 2 to 6 passes of a vibratory roller (with rubber coated drums or those of static weight less than 4 tonnes and nominal amplitude of not more than 0.6 mm) will further help in compaction of bedding sand and joint filling.

6.3.2.8.3 Joint filling

The importance of complete joint filling cannot be over-emphasised. Unfilled or partially filled joints allow blocks to deflect, leading to loose blocks, possibly spalling the edges and a locally disturbing bedding sand layer.

After the compaction of the bedding sand has been completed (and some bedding sand has been forced up in the joints between blocks), the joints should be completely filled with sand meeting the desired specifications, as given in Section 6.3.1.6. The joint filling sand should be stockpiled at suitable locations for convenience. There should be minimum delay in joint filling; the process should in any case, be completed by the end of the day's work.

The operation of joint filling comprises of spreading a thin layer of the joint filling sand on the block surface and working the sand into each joint by brooming. Following this, a few passes of heavy plate compactor are applied to facilitate fine sand to fill the joints. The sand should be broomed or spread over the surface with a small surcharge.

Dry sand and dry blocks are best for the filling of joint, as damp sand tends to stick at the very top of the joints; also, if the blocks are wet and the sand dry, the sand will again

stick at the joint top. Hence, if either the blocks or sand are wet, one may get a false impression of the joints being full, but the next rain will reveal that they are actually hollow. If the weather does not allow sand and blocks to be dry, the joint filling sand should be washed in by light sprinkling of water. In this case, several cycles of application of sand, water-sprinkling and plate compaction will be necessary to completely fill the joints.

6.3.2.8.4 Opening to traffic

Until all the joints are filled completely, no traffic should be permitted over the block pavement. In case of lime or cement treated layers in the pavement, it must be ensured that these are given at least 14 and 7 days respectively to cure, before traffic is permitted. The block pavement should be inspected frequently, to ensure that any incompletely filled joints, exposed by traffic and/or weather are promptly filled. Such frequent inspection should be continued till dust and detritus from the roadway tightens the surface of the joints.

6.3.2.8.5 Laying and Surface Tolerances

While the laying, the surface tolerances, given below may be observed:

Layer/Item	Tolerance
Subgrade	+/-25 mm of nominated level
Select subgrade/Sub-base	0 to -10 mm of nominated level
Base Course	0 to +10 mm of nominated level 10 mm deviation from a 3 m straight edge
Plan deviation: from any 3 m line from any 10 m line	10 mm (maximum) 20 mm (maximum)
Vertical deviation from 3 m line at kerbs intrusions, channels, edge restraints elsewhere	+3 mm, 10 mm
Maximum difference in surface level between adjacent paving units	+10 mm, -15 mm
Deviation of finished surface level from designated level	+10 mm, -15 mm
Joint width range	2 mm to 4 mm
Percentage of joints outside range	10% max. along 10 m line

6.3.2.8.6 Detailing block pavements

Essentially, there are three important aspects in detailing as given below :

- Curves
- Treatment of intrusions, and
- Changes in alignment.

Curves: It is necessary to cut the paving units to fit the edge restraints. Rectangular blocks of a similar or contrasting colour as an edging have been used to minimise the visual effects of small errors in block cutting. To avoid unsightly and potentially weak

construction joints, it is often preferable to change the laying pattern at the curve. For example, the curve itself can be installed in herringbone bond and yet the pavement can revert to stretcher bond on the approaches.

Pavement intrusions: On some pavements, like in city streets, there could be several intrusions, like, manholes, drainage gulleys, etc. where mating these intrusions with the pavement is desirable. Around intrusions, it is good practice to lay along both sides of the intrusion simultaneously so that closure is made away from the starting workface, rather than carrying the pavement around the intrusion to return to the original -laying face to avoid accumulation of closing error.

Changes in alignment: Changes in alignment of a road pavement can sometimes be achieved by the use of special blocks. However, it is generally easier to choose a block that can be installed in herringbone bond and simply cut the blocks to fit the edge restraints. Where aesthetic requirements or shape of the paving unit dictate the use of stretcher bond, then only a 90° shape change in alignment can be achieved without cutting the blocks. At intersections, if a herringbone bond laying pattern is adopted, the paving can proceed without the need for construction joints. An alternative to this is to install a shoulder (support) course of rectangular paving units between the main roadway and the side streets; this permits different laying patterns to be used in the two roadways.

6.3.3 Maintenance

6.3.3.1 General

The block pavement requires initial maintenance soon after its laying, say after a week or two for checking sand in the joints. Subsequently, the maintenance is in the form of replacing any damaged block/blocks or raising the settled section, if any.

6.3.3.2 Initial Maintenance

After about a week of laying the blocks there is a need to inspect the surface to check for any loss of sand at joints. Wherever sand level has dropped down it should be reinstated. This type of inspection should continue for two to three months till the sand level is stabilized and topping up is no more required. With time the joints receive fine dust and detritus thus making them waterproof.

6.3.4 Laying of Concrete Paving Blocks

6.3.4.1 Base

The Finished surface of the concrete base shall match the design profile of the concrete blocks within ± 10 mm.

Compaction shall be done with vibratory roller. In restricted areas where normal rollers cannot operate, hand-held or plate vibrators should be employed.

6.3.4.2 Bedding Sand Layer

The bedding sand layer shall be from either a single source or blended to achieve the following grading.

IS Sieve Size	Per cent Passing
9.52 mm	100
4.75 mm	95-100
2.36 mm	80-100
1.18 mm	50-95
600 micron	25-60
300 micron	10-30
150 micron	0-15
75 micron	0-10

Single sized, gap-graded sands or those containing an excessive amount of fines will not be used. The sand particles should preferably be angular type.

The joint-filling sand should pass a 2.35 mm sieve and be well graded. The following grading is recommended:

Sieve Size	Percent Passing
2.36 mm	100
1.18 mm	90-100
600 micron	60-90
300 micron	30-60
150 micron	15-30
75 micron	0-10

The use of cement in the joint-filling sand is not recommended as a general practice as the cemented sand is likely to crack into segments which are easily dislodged.

Average thickness of this laying course shall be 20 to 40 mm.

The sand should be slightly moist, and the moisture content shall be about 4 per cent by weight.

It should contain not more than 3 per cent by weight of clay and silt and the materials shall be free from deleterious salts or contaminants.

The finished surface of the bedding layer shall match exactly the design profile as indicated on the drawings.

Before placing the bedding layers, the surface of concrete should be cleared by sweeping.

Walking or driving on the finished surface of the bedding layer shall not be permitted.

6.3.4.3 Concrete Paving Blocks

Laying of the blocks shall be done, precisely at the indicated level and profile and in a way that a good surface draining to the gulley chambers is assured.

Around gulley chambers and inspection pits the pavement shall have a level of 5 mm higher than the above-mentioned elements.

The blocks shall be laid to the pattern directed by the Engineer, or the pattern recommended by the designer. The blocks shall be laid as tight as possible to each other. The maximum joint width shall be limited to 3 mm.

Laying of broken blocks is not allowed except along connections or edges. The maximum length of a purpose broken block is 100 mm. Breaking of the blocks shall be done with a "block splitter" or a mechanical saw.

Fine angular sand as per specification shall be brushed into the joints, and thereafter compaction shall be done with a vibrating plate compactor on a clean surface. After compaction, again fine angular sand shall be brushed into the joints.

6.3.4.4 Surface Tolerances

Surface tolerance for finished surface shall be ± 5 mm from the design level.

The surface tolerance for base course shall be in the range of 0 to +10 mm from nominated level and 10 mm deviation from a 3 m straight edge.

The surface tolerance for sub-base shall be within 0 to 20 mm of nominated level.

6.3.5 Field/laboratory tests

The field/laboratory tests shall be conducted by the Contractor at his own cost in an Engineering College/ approved technical institution as directed by the Engineer.

6.4 PVC Coated Chain Link Fence with Precast Concrete Poles

6.4.1 New Chain Link Fence

6.4.1.1 Precast RCC Posts & Struts

All posts and struts shall be of standard size of 150 mm x 150 mm, the length of posts being 1.5 m above ground (Total length 2.1 m) or as specified and that of struts being minimum of 1.7 m above ground. A tolerance of 12 mm in length and 3 mm in other dimensions shall be permissible. These shall be precast cement concrete M30 reinforced with steel bars without any honeycombs as directed and finished smooth with cement mortar 1:2 (1 cement: 2 fine sand) conforming to IS:456. The specifications for R.C.C. work shall apply. These posts and struts shall have 10 mm dia. holes @ 300 mm c/c along their lengths. The posts and struts shall be free from cracks, twists, and such other defects. G.I. staples on wooden plugs or 6 mm bar nibs shall be provided as directed by Engineer-in-Charge while casting the posts.

6.4.1.2 PVC coated GI Chain Link Fabric Fence

PVC coated GI chain link fabric fence shall be conforming to IS: 2721-2003. The mesh wire and the line wire of the fabric shall be manufactured from galvanized steel wire conforming to IS: 280-2006, having a tensile strength within the range of 400 to 550 MPa. The fabric shall be provided with heavily coated galvanized line wires to act as additional selvage to strengthen the fabric when used for fencing purposes or as per the requirement of the Employer. The line wire may be supplied separately in coils/bundles/cut lengths to be used for fencing purposes. The line wires are required to be inserted after erecting the fabric with straining posts. Two number of line wires for fabric of height up to 1.50m to be provided one each at top and bottom of the fabric. Three numbers of line wires for fabric of height 2.5 m and more to be provided one each on top, middle and bottom of the fabric.

PVC coated GI chain link fence shall be 1.50m high having the diagonal opening (Diamond Shape) of mesh size 50mm x 50mm in both ways or specified otherwise of approved brand and made of poly coated 3.15mm GI wires and PVC coated of green colour or shade. The chain link fence fabric shall have zinc coating of type 'heavy' as given in IS:4826 or in IS:12753. Total Dia of the GI wire with the PVC coating shall be 4mm.

The chain link shall be of approved make and shall be got approved by the Engineer-in-Charge before incorporation in the work and as directed by the Engineer in Charge.

Any damaged or inferior material shall be rejected and must be replaced by a new one to the satisfaction of the Engineer-In-Charge, by the Contractor at his own cost.

6.4.1.3 Spacing of Posts and Struts

The spacing of posts shall be minimum three metres centre to centre, unless otherwise specified, or as directed by the Engineer-in-Charge to suit the dimensions of the area to be fenced. Every 100m, last but one end post and corner posts shall be strutted on both sides and end posts on one side only, unless shown otherwise. Struts shall also be provided at the locations where the fencing is diverting from its main alignment.

6.4.1.4 Fixing of Posts and Struts

Pits 40 cm x 40 cm and 85 cm deep or as directed shall first be excavated true to line and level to receive the posts. In the case of struts, pits 70 cm x 40 cm x 85 cm deep or as directed shall be excavated to suit the inclination of the strut so that it is surrounded by concrete by not less than 15 cm at any point. The pits shall be filled with a layer of 15 cm thick M30 cement (6 graded stone aggregate 40 nominal size). The posts and struts shall then be placed in the pits, the posts projecting to the specified height above ground, true to line and position. The M30 cement concrete shall be filled in up to 5 cm for posts and 10 cm for struts below ground level at the base of the concrete so that the posts are embedded in the cement concrete block of size 40 cm x 40 cm x 50 cm and strut in block of size 70 cm x 40 cm x 50 cm. The concrete in foundations shall be watered for at least 7 days to ensure proper curing. The remaining portions of pits shall be filled up with excavated earth and the surplus earth disposed of as directed by the Engineer-in-Charge and the site cleared.

Supporting Pole to be fixed with Main pole thoroughly with 50mm wide GI Strip along both ends rigidly with 10mm dia. GI Bolt.

6.4.1.5 Fixing of PVC coated GI Chain Link Fabric Fence

The PVC coated GI chain link shall be stretched and fixed in specified width, strengthening with line wires or nuts bolts & washers as required to be done complete as per the direction of Engineer-in-Charge. Top & bottom edge lining should be secured tightly with PVC coated 4mm dia. stretched GI straight wires.

Chain fencing shall be secured between respective concrete posts by 2100mm x 50mm x 4mm GI strips, 10mm dia. threaded bolts, washers & nuts as mentioned in the drawings or technical specifications. Bolts, nuts & washers shall be of galvanized to a min. 80micron coating.

The PVC coated chain link shall be held to the R.C.C. posts by means of G.I. staples fixed to wooden plugs or G.I. binding wire tied to 6 mm bar ribs fixed while casting the posts. Turn buckles and straining bolts shall be used at the end posts.

6.4.1.6 Project Technical Specifications

These specifications shall be read in conjunction of The Project Technical Specifications such as for Steel work including fabrication, welding, connections, earthwork, plain & reinforced concrete, reinforcement, masonry etc whichever are relevant and applicable.

6.4.1.7 Measurements

The length of the finished work PVC coated chain link fence shall be measured in a running meter correct to a cm. Quantity of RCC post and struts to be measured in numbers.

6.4.1.8 Rate

The rate shall include the cost of supply, transportation, installation, labour, manpower and materials, and PPE, tools, tackles & equipment involved in all the operations described above including the cost of posts with holes, struts, turn buckle, straining bolts,

all necessary accessories & fittings, excavation, backfilling, and concrete in foundations etc complete in all respect to the satisfaction of the Engineer-In-Charge.

6.4.2 Removal and Rerouting of Existing Chain Link Fence

The Contractor shall remove the existing chain link fence inside the proposed Ro-Ro Yard area, fence posts with attached accessories, fittings, anchor plates, and foundation block as indicated on the drawings, from the site of work and disposed of properly or reuse the same in a manner approved by the Engineer. All other trash and debris generated in the performance of the work shall also be removed and disposed of properly. The Contractor shall make all the efforts to remove the fencing in such a manner that the fencing with good condition can be reused wherever to the extent possible.

The Contractor shall comply with the HSE requirements. It is the intent of this specification to dismantle, remove and dispose of an existing fence. The contractor is responsible for furnishing all supervision, labour, equipment, tools, and incidentals necessary to complete the work.

The Contractor shall be required to protect existing structures/facilities/utilities such as pipelines, power lines, buildings, gates etc. which may be located in the project area. The Contractor shall be required to repair or replace such existing structures/facilities/utilities if damaged as a result of their operations.

6.4.2.1 **Mode of Measurement and Rate**

The quantity to be paid for shall be the number of linear meters of chain link fencing removed and disposed of regardless of height, measured along the top of the fencing, in accordance with the drawings and as directed by the Engineer.

The separate payment shall not be made towards any quantity or number of fence post & struts, either steel or concrete, removed and disposed of in accordance with the drawings and as directed by the Engineer.

The unit price per linear meter for the removing and disposing of the chain link fence shall include the cost of furnishing all supervision, labour, manpower, tools, tackles, equipment, PPE, and materials necessary to complete the work of removing and disposing existing fence and posts & struts including its transportation. Any damage caused by the Contractor's operation to the existing structures & appurtenances to remain and/or the surrounding areas shall be repaired/replaced by the Contractor as directed by the Engineer, at no cost to the Employer. Rate shall be inclusive of removal and rerouting of the complete fencing with all means and staking at the desired location within the port premises as directed by the Engineer in charge.

6.5 Reinforced Concrete

6.5.1 General

6.5.1.1 Codes of Practice

The provisions of IS 456 shall be generally applicable to the Works. Concrete shall be a designed mix unless specifically stated otherwise. Specific list of codes applicable is given in section 6.5.4.

6.5.2 Product

6.5.2.1 Designed mixes

The Contractor shall select the mix proportions of the designed mix in order to satisfy the strength and other requirements of the contract. These requirements are detailed in the schedule of mixes, Table 6-5 of this specification. This table specifies various classes of design mixes which are to be interpreted as follows:

- Mix Design A1 – For all lean concrete M15.
- Mix Design C1 – For all mass concrete M30.
- Mix Design D1 – For all reinforced concrete M30.

Table 6-5: Schedule of Design Concrete Mixes

Mix reference	A1	C1	D1
Use:	Lean Concrete	Mass Concrete	Reinforced Concrete
Characteristic strength N/mm ²	15	30	30
Nominal max. aggregate size mm	20	40	20
Cement-type	Refer Cl. 6.5.2.2.2	Refer Cl. 6.5.2.2.2	Refer Cl. 6.5.2.2.2
Standard (grade 43)			
Min cement content(kg/m ³)	240	300	330
Max cement content(kg/m ³)	450	500	500
Water/cement ratio			
Absolute max.	0.60	0.45	0.45
Nominal design	0.57	0.43	0.43
Type of coarse aggregate	Natural/crushed	Natural/crushed	Natural/crushed
Maximum chloride content by water cement %	N/A	0.1	0.1
Workability – slump(mm)	75+25	75+25	75+25

Mix reference	A1	C1	D1
Max temperature at placing (c)	N/A	32	32
Maximum sulphate content by Wt. cement %	N/A	4	4
Maximum alkali content of mix kg/m ³	N/A	3	3
Maximum drying shrinkage%	N/A	N/A	N/A
Impermeability to water			
DIN water penetration	N/A	N/A	N/A
ISAT BS 1881	N/A	N/A	N/A
Capillary rise	N/A	N/A	N/A

6.5.2.2 **Materials for concrete**

6.5.2.2.1 General

All materials which may be used in the Plain or Reinforced Cement Concrete Work shall be of standard quality conforming to IS or equivalent and shall have IS certification mark as far as possible unless otherwise approved by the Owner. The Contractor shall get all materials approved by Owner prior to its procurement and before actual use. The Owner shall have the right to determine whether all or any of the materials offered or delivered for use in the Works are acceptable. Any material brought to site and not conforming to specification and instruction of Owner shall be rejected and the Contractor shall have to remove the same immediately from site at his own expenses.

6.5.2.2.2 Cement

6.5.2.2.2.1 *General*

The cement used shall be ordinary Portland cement or Portland slag cement or Portland pozzolana cement conforming to relevant codes as specified in Section 6.5.4 of this document or as specified and /or directed by the Owner.

6.5.2.2.2.2 *Tests after delivery*

Each consignment of cement may, after delivery on the site and at the discretion of the Owner, be subjected to any or all of tests and analysis required by the relevant Indian Standard Specifications. Facilities for testing shall be provided by Contractor at his own cost.

6.5.2.2.2.3 *Storage on the site*

The cement shall be stored in a suitable weather-tight building and in such a manner as to permit easy access for proper inspection to prevent deterioration due to moisture and to minimize warehouse deterioration. Cement of different types and brands shall be kept in separate storage.

All accepted cement stored on the site shall be arranged in batches and used in the same order as received from the manufacturer. The Contractor shall maintain cement register in which all entries shall be completed day to day showing the quantities

received, date of receipt, source of dispatch, type of cement, etc. and the daily cement consumption on site also. The register shall be accessible to the Owner for his verification.

6.5.2.2.2.4 *Rejection of cement*

The Owner may reject any cement because of any tests thereof, notwithstanding the manufacturer's certificate. He may also reject cement which has deteriorated owing to inadequate protection from moisture or due to intrusion of foreign matter or other causes. Any cement which is considered defective by the Owner shall not be used and shall be promptly removed from the site of Work by the Contractors at his own expense.

6.5.2.2.3 *Aggregates for concrete*

6.5.2.2.3.1 *General*

Coarse and fine aggregates for concrete shall conform in all respect to IS: 383, "Specifications for Coarse and Fine Aggregates from Natural Sources for Concrete". Aggregates shall be obtained from a source known to produce those satisfactory for concrete. Aggregates shall consist of naturally occurring sand and gravel or stone, crushed or uncrushed, or a combination thereof. They shall be chemically inert, hard, strong, dense, durable, clean, and free from veins, adherent coatings and shall be of limited porosity.

6.5.2.2.3.2 *Deleterious material*

Aggregates shall not contain any harmful materials such as iron pyrites, coal, mica, shale or similar laminated materials, clay, alkali, soft fragments, seashells, organic impurities, etc. In addition to the above, for reinforced concrete, any material which might cause corrosion of the reinforcement and aggregates which are chemically reactive with the alkalis of cement shall not be used.

The maximum quantities of deleterious materials in the aggregates, as determined in accordance with IS: 2386 (Part-II) "Methods of Test for Aggregates for Concrete", shall not exceed the limits given in Table-I of IS: 383

6.5.2.2.3.3 *Coarse aggregates*

Coarse aggregate is aggregate most of which is retained on 4.75mm IS sieve. These may be obtained from crushed or uncrushed gravel or stone and may be supplied as single sized or graded aggregates given in Table-II of IS: 383.

The Owner may allow all-in-aggregate to be used provided they satisfy the requirements of clause 4.4 and Table-IV of IS: 383.

6.5.2.2.3.4 *Fine aggregates*

Fine aggregate is aggregate most of which passes 4.75mm IS sieve but not more than 10% pass through 150 micron IS Sieve. These shall comply with the requirements of grading zones I, II and III and given in Table-III of IS: 383. Fine aggregate conforming to grading zone IV shall not be normally used in reinforced concrete unless tests have been

made by the Contractor to ascertain the suitability of the proposed mix proportions and approved by the Owner.

Fine aggregate shall consist of natural sand resulting from natural disintegration of rock and which has been deposited by streams or glacial agencies, or crushed stone sand or crushed gravel sand. Sand shall be used yellow sand from the Dabholi area only.

6.5.2.2.3.5 *Sampling and testing*

In case of doubt the Owner may require the Contractor to carry out tests, at the Contractor's expense in accordance with relevant IS codes.

6.5.2.2.3.6 *Storage of aggregates*

The Contractor shall at all times maintain at the site of Work such quantities of aggregate as are considered by the Owner to be sufficient to ensure continuity of Work.

Each type and grade of aggregate shall be stored separately on hard firm ground having sufficient slope to provide adequate drainage to rainwater.

Any aggregate delivered to site in a wet condition or becoming wet at site due to rain shall be kept in storage for at least 24 hours to obtain adequate drainage, before it is used for concreting, or the water content of mix must be suitably adjusted as directed by Owner.

6.5.2.2.4 *Water*

Water used for concrete shall be clear and free from injurious amounts of Oil, Acid, Alkali, Organic matters, or other harmful substances in such amounts that may impair the strength or durability of structure. Potable water shall generally be considered satisfactory for mixing and curing concrete.

The Owner may require the Contractor to prove at latter's expense, that the concrete mixed with water proposed to be used should not have a compressive strength, lower than 90% of the strength of concrete mixed with distilled water.

The Owner may require the Contractor to get the water tested from an approved laboratory at his own expenses and in case the water contains any sugar or excess of acid, alkali, any injurious salts, etc. the Owner may refuse to permit its use.

6.5.2.2.5 *Admixtures*

Admixtures such CICO grade I or Fosroc or equivalent may be used in concrete only with the approval of Owner. The same shall be proved to be consistent with the mix design.

6.5.2.2.6 *Reinforcement*

6.5.2.2.6.1 *Mild steel bars*

The reinforcement shall normally be mild steel in the form of round bars, conforming to IS: IS: 432 - Grade 1 unless specified otherwise.

6.5.2.2.6.2 *Hard-drawn steel wire fabric*

When specified on the drawings, hard-drawn steel wire fabric shall be used conforming to IS: 1566 and IS: 432 (Part 2); it shall be of an approved type and of the weights and dimensions shown on the drawing.

6.5.2.2.6.3 *High yield deformed steel reinforcement*

Cold twisted high yield deformed steel bars shall conform to IS: 1786.

6.5.2.2.6.4 *Other bars and sections*

Any other type of reinforcement bars specified on the drawings shall conform to its respective Indian Standard Specification. Medium tensile steel bars when specified on the drawings shall conform to IS: 432.

6.5.2.2.6.5 *Test certificates*

The Contractor shall supply to the Owner a manufacturer's test certificate for each consignment of reinforcement delivered to the site, together with a delivery note stating the weight, number, length, dimension, and place of origin of the bars or fabric in each consignment.

6.5.2.2.6.6 *Samples of testing*

The Contractor shall, under the supervision of the Owner, cut samples from any of the reinforcing bars or fabric whenever directed and the Contractor shall dispatch such samples for testing as the Owner may want from time to time direct. Minimum sample length shall be 600 mm or 20 times the bar diameter whichever is greater.

6.5.2.2.6.7 *Binding wires*

All binding wire shall be galvanized steel wire no 16 SWG (1.6 mm diameter).

6.5.3 **Execution**

6.5.3.1 **Reinforcement**

6.5.3.1.1 **Welding**

Field welding of reinforcing bars will not be permitted without the written consent of the Owner. Where welding is permitted it must be at staggered locations. Tests shall be made to prove that the joints are of the full strength of bars connected. Welding of reinforcement shall be done in accordance with the recommendation of IS: 2751 and IS 9417.

6.5.3.1.2 **Storage**

All reinforcement shall be stored at least 300 mm off the ground. Bar or rod reinforcement shall be stored in suitable racks. Fabric shall be stored level on bearers to prevent distortion. Reinforcement shall be kept in a clean condition until it is required to be used.

6.5.3.1.3 **Cutting and binding**

Bar schedules

The preparation of bar schedules necessary for the approved method and sequence of construction including any additional reinforcement required will be the responsibility of the Contractor. The schedules shall be submitted to the Owner for approval before cutting or bending.

Cutting & bending

General construction details and workmanship relative to reinforcement including bar bonds, lap splices and installation shall be in accordance with IS: 2502 - Code of Practice for Bonding and Fixing of Bars for Concrete Reinforcement, as well as the detailing of reinforcement given in IS: 456.

Bars shall be cut and bent to the dimensions shown on the drawings and schedules in accordance with IS 2502.

All bars shall be cold bent by the gradual and uniform application of pressure such that the material is not damaged in any way. Heating of the bars shall not be permitted.

Tolerances

Tolerances shall be as specified in IS 2502.

Re-bending

Cold worked bars or hot rolled high yield bars shall not be straightened or bent again once having been bent. Where it is necessary to bend mild steel reinforcement projecting from the concrete, the internal radius of bend shall not be less than three times the diameter of the bar.

6.5.3.1.4 Fixing

Placing of reinforcement

The size, form, spacing and location of all steel reinforcement shall be in exact accordance with the drawings. The Contractor shall ensure that the reinforcement is fixed and placed correctly in all respects. Within a tolerance of +5 mm of the correct position, and that it shall not move in the forms during concreting. All ties, links, stirrups, etc., shall be taught and the bars properly braced and tied.

There shall be no direct connection between any reinforcement within a concrete member and any metalwork on the surface of the member, like embedded plates, bolts etc.

The Contractor shall provide all spacer bars, chairs and distance pieces necessary to retain the reinforcement in the correct position and to maintain a rigid reinforcement cage during concreting.

Binding wire

Binding wire shall be finished tight with the correct tools. The free ends of the binding wire shall be bent inwards away from the formwork.

Splices and laps

No splices or overlapping of reinforcement shall be made except where shown on the drawings or approved by the Owner. Unless otherwise shown on the drawings, the bars shall be provided with an overlap of not less than 40 diameters of the smaller bar. The gap between pairs of lapped bars shall not be less than the diameter of the larger bar or the maximum size of the concrete aggregate. Fabric reinforcement shall be fixed in position with lapped joints of at least two meshes and shall be securely bound to any supporting bars with binding wire.

Starter bars

Reinforcement temporarily exposed from the concrete such as starter bars, shall be continuously protected against corrosion before and after concreting manner to be approved by the Owner.

Tie bars

All reinforcement passing through a movement joint shall be protected with three coats of approved bituminous paint after cleaning and preparing the bars. The protection shall extend across the joint and a minimum of 25 mm into the concrete.

Surface preparation of reinforcement in broken out concrete

Any exposed reinforcement shall if directed by the Owner be de-greased with suitable solvent. Reinforcement shall then be grit-blasted to IS standard or BS-4232 second quality. The Contractor shall ensure that the reinforcement is cleaned as far as is practicable over the full circumferential area of the bar and shall use needle guns, wire brushes or other means to clean areas that are inaccessible for grit-blasting. All corrosion products including magnetite shall be removed. The period between completing cleaning of reinforcement and encasing in repair concrete shall be minimized and in no case exceed 48 hours.

Anti-corrosion protective agents shall not be used to protect cleaned reinforcement.

Inspection of reinforcement

No concreting shall be commenced until the Owner or owner's representative has inspected the reinforcement fixed and placed in position and given his written approval. Prior to concreting the reinforcement shall be washed with fresh water to remove any surface contamination and the formwork shall be free of surplus water before concrete is placed.

Cover

Concrete spacer blocks of the same strength as parent concrete shall be used to ensure correct cover to the reinforcement. This clear cover shall be as shown on the drawings or as per instructions of the Owner.

6.5.3.2 Formwork and surface finish

6.5.3.2.1 Formwork generally

Formwork shall include all temporary or permanent forms required for forming the concrete, together with all temporary construction required for their support. The provisions of IS: 456 shall be generally applicable to the Works. Finished concrete surfaces shall not be outside the tolerances normally achievable as given in IS: 14687. Any chamfer, fillet or camber required shall be provided along with the formwork.

The Contractor shall be entirely responsible for the sufficiency and stability of the formwork and for the safe removal of the same so that, after hardening, the concrete shall be in the position and of the shape dimensions and surface finish described in the contract. The Contractor shall, if required, submit Working Drawings and supporting calculations of the formwork he proposes to use for the approval of the Owner before commencing the Work. Allowance shall be made for any loading deflections to false Work that will occur during concreting. Such approval shall in no way relieve the Contractor of his responsibilities.

6.5.3.2.2 Formwork construction

Formwork shall be constructed of metal, sound well-seasoned clean timber or other approved materials and shall be constructed so as to be rigid during the casting of concrete.

All formworks shall be adequately propped, braced and fixed in the correct position and shall be sufficiently strong to resist the pressure of wet concrete and disturbance due to flotation. Formwork shall be strong enough to withstand the action of vibrators without displacement, distortion, or leakage and to carry the necessary constructional traffic.

6.5.3.2.3 Immersion in sea water

Where formwork is erected for concreting in tidal conditions it shall be suitable in every respect for this use and resistant to immersion in sea water.

6.5.3.2.4 Finish, fixing and striking

Rough finish

Formed concrete surfaces which are not visible in the finished Work may unless specified have a rough finish. A rough finish is defined as one which meets the general requirements of this specification without any extra requirements.

Formed finishes for visible

Formed concrete surfaces which will be visible in the finished Work shall be formed to one of the following two standards, as shown on the drawings.

Type A: Small blemishes caused by entrapped air or water may be acceptable, but the surface shall be free from voids, honeycombing and other blemishes.

Type B: All surfaces should be true with clean surfaces. Only very minor surface blemishes shall be permitted with no staining or dis-colouration from the release agent.

Tolerances for visible formed concrete surfaces

The following parameters shall be used to determine the acceptability of the quality of finish.

- Deviation from plane
- Local deviation from plane
- Joints between panels

The minimum allowable tolerances for each type of formed finish are shown in Table 6-6, but the tolerance shall also be within the limits required by any equipment and pipe support installations.

Chamfers and fillets

Chamfers and fillets shall be formed on all external and internal corners to the sizes shown on the drawings or agreed by the Owner. Where no detail or instruction is given the chamfer or fillet shall be 40mm x 40mm.

Cambers

Formwork for the soffits of suspended members shall be erected with an upward camber of 6mm for each 3m of clear span.

Fixings, holes etc.

The Contractor shall be responsible for obtaining all necessary information from his sub-contractors and suppliers in connection with holes, mortices, chases, ducts, and fixings of any description required for inclusion in the Works.

Holes, mortices, chases etc., shall be formed by the provision of the necessary inserts at the time of casting the concrete. No holes, mortices, chases, etc., shall be cut in any concrete without the approval of the Owner.

Before placing concrete all devices for forming, holes, slots and other cavities shall be securely fixed to the formwork and all items to be embedded in the concrete shall be firmly secured in position.

All pipes, bolts, steelwork, and other fittings required to be built in or through the concrete shall be firmly fixed in the formwork, which shall be neatly cut and fitted to suit to prevent the escape of grout. Insert into reinforced concrete shall be of an inert material.

Use of tie-bolts

Where internal metal tie-bolts are permitted, they or their removable parts shall be so fixed that they can be easily removed when the formwork is removed without damage to the concrete. The remaining holes shall be filled with mortar of the same fine aggregate and cement as the concrete, mixed in the proportions of 1:2 cement/sand by weight, and shall provide a watertight seal. No permanently embedded metal part shall have less concrete cover than that specified to the reinforcement, or 75 mm whichever is greater.

Under no circumstances shall wire ties be used.

Preparation of formwork

The inside surfaces of formwork shall, except for permanent formwork, or unless otherwise agreed by the Owner be coated with an approved non-staining mould oil to

prevent adhesion of the concrete to the formwork. Release agents shall be applied strictly in accordance with the manufacturer's instructions and shall not come into contact with the reinforcement or fixing devices. Different release agents shall not be used in formwork to adjacent area of concrete which will be visible in the finished Work.

Cleaning of formwork

Before any concreting is commenced, all formworks shall be cleaned to remove dirt, shavings, sawdust, and other refuse. Formwork shall in general be cleaned out using oil free compressed air. All formworks shall be subject to the written approval of the Owner before any concrete is placed.

Openings for inspection of the inside of the formwork and where agreed for the removal of water used for washing out, shall be formed so that they can be conveniently closed before concreting.

Striking of formwork

Formwork shall be removed carefully at such a time and in such a manner that it does not damage the concrete. All formworks shall be so constructed as to permit easing and removal without jarring or damage to the concrete. The Owner may direct that additional concrete cubes are made to check the actual field strength of concrete prior to giving approval for formwork removal.

The Contractor shall be responsible for properly supporting all concrete until it is sufficiently strong for the formwork to be removed. No formwork shall be removed without the prior approval of the Owner but, notwithstanding such approval, the Contractor shall retain complete responsibility for all formwork and any consequences of the striking being premature or harmful. The minimum period of time before striking vertical formwork shall be 24 hours from casting the concrete.

Temporary loads

Materials shall not be stacked on, or construction loads applied to beams or slabs without the approval of the Owner.

Re-use

Where it is intended that formwork is to be re-used it shall be thoroughly cleaned and made good to the satisfaction of the Owner.

Unformed surface finish-slabs

Unless otherwise directed in the Contract or by the Owner the unformed surface finish of concrete slabs (including angles making less than 15 degrees to the horizontal) shall be uniformly levelled and screeded using a mechanical vibrating screed to produce a tamped surface to the levels and falls shown on the drawings. Subsequent making up will not be allowed. All such unformed surfaces shall then be given a brush finish unless otherwise shown on the drawings.

Trowelled Finish

Where a surface is to have a trowelled finish, the surface shall, after the moisture film has disappeared and the concrete has hardened sufficiently to prevent laitance from being worked to the surface, be trowelled (wood or steel) under firm pressure to produce a dense, smooth uniform surface free from trowel marks.

Brush finish

To achieve a brush finish, the surface shall first be wood trowel finished then brushed in the direction of falls with a wire broom not less than 450 mm wide. The tufts of the broom shall be of 32-gauge tape wire, initially 100mm long. The texture depth produced by brushing shall be to the approval of the Owner. Brushing shall be carried out prior to the application of a curing membrane.

Brushes made of other materials may provide an equally acceptable finish, but their suitability must be demonstrated to the satisfaction of the Owner.

Sloping surfaces

Formwork shall be provided for the top faces of sloping Work where the slope exceeds 15 degrees from the horizontal and shall be anchored to prevent flotation.

6.5.3.2.5 Remedial treatment

Remedial treatment of surfaces

Any remedial treatment to surfaces shall be agreed with the Owner following inspection immediately after removing the formwork and shall be carried out without delay.

Honeycombed or otherwise defective concrete shall be cut out to its full extent and made good with concrete of the appropriate grade as directed by the Owner.

Any concrete, whose surface has been treated before being inspected by the Owner shall be liable to rejection and replacement at no extra cost to the Contractor.

Stains

The Contractor shall ensure that permanently exposed concrete surfaces are protected from rust marks and stains of all kinds.

Formwork for the horizontal and vertical faces and curved or splayed edges for any equipment foundations, support, pipe supports, or cable slots shall be of the highest quality such that smooth, true and continuous surfaces are formed which are free from surface effect. The surface for these parts shall be constructed within the following tolerances:

Table 6-6: Tolerances for visible formed concrete surfaces

Type	Limits for	
Characteristic	A	B
Deviation from Plane Measured over a whole element by reference to a straight line (overall length L).	8 mm or 0.002L Whichever is the lesser	5 mm or 0.0015L

Local Deviation from Plane Measured as deviation from a 3m straight edge.	5 mm	3 mm
Joints Between Elements Measured width in relation to design width (d max-d) or (d-d min)	10 mm	5 mm

6.5.3.3 **Concrete quality**

6.5.3.3.1 Characteristic strength

The specified characteristic strength of a designed mix shall be the 28-day compressive cube strength (N/mm²) equal to the value in the grade designation of the schedule of mixes, as per Table 6-5.

6.5.3.3.2 Mix reference

The mix reference of concrete shall define its grade, nominal maximum size of aggregate, type of cement, type of aggregate, minimum cement content, maximum water/cement ratio and rate of sampling for strength testing as described in the schedule of mixes, Table 6-5.

6.5.3.3.3 Water/cement ratio

The water/cement ratio of the concrete mix shall be the minimum value required to give adequate workability of the concrete but shall not exceed the maximum value stated in Table 6-5 which is a free water/cement ratio.

6.5.3.3.4 Chloride content of concrete

The total chloride content of the concrete mix, expressed as a percentage of chloride ion by mass of cement, shall not exceed 0.1% for concrete made with cement to IS 269. The chloride content shall be measured in accordance with IS 6925.

6.5.3.3.5 Sulphate content of concrete

The total Sulphate content of the concrete mix of Sulphur trioxide by mass of Sulphur trioxide by mass of cement shall not exceed 4.0%.

6.5.3.3.6 Alkali content of concrete

The total acid- soluble alkali content of the mix, expressed as equivalent sodium oxide, shall not exceed 3kg/m³ when measured as described in the British Cement Association document “minimizing the risk of alkali aggregate reaction”.

6.5.3.3.7 Drying shrinkage

Drying shrinkage shall not exceed 0.05%

6.5.3.3.8 Impermeable

All concrete shall be designed to be dense, durable and have a high impermeable. Concrete shall be tested at frequencies and locations as directed by the Owner and specimens shall meet the following criteria at an age of 28 days:

Water penetration to DIN 1048 part 1- max 20mm

Initial surface absorption of concrete (ISAT) to BS 1881 Pt 5

Max flox	time
(Ml/m ² /s)	mins
<0.25	10
<0.17	30
<0.10	70
<0.07	120

Capillary rise to Concrete Society reports no 31 1987 section 4.2.2 (taywood sorption test) - max rise in 4 hrs <10mm.

The Owner may require concrete to be tested in accordance with other test procedures which shall include, but shall not be limited to:

- Porosity as per Rilem CPC 11.3 'absorption of water by immersion under vacuum'.
- Rapid determination of the chloride permeability of concrete as per AASHTO T277-83.

6.5.3.3.9 Trial mixes

General

The Contractor shall prepare trial mixes using the approved aggregates and cement and, where applicable, approved admixtures. He shall make, cure and test specimens for strength and other tests in the specification as directed by the Owner. Specimens for strength shall be 150 mm cubes for each class of concrete in accordance with IS 516, except that cubes shall be cured in water at the ambient air temperature. The Contractor shall give notice in writing to the Owner to enable him to be represented at the making of the trial mixes and compressive testing of the cubes.

Mixing

Trial mixes shall be made at temperatures similar to those likely during construction and preferably using the batching plant and transport to be employed in the Works. The trial mixes shall be transported a representative distance before making the test cubes.

Workability

Mix proportions shall be properly balanced without excess of any constituents. The free water cement ratio shall be the minimum possible having regard to proper compaction by means specified. The slump and compacting factor when measured shall be within the range +25 mm and +0.03 respectively of the optimum values shown in Table 6-5.

Test cubes

Nine 150 mm test cubes shall be taken from three separate batches for each mix reference of concrete. From each set of nine test cubes three cubes shall be tested at 7

days and three at 28 days. The three remaining cubes shall be tested at 90 days and the results will be used by the Owner to assess long term compressive strengths.

The average crushing strength of the three sets of three cubes tested at the specified age shall exceed the specified characteristic strength by at least twice the designed standard deviation. Where there is no evidence of the standard deviation which may be expected to be achieved under similar conditions the designed standard deviation shall be assumed to be not less than 7N/mm^2 .

If the difference between the greatest and the least individual results for any set of three cubes is more than 20 per cent of the sum of the specified minimum crushing strength plus twice the designed standard deviation the results for that set shall be discarded. An additional set of three cubes shall be made and tested to provide a replacement set of results.

Approval of mixes

The Contractor shall submit to the Owner for approval full details of the trial mixes he proposes to adopt for the Works, including:

- The grading of the coarse and fine aggregates.
- The ratio by weight of all constituents of the mix
- The compacting factor and slump test results
- The test cube results.
- Water penetration test

No concrete shall be used in the Permanent Works until the test cubes have attained the required strength at the age specified and the mix has been approved in writing by the Owner.

Calculations to be provided

The Contractor shall supply copies in triplicate to the Owner of all calculations relevant to the determination of the proportions of each class of each, approved in writing, by the Owner.

6.5.3.4 Batching and mixing

6.5.3.4.1 Concreting plant

All concrete shall be machine mixed unless otherwise approved in writing by the Owner. The type, capacity and design of the concreting plant shall be suitable in every respect for its purpose. Its performance and disposition shall be to the satisfaction of the Owner. The use of continuous mixers shall not be permitted.

6.5.3.4.2 Measuring materials

All cement and aggregates shall be measured by weight. The amount of water added shall be measured, due allowance being made for the water content of the aggregate.

The moisture content of the fine aggregate shall be measured continuously in the hopper by an approved device. The amount of admixtures shall also be measured.

6.5.3.4.3 Accuracy of measuring equipment

Weight-batching machines shall be kept clean and in good condition and adjustment.

The Owner shall require the Contractor, at reasonable intervals of time, to check the accuracy of each weight-batching machine and each water measuring device in the presence of the Owner. The accuracy to be attained in each case shall be within +2.5% of the quantity of cement, water or total aggregates being measured.

6.5.3.4.4 Mixing

All concrete shall be machine mixed unless agreed otherwise by the Owner. Concrete shall be thoroughly mixed to a uniform consistency. Each batch of concrete shall be mixed for a minimum of two minutes after all the materials have been added. Unless agreed otherwise by the Owner.

The mixer shall be washed out with fresh water before mixing the first batch after any stoppage or, alternatively, the first mix shall be discarded. After every stoppage, the mixer shall be thoroughly cleaned and washed out.

Concrete shall be discharged from the mixer or agitator onto a level, clean, watertight platform, or floor or into watertight receptacles.

Concrete which has commenced to set shall not be re-mixed and shall not be used in the Permanent Works.

6.5.3.5 **Quality control and testing**

6.5.3.5.1 Quality control

The Contractor shall provide full time on site a fully qualified concrete supervisor whose duties shall include day to day supervision of the concrete constituents and the concrete mixing, placing, sampling, testing and record keeping operations.

The Contractor shall ensure that his concrete supervisor is aware of the importance of maintaining a uniform quality of concrete and that he is experienced in detecting variation in quality and workability and rapidly correcting the same.

The Contractor shall carry out such tests as the Owner may require to check the proportions of the ingredients of any concrete being produced.

6.5.3.5.2 Frequency of testing concrete

Six 150 mm test cubes shall be made from each sample of concrete taken from any section of Work as required by the Owner. Samples of concrete shall be taken for each mix reference at the frequency specified in IS 516, or for each shift of Work where this is less than the rate specified. Cubes shall be made, transported, cured and tested in accordance with relevant IS code. The cubes shall be made at the point of placing and at the time of placing.

Three cubes shall be tested at 7 days and three at 28 days. The average of the three cubes strengths shall be taken as the test result.

6.5.3.5.3 Compliance with Characteristic Strength

Compliance with the characteristic strength shall be assumed if both the following conditions are met:

The average strength at 28 days determined from any group of four consecutive test results exceeds the characteristic strength by not less than 3N/mm^2 for concretes of grade 30 and above, and 2N/mm^2 for concretes of lower grades. Where only two sets of results have been taken, the mean must exceed the characteristic strength by not less than 2N/mm^2 .

Each test result at 28 days is not less than the characteristic strength minus 3N/mm^2 for concretes of grade 30 and above and 2N/mm^2 for concretes of lower grades.

If only one test result fails to meet condition (ii) then that result will be considered to represent only the particular batch of concrete from which the set of three cubes was taken, provided the average strength of the group satisfies condition (i).

If more than one test result in a group fails to meet condition (ii) or if the average strength of any group of four consecutive test results fails to meet condition (i) then all the concrete in all the batches represented by such cubes shall be deemed not to comply with the strength requirements.

6.5.3.5.4 Results of tests

The results of all Works tests carried out to control the quality of concrete and concrete materials shall be recorded by the Contractor on suitable forms provided by him which shall be subject to the approval of the Owner. The Contractor shall supply to the Owner three copies of the results of each test.

6.5.3.5.5 Unsatisfactory test results

Should any of the results of the specified Works tests on concrete or materials be unsatisfactory the Owner may take one of the following actions:

- Unsatisfactory test results relate be cut out and replaced.
- Instruct the Contractor to carry out additional tests and/or works to ensure the soundness of the structure at the Contractor's expense.
- Acceptance of the Work or any decision to do so shall be at the Owner's discretion and with the owner's approval and a reduction in the rate of payment for the appropriate items shall be made by the Owner.
- In the case of any test result at 7 days being less than 55% of the characteristic strength, or an amended value based on test results for the trial mixes, the Owner may order that the Work affected be stopped but that it shall not be liable to rejection until the results of the 28 days tests are known. Any delays to construction due to the test results at 7 days being unsatisfactory shall be at the Contactor's expense.

- Following the failure of test cubes to reach the required standard, the Contractor shall, on the instructions of the Owner, take one or both of the following steps:
- He shall alter his methods of making concrete and for controlling its quality so as to reduce its variability.
- He shall alter the proportions of the concrete mix so as to increase its compressive strength.

6.5.3.5.6 Ready mixed concrete

Ready-mixed concrete shall be used only with the agreement of the Owner and shall comply with all the requirements of this specification for concrete unless otherwise stated, and also the following special requirements.

- The Contractor shall be entirely responsible for demonstrating to the Owner that the ready-mix concrete which he proposes to use will comply with the specification and that the concrete actually used in the Works also full complies.
- The ready-mix plant proposed by the Contractor for each mix reference shall be subject to truck mixers. The time of introduction of water to the mix shall be recorded on the delivery note together with the weight of the constituents of each mix.
- The concrete shall be carried in purpose-made agitators, operating continuously, or truck mixers.
- Ready-mix concrete shall, where applicable, comply with the requirements of IS 4925.
- When truck-mixed concrete is used, water shall be added under supervision either at the site or at the central batching plant as agreed by the Owner, but in no circumstances shall water be added in transit.

6.5.3.6 **Casting of concrete**

6.5.3.6.1 Workability

The concrete shall be of only sufficient workability that it can be readily worked into position and compacted taking into consideration the particular conditions under which the concrete is being placed.

Workability shall be measured at a minimum frequency equal to the sampling rate and at such times as directed by the Owner.

Measurement shall be by one of the following tests in accordance with IS 1199 and shall be within the following limits of the optimum values given in Table 6-5.

- Slump +25 mm or+ one third of the optimum value, whichever is the greater
- Compacting factor +0.03 where the optimum value is 0.9 or more.

6.5.3.6.2 Construction sequence

The sequence of construction shall be such as to satisfy the specification and any particular requirements for the Works under the Contract or as shown in the drawings.

The Contractor shall prepare a detailed method statement for approval by the Owner.

Concrete shall be poured in complete bays between consecutive joints in locations approved by the Owner. The maximum permissible crack width 28 days after completion of curing shall be 0.10mm. the Contractor shall provide the facilities to enable the full surface area of all exposed concrete to be inspected and cracks to be measured at times to be agreed, and shall be responsible for repairing or sealing, as agreed with the Owner, all cracks which exceed this value.

6.5.3.6.3 Transportation of concrete

All concrete shall be transported in bottom-opening skips or vehicles of a type and size approved by the Owner. Concrete shall be so transported and placed that contamination, segregation or loss of the constituent materials does not occur.

6.5.3.6.4 Placing concrete

Concrete shall not be placed in any part of the Works without the prior written approval of the Owner who shall be given a minimum of 24 hours' notice by the Contractor. No concrete shall be placed outside normal working hours.

The bottom of all ground formations which are to receive in-situ concrete shall, unless specified to the contrary, first be covered with a 50 mm minimum thickness blinding layer of mass concrete mix to form a clean, dry, hard, working surface.

Concrete shall be placed in its final position and all compactions shall be completed within 30 minutes of the time of water being added to the mix. Where a retarding admixture has been used and hot weather concreting precautions are in place this time may be extended up to a maximum of 2 hours after written approval by the Owner.

Fresh concrete shall not be placed against previously placed concrete which has been in position for more than 30 minutes or where the initial set has taken place.

Concrete shall be placed and compacted in such a way that previously placed and compacted concrete is not disturbed. Concrete shall not be placed in a manner which in the Owner's opinion precludes even distribution of constituents and full compaction of the concrete.

Concrete shall be placed and compacted uniformly in layers not exceeding 300mm in depth in its final position in the Works and shall not be caused to flow into position by vibration or other means. The surface of the Work shall be kept generally horizontal. In deep sections the concrete profile shall advance in 300 mm stepped layers to avoid placement against concrete where the initial set has taken place.

When the cement content of a mix exceeds 400kg/m³ and the minimum dimension of concrete to be placed in a single pour exceeds 700 mm special precautions shall be taken to ensure temperature differentials exceeding 20°C is not generated within the concrete. Where required the Contractor shall submit proposals for approval by the Owner for demonstrating compliance with this requirement prior to concreting.

Concrete shall be placed in such a way as to avoid any joints other than the joints shown on the drawings or approved by the Owner.

No concrete shall be allowed to fall more than 2 meters during placing. For heights of fall greater than 2 meters, chutes or pipes shall be used.

If the Contractor proposes to place concrete by pumping or pneumatic means, he shall submit his proposals for the Owner's approval and shall not commence operations until such approval has been obtained.

6.5.3.6.5 Concreting during wet weather

No concreting shall be carried out during periods of continuous heavy rain unless the concrete is completely covered during mixing, transporting, and placing to the satisfaction of the Owner. If rain should interrupt concreting the concrete shall be adequately protected.

6.5.3.6.6 Concreting during hot weather

Hot weather Concreting: Any operation of concreting done at atmospheric temperatures above 40°C or any operation of concreting (other than steam curing) where the temperature of concrete at time of its placement is expected to be beyond 40°C.

When the air temperature rises above 40°C or the anticipated evaporation loss from the freshly placed concrete, exceeds 1kg/m²/hr, special precautions shall be taken in accordance with IS: 7861 (Part 1) – 1975 and to the specified maximum water/cement ratio, and other special batching, placing, and curing techniques. All aggregates shall be stored in the shade prior to batching. Steel reinforcement and shuttering exposed to the sun should be mist sprayed with fresh water immediately before placing the concrete.

Concreting shall not be carried out if the temperature of the concrete mix at the point of placing exceeds 30°C where concrete pours are greater than 1m thick the temperature of mix shall be further reduced as directed by the Owner. Cooling arrangements shall be to the approval of the Owner.

For hot and cold weather precautions to be taken are as follow:

In order to maintain lower mix temperatures concrete may be mixed and placed at night subject to the written approval of the Owner and provided the lighting and other arrangements are to his satisfaction. As same in case of cold weather avoid concreting during nighttime.

Temperature of coarse aggregate shall be maintained as per IS specifications by use of Ice Flakes for mass concrete. In hot weather, ice flakes shall be added in the concrete or aggregate shall be kept cool by sprinkling water. Necessary corrections shall be performed in the mix design of the concrete.

Coarse aggregate shall be stored under shed in case of hot weather temperature.

In hot weather, the formwork shall be sprinkled with water before commencing the concrete work.

6.5.3.6.7 Compaction and finish

Concrete shall be compacted into place by means of a sufficient number of approved internal vibrators of adequate power with a frequency of not less than 100 hertz. Mechanical vibrators shall only be operated by trained and experienced workmen. Care shall be taken to avoid contact with reinforcement of formwork. An adequate number of stand-by vibrators shall be available at each pour in case of breakdown.

Concrete shall be thoroughly worked around the reinforcement and against whatever surface it adjoins so that a dense homogeneous mass is produced, all entrained air is expelled and the concrete surface when exposed is free from air pockets, honeycombing and other defects.

If vibrating screeds are used for slab Work, they shall be of sufficient power to compact the full depth of the slab being cast, over the full length of the screed.

Should there be evidence of plastic settlement cracking; the affected concrete may be re-vibrated whilst the concrete is still plastic, by a method approved by the Owner, to re-compact the disturbed concrete. The Contractor shall take appropriate measures to reduce the possibility of cracking in further pours.

6.5.3.6.8 Attendance of steel fixer

During concreting of all reinforced work, a competent steel fixer shall be in attendance throughout. It shall be his duty to ensure that the reinforcement and other embedded items are kept in position as the work proceeds.

6.5.3.7 Joints

6.5.3.7.1 Movement joints

Movement joints shall be formed in the positions and to the details shown on the drawings. Joint fillers, sealing compounds and water bars shall be incorporated in these joints in strict accordance with the drawings and the manufacturer's instructions.

The faces of movement joints shall have a formed type B finish as defined in section 6.5.3.2.4.

6.5.3.7.2 Joint fillers

Compressible filler sheets of the thickness shown on the drawings shall be made of bitumen impregnated wood fibres to the approval of the Owner. They shall not extrude when compressed and must return to at least 80% of the original thickness after compression. Water resistant joint filler board shall be made of preformed bitumen bonded cork, as kork-pak manufactured by Serviced Ltd. or equivalent.

6.5.3.7.3 Joint sealants

Sealants for joints shall be as per the design. The polysulphide type shall be a two-pack mix complying with relevant code of practice. The pitch polyurethane type shall be nitoseal 220 as manufactured by Fosroc or similar approved. The rubber-bitumen type shall be plastic grade 99, or similar approved. All sealants shall be stored and applied fully in accordance with manufacturer's recommendations. Joint sealants shall be compatible with the joint filler and old other adjacent surfaces.

6.5.3.7.4 Polythene membranes

Polythene sheeting membranes shall be minimum 250 microns, laid flat without trapping air. A lap of 300 mm shall be provided between sheets.

6.5.3.7.5 Construction joints

Stoppages in concreting at the end of a period of Work shall be made at properly formed construction joints in positions of low shear stress and approved by the Owner. Where required by the Owner recesses shall be formed in construction joints in positions of low shear stress and approved by the Owner. Where required by the Owner recesses shall be formed in construction joints in order to form a key with adjacent concrete. A rebate at least 25 mm wide by 40 mm deep shall be formed on the exposed face of any joint so that the finished Work shows a clean straight line.

Formwork to provide stop ends for vertical joints in reinforced concrete shall be firmly fixed and scribed around the reinforcement. Such concrete as passes through the stops shall after setting be hacked off and removed. Retarding agents shall not be permitted on formwork to stop ends.

The surface of construction joints shall, when the concrete has set but not hardened, be prepared by removing the outer mortar skin using a stiff brush and a fine spray of water, to the extent that the large pieces of coarse aggregate are exposed but not damaged or dislodged. Alternatively, expanded metal mesh may be used to form a roughened surface, the mesh being removed with care within 24 hours of casting.

If this procedure is not possible the laitance shall be removed with a combined jet of air and water. If the concrete is too hard, sand blasting, wire brushing or scrubbing may be used with care with the approval of the Owner.

The prepared joint surface is to be cured using only fresh water. It shall be thoroughly cleaned with compressed air or other equally efficient method and then jetted with clean water shortly before the adjacent concrete pour is placed. Special care shall be taken to butt the new concrete thoroughly against the old.

Concreting beyond construction joints shall not take place for at least 24 hours after forming the joint face.

6.5.3.8 **Curing**

6.5.3.8.1 Protecting concrete

Immediately after compacting and finishing, and thereafter until the concrete has achieved the strength specified, the concrete shall be protected from the harmful effects of weather, including rain, sun, wind, rapid temperature changes and from drying out.

The concrete shall also be protected from other work in progress. No equipment, vehicles, workman or materials shall be permitted on recently placed concrete until the Owner considers the concrete to be sufficiently strong and hard not to be damaged thereby.

6.5.3.8.2 Curing method

Reinforced concrete shall not be allowed to come into contact with sea water for a period of 28 days from the date of placing.

All concrete wherever possible, shall be wet cured under shade for a minimum period of 14 days after casting wherever possible. Curing water shall be potable water free from deleterious salts. The methods for the provision of curing water and curing shall be to the approval of the Owner, and in principle as follows.

In other cases, appropriate methods to cure shall be adopted as directed by the Owner.

6.5.3.8.3 Concrete to cope

Quick drying brush applied rubberised bituminous liquid emulsion curing membrane, master-seal 410 or similar approved.

6.5.3.8.4 Horizontal surfaces

Polythene sheeting of minimum thickness 0.1mm placed directly after finishing.

Immediately after final set has taken place the polythene shall be replaced with 2 layers of wet Hessian and recovered by the polythene.

The Hessian shall be kept continuously soaked by sprinkled or sprayed water as necessary.

6.5.3.8.5 Vertical or inclined surfaces

Polythene over 2 layers of wet Hessian shall be firmly secured to all surfaces immediately after the removal of the formwork.

The Hessian shall be kept continuously wet by sprinkled or sprayed water as necessary. The use of curing compounds shall not be permitted.

Polythene sheeting used for curing shall be well sealed and fastened at all stages.

6.5.3.9 **Inspection and records**

6.5.3.9.1 Inspection of concrete surfaces

No concrete surface shall be worked on in any way after the removal of formwork, or permanently covered up, until it has been inspected and approved by the Owner.

6.5.3.9.2 Tolerances

Except where otherwise noted in the specification or on the drawings concrete surfaces shall be cast within the tolerances set out in Table 6-6 of this section.

6.5.3.9.3 Records

Detailed records shall be kept by the Contractor of all batches of concrete, of their mix ref, date and time of manufacture, position in the Works and of all associated tests and measurements. Records shall also include actual casting sequence and actual mix constituent quantities. During hot weather mix and ambient temperatures and wind speed shall be recorded. Three copies of all records shall be supplied to the Owner, within 24 hours of the recorded event.

6.5.3.10 Defective concrete

6.5.3.10.1 Rejection and reconstruction of faulty work

Concrete poured under this contract, which is defective from any because whatsoever shall, if so, directed by the Owner, be cut out and the Work reconstructed at the Contractor's expense.

If there is any doubt concerning the strength or quality of previously placed and hardened concrete, or the position of the reinforcement the Owner shall decide whether the Contractor shall undertake core sampling or rebound testing, or a cover meter survey of the suspect concrete as follows: -

- 150 mm diameter core samples shall be taken at locations directed by the Owner, following a cover meter survey if necessary. The cover meter shall be used in accordance with BS 1881: Part 204, the cores shall be tested in accordance with BS 1881: Part 120 and the equivalent cube strength shall be determined. Core holes in concrete which is to remain in the Works shall be repaired by filling with concrete or mortar of the strength specified for the surrounding concrete.
- A series of rebound hammer tests shall be taken at locations directed by the Owner in accordance with IS13311: Part 2 or BS 1881 Part 202. Correlation between strength and rebound number shall be carried out using 150 mm cubes of the same concrete mix ref. the suspect concrete.

6.5.3.11 Breaking out of concrete

6.5.3.11.1 Removal of concrete

The extent of concrete removal on repair works to existing structures shall be as shown on the drawings or directed by the Owner.

Broken out concrete surfaces and exposed reinforcement shall be protected from saltwater splash and spray. The period between breaking out existing concrete and placing new repair concrete shall be minimized and in no cases longer than 7 days.

The Contractor's method of breaking out shall be designed to minimize damage to existing concrete. The Contractor shall submit details of his proposed method equipment and staff to be used and shall obtain the Owner's approval for such prior to commencing Work.

6.5.3.11.2 Surface preparation of concrete

Concrete surfaces which have been cut-back shall be prepared by grit-blasting or scrubbing and chipping out loose projecting coarse aggregate to expose a sound matrix of rough profile. Marine and vegetable growth shall be removed by high pressure water jetting or similar means to expose the concrete face and the Contractor shall ensure that all oil or grease is removed by steam cleaning in conjunction with suitable detergent. Surfaces shall be thoroughly cleaned by high pressure air-lance.

The parent concrete shall be soaked with fresh water for a period not less than 8 hours to concreting such that the bonding surface is in a saturated surface dry condition at the

time of placing the repair concrete. Bonding agents shall not be employed unless approved by the Owner.

6.5.3.12 Concreting underwater

6.5.3.12.1 Approval

Where concrete is to be placed under water the Contractor shall submit his detailed proposals for the method of working, equipment and personnel for the approval of the Owner. No such Work shall be undertaken until this approval has been given.

Concrete which is to be placed under water using the tremie method shall have the following characteristics: -

- The minimum cement content of the concrete shall be 400 kg/m³. The cement shall be ordinary Portland cement. Cement containing cement replacement material may be used subject to the approval of the Owner.
- The workability of the concrete shall be increased so that the slump is 150mm+ 25 mm, or the flow is 575+75mm.
- Maximum aggregate size shall be 20mm and fine aggregate proportions shall be between 40% and 50% of the total aggregate content.
- The characteristic strength of the concrete shall be 45N/mm².
- A cellulose polymer additive (approved by Owner) shall be included in the mix in accordance with the manufacturer's recommendations.

Concrete to be placed under water shall be placed continuously and sufficient supply of aggregates, cement and water shall be available at the plant prior to the commencement of the tremie concreting. No concrete shall be placed without the Owner has approved all preparations for the Work.

6.5.3.12.2 Trial pours

On-shore trials shall be carried out to ensure a proper understanding of the method of working followed, if considered necessary by the Owner, by underwater trials which shall be carried out in such a way that the resultant Work can be retrieved and examined.

6.5.3.12.3 Tremie filling of structures

The maximum distance between tremie pipes shall be 4.5 meters and pipes should be located so that concrete does not flow horizontally more than 3.0 meters from a pipe position. Where two or more pipes are used in the same pour simultaneously, care shall be taken to ensure that the concrete level at each pipe position is maintained equal. The pipes shall be suspended from staging mounted so that the pipe can be moved vertically. The pipes will be fed through a hopper. Each pipe shall comprise removable sections to allow the pipe to be shortened as concreting proceeds. All removable items and loose connections shall have chain connections to prevent loss.

6.5.3.12.4 Tremie pipes

The tremie pipes shall be clean, watertight and of adequate diameter to allow the free flow of concrete; neither less than 200mm diameter nor greater than 300mm. the method of plugging shall be approved by the Owner. The tremie pipe shall extend to the formation level prior to the commencement of concrete pouring and care shall be taken to ensure that all water is expelled from the pipe during the initial charging process. A minimum embedment of 1.5m of the tremie pipe in concrete shall be maintained throughout concrete pouring to prevent re-entry of water into the pipe.

Horizontal movement of the tremie pipe will not be permitted after commencement of the pour.

6.5.3.12.5 Formation preparation

The formation of each pour shall be kept clean, free of silt and other harmful material. If necessary, the direction of the pour shall be ordered by the Owner, to enable harmful material to be displaced by the fresh concrete. All gaps and lifting holes exceeding 10mm minimum dimension in and between formwork shall be sealed prior to pouring tremie concrete.

All surface laitance and poor-quality concrete from previous pours shall be removed prior to placing new concrete.

6.5.3.12.6 Tremie pours

The concrete pour shall be completed in such a manner and within such time that the concrete above the foot of the tremie remains workable until the pour is complete.

The method of placing shall be such as to prevent any concrete from dropping through the water into the construction area, and to ensure that the maximum density of the concrete is achieved in its final position. Divers shall be employed where necessary to ensure that even placing of the concrete, which shall be placed as far as possible in horizontal and not with steep unsupported faces.

The rate of placing concrete shall be such that the pressure on the formwork shall not endanger its stability.

6.5.4 Codes and references

Indian and other standards and codes of practice referred to in this section are as follows:

Standards and codes of practice

IS 456	- Plain and Reinforced Concrete Code of Practice
IS 1786	- Specification for High Strength Deformed Steel Bars and Wires for Concrete Reinforcement (Third Revision)
IS 2502	- Code of Practice for Bending and Fixing of Bars for Concrete Reinforcement
IS 2751	- Recommended Practice for Welding of Mild Steel Plain and Deformed Bars For Reinforced-Construction (First Revision)
IS 9417	- Recommendations for, Welding Cold Worked Bars for Reinforced Concrete Construction (First Revision)

IS 269-2015	- Ordinary Portland Cement - Specification
IS 516	- Method of Tests for Strengths of Concrete
IS 1199	- Method of Sampling and Analysis of Concrete
IS 2386	- Methods of Test of Aggregates for concrete
Part 1	- Particle Size and Shape
Part 2	- Estimation of Deleterious Materials and Organic Impurities
Part 3	- Specific Gravity, Density, Voids, Absorption and Bulking
Part 4	- Mechanical Properties
Part 5	- Soundness
Part 6	- Measuring Mortar Making Properties of Fine Aggregates
Part 7	- Alkali – Aggregate Reactivity
Part 8	- Petrographic Examination
IS 14687	- Guidelines for False Work for Concrete Structures
IS 455	- Specification for Portland Slag Cement
IS 1489	- Specification for Portland Pozzolana Cement
IS 383	- Specification for Coarse and Fine Aggregates from Natural Sources for Concrete
IS 432	- Specification for Mild Steel and Medium Tensile Steel Bars and Hard – Drawn Steel Wire for Concrete Reinforcement
IS 1566	- Specification for Hard- Drawn Steel Wire Fabric for Concrete Reinforcement
IS 6925	- Methods of Test for Determination of Water-Soluble Chlorides in Concrete Admixtures
IS 4925	- Concrete Batching and Mixing Plant – Specification
IS 13311: Part 2	- Methods of non-destructive testing of concrete: Part 2 Rebound hammer
ACI305R	- Guide to hot weather concreting
RILEM CPC11.3	- Absorption of water by immersion under vacuum
AASHTO T277.83	- Standard Method of Test for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration
DIN 1048-1	- Testing concrete: Testing of fresh concrete
BS 8110: part 1	- Structural use of Concrete: Code of Practice for Design and

Construction

BS 1881 - Method of Testing Concrete

British Cement association - Specification for Formed Concrete Surfaces (1987)

British Cement association - "Minimizing the Risk of Alkali Aggregate Reaction"

6.6 Precast Concrete

6.6.1 General

6.6.1.1 Compliance

Precast concrete shall comply with the requirements of Section 6.5 in so far as they are applicable or except where varied by the requirements of this section.

6.6.2 Product

6.6.2.1 Casting tolerances

Tolerances for precast units shall be within 3mm of true dimension with the following exception: length of beams up to 6m +7.5mm, before any interlocking units are placed, they shall be checked in the precast yard for fit against the units which will be adjacent in the permanent works. No adjustment for fit shall be made without the approval of the Owner, who may reject such units.

6.6.2.2 Marking and serial number

Units shall be clearly and indelibly marked to show the member marks, the date of casting and the orientation of the unit in the works. The markings shall be in such a position that they will not be seen in the completed work.

6.6.3 Execution

6.6.3.1 Working drawings

All the working drawings will be issued to the contractor, and it is the responsibility of contractor to work as per drawings issued.

6.6.3.2 Method of casting, handling, storage etc

The Contractor shall submit proposals for the Owner's approval for his method of casting, curing, handling and storage and for the erection sequence. When the method has been approved no changes shall be made without the written consent of the Owner.

Prior to cutting and bending of reinforcement for production units, the Contractor shall assemble a complete reinforcement cage for each type of unit, for inspection and approval by the Owner.

6.6.3.3 Surface finish

Precast concrete units shall generally be formed with a class B finish as defined in Section 6.5.3.2.4

The surfaces of precast units which will subsequently receive grout or concrete to form a structural connection with in-situ concrete shall be prepared by removing the outer mortar skin when the concrete has set but not hardened, using a stiff brush and a fine spray of water, to the extent that the larger pieces of coarse aggregate are exposed but not damaged or dislodged.

The position of interlocking units in relation to their casting moulds shall also be marked. The markings shall be such as to identify the correct location of units relative to each other after checking for fit.

6.6.3.4 Handling

Precast units shall be lifted or supported only at points approved by the Owner and shall be handled and placed without impact or vibration. Care shall be taken not to distort any reinforcement projecting from units.

The use of cast in steel hooks, eyes or fittings for lifting shall not be permitted.

6.6.3.5 Loading during handling

Precast units shall at no time be subjected to loading during handling, including their own weight, which will induce a compressive stress in them exceeding 0.33 times their compressive strength at the time of loading or of their specified characteristic strength whichever is the less.

For the purposes of this clause, the assessment of the strength of the concrete and the stress produced by the loads shall be subject to the agreement of the Owner.

6.6.3.6 Support to precast units

The Contractor shall be responsible for providing all necessary support to precast units during concrete operations. Unless otherwise shown, precast slabs and beams shall be evenly bedded on a 15 mm nominal thickness of 1:4 cement sand mortar. The gap between adjacent blocks shall be sealed with approved material before pouring the in-situ concrete cope.

6.6.3.7 Erection

General erection requirements

Erection responsibilities of the Contractor shall include the safe and proper placing, aligning and levelling of precast elements on the accepted bearing surfaces and affecting their proper securement.

Guying, bracing and shoring

The Contractor shall provide proper sequence and maintain all temporary supports shown or required to control alignment, deflection, and stress levels.

Hoisting equipment

The Contractor shall provide proper hoisting equipment. Hoisting devices shall be attached at designated lifting points.

Precast units shall be erected by the Contractor without damage to shape or finish. Damaged units shall be repaired or replaced, as determined by the Owner.

Precast units shall be erected level, plumb, square and true by the Contractor within allowable tolerances. Precast units shall be aligned to maintain uniform horizontal and vertical joints, as erection progresses. Erections tolerances shall conform to Table 6.5.

Table 6.5: Erection Tolerances

Description	Tolerances (mm)
Variation from plumb:	
In any 6m run or story height	6
In any 12m height or longer run	12
Variation from level or elevation:	
In any 6m run	6
In any 12m run	12
At any location	±12
Variation from theoretical position in plan:	
At any location	±6
Offsets in alignment of adjacent members at any joint:	
In any 3m run	1.5
In any 12m or longer run	6

6.6.3.8 Records

A record shall be kept of the position in the works of each unit and the date on which it was placed into position.

6.6.3.9 Cast in sockets

Cast in sockets used for temporary works shall be either removed, made of stainless-steel grade 316S or galvanized steel and sealed to the Owner approval.

6.6.3.10 Cleaning

After installation of completed precast units, the Contractor shall clean soiled joints and concrete surfaces with an approved detergent and water, using fiber brush and sponge, and rinse thoroughly with clean potable water. Other methods shall be used as recommended by the Contractor and approved by the Owner.

Use of acid solution to clean precast units shall be used only to clean those stains remaining after more conservative methods have been tried unsuccessfully. Acid solution to be used shall be reviewed by the Owner prior to use. Extreme care shall be used to prevent damage to precast concrete surfaces and to adjacent materials.

Upon completion of work, premises shall be left neat and clean by the Contractor to the satisfaction of the Owner.

6.6.4 Codes and references

6.6.4.1 Standards and codes of practice

Standards and other codes referred to in this section are same as described in section 6.5.4.

6.7 Formworks

6.7.1 Providing ordinary formwork with shuttering plywood / steel sheathing

Providing ordinary formwork with shuttering plywood / steel sheathing and steel supporting system so as to give fair finish, including centering, shuttering and propping, etc. complete, height of propping and centering below supporting floor to ceiling not exceeding 4.5 m., and removal of the same for in-situ reinforced concrete and plain concrete work, in foundations, footings, bases of columns, walls, any shape of columns, slabs, beams, walls, sills, lintel, coping, horizontal/ vertical fins, vaults, circular lift shaft, etc. for any shapes and locations as directed by engineer in charge. (For all civil, plumbing & electrical works).

6.7.1.1 Materials

Shuttering plywood shall conform to M-26B. The thickness of the plywood sheathing shall be as per the shape and size of the concrete member.

The dimensions of scantling and battens shall conform to the design. The strength of the wood shall not be less than that assumed in the design.

Contractors shall design the formwork and get it approved by the Engineer-in-charge.

6.7.1.2 Workmanship

The formwork shall conform to the shape, lines and dimensions as shown on the drawings and shall be so constructed so as to remain sufficiently rigid and water-tight, during the placement and compaction of the concrete. Adequate arrangement shall be made by the Contractor to safeguard against any settlement of the formwork during the course of concreting and after concreting. The formwork of shuttering, centering, scaffolding, bracing, etc. shall be as per the design and shall be made from shuttering plywood with batten/ steel plates and steel supporting system. In case of double height, false staging should be erected preferably with Acro-props & spans or H frames.

Cleaning & Treatment of Forms: All rubbish, particularly chipping, shaving and saw dust shall be removed from the interior of the form before the concrete is placed and the formwork in contact with concrete shall be cleaned thoroughly. The surface shall be coated with approved release agent as directed by Engineer in charge or Architect. Care shall be taken that the coating is not applied on the construction joints surface and steel reinforcement bars.

6.7.1.3 Stripping time

In normal circumstances and where ordinary Portland cement is used, formwork may be struck after expiry of the following periods:

- (a) Sides of walls columns and vertical faces of beam -- 6 to 24 hours.
- (b) Slab soffit (props to be refixed immediately after removal of formwork) -- 3 days
- (c) Beam soffits (Props left under) -- 7 days.
- (d) Removal of props for slabs -

(i) Slabs spanning up to 4.5 m-- 7 days.

(ii) Slabs spanning over 4.5 m. --14 days.

(e) Removal of props to beams and Arches -

(i) Spanning up to 6 m. -- 14 days.

(ii) Spanning over 6 m. --21 Days.

- Procedure while removing the formwork: All formwork shall be removed without such shocks or vibrations as would damage the reinforced concrete surface. Before the soffit formwork and struts are removed, the soffits and the concrete surface shall be exposed where necessary, in order to ascertain that the concrete has sufficiently hardened.

6.7.1.4 Centering

The centering to be provided shall be got approved. It shall be sufficiently strong to ensure absolute safety of the formwork and concrete work before, during and after pouring concrete till it achieved full strength. Watch should be kept to see that behaviour of centering and formwork is satisfactory during concreting. Erection should also be such that it would allow removal of forms in proper sequence without damaging either the concrete or the forms to be removed.

The props of centering shall be provided on firm foundation or base of sufficient strength to carry the loads, without any settlement. Wedges shall be provided at the base of the fixed prop (wooden and steel) for its easy removal. Props shall be adequately braced to withstand the lateral forces.

The centering and formwork shall be inspected and approved by the Engineer-in-charge, before concreting. But this will not relieve the Contractor of his responsibility for strength, adequacy and safety of formwork and centering. If there is a failure of formwork or centering, the Contractor shall be responsible for the damages to the work, injury to life and damage to property.

For walls, columns and beams, the shuttering plates on either side shall be bolted with tie rods made from spring coils on either side, welded with two nos 8mm MS rods. PVC cone shall be placed on either side of the tie rod. The whole tie rod assembly along-with PVC cone shall be placed/fixed with special type of bolts on either side of the shuttering plates. Length of the tie rod along-with PVC cone shall be equal to the width / thickness of the element to be shuttered.

6.7.1.5 Scaffolding

All scaffolding, hoisting arrangements and ladders, etc. required for facilitating of concreting shall be provided and removed on completion work by Contractor, at his own expense. The scaffolding, hoisting arrangement, ladders etc. shall be strong enough to withstand all live, dead and impact loads expected to act and shall be subject to the approval of the Architect and Engineer-in-charge. However, Contractor shall be solely responsible for the safety of the scaffolding, hoisting arrangement, ladders, work and workmen, etc.

The scaffolding, hoisting arrangements and ladders shall allow easy approach to the work spot and afford easy inspection.

6.7.1.6

Reuse

Before re-use, all forms shall be inspected by the Engineer-in-charge and their suitability shall be ascertained. If, any of the forms are found to be unsuitable, they shall be immediately removed from the site. The forms ascertained for re-use, shall be scarred, cleaned, and joints gone over and repaired, wherever required. The inside surface shall be retreated to prevent adhesion to concrete.

- Mode of measurements and payment:

The rate shall be including in the cost of RCC work for all floor, all height, all size, all shape.

Extra over item for (Form work) providing and erecting false staging with MS props or MS H frames for each additional height (height more than 4.5 m. and up to 9.0 m.) of propping and centering where the height of propping and centering exceeds 4.5 m. between supporting floor to ceiling, including temporary masonry work or stone pillars for supporting as required all etc. complete as directed by engineer in charge. No staging shall be measured for vertical walls, columns & beam sides and only plan area is to be measured. (For all civil, plumbing & electrical works).

The material shall be steel H-frames, steel plates, steel props, base plate, bracing, spans, channels etc.

The false staging work for double height shall be designed by contractor so that it shall be able to resist forces like live load, dead load, impact load, lateral loads or any other incidental loads and get it approved by Engineer-in-charge before starting the centering work.

Vertical members shall be placed directly over those below or shall be so designed and placed that the load shall be transmitted directly to them. Proper horizontal and diagonal bracing in both the directions and at both the stages shall be provided. The completed false staging work for double height formwork shall be got inspected by and got approved by Engineer-in-charge before placing the reinforcement bar.

If there is a failure of formwork or centering /staging, contractor shall be solely responsible for the damage of the work, injury of life and damage to property.

Only mould release agent of approved make shall be applied on shuttering materials before use. Oil should not be permitted.

6.7.2

Providing formwork for exposed concrete surface

Providing formwork for exposed concrete surface in desired pattern and size, using laminated shuttering plywood / best quality steel plates and steel sheeting, including neat cleaning and rendering as per approved sample for uniform finish the exposed concrete surface, as directed by the Architect and Engineer in charge. (Same kind of shuttering material should be only used for standard and residual sizes. Oil should not be permitted on steel plates. Only mould release agent of approved make should be used.) (For all civil, plumbing & electrical works).

- **Materials and workmanship**

The relevant specification of item shall be followed except that the laminated shuttering plywood / best quality sheathing of steels and/or plates of steel shall be used instead of ordinary shuttering plywood / steel sheathing, to obtain a desired smooth exposed surface finish. The surface shall be rendered and touched up to the satisfaction of the Engineer in charge. The exposed surface shall be in desired pattern and size as per the drawing. The shuttering shall have restricted reuse to obtain good surface finish. Before re-use, all forms shall be inspected by the Engineer-in-charge and their suitability shall be ascertained. If, any of the forms are found to be unsuitable, they shall be immediately replaced. Only similar type of material shall be used for the entire work. The surface shall be presentable without further treatment. Only mould release agent of approved make shall be applied on shuttering materials before use. Oil should not be permitted.

For walls, columns and beams, the shuttering plates on either side shall be bolted with tie rods made from spring coils on either side, welded with two nos. 8mm MS rods. PVC cone shall be placed on either side of the tie rod. The whole tie rod assembly along-with PVC cone shall be placed/ fixed with special type of bolts on either side of the shuttering plates. Length of the tie rod along-with PVC cone shall be equal to the width / thickness of the element to be shuttered.

- **Mode of measurements and payment**

The measurement of formwork shall be taken for the formwork done with laminated shuttering plywood / best quality steel sheathing. The relevant specification of respective item shall be followed. The cost for spring coil and PVC cone shall be included in the rate.

The surface, which is shown exposed in the drawing, shall only be paid for the rate shall be for a unit of one m². The rate shall include the rendering and touch up work.

6.8 Masonry works

6.8.1 Providing and laying brick work

Providing and laying brick work using common burnt clay conventional building bricks conforming to IS 1077-1992 having compressive strength not less than 35 Kg/cm² in cement mortar 1:4 (1 Cement: 4 coarse Sand) for all floors / all heights / all levels, in any shape, in any position, including curing, scaffolding, etc. complete, as directed. (For all civil, plumbing & electrical works).

6.8.1.1 Materials

Water shall conform to M-1. Cement to M-3. Sand to M-6. Brick to M-15. Cement mortar to M-11.

6.8.1.2 Workmanship

Relevant specifications of bricks, soaking and laying of bricks, joints, curing, etc. shall conform to sec. 6.8.1.

6.8.1.3 Proportion

The proportion of the CM shall be as mentioned in the item description (cement: medium sand), by volume.

6.8.1.4 Soaking of bricks

The bricks required for masonry shall be thoroughly wetted with clean water for about 24 hours before use or as directed. The cessation of bubbles, when the bricks are wetted with water is an indication of thorough wetting of bricks.

6.8.1.5 Laying

Bricks shall be laid in English bond unless directed otherwise. Half or cut bricks shall not be used except when necessary to complete the bond; closer and in such case, it shall be cut to required size and used near the ends of walls.

A layer of mortar shall be spread on full width for suitable length of the lower course. Each brick shall first be properly bedded and set home by gently tapping with the handle of the trowel or wooden mallet. Its inside face shall be flushed with mortar before the next brick is laid and pressed against it. On completion of the course, the vertical joints shall be fully filled from the top, with mortar.

The walls shall be taken up truly in plumb. All courses shall be laid truly horizontal, and all vertical joints shall be truly vertical. Vertical joints in alternate courses shall generally be in one vertical plane. The thickness of brick course shall be kept uniform.

The bricks shall be laid with the frog facing upwards. A set of tools comprising of wooden straight edges, Manson's spirit level, square half meter rub (right angle), pins, string, level pipe and plumb shall be kept on the site of work for frequent checking during the progress of work.

Both the faces of walls, having thickness greater than 23 cm. shall be kept in proper plumb. All the connected brick work shall be kept not more than 1 m. over the rest of the work. Where this is not possible, the work shall be raked back according to bond (and not left toothed) at an angle not steeper than 45°. In a day brick work shall not be laid more than 1m or 10 courses in height.

All the fixtures, pipe outlets of water, etc. which are required to be built in the wall shall be embedded in CM, as per the drawings or as directed. The frames of doors, windows, cupboards, etc. shall be housed into the brick work at the correct location and level, as directed. The heavy steel doors, windows frames, etc. shall be built in with brick work, but for ordinary steel doors and windows, required opening for frames, hold-fasts, etc. shall be left in the wall and frames shall be embedded later on in order to avoid damage to the frames.

Necessary scaffolding shall be provided by the Contractor. The supports of the scaffolding shall be sound and strong, tied together with horizontal pieces over which the scaffolding planks shall be fixed. Normally simple scaffolding only shall be allowed. In this case horizontal pieces of the scaffolding shall rest in the holes, made in the header course only. The Contractor is responsible for providing and maintaining sufficiently strong scaffolding so as to withstand all loads likely to come upon it.

No through holes shall be left in brickwork to support the scaffolding. Only double scaffolding shall be erected. In case the holes are left in the brickwork, it shall be filled with 1:4:8 PCC.

6.8.1.6 Joints

Bricks shall be so laid that all joints are quite flush with mortar. Thickness of joints shall not exceed 12 mm. The face joints shall be raked out as directed by raking tools daily, during the progress of work, when the mortar is still green so as to provide key for plaster or pointing to be done, subsequently.

The face of bricks shall be cleaned every day on which the brick work is laid and all mortar dropping shall be removed.

At the end of day's work or on holidays the top of unfinished masonry shall be kept wet. If the mortar becomes dry, white, or powdery, for want of curing, work shall be pulled down and re-built at Contractor's expense.

6.8.1.7 Curing

Fresh work shall be protected from rain suitably. Masonry work shall be kept moist on all the faces for minimum period of 7 days. The top of masonry work shall be kept well wetted at the end of the day's work.

6.8.1.8 Preparation of foundation bed

If the foundation is to be laid directly on the excavated bed, the bed shall be levelled, cleared off all loose materials, cleaned and wetted before starting masonry work. If masonry is to be laid on concrete footing, the top of concrete shall be roughened, cleaned, and moistened. The Contractor shall obtain approval of the Engineer-in-charge for the foundation bed before foundation masonry is started. When pucca flooring is to be provided flush with the top of the plinth, the inside of the plinth wall shall be lowered

down having an offset of the same thickness of the flooring with respect to the outside plinth wall top or as directed.

6.8.1.9 Mode of measurements and payment

The measurement of this item shall be taken for the brick masonry fully completed in foundation up to plinth or above plinth for all levels, heights, shapes and locations as per the item description. The limiting dimensions not exceeding those shown on the drawings or as directed shall be final. Battered, tapered and curved portions shall be measured net.

No deduction shall be made from the quantity of brick work, nor shall any extra payment be made for embedding in masonry or making holes in respect of following items:

- End of joists beams, posts, girders, rafters, purlins, trusses, corbel, steps etc. where cross sectional area does not exceed 500 Sq.cm.
- Architectural openings in walls, parapet, and compound walls, not exceeding 1.0 m². area.
- Wall plates and bed plates, bearing of slabs, chajjas and the like whose thickness does not exceed 10 cm. and the bearing does not extend to the full thickness of wall.
- Drainage holes, recesses for cement concrete blocks to embed hold fasts for doors, windows etc., forming toothing, grooves etc. and providing cramps for holding stone lining.
- Iron fixtures, pipes up to 300 mm. dia.; holdfasts and doors and windows built into masonry and sanitary and water supply pipes, etc., for concealed electrical wiring and any other fixtures or inserts.
- Forming chases of section not exceeding 350 cm². in masonry.

Apertures for fireplaces shall not be deducted nor shall extra labour required to make splaying of jambs, throating, and making arches over the aperture be paid for separately. The rate shall include for work of any shape e.g., pillars of any size and shape, curved or tapered walls, drip courses, projections, parapets, load bearing walls, sills, ottas, steps, tank walls, platforms and counter walls, ducts, channels, and architectural mouldings like corbelling, pattas, etc.

The rate shall be for a unit of one m².

6.8.2 Providing and laying half brick masonry work

Providing and laying Half brick masonry work, (115mm thick) using common burnt clay conventional building bricks confirming to IS 1077-1992, having crushing strength not less than 35 Kg/cm², in cement mortar 1:4 (1 Cement: 4 coarse Sand) without reinforcement for all floors / all heights / all levels, in any shape, in any position, including curing, scaffolding, etc. complete, as directed. Between floor level and lintel level provide horizontal RCC bend as per directed by engineer in charge. Concrete and reinforcement shall be paid in relevant items. Rate shall be inclusive necessary form work for RCC bend. (For all civil, plumbing & electrical works).

6.8.2.1 Materials

Bricks shall conform to M-15. Water to M-1. Cement to M-3. Sand to M-6. Cement mortar to M11.

6.8.2.2 Workmanship

Relevant specifications of bricks, wetting and laying of brick, joints, curing, etc. shall conform to item no. 6.8.1 except that the brick work of half bricks, 115 mm. thick shall be carried out, at all heights, levels, location, shapes etc. The thickness and the C.M shall be same as mentioned in the item description.

All bricks shall be laid stretcher wise, breaking joints with those in the upper and lower courses. The wall shall be taken truly plumb. All courses shall be laid truly horizontal, and all vertical joints shall be truly vertical. The bricks shall be laid with frogs upwards. A set of mason's tools shall be maintained on work site as required for frequent checking.

MS bars, 6 mm. dia., 2 nos. shall be provided at every 3rd course. The end of reinforcement shall be fully embedded in the main wall on both sides as directed. Reinforcement shall be placed on top of the bottom most course and then on every 3rd course. Lap shall be of 15 cm.

In a day brickwork shall not be laid more than 1m or 10 courses in height.

The joints in course where reinforcement is placed shall allow sufficient mortar cover to the reinforcement.

6.8.2.3 Mode of measurements and payment

The half brick masonry work for all heights, levels, locations and shapes shall be measured under this item. The limiting dimensions shall not exceed those shown in the plan or as directed. Any work done extra over the specified dimensions shall not be measured and paid for. The rate shall include the reinforcement if it is given in the item description.

The relevant specifications of item no. 6.8.1 shall be followed. The length shall be measured nearest to one cm.

The rate shall be for a unit of m².

6.8.3 Cavity Walls

Extra labour only for forming for 300 /350 mm wide cavity walls with thickness of both side leaves of 115 mm. Extra labour rate shall be for RCC wall ties, forming weep (below) and vent(upper) holes, closing of cavities at sill jamb and head etc. complete as directed by engineer-in-charge for all floors, levels, and shapes. Mode of measurement shall be as under: -

- Brick work in cavity walls shall have half (115 mm) brick thickness or 230 mm thickness as per item no 6.8.1 shall be measured and paid in relevant Contract item. RCC and reinforcement for band should be paid in relevant items.
- Width of cavity wall shall not be measured.

- Labour and material for closing cavities at the jambs, bottom of wall, sills and heads of opening shall be as described and measured in relevant Contract items.
- The item shall include use of device for keeping cavity clear and forming the requisite weep and vent holes and nothing extra on this account shall be payable.
- Length and height of the cavity wall for only one side shall be measured and paid.

6.8.3.1 Materials

Bricks shall conform to M-15. Water to M-1. Cement to M-3. Sand to M-6. Cement mortar to M-11.

6.8.3.2 Workmanship

Relevant specifications of bricks, soaking and laying of bricks, joints, curing, etc. shall conform to item no.

6.8.4 Providing and laying uncoursed rubble masonry in foundation

Providing and laying un-coursed rubble masonry, with hard stone of approved quality, in foundations and plinth / in super structure at any height any level having Crushing Strength 100 Kg/sq.cm in Cement mortar 1:6 (1 cement: 6 coarse sand) including levelling, flush pointing, curing etc. complete, with all lead and lift as directed by engineer in charge. (For all civil, plumbing, and electrical works)

6.8.4.1 Materials

The cement mortar shall conform to M-11. Stones to M-16.

6.8.4.2 Workmanship

- Dressing of stones:

Stone used for uncoursed rubble masonry work shall be hammer dressed on the sides, and beds in such a way as to close up with the adjacent stone in the masonry work as strongly as possible. The face stone shall be dressed in such a manner as to give a specified pattern such as diagonal touching etc. The face of the stone shall be so dressed that brushing on the exposed face shall not project by more than 40 mm. from the general wall surface and on the face to be plastered, it shall not project by more than 19 mm. nor shall have depressions more than 10 mm. from the average wall surface.

- Laying:

All the stone shall be sufficiently wetted before laying to prevent absorption of water from mortar. The wall shall be built truly in plumb (or true to required batter when so specified). All connected walls in a structure shall normally be raised up uniformly and regularly. However, if for any specific reason, one part of masonry is required to be left behind, the wall shall be racked back at an angle not steeper than 45°, vertical toothed joints in masonry shall not be allowed. The work shall be carried out regularly and masonry of any day will not be raised by more than 1 m. in height, at a time.

The stone shall be laid in an uncoursed fashion or random facing etc. However, the masonry is required to be brought to level at various stages viz. plinth level, window sill

level, roof level and any other level specifically shown in the drawings. This may be done by adjusting the laying of stones up to the level specified or the nearest to that level and then by providing levelling coarse of cement concrete 1:5:10 (1 cement: 5 sand: 10 graded stone aggregate 20 mm. nominal size) to bring the masonry work up to the desired level or as otherwise specified.

Proper bonding shall be achieved by closely filling in adjacent stones as well as by using bond stones or through stones as described herein below. Face stones shall extend back sufficiently and bond well with the masonry. The stone shall be carefully set so as to break joints and avoid formation of vertical joints. The depth of stone from the face of wall inward shall not be less than height or breadth at the face. The hearting or interior filling of the wall shall consist of rubble stones which may be of any shape. Neither the face stone nor the hearting stone shall be so small to pass through circular ring of 150 mm. internal diameter in any direction nor shall any of them shall have minimum thickness 100 mm.

All stone shall be carefully laid, hammered down by a wooden mallet into position and solidly embedded in mortar. Chips and spawls of stone may be used wherever necessary to avoid thick mortar beds or joints. At the same time no hollow space shall be left anywhere in the masonry. The chips used shall not be more than 20% by volume of masonry. The hearting stone shall be laid nearly in level with face stones except at vertical bond stone laid at 1 m. intervals or plumbs projecting about 150 to 200 mm. shall be firmly embedded to form vertical bonding in masonry.

- Bond stones:

Bond stones or through stones running right across the thickness of the wall shall be provided in walls up to 600 mm. thick. In thicker walls two stones overlapping each other by at least 150 mm. shall be provided across the thickness of the wall to form bond stones. There shall be at least one bond stone for every 0.5 Sq.m. of walls surface. The bond stone shall be marked by a distinguishing letter during construction for subsequent verification and shall be laid staggered in subsequent layers.

- Quoins:

The quoins or corner stone shall be selected stone neatly dressed with hammer and/or chisel to form the required corner angle and laid header and stretcher alternatively. The bed and top surface of quoins shall be chiselled, dressed to give horizontal joints. The quoins shall have a uniform chisel draft of at least 25 mm. width at four edges of each exposed face, all the edges of the same face being in one plane. No quoin stones shall be smaller than 0.025 Cub.m. in volume.

- Jamb stones:

The jamb stone shall be made with stone specified for quoins, except that the stone provided on the jambs shall have their length equal to thickness of wall up to 600 mm. and a line of headers shall be provided for walls thicker than 600 mm. as specified for bond.

- Joints:

All the joints shall be completely filled with mortar and their width shall not exceed 25 mm. When plastering or pointing is not required to be done, the joints shall be struck and

finished simultaneously while laying the stone. Otherwise, the joints shall be racked to a minimum depth of 20 mm. by a racking tool, during progress of laying while the mortar is still green.

- Scaffolding:

Single or double scaffolding shall be used. The scaffolding shall be strong and sound. The holes left in masonry for supporting scaffolding shall be filled and made good with 1:4:8 PCC before plastering or pointing.

- Curing:

Green work shall be protected from rains by suitably covering the same. Masonry shall be kept constantly moist on all the faces at least for a period of 7 days. The top of masonry shall be flooded at the close of the day.

6.8.4.3 Mode of measurements and payment

All work shall be measured on the basis of finished dimensions and measured net except where otherwise specified. Only specified dimensions shall be allowed. Anything extra shall not be measured and paid for. The masonry work in foundation and plinth shall be measured under this item. No deduction shall be made, nor shall extra payment be made for the following:

- Ends of joints, beams, posts, girders, rafters, purlins, trusses, corbels, etc. each up to 500 Sq.cm. in section.
- Opening each up to 0.1 Sq.m.
- Wall plates and bed plate's bearings of chhajja and like up to 10 cm. depth (hearing of floor and roof slabs shall be deducted from masonry).
- Drain holes and recesses for cement concrete block to embed holdfasts for doors and windows.
- Building in the masonry iron fixtures pipes up to 300 mm. dia holdfasts of doors and windows.
- Forming cheeses in masonry up to section of 350 Sq.cm.

The rate shall be for a unit of one Cub.m.

6.8.5 Providing and laying coursed rubble masonry above plinth level

Providing and laying coursed rubble masonry, with hard stone of approved quality, for superstructure above plinth level and for all the floors, in CM 1:6 (1 cement: 6 coarse sand) including levelling, flush pointing, curing etc. complete, with all lead and lift as directed by engineer in charge. (For all civil, plumbing, and electrical works)

6.8.5.1 Materials and workmanship

The relevant specifications of item no. 6.5.4 shall be followed except that the coursed rubble masonry works shall be carried out for superstructure above plinth level for all floor levels.

Single or double scaffolding may be used. The scaffolding shall be strong and sound. In case single scaffolding is used, the holes shall be carefully made good as directed.

6.8.5.2 Mode of measurements and payment

The relevant specifications of item no. 6.5.4 shall be followed.

The rate shall be for a unit of one Cu.m.

6.9 Plaster and pointing

6.9.1 Plastering

6.9.1.1 ***Providing and laying average 8 to 10 mm thick single coat mala finish plaster***

Providing and laying average 8 to 10 mm thick single coat mala finish plaster in CM 1:4, on ceilings and stair soffits at all floors, all shapes and all heights with necessary scaffolding, curing, making grooves, forming pattas, hacking properly RCC surface etc. complete as directed by Engineer-in-charge. (For all civil, plumbing and electrical works)

- **Materials:**

Water shall conform to M-1. The cement mortar of proportion 1:3 shall conform to M-11.

- **Workmanship:**

Scaffolding: Steel scaffolding shall be sound. These shall be properly examined before erection and use. Stage scaffolding shall be provided for ceiling plaster, which shall be independent of the walls. The sample shall be approved by engineer-in-charge before starting the work.

- **Preparation of back ground:**

The surface shall be cleaned of all dust, loose mortar droppings, traces of algae, efflorescence and other foreign matter by water or by brushing. Smooth surface shall be roughened by wire brushing if it is not hard and by dense hacking if it is concrete. In case of concrete surface, if a chemical retarder or shuttering oil has been applied to the form work, the surface shall be roughened by wire brushing and all the resulting dust and loose particles shall be cleaned off and care shall be taken that none of the retarder is left on the surface. Trimming of projections on brick/concrete surface wherever necessary shall be carried out to get an even surface.

Raking of joints in case of masonry wherever necessary shall be allowed to dry out for sufficient period before carrying out the plasterwork.

Scaffolding for carrying out plastering work shall be double scaffolding having two sets of vertical supports so that the scaffolding is independent of the walls.

- **Preparation of surface:**

All putlog holes in brickwork and junction between concrete and brickwork shall be properly filled in advance. Joints in brick work shall be raked about 10 mm. and concrete surface shall be hacked to provide grip to the plaster. Projecting burrs of mortars formed due to gaps at joints in shuttering shall be removed. The surface shall be scrubbed clean with wire brush/coir brush to remove dirt, dust etc., and the surface thoroughly washed with clean water to remove efflorescence, grease and oil etc., and shall be kept wet for a minimum of two hours before application of plaster.

For external plaster, the plastering operation shall be started from the top floor and carried downwards. For internal plaster, the plastering operations may be started wherever the building frame and cladding work are ready and the temporary supporting ceiling resting on the wall of the floor have been removed. Ceiling plaster shall be completed before starting plaster to walls.

- Applications of plaster:

The plaster about 5 cm. x 5 cm shall be first applied horizontally and vertically at not more than 2 m. intervals over the entire surface to serve as gauge. The surfaces of these gauges shall be truly in plane of the finished plastered surface. The mortar shall then be applied in uniform surface slightly more than the specified thickness, then brought to a true surface by working a wooden straight edge reaching across the gauges with small upwards and sideways movements at a time. Finally, the surface shall be finished off true with a trowel or wooden float according to the texture, smooth or sandy granular, as may be required. Excessive Trowelling or over working the float shall be avoided. All corners, arises, angles and junctions etc. shall be carried out with proper templates to the size required. The surface shall be finished smooth using neat cement at the ratio of 2.2 kg/Sq.m.

Cement mortar shall be used within half an hour after addition of water. Any mortar or plaster which is partially set shall be rejected and removed from the site.

In suspending the work at the end of the day, the plaster shall be left out, clean to line both horizontally and vertically. While recommencing the plaster, the edges of the old work shall be scrapped clean and wetted with cement putty before plaster is applied to the adjacent areas to enable the two to properly join together. Plastering work shall be closed at the end of the day on the body of the wall and shall not be nearer than 15 cm. to any corners or arises. Horizontal joints in plasterwork shall not also occur on parapet tops and copings as these invariably lead to leakage. No portion of the surface shall be left out initially to be patched up later on.

Each coat shall be kept damp continuously till the next coat is applied or for a minimum period of 7 days. Moistening shall commence as soon as plaster is hardened sufficiently. Soaking of walls shall be avoided and only as much water as can be readily absorbed shall be used, excessive evaporation on the sunny or windward side of building in hot air or dry weather shall be prevented by hanging mats or gunny bags on the outside of the plaster and by keeping them wet.

- Mode of measurements & payment:

The rates shall include for work at any height, position, and floor and for all necessary scaffolding, etc. as may be required. The rates shall also include for hacking and/or bush hammering to form key for plaster and for spatter dash treatment, as specified, as and where necessary.

The rates shall also include for all work in narrow width, arises, rounded angles, chamfered external angles, drip moulds, grooves and for making good after all trades.

The rate shall also include for groove with cement finish up to 12 mm. x 6 mm. to be formed in plaster at junction of slab and beam and slab and brick without any extra charge. The rate shall also include for similar grooves in plaster at the junction of masonry and wood or steel door/window/ventilator frame or at bottom of beam/lintels as drip moulds without extra charge.

All plastering shall be measured in Sq.m, unless otherwise specified. Length, breadth or height shall be measured correct to a centimetre.

Thickness of the plaster shall be exclusive of the thickness of the key i.e., grooved or open joints in brick work, stonework, etc. or space between laths. Thickness of plaster shall be average thickness with minimum 8 to 10 mm at any point on the surface.

The measurement of wall plastering shall be taken between the walls or partitions (dimensions before plastering being taken) for length and from the top of floor or skirting to ceiling for height. Depth of cover of cornices if any shall be deducted.

Soffits of stairs shall be measured as plastering on ceilings. Flowing/folding soffits shall be measured separately.

For jambs, soffits, sills, etc., openings exceeding 0.5 Sq.m and not exceeding 3.0 Sq.m, area deductions and additions shall be made in the following manner: -

(a) No deductions shall be made for end joints, beams, posts, etc. for openings not exceeding 0.5 Sq.m. each and no addition shall be made for reveals, jambs, soffits, sills, etc. of these opening for finish to plaster around ends of joints, beams, posts, etc.

(b) Deduction for openings exceeds 0.5 Sq.m. but not exceeding 3.0 Sq.m. each shall be made as follows and no addition shall be made for reveals, jambs, soffits, sills, etc. of these openings.

(i) When both faces of any wall are plastered with same plaster, deduction shall be made for one face only.

(ii) When two faces of any wall are plastered with different types of plasters or if one faces is plastered and the other pointed, deductions shall be made from the plaster or pointing on the side of frame for door, windows, etc. on which width of reveals is less than that on the other side but no deductions shall be made on the other side. Where width of reveals on both faces of all is equal, deductions of 50% of area of opening on each face shall be made from area of plaster and/or pointing as the case may be.

For openings having door frames equal to projection beyond the thickness of wall, full deduction for opening shall be made from each plastered face of the wall. Jambs, soffits and sills shall be measured separately and paid for.

In case of openings having area above 3.0 Sq.m each, full deduction shall be made for the opening, but jambs, soffits, and sills shall be measured additionally.

The rate shall be for a unit of one Sq.m.

6.9.1.2 Providing and laying average 12mm thick single coat cement finish cement plaster

Providing and laying average 12mm thick single coat cement finish cement plaster (internal) in CM 1:4 on sides of masonry work, at all floors, all shapes and all heights with necessary scaffolding, curing, making grooves, forming pattas and drip moulds, hacking the RCC surface etc. complete, with floating coat of cement slurry as directed by Engineer-in-charge. (For all civil, plumbing and electrical works)

a) Super Structure - Up to second floor

b) Super Structure - Second floor and above

- Materials & workmanship:

The relevant specifications of item no. 6.9.1.1 shall be followed same except that the thickness shall be 15 mm. instead of 10 mm. The surface shall be finished smooth using neat cement at the ratio of 2.2 kg/Sq.m.

- Mode of measurements & payment:

The mode of measurement and payment shall be the same as in item no. 6.9.1.1

The rate shall be for a unit of one Sq.m.

Providing and laying average 15 mm thick single coat mala finish plaster (internal plaster) in CM 1:4, on sides of masonry work / block work / RCC at all floors, all shapes and all heights with necessary scaffolding, curing, making grooves, forming pattas, hacking properly RCC surface etc. complete as directed by Engineer-in-charge (for all civil, plumbing & electrical works).

The relevant specification of 7 shall be followed except that the thickness of the plaster shall be 15 mm instead of 10 mm and mala finish plaster instead of cement finish plaster.

6.9.1.3 Providing & laying average 18 mm. thick cement plaster

Providing & laying average 18 mm. thick cement plaster in two coats (External Plaster) at all heights, all shapes and all levels with first coat in CM 1:4 (1 cement: 4 coarse sand) rough wired finish and second coat in CM 1:2 cement mala finish (finished with steel trowel) including scaffolding, curing, making grooves, forming pattas and drip mould, hacking RCC surface etc. complete, as directed by Engineer-In charge (for all civil, plumbing & electrical works).

- Materials & workmanship:

The relevant specifications of item No. 6.9.1.1 shall be followed except that the thickness of the plaster shall be average 20 mm. and shall be carried out as specified in the item. The base coat shall be carried in CM 1:4 having average 12-15 mm. thickness. Before the plastered surface hardens roughing shall be done to receive the second coat. Second coat shall be applied only after minimum curing of 72 hours. The second coat shall be carried out in CM 1:3 having average 8-5 mm thickness. The surface shall be finished smooth with steel trowel (Mala finish).

- Mode of measurements and payment:

The relevant specifications of item No. 6.9.1.2 shall be followed.

The rate shall be for a unit of one Sq.m.

6.9.1.4 Providing and laying average 18 mm. thick Sand face cement plaster

Providing and laying average 18 mm. thick Sand face cement plaster on walls up to any height above ground level and for all shapes consisting of average 10 mm. thick backing coat of CM 1:4 (1 cement: 4 coarse sand) and average 8 mm. thick uniform grained textured finish coat by using wooden Gutka, sponge or special tools and machines in CM 1:2 (1 cement : 2 sand), including scaffolding, forming grooves, drip moulds, pattas, hacking RCC surface, curing etc. complete as directed by engineer in charge (for civil, plumbing & electrical works).

- Materials: Water shall conform to M-1. Cement mortar shall conform to M-11.

- Workmanship:

The work shall be carried out in two coats. The backing coat (base coat) shall be 12-15mm thick in CM 1:4 (1 cement: 4 coarse sand) and the relevant specifications of item no. 6.9.1.1 and 6.9.1.3 shall be followed. Before the first coat hardens its surface shall be beaten up by edges of wooden tapers and close-wired finish shall be made on the surface. The subsequent coat shall be applied after this coat has been allowed to set for 3 to 5 days depending upon the weather conditions. The surface shall not be allowed to dry during this period. Before applying the second coat neat cement slurry shall be applied on the wall surface.

The second coat shall be completed to average 6 mm. thickness in CM 1:2 as described above. The surface shall then be tapered to uniform grained texture by using Wooden Gutka/ sponge / special tools and machine (as directed by engineer in charge), as specified. The sample of sand face shall be got approved before the work is started. The whole work shall be carried out uniformly as per the sample approved.

- Curing:

The curing shall be started overnight after finishing of the plasterwork. The plaster shall be kept wet for a period of 7 days. During this period, it shall be protected from all damages.

- Mode of measurements and payment:

The relevant specifications of item No. 6.9.1.2 shall be followed. The rate shall be for all floors, all heights, all levels and all shapes.

The rate shall be for a unit of one Sq.m measured flat.

6.9.1.5 Providing and fixing hexagonal chicken-mesh

Providing and fixing hexagonal chicken mesh of size 20 mm. x 20 mm. of 26 gauge and minimum 200mm wide patta with GI nails at junction of concrete and brick work or between different materials, etc. as directed by engineer in charge. (For all civil, plumbing & electrical works).

- Material: Chicken wire mesh having openings 20 mm. x 20 mm. of 26 gauges shall be provided as directed.

- Workmanship:

The mesh is to be fixed with nails and cement paste at the junctions of different materials (column and brickwork, at beam bottom level- on the face of beam and brickwork) to avoid cracks in the plaster.

Chicken mesh shall be fixed in advance of the plasterwork. Chicken mesh shall be fixed in such a way that it is totally concealed in the plaster. Chicken mesh shall be fixed in such a way that minimum 75mm mesh is provided on either side of the joint. The mesh shall be fixed with both the elements with the help of nail/ screws. Drilling shall be carried out if required in RCC member.

The mesh shall be overlapped by 15 cms in the length while joining the two pieces of mesh and also at corners.

- Mode of measurement and payment:

No extra payment will be made, and this shall be considered in plastering rate, whenever required, the item will be measured in Sq.m. No extra payment shall be done for over lapping of mesh and wastage.

6.9.2 Pointing

6.9.2.1 **Pointing with 1:2 cement mortar**

Pointing on brick work/ block/ stone (only on expose masonry work) with cement mortar 1:2 (1 cement: 2 sand), grove pointing with necessary scaffolding, curing etc. complete as directed by engineer in charge. (For all civil, plumbing & electrical works).

- Materials:

Water shall conform to M-1. Cement mortar shall conform to M-11.

- Workmanship:

The flush pointing work shall be carried out with cement mortar of proportion 1:2 (1 part of cement and 2 parts of coarse sand) by volume.

- Preparation of surface:

The joints shall be raked to such a depth that the average of new mortar measured from either the sunk surface of finished pointing or from the edge of the brick shall be average 10 mm.

The joints shall then be cleaned with a wire brush and wetted thoroughly for 6 hours before pointing is commenced.

- Application of mortar & finishing:

The mortar shall be pressed into the raked-out joints with a pointing trowel according to the type of pointing specified in item. The mortar shall not spread over the corner edges or surface of the masonry. The pointing shall then be finished with the pointing tools and horizontal joints false lined with mason's string.

- Curing: The pointing shall be cured for 7 days. During this period, it shall be suitably protected from all damages.

- Mode of measurements and payment:

No deductions shall be made for end of joints, beams and posts, etc. for openings not exceeding 0.5 Sq.m each and no addition shall be made for reveals, jambs, soffits, sill, etc. of these openings.

Deductions for openings exceeding 0.5 Sq.m. but not exceeding 3.0 Sq.m. each, shall be paid as follows and no addition shall be made for reveals, jambs, soffits, sills, etc. of these openings.

(i) When both faces of walls are pointed with same type of pointing deduction shall be made for one face only.

(ii) When two faces of walls are pointed with different type of pointing or if one face is plastered and the other is pointed, deduction shall be made in the plaster or pointing on the side of frame for door, windows, etc., on which the width of reveals is less than that on the other side but no deduction shall be made from plaster or pointing on the other side.

(iii) When only one face is treated and the other face is not treated, full deduction shall be made, if the width of the reveals on the treated side is less than on the untreated side, but if the width of the reveal is more, then no deduction shall be made nor any addition shall be made for reveals jambs soffits, sills, etc.

In case of openings of area above 3.0 Sq.m. each, deduction shall be made for opening but jambs, sills and soffits, shall be measured.

The rate shall be for a unit of one Sq.m. The rate shall include scaffolding etc. complete.

6.9.2.2 Providing cement vata

Providing cement vata, 10 cm. x 10 cm. size, and quarter round concave / triangular in cement concrete 1:2:4 including neat cement finishing, curing, hacking the RCC surface, etc. complete (for all civil, plumbing & electrical works).

- Materials: Water shall conform to M-1. Cement mortar shall conform to M-11.
- Workmanship: The work of cement vata of 10 cm. x 10 cm. size shall be carried out at junctions of parapets and terraces as directed. The vata shall be finished in quarter round shape. The work shall be carried out in the best workman-like manner. The internal portion of rainwater pipe shall be rounded off properly during constructing the vata. The work shall be cured for 7 days.
- Mode of measurement and payment:

The work shall be measured for finished item in Rmt.

The rate shall be for a unit of one Rmt. The rate shall include hacking the RCC surface, curing etc. complete.

6.10 Steelworks

6.10.1 General

This specification covers the construction and erection of structural steel members.

6.10.2 Product

6.10.2.1 Structural steel

All structural steel shall conform to IS: 2062. The steel shall be well and cleanly rolled to the dimensions and weight specified by the IS, subject to the permissible tolerances as per IS: 1852. The finished materials shall be reasonably free from cracks, surface flaws, laminations, rough and imperfect edges, and all other harmful defects mentioned in IS: 2062 and shall have a smooth finish. The material shall be free from loose mill scale, rust pits or other defects affecting the strength and durability. River bars shall conform to IS:1148. The decision of the Engineer-in-charge regarding rejecting any steel section on account of any of the above defects shall be final and binding to the Contractor.

Structural steel shall conform to the mechanical properties as described in Table 6-7.

Steel supply to specifications equivalent to those listed in Table 6-7 shall be considered as substitution and shall require written approval by the Owner.

Table 6-7: Mechanical Properties of Structural Steel

Grade Designation	Quality	Tensile Strength R_m , Min MPa ¹⁾ (See Note 1)	Yield Stress R_{eH} , Min MPa ¹⁾			Percentage Elongation A , Min at Gauge Length, $L_0=5.65$	Internal Bend Diameter Min (See Note 2)		Charpy Impact Test (See Note 3)	
			<20	20-40	>40		≤ 25	>25	Temp °C	Min J
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
E 250	A	410	250	240	230	23	2t	3t	—	—
	BR								RT	27
	B0								0	27
	C								(-) 20	27
E 275	A	430	275	265	255	22	2t	3t	—	—
	BR								RT	27
	B0								0	27
	C								(-) 20	27
E 300	A	440	300	290	280	22	2t	—	—	—
	BR								RT	27
	B0								0	27
	C								(-) 20	27
E 350	A	490	350	330	320	22	2t	—	—	—
	BR								RT	27
	B0								0	27
	C								(-) 20	27
E 410	A	540	410	390	380	20	2t	—	—	—
	BR								RT	25
	B0								0	25
	C								(-) 20	25
E 450	A	570	450	430	420	20	2.5t	—	—	—
	BR								RT	20
E 550	A	650	550	530	520	12	3t	—	—	—
	BR								RT	15

E 600	A	730	600	580	570	12	3.5t	—	—	—
	BR								RT	15
E 650	A	780	650	630	620	12	4t	—	—	—
	BR								RT	15

NOTES

1 In case of product thickness/diameter more than 100 mm, lower minimum limit of tensile strength may be mutually agreed to between the purchaser and the manufacturer/supplier.

2 Bend test not required for thickness > 25 mm for grades E 300 to E 650. 't' is the thickness of the test piece.

3 For sub-quality BR, impact test is optional; if required, at room temperature (25 ± 2°C).

¹⁾ 1MPa = 1N/mm² = 1MN/m² = 0.102 kgf/mm² = 144.4 psi.

All the structural steel shall be one of the steel grades as defined, unless otherwise specified on the bid drawings.

6.10.2.2 General requirements

6.10.2.2.1 Mill tests

All mandatory inspection and testing listed in ASTM A6, "Standard Specification for General Requirements Rolled Steel Plates, Shapes, Sheet piling, and Bars for Structural Use", shall apply.

Supplementary inspection and test when specified in individual specifications shall also apply.

In addition to above for all steel materials the following are mandatory requirements:

Product Analysis: One sample per heat. Acceptability standards as specified in ASTM designation A6 shall apply for all elements.

In addition, a field weldability test shall be performed in accordance with the requirements of Welding and Weld specification with a heat input of 15-20KJ/cm and the results of the test shall meet the requirements specified for the base material. This requirement shall be a prerequisite for the acceptance of the material.

6.10.2.2.2 Mill certificates

Contractor shall supply the owner with a certificate indicating the process manufacture results of chemical and mechanical tests including specified supplementary tests for the material. Each test certificate shall bear the heat number and other identification marks such that the same can be correlated with the material. These certificates shall be signed by manufacturer's representative and furnish along with material.

6.10.2.2.3 Steel ex-stock

When any steel is supplied from stock, the Contractor shall satisfy the Owner that the steel has been manufactured and tested and complies with all the tests and requirements of the specification under which the steel is being furnished with necessary documentary proof of original manufacturer. The heat numbers on mill certificates should be correlated with the markings on the material. Steel material without acceptable mill certificate shall not be used.

6.10.2.2.4 Special requirements

6.10.2.2.4.1 Carbon Steel

All carbon steel material shall meet the following:

Max. Carbon (C_{max}) = 0.22%

Max. Carbon Equivalent (CE) = 0.45 (For CE formula refer 6.10.2.2.4.2)

6.10.2.2.4.2 Intermediated strength Steel and joint Can Steel

The carbon equivalent shall be a maximum of 0.43 (ladle analysis) as determined from the following formula:

$$CE = C + \frac{C_r + M_0 + V}{5} + \frac{C_u + N_i}{15} + \frac{M_n}{6}$$

6.10.2.2.4.3 Other requirements

All plates used for tubular joint cans 25 mm thick and above shall be ultrasonically inspected for defects and discontinuities in accordance with ASTM A578 Acceptance Standard shall be level II (Supplementary requirements S1 of API Specifications 2H) and through thickness testing as per supplementary requirements S4 of API Specifications 2H.

If it is intended to use plates having defects requiring repair for welding procedure qualification, these plates shall be shipped clearly marked "For Procedure Qualification Only".

6.10.2.2.4.4 Heat treatment

Heat treatment shall be performed on all elements where properties have been degraded by forming and fabrication.

6.10.2.2.4.5 Stress relief

Stress relief heat treatment shall be performed on all materials subject to the following conditions:

Elements subjected to press or roll forming where the temperature of the steel is above 38°C or less than 42°C during the forming operation.

Elements subjected to press or roll forming where the outer fibre strain exceeds five (5) percent as defined by the formula.

$$\text{Percent Strain} = (100 t)/D$$

Where t = thickness of element

D = Outside diameter

Welded assemblies containing one or more elements with the thickness exceeding 65mm.

6.10.2.2.4.6 Stress relief temperatures

All stress relief shall be achieved by thermal methods by heating the element or assembly to a temperature between 590°C and 620°C for carbon steel and intermediated strength steel.

6.10.2.2.4.7 *Local heat treatment*

The use of furnaces is desirable for all heat treatments. When local heat treatments are deemed necessary, a detailed procedure shall be submitted to the Owner for approval prior to performing such heat treatments.

6.10.3 **Execution**

6.10.3.1 **Connections**

6.10.3.1.1 General

All bolts and nuts shall supply with IS: 1367 Technical Supply Conditions for Threaded Fasteners". All bolts including high strength friction grip bolts, nuts and washers shall be hot dip galvanized and shall comply to relevant standards.

6.10.3.2 **Fabrication**

6.10.3.2.1 Shop drawing

All the shop drawings will be prepared by the contractor.

6.10.3.2.2 Fabrication programme

The Contractor shall provide a programme giving details of supply, dates of rolling, sequence, and methods of fabrication.

6.10.3.2.3 Quality control during fabrication

The Contractor shall provide prior to commencement of fabrication details of proposed quality control for all shop work including welding.

6.10.3.2.4 Erection marks

Erection marks shall be stamped or painted all members in a manner approved by the Owner.

6.10.3.3 **Workmanship**

6.10.3.3.1 General

Exposed cut edges of steelwork shall be rounded off by grinding. Ends of members bearing in compression shall be machined so that loads are transmitted over the entire area of contact.

Plates and rolled sections required to be cut to exact lengths shall be accurately cold sawn or machined. Hot sawing or machine gas cutting will be permitted for the ends of beams and other parts in compression.

Burrs left by the cold or hot saw shall be removed and gas cuts shall be dressed free from oxidized metal to a neat and workmanlike finish.

Bolted connection in compression members shall be capable transmitting through the bolts 1.2 times the design load. The ends of the members shall be prepared in accordance with the requirements and the maximum gap allowable between ends will be 2 mm.

All holes shall be drilled. Holes for bolts shall not be more 1.5mm/2.0 mm larger in diameter than the nominal diameter of the bolt as specified on the drawings.

6.10.3.4 Welding

Welding shall be referred to Section 6.11.

6.10.3.5 Bolt connections

6.10.3.5.1 General

Holes shall be drilled accurately to template. Burrs and arises shall be removed from the edges of holes before the parts are assembled and holes shall not be pinched unless the Owner gives permission. No holes shall be gas cut, either during fabrication in shops or during erection at site.

Bolt holes shall be accurately aligned so that bolts can be inserted without force. Bolts shall not be driven home, and drift pins used to draw members into alignment shall not be used in a manner to distort or enlarge bolt holes.

Joint interfaces shall be clean and free from loose scale, loose rust, oil, grease, paint and all other deleterious matter before the joint is assembled unless otherwise instructed.

6.10.3.5.2 High strength friction grip bolts

High strength friction grip bolts shall comply with the following requirements: -

The bolts shall be in accordance with IS 3757: 1985 (Specification for High Strength Structural Bolts (Second Revision))

The Contractor shall demonstrate on site to the satisfaction of the Owner by means of sample bolts and a calibrated bolt load meter that the minimum shank tension is obtained with the type of fastener chosen and the equipment he proposes to use for tightening.

High strength friction grip bolts which have been tightened and subsequently released shall not be used in permanent works.

6.10.3.5.3 Foundation bolts anchorages

The Contractor shall supply and deliver to site all necessary anchorages and foundation bolts which are to be built into the foundation and all templates required for correct location of anchorages and foundation bolts.

Foundation bolts shall be complete with tubular steel sleeves to permit adjustment in position, anchor frames, washers, washer plates and nuts.

After foundation bolts and anchorages have been cast into the concrete, the ends shall be protected by greasing and wrapping with suitable protective material.

After fixing the base plate, bolt holes shall be grouted with neat cement grout of a consistency to the approval of the Owner. Grout shall be used as soon as possible and more than 30 minutes after initial mixing of cement and water. Temporary erection packers under base plates shall be so arranged that they removed on completion of bedding operations.

6.10.3.5.4 Release for delivery

At the satisfactory completion of the inspection and testing the Owner shall issue to the Contractor a notification releasing the steelwork for delivery or shipment to the site. No steelwork shall be delivered or shipped to the site until the Contractor has obtained from the Owner his notice releasing such steelwork for delivery or shipment.

6.10.3.6 **Transport and storage**

6.10.3.6.1 Programme

The Contractor shall provide a proposed programme and method for transporting steelwork to site.

6.10.3.6.2 Handling and storage

All wire ropes and chain slings used for hoisting and securing loads shall be covered to prevent scoring, chaffing and other damage.

Softwood timber bearers with a sufficient contact area to prevent crushing shall be provided at all stages of transporting and storage. Bearers shall be level and sufficient in number to prevent distortion of members. Beams used to support steelwork stored externally shall be sufficiently high to ensure that the lowest parts of the stored members are above and clear of the rainwater splash zone and that from passing vehicles.

Members shall be stacked in such a manner as to permit free drainage of rainwater from the surfaces and to avoid ponding. If covers are provided to store steelwork, timber bearers or other form of support which is acceptable to the Owner shall be used to ensure that covers are not in contact with steel surfaces. The arrangements for ventilating under the covers to minimize condensation shall be acceptable to the Owner.

Projecting stud bolts and cleats shall be avoided where possible.

6.10.3.6.3 Prevention of contamination

Precautions shall be taken at all stages to prevent steelwork being contaminated by oil, cement, soil, chemicals, or other deleterious agents. Should any contamination occur, the contaminating agent shall be removed immediately by swabbing or brushing and the surfaces well washed with clean water.

6.10.3.6.4 Small parts

Bolts, loose nuts, washers of each size, shall be packed separately.

Bins, packages of bolts, nuts, washers, and other small parts shall be stored in boxes, crates, kegs or barrels, none of which shall exceed 70kg gross weight. A list and description of material contained therein shall be plainly marked on the outside of each container.

6.10.3.7 Erection

6.10.3.7.1 Erection drawings

Erection drawings will be issued to the contractor by the employer.

6.10.3.7.2 Assembly and erection

The Contractor shall submit his proposed method of assembly and installation to the Owner for approval before commencing the works. Such approval will not relieve the Contractor of his responsibility to transport, stack, assemble and erect the work without damage, distortion or over stressing. Any component so damaged, etc. shall be replaced or rectified as directed by and to the satisfaction of the Owner.

6.10.3.7.3 Erection stresses

Adequate provision for erection stresses shall be made and for sufficient temporary bracing to keep the frame plumb and in true alignment until completion of erection. As erection progresses, the connections shall be finished to the satisfaction of the Owner to take care of all dead load, wind and erection stresses. Bolted connections must not be left to “weather” for any period of time before final tightening. The Contractor shall be responsible for the stability of the structure at all stages during erection and shall provide and remove on completion any temporary bracing, guys and the like required.

6.10.3.7.4 Safety in erection

The Contractor shall observe the good practices and recommendations for safety in erecting structural frames given in IS 7205:1974 (safety code for erection of structural steel work)

6.10.3.8 Protective coatings

Protective coatings to structural steelwork shall be in accordance with Section 6.12.

6.10.4 References

6.10.4.1 Indian standards and other Standards and codes of practice

Indian and other standards and codes of practice referred to in this section are as follows: -

Standards and codes of practice

IS 808	-	Dimensions for Hot Rolled Steel Beam, Column, Channel and Angle Section
IS 5369	-	General Requirements for Plain and Lock Washers (First Revision)
IS 4218	-	ISO Metric Threads- Part1: Basic and Design Profiles (First Revision)

IS 9595	-	Metal Arc Welding of Carbon and Carbon Manganese Steels-Recommendations
IS 7205	-	Safety Code for Erection of Structural Steel Work
IS 1161	-	Steel Tubes for Structural Purposes – Specification
IS 1367	-	Technical Supply Conditions for Threaded Steel Fasteners
IS 2629	-	Recommended Practice for Hot-Dip Galvanizing of Iron and Steel
IS 3757	-	Specification for High Strength Structural Bolts
IS 2082	-	Steel for General Structural Purposes – Specification

6.11 Welding & Inspection

6.11.1 General

This section modifies and /or supplements the referred codes which apply to all piping and structural welding. These requirements cover welding done at Supplier's fabrication plants, Contractor's yards, or field installations, in water (offshore).

6.11.2 Product

6.11.2.1 Material

Electrodes, Welding wire and Flux

SMA Welding electrodes

The manual metal arc welding electrodes to be used for welding A36/IS 2062 shall conform to the classification E 7018/E 7016 in accordance with AWS classification A 5.1.

The manual metal arc welding electrodes to be used for welding to material 1.6919/A 514 Gr. F/1.8928 or equivalent shall conform to the classification E-10018 M in accordance with AWS classification A 5.5.

6.11.3 Execution

6.11.3.1 Submerged arc welding consumables

The wire-flux combination to be used for welding A 36/IS 2062 shall conform to the classification F 7 PO-EM 12 K of specification of A 5.17 or IS 814 – 2004.

All filler material will be suitable for the position and conditions of its intended use with the P number classification of the base metal to which they are applied.

All electrodes and wires shall be stored in suitable heated dry storage ovens until issued for use. Temperature of storage shall be to manufacturer's recommendations. This material shall be identifiable by means of its original colour coding (or factory labelling, in the case of wire) until the time of use.

If submerged arc welding is utilized, the flux shall be the neutral type. It shall be kept in dry storage and used in accordance with the manufacturer's recommendations regarding temperature and humidity limitations. Flux shall not be reused.

Electrodes and filler wires showing signs of damages or deterioration shall not be used.

6.11.3.2 Inspection of welding materials

All welding materials furnished by the Contractor shall be subject to inspection and test at the site by the Owner. Inspection and tests of materials will be conducted without expense to Contractor when such inspections and / or tests are in addition to those required by these specifications.

Inspection at the mill, shop, and/or fabricating sites will not relieve the Contractor of the responsibility of furnishing welding materials satisfactory to the specification requirements. In the event these materials do not perform on site to the requirements of these specifications, Owner reserves the right to reject such materials at any time.

6.11.3.3 Qualification

6.11.3.3.1 Welding inspectors

Irrespective of any stipulations in the Codes, the Owner's representative shall be the qualified welding inspectors for the Contract resulting from these bid documents.

6.11.3.3.2 Welders and welding operators

Welders and welding operators must be qualified as required by the particular code covering the work, they are to perform by passing a welding test in accordance with ASTM. This qualification is at the Contractor's expense.

Prior to commencement of work Contractor must submit records of qualification to the Owner. If the work turned out by a welder or welding operator shows repetitive defects, Owner retains right to require the retesting of the welder or welding operator at any time. The decision of the Owner regarding the qualifications and requirement of qualification of the welder shall be final. Retesting of the welder shall be at Contractor's expense.

All welders shall be specifically qualified for the type of weld and grade of steel they are employed to weld. Welders qualified to weld only part of the joint utilized shall be restricted to welding on only that portion of the work for which they are qualified.

All welders working on the project shall wear identification cards made at Contractor's cost, which shall contain the photograph and name of the welder, procedure qualified and Engineer's signature.

6.11.3.3.3 Welding consumables

Each Welding electrodes and wire-flux combination intended to be used on the job shall be separately qualified by conducting detailed qualification testing in accordance with the relevant AWS specification to prove their conformity. In case a consumable of a brand name has already been qualified for Owner use earlier, then the Owner reserves the right to waive the qualification testing for that particular brand-named consumable.

6.11.3.3.4 Procedures

Prior to commencing welding work, Contractor shall submit proposed welding procedure specification for Owner's approval. Test results of procedures suitably qualified previously under the Owner or a third-party inspection agency acceptable to the Owner should be submitted. If found satisfactory, these may form the basis for the approval of these procedures without further testing.

Any procedure not previously qualified, and any prequalified procedure whose test results are not satisfactory, shall be qualified afresh as required by the particular code applicable to the work for which the fabrication or assembly of structural members belong in addition to the requirements of AWS D1.1: Structural Welding Code, and AWS Sec IX, latest edition.

- Impact requirements

If AWS specifications do not require minimum Charpy V-Notch impact properties for the electrode and fluxes that are to be used for procedure qualification, then Charpy V-Notch test specimens shall be obtained and tested according to ASTM A370 and E23. The as-deposited weld metal is required to have a minimum impact strength of 27J or 2.77kgm (20ft -lb) – 20oC for welds in tabular joints and other key points. Owner is sole judge of what is a key point.

- Radiographic inspection

In addition to the above requirements the procedure qualification for gas metal arc and related types of welding must include provision for radiographic inspection by testing laboratory acceptable to the Owner. Radiographic Inspection of complete penetration groove procedure tests welds shall be carried out prior to the extraction of impact test specimens.

- Hardness testing

Hardness testing shall be carried out with acceptance criteria as set forth in DNV Rules (1977) and with procedure as given in Appendix C8.3.6 to the same rules.

- Fabrication of welded tubular members (Structural)

For qualifying procedures for fabricating welded tubular members, the transverse tensile strength of the welds shall be determined by tests on weld specimens conforming to the requirements of ASTM Methods and Definitions A 370 "Mechanical Testing of Steel Products, Supplement II, Steel Tubular Products". Weld tensile test specimens shall be taken 90 degrees to the weld, with the weld at the centre as shown in Figure 23 (Tensile test specimen) of ASTM A 370. The bend test specimen as shown in Fig. 31 (a) of ASTM A 370 shall withstand being bent 180 degrees in the jig for guided bent test, substantially in accordance with Fig. 32 of ATM A 370. A bend specimen shall be considered as having passed if no crack or other open defect exceeding 3 mm (1/8inch) measured in any direction is present in the weld metal or between the weld and base material after bending. The position and number of test specimens shall be subject to approval by the Owner.

6.11.3.3.5 Welding practices and requirements

6.11.3.3.5.1 Structural welding

All member intersections including those between floor grating or deck plate and its supporting structural members, shall be seal welded in all areas where strength welds are not required. Steel doubler plates shall be completely seal welded.

Preheating of base metal prior to welding shall be in accordance with the AWS D1.1 “Structural Welding Code” for those materials not having been heat treated in manufacturer for the purpose of increased strength or notch ductility. Such heating should be accomplished by devices which produce uniform heating of all the critical zones around the entire welded zone. When materials intended for joining by welding have been heat treated in manufacture. Contractor shall strictly adhere to heating requirements to the qualified welding procedure pertinent to specific types of materials used and their thickness.

It is extremely important that the finished structure be as free from distortion as possible. The Contractor shall be responsible for preventing or correcting distortion and maintaining alignment. The Owner will have the right to stop the work should excessive distortion become evident.

Welders shall be supplied Tempil Sticks-Thermal Crayons or Pandux Gauges, so that welders and inspector can accurately check and control the temperature of the weldments.

Circumferential butt welds joining pipes of the same diameter shall be welded by the automatic submerged arc process wherever possible. If the joint preparation is such that welding is done from both sides of the welding groove, the inside weld shall be deposited first. The depth of weld deposited from the inside shall not constitute more than 1/3 of the thickness of the members being joined. The back side of the first pass of inside welding shall be gouged, ground or chipped to clean weld metal before deposition of any of the outside weld metal. The inside weld may be deposited by the manual arc-welding process if desired.

Butt welds in structures like piles, braces and conductor pipes shall be back gouged and re-welded from both sides. Welding backup rings shall not be used for butt welded joints of structural tubular members. In joints where welding is possible from only one side, the members shall be carefully contour fitted and bevelled to achieve complete weld penetration.

If pipe contains longitudinal weld seams, the longitudinal seams shall be staggered a minimum of 90 degrees at circumferential butt weld joints. Longitudinal seams shall not be placed within 50mm (2-inch) of any point on the intersection seams between members at tubular joints.

Grooves shall be bevelled to give an included angle of 60°. The groove shall be of the V or X type. Root openings shall be not less than 1.5mm (1/16 inch) and not greater than 5 mm (3/16 inch). Root face shall not be greater than 1.5 mm (1/16 inch).

The covered electrodes for manual welding shall be only in the positions recommended by the manufacturer. The submerged arc welding shall be done in flat position. If submerged arc welding is required on tubular, the tube shall be rotated. A multiple pass technique shall be used.

No fit-ups and associated joint intersection placement operation for major structural joint, especially tubular ones, shall be permitted to occur before one hour after sunrise and after one hour before sunset, such joining operations, to include placement of at least the root pass weld can occur at night, provided the operating conditions are satisfactory to the Owner.

6.11.3.3.6 Structural plates, shapes and stiffness

All welded fabrication involving structural shapes and/or plates shall be joined in the manner designated on the drawings and may require shop drawings. Weld sizes and notes on drawings shall be strictly adhered to, or if not specified shall join sections in such a manner as to develop not less than the net area of the sections joined. Where full penetration welds are specified, the back side of the first pass of welding on double butt welds shall be gouged and ground smooth to sound metal before depositing weld metal to the opposite side. Owner shall have the right to non-destructively test the root of this weld before deposition of weld filler metal. Where welding can only be done from one side, the joining member shall be prepared with proper angle or bevel and shall not contain a root face.

Where strength welds are required by the drawings, or otherwise, to extend only partially around a member of plate joint, a 6mm (1/4inch) fillet seal weld shall be deposited continuously throughout the remaining distance around the member or plate. Owner places special emphasis on the complete seal welding of all intersections (where there is no strength welds) between steel members. Of special note are the beam-to-deck plate and beam-to-beam intersections on the superstructure.

Sections of beams with the same cross section maybe splice welds in the interest of the material economy. The number of splice welds and their locations, with respect to beam ends, shall be dictated by the design function of the beam(s) under consideration. Generally, in cantilever beams, there shall be no splice weld located closer to the point of support than one-half the cantilevered length. For beams employed in any span weld in the centre one-fourth of the span distance nor in one eight segments of the beam nearest any support. No two splice welds shall be located closer together than two times the beam depth or a minimum of three feet whichever is smaller.

Joints between deck plate and bar grating sections shall be fully strength welded.

Stiffeners shall be accurately located and neatly fit between flanges of beams or girders when full surface contact is required. The ends of stiffeners shall be milled or smoothly ground to conform to the geometry of the member to which it is being attached, and/or bevelled in such a manner as to assure 100% fusion in the root of attachment weld, as dictated by the drawings, and/or by Owner.

When members are slotted to receive gusset plates, the slot must be 300 mm (12 inches) or 12 times the member wall thickness, whichever is greater, from any circumferential weld. The slotted member shall be drilled at the end of slot with a drill diameter at least 3 mm (1/8 inch) greater than the width of the slot. Where the gusset plate passes through the slot, the edge of the gusset plate shall be ground to an approximately half round shape to provide better fit-up and welding conditions. Slots shall be at least 12 inches away from longitudinal seam welds.

6.11.3.3.7 Finishing of surfaces

The completed structures shall be free of all scars, grooves, random strikes, burrs, and any other imperfections introduced by handling, scaffolding, lugs, jigs or other welding aids. Fillet welds attaching lugs, girders, scaffold supports, or other temporary attachment shall be so located that their removal can be accomplished without removal of parent metal. These attachments must be removed by cutting with a flame-torch, then by power grinding them to the original plate surface. Removal of these attachments by arc gouging will not be allowed. Repair welds shall not be less than 50 mm (2 inch) in length.

If, in the opinion of the Owner, welded joints contain geometric irregularities contributing to stress concentrations or notch effect, Contractor shall eliminate the condition by grinding. Over-welding will not be permitted to correct such conditions. If additional welding will assist in correction, it shall be done with the Owner's approval.

6.11.3.4 General welding requirements

No weld is to be cooled by quenching or by any means other than natural convection by air.

No weld is to be coated before it has been inspected and accepted.

Welder's identification stamping for piping shall be done using low-stress type air dies. This identification on all structural and pipeline welding shall be done by a paint-marking or tagging system which will avoid die-stamping. The system is to be submitted to the Owner for approval.

Proper grounding of all welding machines is necessary to prevent underwater corrosion damage. The welding machine should be located on and grounded to the structure whenever possible. If this is not possible, the welding machine should be insulated from the barge and the vessel, and an adequately sized cable should be used to ground the structure to the welding machine. Ground clamp connection to the component shall be steel and not brass.

All surfaces or joint faces to be welded shall be free of loose scale, paint, oil or other foreign material. Cleaning shall be accomplished by grinding, power wire brushing or sandblasting.

Components may be cut and shaped by machining, grinding, chipping, flame or plasma-arc cutting or shearing. Mechanically guided equipment shall be used wherever practical. Sheared edges not subsequently fused by welding shall be trimmed by grinding or machining to a minimum depth of 3mm (1/8 inch) to ensure complete removal of cracked or cold worked metal. Components may generally be flame or plasma-arc cut without preheat.

All plate edges or pipe wall ends to be welded shall be examined for laminations before assembly into the structure.

The entire area to be welded shall be warmed before welding is started to a minimum temperature mentioned in the relevant paragraph. Preheat and inter-pass temperatures shall conform to the requirements of this specification or Contractor's qualified welding procedure.

Welding shall not be done when the quality of the completed weld would be impaired by the prevailing weather conditions including but without limitation to airborne moisture,

blowing sands, or high winds. Windshields may be used whenever practical. Owner shall decide if weather conditions are suitable for welding.

No welding shall be performed in any area when the base metal temperature is above 260°C (500°F) in the case of A 36/IS 2062 and 150°C in the case of HSLA steel.

Arc-air gouging shall be an acceptable method for random metal removal and for back gouging, only when followed by grinding to bright metal. The temperature and weather limitations specified above for welding shall apply to all arc-air gouging.

All low hydrogen flux-coated electrodes shall be heated before use by holding in a drying oven for a (300°F) min. to 204°C (400°F) max. or minimum period of two hours at a temperature of 149°C strictly as per the electrode manufacturer's recommendations if available. They shall then be transferred to portable ovens held at about 90°C (200°F) till use. All low hydrogen flux coated electrodes shall be used within two hours after removal from the drying oven. Welding materials left exposed to moisture contamination shall be discarded.

The root (or second) side of all joints to be back welded shall be back gouged to clean sound metal. The back gouged weld root shall be subject to inspection (for porous and unfused metal and cracks) by magnetic particle inspection methods, until the gouging operation has been demonstrated as capable of consistently producing a sound weld surface for subsequent weld passes.

Weld detail, for fillet weld contour and reinforcement of butt-welded joints shall conform to the requirements given in AWS D 1.1. Full or partial penetration groove-welded tee joints shall be contoured smoothly into the upstanding member by building up a filler reinforcement in the inner corner with a minimum transition radius equal to $\frac{1}{2}$ the thickness of thinner member joined but not more than 3/16 inches unless otherwise specified for joint strength.

Partial or deep penetration weld joints are not generally acceptable. However, if such joints are unavoidable and permitted by Owner then root pass of all partial penetration groove welds shall be visually inspected for adequate penetration into the joint before welding is continued.

Root openings in the welding joint wider than permitted by AWS D 1.1 but not greater than the thickness of the thinner member shall be built up by welding to the specified groove dimensions before the parts are joined.

Root openings in the welding joint narrower than permitted by AWS D1.1 shall be chipped or gouged in a manner as to maintain the specified groove dimensions.

All welding shall be accomplished by the approved bead deposit sequence. Weave passes in excess of 2.5 times the electrode diameter shall not be acceptable.

Care shall be exercised to keep arc-strikes and "Weld scars" to a minimum. Temporary fit-up and erection attachments shall be welded with the same care and procedures as for the structural connections.

Radiographic or other inspection operations shall be maintained concurrent with weld completions. All general clean up surface's repairs shall be completed before final inspection.

Welding on primary strength members shall not be permitted on any galvanized surfaces or any surface coated with a lead or zinc bearing paint, unless otherwise specified.

Unless otherwise indicated on the Contract Drawings, the weld joint groove preparation for joining members less than 50 mm (2 inch) thickness through the centre line of the weld shall be AISC type B-L2. Welds in excess 50mm (2 inch) throat thickness shall be welded with AISC type BU-3B or B-L3-S joint preparation whenever possible. If a single groove preparation is employed for welds in excess of 50 mm (2 inch) thickness, qualification of a welding procedure is required as proof that the welding groove is satisfactory.

Electric ovens shall be provided at job sites for baking of electrodes. Small portable ovens shall be used for carrying the electrodes to the welding site. The welder shall draw the electrode from the portable oven one at a time of immediate use.

With the exception of manually welded root runs for submerged arc welding, interruptions shall not take place until at least half of the final weld thickness is achieved all around the joint. In the event of interruptions, controlled cooling of the weld area shall be ensuring, before resumption of welding, the weld shall be inspected visually for cracks and, if required by Owner shall be tested by MPI or liquid penetrant examination.

Contractor shall develop and submit for Owner's approval welding sequences to control warping, creeping or to control build-up of excessive residual stresses in the structure. Contractor shall ensure that these planned sequences are fully adhered to during fabrication.

All seal welding shall be done using minimum 6 mm size fillet welds.

6.11.3.5 Temporary welds

Temporary welds (for temporary handling attachments, lugs, etc.) shall be minimized. When temporary weld is necessary the welding will be performed with the same care, materials, electrodes, minimum preheat, and procedures as for permanent weld installations with a doubler plate whenever possible. However, temporary attachments to permanent members like sea fastenings shall be through a doubler plate.

The temporary weld shall subsequently be removed with an oxy-acetylene torch by severing the attachment above the surface of the structural member and grinding the remainder of the weld deposit flush with the member.

6.11.3.6 Inspection and testing of welds.

6.11.3.6.1 Structural

All welds will be visually inspected as instructed in Section 6 of AWS D1.1 The Owner will be vitally concerned with welds with respect to quality, geometry, fit-up, and site, and will impose the use of gauges and / or non-destructive test procedures when and where they deem necessary. The Owner can ask for proper repair of any defects in welds or materials that they consider to be detrimental to the strength and usefulness of the facility.

If random NDT as specified in this specification indicates non-acceptable defects in a weld, the identification of the weld to the respective welder(s) shall be established and

testing of other welds made by the same welder(s) shall be extended at the discretion of the Owner, up to 100 % at no extra cost to the Owner.

The names of testing houses proposed to be used for independent testing of welds shall be submitted to the Owner for approval prior to testing. Where the extent of inspection is less than 100%, the location of test section shall be agreed by the Owner.

Radiographic examination shall be performed in the following weld areas as per the ASTM or IS Code whichever is more stringent:

- 100% of all girth welds in tubular.
- At the intersection of all tubular member girth and longitudinal seams, minimum 6 inches on either side of seam.
- 30% of each longitudinal seam of all tubular.
- Any questionable weld effect.
- 100% of all beam splices in skid beams, main truss beams and deck beams.

AWS D1.1 is the standard of acceptability for welds inspected by radiography.

All longitudinal seam of factory manufactured welded pipe shall be examined by 100% ultrasonic inspection during production, as directed in ASTM E 273, "Ultrasonic Inspection of longitudinal Welds of Welded Pipe and Tubing" or ASTM E164 "Ultrasonic Contact Inspection of Weldments" or Equivalent IS Code whichever is more stringent and approved by the Owner.

100% ultrasonic testing and magnetic particle inspection of following weld areas shall also be performed:

- All T, K & Y, X and TK joint welds.
- Welds and areas up to 100 mm all around the weld of 10% of all remaining joints (Location of joints to be decided by Owner).

6.11.4 Standards

6.11.4.1 Indian standards and other Standards and codes of practice

Indian and other standards and codes of practice referred to in this section are as follows:

IS 2062	Steel for General Structural Purposes – Specification
IS 814	Covered Electrodes for Manual Metal Arc Welding of Carbon and Carbon Manganese Steel
ASTM E94	Standard Guide for Radiographic Examination
ASTM E142	Method for Controlling Quality of Radiographic Testing

ASTM A370	Standard Test Methods and Definitions for Mechanical Testing of Steel Products
ASTM E23	Standard Test Methods for Notched Bar Impact Testing of Metallic Materials
ASTM E273	Standard Practice for Ultrasonic Examination of the Weld Zone of Welded Pipe and Tubing
ASTM E164	Standard Practice for Contact Ultrasonic Testing of Weldments

American Welding Society Structural Welding Code D1.1, Latest Edition

ASME Boiler and Pressure Vessel Code, Sections V, VIII and IX.

6.12 Protective Coatings

6.12.1 General

This section covers protective coatings to steelwork, metal work and concrete.

All protective coating operations shall be executed in accordance with the requirements of Indian standards except where varied by this specification.

6.12.2 Product

6.12.2.1 **Protective treatment schedules**

Protective treatment to all steelwork and cast-iron work other than stainless steel equipment, fittings and fixings shall be in accordance with the following schedules and the British Standards referenced in section **Error! Reference source not found..**

6.12.2.1.1 Deleted

6.12.2.1.2 Steelwork exposed to atmospheric zone only (out of sea-water zone)

- Minimum system thickness shall be 325 microns Dry Film Thickness (DFT).
- Blast Clean to BS 7079 - Part A1: 2009 (ISO 8501-1:2007) Sa 3 quality to achieve a coarse surface roughness of 50 -75 microns.
- Primer: one coat of zinc rich Epoxy Primer at 75 microns per coat.
- Intermediate Coats: two coats of 2 pack Epoxy High Build MIO at 125 microns per coat minimum.
- An additional stripe coat of MIO shall be applied to the relevant areas.
- Decorative Coat: one coat of Acrylic Polysiloxane at 100 microns per coat

6.12.2.2 **Paint supply**

6.12.2.2.1 Approval of supply

The following details for each type of paint which the Contractor proposes to use to satisfy the requirements of the specification shall be submitted to the Owner for approval before orders are placed.

- Manufacturer name and address
- Brand name and reference number
- Method of application
- Weight per litre (in kg)
- Pack size (litres)
- Volume of solids

- Practical spreading rate (at minimum thickness ignoring waste due to spilling, loss in tins and pipes)
- Full application instruction (including mixing ratios for two pack materials and mixing method for each dry type of paint)
- Drying times; surface dry, hand dry and over coating
- Temperature limits for painting
- Humidity limits for painting
- Cleaning solvent (or thinners)
- Shelf life & special strong requirements
- Hazard data sheets
- Manufacturer's recommendation on any other matter

A period of three weeks shall be allowed by the Contractor for the Owner to approve or require revised proposals which comply with the specification. Orders shall not be placed until the Owner has approved the paint system.

6.12.2.2.2 Delivery and storage of paint

6.12.2.2.2.1 *Paint from same manufacturer*

Unless otherwise agreed by the Owner, all the different paints forming part of the system applied to a particular surface shall be the same manufacturer. Primers used for coating the surfaces of pre-primed components shall be exempt from these requirements.

6.12.2.2.2.2 *Paint containers*

All paint shall be delivered in containers sealed by the manufacturer.

The name of manufacturer, date of manufacture, colour of paint, batch number, shelf life and information regarding special strong requirements shall be clearly shown on each container.

6.12.2.2.2.3 *Paint store*

Paint shall be stored in sealed container in a lock-up store where it is not exposed to extreme temperature. The temperature of the store shall be kept between 4°C and 27°C. Any special strong condition recommended by the manufacturer shall be observed and paint shall be used in order of delivery.

6.12.2.2.2.4 *Shelf life of paint*

Paint which has not been used within the 'shelf life' specified or within 12 months of the date of manufacture whichever is the lesser, shall be replaced with fresh paint.

6.12.2.2.3 General cleaning prior to coating

6.12.2.2.3.1 *Surface deposits*

Any surface deposits of concrete adherent matter shall be removed. Weld slag and spatter shall be removed from all surfaces.

6.12.2.2.3.2 *Surface defects*

All surface defects, including cracks, surface laminations, shelling and deep pitting, likely to be detrimental to the protective coating system, shall be removed. All saw cuts, burrs and sharp edge shall be similarly removed.

6.12.2.2.3.3 *De-greasing surface*

All surface contaminated by oil or grease shall be washed with an emulsion cleaner. Oil or grease may, in location acceptable to the Owner, be removed by washing with proprietary water-soluble mixture of solvent and detergent followed by rinsing with clean water.

6.12.2.2.3.4 *Excessive wire brushing*

Excessive wire brushing resulting in a burnished finish and/or an unacceptable degree of surface roughness shall be made good until the surface complies with one of the above standards of surface finish.

6.12.3 **Execution**

6.12.3.1 **Paint application**

6.12.3.1.1 General

Immediately before application of each coat of paint, the Contractor shall ensure that the surface:

- Meets the standard of preparation described in the contract.
- Is free from harmful residues, including dust, grit and paint degradation products.
- Is free from detrimental contamination.
- Is free from moisture detrimental to the coating to be applied.

6.12.3.1.2 Method of application

Unless otherwise described in the contract, coat paint in a system shall be applied by one of the following methods:

- Brush
- Airless spray
- Air pressure spray

The coating shall be applied in compliance with the manufacturer's recommendations regarding temperature limitation.

6.12.3.1.3 Conditions for painting

Paint shall not be applied under the following conditions unless with the written agreement of the paint manufacturer and Owner.

- During rain, fog, mist or in a dust laden atmosphere.
- When the amount of moisture likely to be deposited on the surface by condensation or rain before or after painting, may have a harmful effect on the paint.
- When wind borne dust may have a harmful effect on the paint.

6.12.3.1.4 Intervals between coats

The intervals between coats shall normally be as recommended by the manufacturer and the Engineer, taking into account the conditions of application. No further coat shall be applied until the coating has dried or cured to the correct degree.

6.12.3.1.5 Coverage rates

The Contractor shall ensure that proposed coverage rates will enable the specified average dry film thickness of each coat to be attained.

Wet film thickness gauges shall be supplied by the Contractor and shall be used to check the rate of paint application.

6.12.3.1.6 Surface effects

Each coat of paint of a specified system whatever thickness applied shall be free from surface defects. The finished system shall have an even and uniform appearance.

6.12.3.1.7 Paint application areas

Where possible paint shall be applied within covered areas where protection is given from the drying effects of the sun and wind. The location of work areas for surface preparation and paint application shall be well separated to avoid any contamination to the paint.

6.12.3.1.8 Supervision of paint application

The Contractor shall provide a suitable experienced supervisor to ensure that the coating systems are applied in strict accordance with the paint manufacturer recommendations.

6.12.3.2 **Galvanizing**

6.12.3.2.1 Galvanizing standards

After final fabrication, by blast cleaning all items so specified shall be hot dip galvanized in according to standard practice and codal provisions.

6.12.3.2.2 Action before galvanizing

Before proceeding with the galvanizing process, the Contractor shall provide full details of the surface preparation and coating method he proposes to adopt and shall not put the

work in hand until the Owner's permission has been received. Such permission shall not relieve the Contractor of his responsibilities under the contract.

6.12.3.2.3 Galvanizing finish

All galvanizing surfaces shall present a uniform and continuous coating, clean and free from drops of spelter or sharp edge.

6.12.3.2.4 Galvanizing nuts and bolts

All nuts, bolts and washers shall be cut galvanized before dispatch to site.

The threads of galvanized items shall be cut to make allowance for the thickness of galvanizing to avoid stripping the portion upon assembly.

6.12.3.3 **Packing, handling and storage**

Fabricated steelwork which is to be stored prior to erection shall be kept clear of the ground and shall be laid out stacked in an orderly manner that will ensure that no pools of water or dirt can accumulate on the surfaces. Suitable packing shall prevent contact between members. Where a cover is provided it shall be well ventilated and not in direct contact with the loading surface.

6.12.3.4 **Safety and health**

The Contractor shall ensure that the coatings are applied in accordance with all current health and safety requirements. Caution shall always be exercised in any operation that generates dust or fumes. All construction plant, and scaffolding shall be safe and in good order.

6.12.4 Codes and references

BS 7079 - Part A1: 2009 (ISO 8501-1:2007) - Preparation of Steel Substrates before Application of Paints and Related Products – Visual Assessment of Surface Cleanliness

6.13

Porta Cabin for Security Guard

The Porta Cabin for Security Guard shall be in accordance with the following technical specification. The Contractor shall take the approval from the Engineer-in-charge prior to procurement and installation of the Porta Cabin for Security Guard.

Size -	6'-0" x 6'-0" (1.83 m x 1.83 m)
Plinth Level -	The entire structure shall be raised above the ground by 6" to 8" or more using steel supports (iron joints) (guarder T).
Strength -	Shall Withstand high velocity of wind and shall be fire resistant.
Seat-	Sitting Arrangement with Cupboard shall be provided.
Telephone Rack -	Yes, shall be provided.
Electricals -	Electrical & Telephone wiring and fittings shall be provided as per specifications shown in below table.

The Porta Cabin installation shall be complete in all respect and shall include all necessary civil and electrical works.

Specification given in following table shall be followed.

Figure 6-1 Specifications of Porta Cabin

Structure	
Component	Material Description
Bottom Periphery	2 mm. GI Cold Form Bended Section - (IS Grade - ESSAR / JINDAL)
Bottom Skid	40 x 60 Rec. GI Pipe with 2' x 2' Grid Spacing - (IS Grade - APOLLO)
Top Periphery	40 x 60 Rec. GI Pipe - (IS Grade - APOLLO)
Top Truss	40 x 60 Rec. GI Pipe with 4' Spacing in between truss with both side slope (IS Grade - APOLLO)
Truss Top Connection	40 x 60 Rec. GI Pipe with 3' Spacing in between rafter section - (IS Grade - APOLLO)
Truss Bottom Connection	2 mm. GI Cold Form "C" 20 x 40 Section with 4' Spacing in between bottom frames - (IS Grade - ESSAR / JINDAL)
Truss Center Section	2 mm. GI Cold Form Bended Section which fixes after both unit connection - (IS Grade - ESSAR / JINDAL)
Main Column	50 x 50 Sq. GI Pipe - (IS Grade - APOLLO)
Window Top Section	1.6 mm. GI Cold Form Bended Section with 3" Weather Guard - (IS Grade - ESSAR / JINDAL)
Window Bottom Section	1.6 mm. GI Cold Form Bended Section for two track sliding type window - (IS Grade - ESSAR / JINDAL)
Roof Drainage	1.6 mm. GI Cold Form Bended Section at single side slop end - (IS Grade - ESSAR / JINDAL)
Window Grill	15 x 15 Sq. GI Pipe - (IS Grade - APOLLO)
Door	18 SWG Specially Corrugated Sheet - (IS Grade - ESSAR / JINDAL)
Wall Framing	2 mm. GI Cold Form "C" 20 x 40 Section - (IS Grade - ESSAR/JINDAL)
Corner Framing	2 mm. GI Cold Form "L" 20 x 40 Section at top corner internal side - (IS Grade - ESSAR / JINDAL)
Roof Sheet	18 SWG - Plain Sheet - (IS Grade - ESSAR / JINDAL)
Wall Sheet	18 SWG Specially Corrugated Sheet - (IS Grade - ESSAR / JINDAL)
Lifting System	8 mm. Profile Hooks at each corner of the unit
Welding Technology	Mig Welding
Interior	
Wall Basic	8 mm. Pre-Lam MDF Board
Insulation	50 mm. fiber glass wool with 15 Kg/M3 Density
Furniture	All furniture made from the MR Grade Ply + 1 mm. Laminate with Edge Bidding
Ceiling	8 mm. Pre-Lam MDF Board
Base Flooring	18 mm. Cement Fiber Bonded Sheet - Asbestos / Bore & Termite free
Finish Flooring	1.2 mm. Vinyl Carpet
Window	Fully Powder Coated with 15 to 20 Micron thickness on regular Aluminium section of Jindal or equivalent fixed as per dimension with the 5 mm. glazed glass
Painting & Coating	
Welding Coating	Zinc Glossy Spray coating at all weld joints for rust prevention on the weld
Priming	Super Epoxy Auto Coat Zinc Phosphate white for designed & developed for Non - Ferrous Material - ESDEE Make
Joint Filler	Auto Coat Universal Polyester putty - ESDEE Make
Surface Finishing	Nytro Cellulose Putty - ESDEE Make
Water Proofing	Polyurethane Sealant at all joints of roofing sections, window sections & appropriate location for prevention of water damage
Final Surface Finish	Two coat of final paint of Poly Urethane - Morning Glory
Total Thickness of coating	100 to 120 Microne
Electrical & Supply	
General Wiring	1 mm. RR Cable / Finolex FR Grade
Heavy Wiring	2.5 mm. RR Cable / Finolex FR Grade
Switches	Semi Modular - Wonder / Vihan
MCB & ELCB	Indo / Schindler
Light Fitting	12 Watt LED Panel - Crompton Greaves
Cabin Fan	Bajaj Make

6.14

Mild Steel Grill Gate

The MS gates including wicket gate of required size as shown on the drawings shall be installed at the location and in position fabricated out of structural steel sections such as channels, joists, angles, flats, plates, pipes, welded steel wire mesh and sheets.

All materials and components required for the fabrication/manufacture of gate structures shall conform to the requirement of relevant Indian Standards. The mild steel grill gate shall be fabricated with structural steel section, including fabricated hinges, pivot blocks, locking arrangement, welding, riveting including stiffeners, bracing, fabricated hinges, MS AL drop locking arrangement, tempered steel pivots, guide track of M-Steel, bronze aluminium ball bearing arrangement, castor wheels, painting etc. all complete as per drawing, specification and as directed by Engineering in-charge all complete with oil painting / synthetic enamel painting in three coats of approved colour shade etc. complete. Weight of gate shall be minimum 50 kg /sq. m or unless otherwise stated / shown on the drawings.

The structural steel works for gates shall include supply, fabrication, transportation, erection complete with, tower bolts, GI pipe ss tube, tempered steel templates, tempered steel pivots, caster wheels with bearing arrangements, guide roller & shoes and placing in position embedded parts in concrete/brickwork and in pavement or road surface including cutting, grinding, drilling of holes, welding, and painting etc complete.

The workmanship for fabrication and installation of gates shall be with standard quality control, and shall include straightening, cutting, holing, bolting, welding, casting – forgings, tolerances, surface preparations, painting, etc complete in all respect. The gate shall be constructed with high level of workmanship in straight line, level, alignment, smooth finish etc complete.

The mild steel gates shall be manually operated the gates should be double leaf sliding type.

All structural sections shall be conforming to IS 2062 Specifications for structural steel. (Standard quality), and IS 808 Specifications for rolled steel beam, channel, and angle sections, and IS 6603 Specifications for steel bars and flats.

The welding for gates shall be in accordance with IS 816 Code of practice for use of Metal Arc Welding for general Construction in Mild Steel.

Fabrication, erection, and installation of mild steel gate shall be conforming to IS 800 Code of practice for use of structural steel in general building constructions.

The Project Technical Specifications for Steel work including fabrication, welding, connections, earthwork, plain & reinforced concrete, reinforcement, masonry etc whichever are relevant and applicable shall be read in conjunction with this specification.

6.15

Storm Water Drainage Channel

All the surface drainage lines for storm water shall be laid in the alignment as shown on the drawings. The surface drainage system shall be designed for surface washings and / or rain / fire water as the case may be. Paved or Unpaved open areas shall be drained through RCC drains, either cast-in-situ or precast 'U' drain and connected to main storm drains. The storm water drainage shall be constructed with high level of workmanship in straight line, level, alignment, slope, gradient, smooth finish etc complete.

The paved area shall be sloped towards the drains with a minimum slope of 1 in 200 or unless otherwise stated/shown on the drawings. The maximum velocity for 'U' drains shall be limited to 1.8m/sec. However minimum velocity for self-cleansing of 1.5m/sec shall be ensured. The bed slope of drain shall not be milder than 1 in 1000 in longitudinal direction. The storm water drainage system shall take into account the topography of the pavement area, area drainage patterns, catchment area and intensity of rainfall etc. The drainage system shall be designed for a precipitation intensity equal to hourly rainfall for a return period of 1 in 50 years. The Invert level of drainage drain shall be decided in such a way that the water can easily be discharged above the invert level of existing storm water drainage network to which the storm water is to be led. The RCC 'U' drain shall be sized for carrying the design discharge when running full.

The RCC 'U' drains shall be minimum 550 mm wide of RCC construction. The reinforced cement concrete for pipes for 'U' drain shall be conforming to IS:456 with minimum thickness of wall and base slab of 150mm or as per design considerations or unless otherwise stated/shown on the drawings, whichever is higher. For crossings at the Entry/Exit gate, the RCC Precast cover slab as per design considerations or unless otherwise stated/shown on the drawings, whichever is higher, conforming to vehicular loading shall be provided.

The grade of concrete for 'U' drain shall be M30. The grade of reinforcement for RCC 'U' drain shall be Fe 500D conforming to IS 1786.

Minimum clear cover of concrete to reinforcement shall be 30 mm unless otherwise stated/shown on the drawings.

The blinding concrete between excavated trench and 'U' drain shall be provided of minimum 75mm thickness of PCC grade M15.

The joints between the precast units of 'U' drain shall be filled with cement sand mortar 1:4 and flush pointed with cement sand mortar 1:2. However, all the construction joints or cold joints in the concrete shall have the full water tightness.

The Project Technical Specifications for earthwork, plain & reinforced concrete, reinforcement, formwork & cantering etc whichever are relevant and applicable shall be read in conjunction with this specification.

6.16 High Mast Unit

6.16.1 Removal and Reinstallation of Existing Lighting High Mast

The Contractor shall remove the existing Lighting High Mast inside the proposed Ro-Ro Yard area, lighting fixtures, electrical cables, chambers, boxes, pedestals, supports with attached accessories, fittings, anchor plates, and foundation block as indicated on the drawings, from the site of work and reinstall the same in a manner approved by the Engineer. All other trash and debris generated in the performance of the work shall also be removed and disposed of properly.

The Contractor shall ensure to remove the existing High Mast properly in such a manner that the entire High Mast system shall be reinstalled complete in all respect including civil, electrical mechanical, testing and commissioning.

The Contractor shall comply with the HSE requirements.

It is the intent of this specification to dismantle, remove and reinstallation of an existing lighting high mast. The contractor is responsible for furnishing all supervision, labour, equipment, tools, and incidentals necessary to complete the work.

The Contractor shall be required to protect existing structures/facilities/utilities such as pipelines, power lines, buildings, gates etc. which may be in the project area. The Contractor shall be required to repair or replace such existing structures/facilities/utilities if damaged as a result of their operations.

6.16.1.1 **Mode of Measurement and Rate**

The quantity to be paid for shall be the number of Lighting High Mast removed and reinstalled regardless of size & height, in accordance with the drawings and as directed by the Engineer.

The separate payment shall not be made towards any quantity or number of civil, electrical and mechanical works removed and redone in accordance with the drawings and as directed by the Engineer.

The separate payment shall not be made towards new foundations, pedestals, base plate and anchor bolts, additional cables & wiring, necessary consumables for associated civil, electrical and mechanical works.

The separate payment shall not be made towards testing and commissioning of the Lighting High Mast.

The unit price per number for the removing and reinstalling the Lighting High Mast shall include the cost of furnishing all supervision, labour, manpower, tools, tackles, equipment, PPE, and materials necessary to complete the work of removing and reinstalling existing Lighting High Mast, lighting fixtures, electrical cables & wires, junction boxes, chambers, including its transportation. Any damage caused by the Contractor's operation to the existing structures & appurtenances to remain and/or the surrounding areas shall be repaired/replaced by the Contractor as directed by the Engineer, at no cost to the Employer. Rate shall be inclusive of removal and rerouting of the complete Lighting High Mast with all means and reinstalling at the proposed location

within the port premises as shown on the drawings and as directed by the Engineer in charge.

6.16.2 New High Mast Specifications

6.16.2.1 Mast

This may have supplied as free issue material of Bajaj Make with 24nos LED lights Fixtures by Employer.

Mast shall be made of the hot dipped galvanized MS material, and the types of the plates/ sheets used for the mast shall be specified along with their sizes/gauges and the national (IS) or international specifications to which these conform to.

The design responsibility of the mast structure and foundation structure shall be borne by the Contractor. The design life of High Mast shall be 50 years. The Contractor shall submit the design report of the high mast and its foundation structure for the approval of the Employer prior to commencement of the works. The design of the Mast for bearing the wind pressure shall be as per the requirements of the Indian and International Standards for SAFETY. It shall be the sole responsibility of the Contractor / Vendor supplying and installing the high mast unit to study record and assess the wind pressure in the location proposed for high mast installation and to supply and install the high mast unit accordingly so that it is a totally safe and hazard-free installation. This shall be based on the HIGHEST wind pressure recoded in LAST 25 YEARS IN THE REGION where the High Mast Unit is to be installed.

The number of pieces that will constitute this mast and the overall length of the Mast above the ground level shall be clearly specified. The overlapping MUST be as per the I.S Standards/International Standard.

The welding and bolting or breaking due to wind pressure and / or due to its own weight and / or due to the weights of flood lights, control gear boxes, lamps or due to improper design. The relevant or international standards to which this conforms shall be specified.

6.16.2.2 Foundation

The foundation of the complete High Mast Unit shall be RCC Foundation suitable for the soil where the High Mast Unit is proposed to be installed complete with the required foundation bolts.

The soils at that proposed location shall be tested by the bidding company, at its own cost and the design of the proposed foundation with its foundation bolts shall be prepared and certified by a registered structural engineer/ consultant having at least 15 years' experience and shall be got approved from the Civil Department of desired local Engineering College before the execution of the foundation.

The curing of the foundation must be done very thoroughly as per standard practice. The cured foundation shall be got certified by a licensed structural engineer/consultant having at least 15 years' experience.

These certificates shall be given in original to the Engineer-in charge.

6.16.2.3 Wire Ropes

Non-corrodible, ISI mark, stainless steel wire ropes of AISI 316 grade shall only provide to raise and lower the lantern carriage and shall be of flexible type as is recommended for use in such Masts and it shall be of such a size that the factor of safety is 500%. These stainless-steel wire ropes shall be ISI marked and the test certificate or rope shall be supplied after installation of the unit but before commissioning it. These wire ropes shall have no joints.

6.16.2.4 Winch Assembly

A suitable winch assembly shall be provided having required winch drums so that raising, lowering, and levelling of lantern carriage is possible and that no inter winding of the wire ropes takes place. This shall be self-lubricating type by means of oil-bath having recommended lubricant.

The driver spindle must be able to be positively locked, when not in use, by automatic means.

The winch assembly shall be capable of operation by hand and also by means of a power device.

6.16.2.5 Electric Drive or Power Tool

The power tool or electric drive shall be heavy duty ISI marked electric motor. The specifications of this motor must be mentioned in the offer.

6.16.2.6 Lantern Carriage

A suitable and a totally safe and hot dipped galvanized lantern carriage with 300% factor of safety, shall be provided having provision for installation of flood light fittings and their CG boxes and the required balancing weights etc.

6.16.2.7 Outdoor Type Electrical Control Panel

The necessary outdoor type of electrical control panel provided with a suitable circuit breaker, earth fault protection, inters connections and double earthing arrangement shall be provided. This shall have a facility to lock.

6.16.2.8 Aviation Obstruction Light

One number twin dome type Aviation obstruction light with 100 W GLS lamp is to be supplied and commissioned with all required cable at the top of the High Mast Unit to meet the statutory requirements of Department of Civil Aviation.

6.16.2.9 Earthing & Lightning Protection

Two numbers, 300 mm x 300 mm x 6 mm GI plate earthing with 2 Mt. long 19 mm dia "B" class GI pipe wood coal, salt lumps etc, as per IS: 3043 shall be provided and 25 mm x 3 mm GI strips shall be laid at least 600 mm below ground and shall be firmly connected to the two earth terminals of the Mast. Lightning Finial shall be solidly fixed to the centre of the head frame and shall be earthed as per relevant IS by a separate earthing other than those mentioned above.

6.16.2.10 Test Certificates

The certificates of the Mast, winch drive, stainless steel wire ropes etc. duly signed by the competent Authority of the Contractor shall be submitted to the Engineer-in-Charge after installation of the Unit but before commissioning it.

6.16.2.11 Approval from Electrical Inspectorate

The complete installations shall be got approved from the Competent Authority of the Electrical Inspectorate and it shall be submitted to the Engineer -in-charge before commissioning of the High Mast.

6.16.2.12 Literature

The Contractor's literature giving the details of High Mast Unit and lanterns shall be submitted with the offer.

6.16.2.13 Technical Specification Sheets

These technical specification sheets shall be duly signed by the authorized signatory of the manufacturing company on every page, and these shall also be enclosed with the offer.

6.16.2.14 Erection of The High Mast Unit

The use of proper erection devices and equipment's shall be made. All persons involved with erection & commissioning must be insured and no persons unauthorized shall be allowed by the erecting company to be present in 50 mts. radius from the foundation till the erection is completed.

Any accident caused because of falling, breaking, crippling or bending of the High Mast at any point of time shall be the total responsibility of the Contractor / Vendor which is supplying and erecting the High Mast Unit.

6.16.2.15 Guarantee

The complete High Mast Unit shall be guaranteed for two years from the date of commissioning.

APPLICABLE STANDARDS

The following will be applicable:

- | | |
|-----------------------------|--|
| a) IS 875 (Part 3) – 2015: | Code of practice for Design Loads (other than Earthquakes) for Buildings and structures. |
| b) BE EN 10025/DIN 17100: | Grades of M. S. Plates. |
| c) BS ISO 1461: | Galvanizing |
| d) BS 5135/AWS: | Welding |
| e) TR No. 71996 of ILE, UK: | Specification for Mast and foundation. |

6.17 External Fire Fighting with Fire Hydrant Reinstalled

6.17.1 General

Work under this subhead is time-bound and has to be completed within the time limit set in the tender. Work shall be executed in accordance with an agreed schedule which shall be submitted by the tenderers along with offer and agreed to by owners. The existing system mentioned in 6.17.2

6.17.2 Removal and Rerouting of Existing Fire-fighting Lines

The Contractor shall remove the existing Fire-fighting Lines inside the proposed Ro-Ro Yard area, fire hydrants, valves & chambers, hose pipes, boxes, electrical, pedestals, supports with attached accessories, fittings, anchor plates, and foundation block as indicated on the drawings, from the site of work and disposed off properly or reuse the same in a manner approved by the Engineer. All other trash and debris generated in the performance of the work shall also be removed and disposed of properly. The Contractor shall make all the efforts to remove the Fire-fighting lines in such a manner that the fire-fighting lines with good condition can be reused wherever to the extent possible.

The Contractor shall comply with the HSE requirements.

It is the intent of this specification to dismantle, remove and dispose of an existing fire-fighting lines. The contractor is responsible for furnishing all supervision, labour, equipment, tools, and incidentals necessary to complete the work.

The Contractor shall be required to protect existing structures/facilities/utilities such as pipelines, power lines, buildings, gates etc. which may be located in the project area. The Contractor shall be required to repair or replace such existing structures/facilities/utilities if damaged as a result of their operations.

6.17.2.1 Mode of Measurement and Rate

The quantity to be paid for shall be the number of linear meters of fire-fighting lines removed and disposed of regardless of size & height, measured along the top of the fire-fighting lines, in accordance with the drawings and as directed by the Engineer.

The separate payment shall not be made towards any quantity or number of fire hydrants, valves & chambers, hose pipes, boxes, of any material, electrical, etc. removed and disposed of in accordance with the drawings and as directed by the Engineer.

The unit price per linear meter for the removing and disposing of the fire-fighting lines shall include the cost of furnishing all supervision, labour, manpower, tools, tackles, equipment, PPE, and materials necessary to complete the work of removing and disposing existing fire-fighting lines, fire hydrants and valves & chambers, including its transportation. Any damage caused by the Contractor's operation to the existing structures & appurtenances to remain and/or the surrounding areas shall be repaired/replaced by the Contractor as directed by the Engineer, at no cost to the Employer. Rate shall be inclusive of removal and rerouting of the complete fire-fighting lines with all means and staking at the desired location within the port premises as directed by the Engineer in charge.

6.17.3 Scope of work

The scope of work in this subhead shall consist of furnishing all labour, materials, equipment and appliances necessary and required to completely do all work relating to the installation, testing & commissioning of Fire Fighting System as described herein after and shown on the drawings. The scope of work in general shall include the following.

- i) Rerouting of Fire Fighting Accessories and related electrical works.
- ii) Rerouting of External Fire Hydrant System.

Without restricting to the generality of the foregoing, the work shall include the following:

A Hydrant System covering the entire complex and consisting of the following as available on site:

- A. Piping system ancillaries such as Suction and Delivery Headers, Air Vessel, Pressure Gauges, Pressure Switches, Pump Panel etc. as required.
- B. External Hydrant Ring Main of 150mm dia with single headed Yard Hydrants, RRL Hoses, Branch Pipes etc. all housed in a Hose Box.
- C. To obtain the approval of the relevant drawings before actual installation at site and to get the complete installation inspected and passed by the concerned authorities, as may be necessary as per local bye-laws. (Any fee payable to the local bodies.

6.17.4 Contractor's Experience

Contractors shall engage specialist agency only for this work of Fire Fighting systems.

The selected specialist agency must have sufficient experience in the execution of such work as specified.

Contractor must submit with the tender a list of similar jobs carried out by him as required along with the name of works, name and address of clients, year of execution, capacity of plant and value of work.

6.17.5 Technical Information

Contractor shall submit along with the tender copies of detailed specifications, cuts, leaflets and other technical literature of equipment and accessories offered by him.

Contractor's attention is specially invited to the special conditions and other clauses in the agreement which required the contractor to:

- Submit detailed shop drawings.
- Use material of specific makes and brands
- Obtain all approvals from Fire Fighting authorities.
- Execute the entire work on a turn-key basis so as to provide a totally operating plant.

6.17.6 Approvals

The contractor shall prepare all submission drawings and obtain all approvals of firefighting works from firefighting authorizes.

6.17.7 System Description

The Hydrant System shall comprise all required accessories including valves, special fittings, instrumentation, control panels and any other components required to complete the system in all respects.

The Hydrant System shall be semi-automatic in action and shall be laid covering the entire area externally with independent piping system.

The Hydrant System shall be kept pressurized at all times.

The pressure in the hydrant pipe work shall be kept constant at 6 Kg/cm². In the event of fire when any of the hydrant valve in the network is opened, the resultant fall in header pressure shall start the AC motor driven fire pump through pressure switches automatically. There shall be one Diesel Engine Driven pump as standby for both hydrant system. In case of failure of electricity or failure of Electric Pump to start on demand, the standby Diesel Pump shall automatically take over.

However, shutting down of the pump set shall be manual except for the Jockey Pump which shall start and stop automatically through pressure switches. In addition to auto start arrangements, the main pump shall also have an over-riding manual starting facility by push bottom arrangement.

The ping for the hydrant system in the yard shall be laid in soil 1 Metre deep or in rectangular trench. The pipe laid in soil shall be protected as specified.

The yard hydrants shall be placed at a regular spacing of 45m centre to centre. The following accessories are proposed near each yard hydrant.

- One no. gunmetal single headed hydrant Vales.
- Two nos. RRL Hoses of size 63mm dia x15m long.
- One no. gunmetal Branch pipe.

Gun metal hydrant valve, RRL hose and gunmetal branch pipe will be accommodated in an aluminium hose box mounted on brick pedestals.

6.17.8 General Specifications

6.17.8.1 Pipes and Fittings

Pipes for Wet Riser system shall be of GI pipe (Heavy Duty). Pipes up to 150mm dia shall be GI and conform to IS-1239. Pipes with dia 200mm and above (6mm thick) shall be MS and form to IS-3589. All pipes shall be I.S.I. marked. Fittings for black steel pipes shall be malleable iron suitable for welding or approved type cast iron fittings with tapered screwed threads.

6.17.8.2 **Jointing**

Joint for black steel pipes and fittings shall be metal-to-metal tapered thread or welded joints. A small amount of red lead may be used for lubrication and rust prevention in threaded joints.

Joints between C.I. or black steel pipes, valves and other apparatus, pumps etc. shall be made with C.I. or M.S. flanges with appropriate number of bolts. Flanged joints shall be made with 3mm thick insertion rubber gasket.

Note: Joints for pipes and fittings up to 50mm diameter shall be threaded joints using Teflon Tape or equivalent bonding tape on the threads. Joints for pipe and fittings above 50mm diameter shall be welded joints.

6.17.8.3 **Pipe Protection**

- All pipes in underground masonry trenches/service tunnels, above ground and in exposed locations shall be painted with one coat of red oxide primer and two or more coats of synthetic enamel paint of approved shade.
- Pipes in wall chases shall be protected from corrosion by 2 coats of bituminous paints.
- Protection of Underground pipes.

The underground steel pipes shall be protected by coating and wrapping. The coating and wrapping shall be done, in general as per IS:10221-1982.

6.17.8.4 **Installation of Pipes**

All pipes shall be adequately supported from ceiling or walls by structural clamps fabricated from M.S. structural e.g., rods, channels, angles and flats. All clamps shall be painted with one coat of primer and two coats of black enamel paint. The contractor shall provide inserts at the time of slab casting or provide suitable anchor fasteners.

The pipe supports or hangers shall be designed to withstand combined weight of pipe, pipes fittings, fluid in pipe and insulation. Pipe supports shall be of steel and coated with rust preventing paint and finished with two coats enamel paint.

The maximum spacing for pipes supports shall be as below:

Pipe (MM)	Spacing (MTR)	Size of support
Up to 25	2.0	6mm
32 to 65	2.4	8mm
75 to 125	2.7	10mm
150 & above	3.0	12mm

Pipes supports shall be spaced at maximum interval of 1.5 mtrs. on either side of heavy fittings and valves. Wherever piping passes through walls, pipes sleeves of diameter larger than that of piping shall be provided. Pipe sleeves shall be of steel or cast-iron pipe.

The underground piping shall be supported with cement concrete blocks of suitable size and strength provided at an interval of 2.5 mtrs. The pipes shall be laid at 1 mtr. Depth (top of the pipe) and trench excavated for sufficient width. The rate of pipes shall include the scope of excavation / refilling the trench. 1:2:4 concrete thrust blocks are also to be provided at turning of pipe. The cost of installation includes concrete pedestals etc. as required and to be included in the item rate.

6.17.8.5 Valves & Other Accessories

Air Release Valve, Full Way Ball Valve, Butterfly Valve, Non-return Valve, Drain Valve and Pressure Switches shall be provided if required.

6.17.9 External Fire Hydrants

Yard Hydrant valves shall be single headed as per IS:5290. The valve shall be complete with hand wheel, quick coupling connection spring loaded type and gun metal blank cap. The Yard Hydrant shall be laid on 150mm dia Hydrant Ring Main, branched off to 80mm dia and Stand Post of 80mm dia.

6.17.10 Deleted

6.17.11 Hose pipes, Branch Pipes and Nozzles

Hose Pipe: Hose pipe shall be rubber lines woven jacketed and 63mm in diameter. They shall conform to type-2 (Reinforced rubber lined) of IS:639-1979. The hose shall be sufficiently flexible and capable of being rolled.

Each run of hose pipe shall be complete with necessary coupling at the ends to match with the landing valve or with another run hose pipe or with Branch pipe. The couplings shall be of instantaneous spring lock type.

Branch Pipe: Branch pipe shall be of gunmetal 63mm dia and be complete with male instantaneous spring lock type coupling for connection to the hose pipe. The branch pipe shall be externally threaded to receive the nozzle.

Nozzle: The nozzle shall be of copper or gunmetal, 20mm in internal diameter. The screw threads at the inlet connection shall match with the threading on the branch pipe, the inlet end shall have a hexagonal head to facilitate screwing of the nozzle on to the branch pipe with nozzle spanner.

End couplings, branch pipes, and nozzles shall conform to IS:903-1985, two hoses of 15 mtr. Lengths with couplings shall be provided with each external (yard) hydrant. One nozzle and one branch pipe with coupling shall be provided with each yard hydrant.

6.17.12 External Fire Hose Cabinet

The external fire hose cabinet to accommodate the hose pipes, branch pipe nozzle and the hydrant outlets shall be fabricated from 1.5m sheet steel. This shall be lockable and provided with centre opening glazed doors.

The support for hose cabinet shall be of brick work up to a height of 0.5m above ground level. The depth of footing for this support shall be minimum 50cm below ground level, resting on levelling course of minimum 10cm of PCC (1:5:6). The brick work shall be plastered in cement mortar (1:6). The hose cabinet shall be painted red and stove enamelled.

6.17.13 Hose Reel

The hose reel shall be directly tapped from the riser through a 25mm dia pipe, the drum and the reel being firmly held against the wall by use of dash fasteners. The Hose Reel shall be swinging type (180 degrees) and the entire Drum, Reel etc. shall be as per IS:884. The rubber tubing shall be of approved quality and the nozzle shall be 6mm dia shut off type.

6.17.14 Brigade inlet Connections

One set of 4 ways collecting head Fire Brigade connection shall be provided at the location indicated in the drawing.

The inlet to the riser shall be with 150mm dia sluice valve and non-return valve. The scope shall include providing necessary reducers, tees bends, and special fittings as required. Necessary enclosure mad of 2mm thick sheet metal with support shall be provided, as in the case of hose cabinets.

6.17.15 Power and Control Panel and Other Control Compenents

6.17.15.1 Scope

This section covers the detailed requirements of the power and the control panel for the wet riser system, and also for the various control components in the system.

6.17.15.2 Power and Control Panel

6.17.15.2.1 Constructional Requirements

General Features

The power and control panel shall be totally enclosed, free standing floor mounted cubic type, fabricated out of sheet steel not less than 2mm thick. Where necessary, additional stiffening shall be provided by angle iron framework. General construction shall be of compartmentalization and sectionalisation such as mains incomes, electric fire pump, diesel fire pump, pressurization pump, and control, so that there is no mix up of power and control wiring and connections in the same sections as far as possible. The panel shall also have the space for cable allays. The space for cable alleys shall be at least 200mm wide to the entire depth of panel. The panel shall be front operated type with all connections accessible from the front. Front doors shall be hinged type. Back doors shall be hinged type or removable type for inspection. The door hinges shall be of concealed type. The doors for bus bar chamber shall be of removable type with the help of bolts. The doors shall be provided with quick fixing doors knobs with indication. The general arrangement of the panel shall be got approved before fabrication the cubicle construction shall be to IP 21 as per IS:2147.

6.17.15.2.2 Cable entries and gland plates.

All cable entries shall be through gland plates which are removable and sectionalized. Where heavy cable are brought in and terminated, suitable clamps shall be incorporated to relieve the stress on the glands due to the weight of the cable. Cable entries may be from top or bottom depending on the equipment layout and cable scheme as approved.

6.17.15.2.3 Bus bar and Connections.

The Bus bar shall be air insulated, and of aluminium of high conductivity electrolytic quality (grade E 91 E to IS:5082) and a adequate cross section. Current density shall not exceed 1.3 amps. Per sq.cm. All connections to individual circuits from the bus bars shall preferably be with solid connections. The bus bars and the connections shall be suitable covered with PVC sleeves or in an approved manner. Bus bar shall be suitably supported using non-hygroscopic insulated supports. High tensile bolts and spring washers shall be provided at bus bar joints.

6.17.15.2.4 Earthing Arrangement.

GI strip 24mm x 5mm shall be run at the rate of the board 2 nos., earth terminals shall be provided at the ends of the GI strip for connection to earth system.

6.17.15.2.5 Terminal Blocks and Small Wiring.

Terminal blocks shall be heavy duty type and generally not less than 15 amps 250V grade up to 100V, and 600V grade for the rest of the functions. They shall be easily accessible for maintenance. All control wiring inside the panel shall be with PVC insulated copper conductor of 2.5 sq.mm size and 600V grade conforming to IS:694-1977. Suitable colour-coding may be adopted. Wiring harness shall be nearly formed and run preferably function wise, and as far as possible segregated voltage wise, Identification ferrules shall be used at both ends of the wires.

6.17.15.2.6 Instruments and Lamps.

All indication lamps and instruments shall be flush mounted type in front of the panel. The voltmeter and ammeter shall of size 100mm nominal (dial size) conforming to clause 1.5 of IS 1248 for accuracy.

Current transformers shall be provided with ammeters.

Indicating lamps to indicate the availability of electric supply shall be provided at the incoming section. Necessary indicating lamps for alarm indication and battery charging shall be provided in the respective sections.

All indicating lamps and meter shall be protected with HRC cartridge type fuses.

6.17.15.2.7 Labels

All internal components shall be provided with suitable identification labels. Suitably engraved labels shall be fixed at the panel for all switches, instrument push buttons, indicating lamps etc.

6.17.15.2.8 Painting

The entire panel shall be given a primer coat of red lead after degreasing and phosphating treatment and two coats of final paint or approved shade before assembly of various items.

6.17.15.3 Equipment Requirements

6.17.15.3.1 General

The power and control panel shall comprise individual section for the various equipment's of the system and controls, in a combined cubicle type design. All switches MCCB, MCBS and fuse/fuses switch unit shall be conforming to relevant IS.

6.17.15.3.2 Incomer Section & Outgoing Section

(A) Incomer section

1 no. 300 amps TPMCCB unit complete. One set of 96 mm square Ammeter (0-400 Amps) complete with selector switch and CTS. One set of 96mm square Voltmeter (0-500 V) completes with control fuses and selector switch. One set of phases indicating lights with control fuses. One set of 4 strips of 300 Amps aluminium busbars.

(B) Outgoing Feeder.

(i) One number of 250 A, ps TP MCCB unit complete, SP Preventer, ML 4 type contractor for star delta starting, start and stop push buttons, auto-manual switch, Ammeter with CTS, A S S , phase indicating lights. Auxillary Contractors for interlocking / sequence of operation, control terminals complete in all respect with interconnections for Hydrant Pump and sprinkler pump.

(ii) Two numbers of 63 Amps rated TP MCCB unit complete, ML 1.5 type contractor D O L starting with overload relay, start and stop button. Ammeter, CTS and selector switch, phase indicating lights, AUxillary contacts for interlocking / sequence of operation, control terminals complete in all respect for Jockey Pump & fire booster pump.

(C) Control wiring from pressure switches of different settings in Hydrant and Jockey Pumps, for sequence of operation shall be included to complete the system.

(D) Colour code with ferrule marking shall also be made.

(E) The wiring shall be PVC insulated and PVC armoured aluminium conductor cable of 650 /100 volts grade conforming to IS 1554 as required from Fire Pump Board to motor and cable of suitable size.

6.17.15.3.3 Control Section

This section shall incorporate the following -

- a) Control components integrating the various sections, so as to satisfy the functional requirements.
- b) Battery charger unit with boost / float charge facility with voltmeter, capable of independently charging 2 sets of batteries at a time.
- c) Visual / audio alarms, not covered in individual sections.



- d) Lamps healthy test facility.
- e) Instruments, indicating lamps, pushbuttons, fuse terminal blocks etc. As are required.
- f) Test facility to simulate operation of hydrants.

6.17.15.4 Other Control Components

6.17.15.4.1 Pressure Switches

Pressure switches shall be provided for switching on and off the pressurization pump at present pressures and also for switching off the fire pump at present pressure. Being the main component for initiating the signal for the operation of the pumps, the pressure settings shall be totally reliable, sturdy in construction and of long life. The pressure settings shall be adjustable.

6.17.15.4.2 Power Supply for Controls

In order to ensure that the control systems remain co-operational at all times the control system shall be designed for 24 VDC operation fed from the battery. This shall be independent of the starting battery for the engine i.e., battery shall remain trickle charged at all times from the separate battery charger at the control system.

6.17.16 Electrical Work and Earthing

Scope

This section covers the detailed requirements of electrical works including earthing, for the materials installation.

Electric power supply shall be terminated in the incoming switch gear of the power and control panel by the Department. All further connections to the various components of the system shall be the responsibility of the contractor, for a complete and working system, satisfying all the functional requirements.

The scope shall particularly include the following:

Power and Control Panel(s) as given in relevant section.

All inter-connections with multi-core armoured copper cables of size suitable between various control units and control panel(s)

All power cable connections with multi-core armoured aluminium cables of size as specified in BOQ, between panels, motors etc.

Necessary earthing with 2 Nos. G.I. plate electrodes and loop earthing.

The work shall be carried out conforming to CPWD General Specifications for Electrical Works Part-I (Internal) amended up to date and Part-II (External) amended up to date.

6.17.17 Deleted

6.17.18 Deleted

6.17.19 Testing

6.17.19.1 Testing on Completion of Installation

The entire system shall be tested after completion of installation.

Standards and Codes

1	IS-1648-1961	Code of Practice for fire safety of building (general) firefighting equipment and maintenance
2	IS-3844-1966	Code of practice for installation of internal fire hydrant in multi-storied building.
3	IS-2217-1963	Recommendation for providing first aid and fire fighting arrangement in public buildings.
4	IS-2190-1971	Code of practice for selection, Installation and maintenance of portable first fire appliance.
5	IS-3589	Electrically Welded Steel pipes (Medium class)
6	IS-1239	Mild steel tubes, Tubular and other wrought steel fittings (Medium class)
7	IS-780	C.I. Double flanges sluice valve.
8	IS-778	Gun Metal Valve.
9	IS-909-1965	External fire hydrant (underground)
10	IS-5290-1969	Internal Landing Valve.
11	IS-884-1969	First and hose reel
12	IS-934-1976	Specification for portable chemical fire Extinguisher soda acid type.
13	IS-2873-1969	Specification for fire extinguisher for carbon dioxide.
14	IS-2189 & 2109	Automatic fire alarm system or BSS-3116
15		National Building Code

List of approved makes for firefighting works

S.No.	Material	Brand Name
1.	M. S. Pipes	Jindal Hissar / Surya Prakash
2.	G.I. Pipes	Jindal Hissar / Surya Prakash
3.	Gun Metal Valves (Gate, Globe)	Kirloskar / Leader / Zoloto / AIP
4.	CI Double flanged sluice valves & check valves.	Kirloskar
5.	Butterfly Valves	Kirloskar / Audco/ Zoloto / AIP

6.	CI double flanged non-return valves	Kirloskar
7.	Suction Strainer	Leader / Sant.
8.	Sprinkler (UL Listed)	Spray Safe / HD / Viking / Tyco
9.	Fire Hydrant Landing Valves, Fire brigade connection (ISI marked)	Minimax / Newage / Guards
10.	Installation Valve (ISI Marked)	Spray Safe / HD
11.	Fire hose pipes, First Aid Hose Reel (ISI Marked)	Jaysree/ Minimax/ Newage / Chhatariya / Guards.
12.	Branch Pipe, Nozzle and coupling	Minimax / Newage / Guards
13.	Fire Extinguishers	Minimax / Guards
17.	Single phasing preventer /over load protection unit.	Siemens / Minilee
18.	Pressure Switch	Danfoss / Swizer
19.	Pressure Gauge	H. Gure / Fiebig
20.	Relays	L&T / Siemens
21.	Contractors	L&T / Siemens
22.	Control Cable	CCI / Gloster / Havells
23.	Diesel Engine for Fire Fighting	Cummins
24.	Moulded case circuit breakers.	L&T/ Siemens
27	Ammeter, Voltmeter	Universal
28.	Selector switch, push button switch/emergency switch	L&T / Siemens
29.	1.1 KV LT Cables (ISI marked)	CCI / Gloster / Havells
31	Fire electrical control panel	Diamond electrical / SPC electrotech Pvt. Ltd.

6.19 Security surveillance with CCTV camera

The security surveillance system shall be state-of-the-art video surveillance system for security of people and assets. A network camera-based surveillance system is proposed in the common areas, entry/exit and yard area. Cameras themselves will have in-built web-browser for direct access/viewing from any authorized personnel. In selected areas the camera may have a two-way audio capability. The intelligence shall be built in the camera itself and the system shall support intelligent object detection, intelligent motion detection and thus the system shall ensure. intelligent video analysis using powerful camera endpoints coupled with management software.

Standards & Certifications

- ONVIF
- Complete range of IEEE and ISO/OSI model standards and ethernet protocols
- UL listed, certified & approved components.
- Full set of IEEE802.x, ANSI/EIA/TIA-568-C.2 standards, ISO/CENELEC specifications

6.19.1 General

1. Set up a single-mode fibre optic network to connect the CCTV cameras to the central control room, any other location & Satellite monitoring stations. This will include.
 - a) Trenching,
 - b) Conduiting through PVC/HDPE pipes (underground).
 - c) Laying of FO cable.
 - d) The cable route must be properly marked with concrete markers at every 50 meters. The text to be written on each marker will be finalized at the time of implementation.
2. Install and set up the CCTV cameras.
3. Integration of additional Camera licenses in the Existing Video Management Server & Recording Server at central control room for CCTV with all necessary monitoring services from 1st day of installation.
4. Replacement of all defective equipment during warranty periods.
5. Supply of all hardware, software and any required accessories to complete the entire system.
6. The CCTV system must have the facility to connect over network to the central control room. The central control room must have the capability and Provision to pull/access the saved data over the network.
7. All electrical power supply jobs required to provide power to the equipment will be the responsibility of the Contractor.
8. If maintenance is required at the power tapping point from the internal power supply, the Contractor shall inform Electrical Engineering Department and ask for shutdown.
9. While working in the electrical circuit including poles and cables, the Contractor shall use PPE and follow all safety practices as per CEA regulations.
10. The tools and tackles, transportation etc. required for operation and maintenance of the entire system shall be arranged by the Contractor.

6.19.2 High Performance Colour Day-Night Outdoor Fix Dome Camera

- 1/4-in.-type CCD/CMOS or equivalent
- Sensitivity day mode 0.5 lux and night mode 0.01 lux
- 30x optical zoom and 12x digital zoom.
- Wide Dynamic Range (WDR): Minimum 60 dB and Sodium Vapour White Balance mode.
- Dual recording-iSCSI and SD card. Minimum 32 GB SD Card to be provided.
- Effective Picture Elements- PAL: 440,000
- Lens 30x Zoom.
- Focus-Automatic
- Optical Zoom Field of View 1.7° to 57.8°
- Video Output 1.0 Vp-p, 75 Ohm
- Gain Control Auto/Manual
- Electronic Shutter Speed 1/1 to 1/10,000 sec.
- Signal-to-Noise Ratio (SNR) >50 dB
- White Balance
- Camera Setup/Control Via Web browser
- Pan Range 360° continuous
- Tilt Angle minimum 10° above horizon
- Video compression H.264, MJPEG/MPEG.
- GOP Structure IP, IBP, IBBP
- Resolution- (Horizontal x Vertical, PAL/NTSC):4CIF/D1 704 x576/480 (25/30 ips, or 50/60 fields/s for interlaced fields)
- Ethernet 10-Base T/100 Base-TX, auto-sensing, half/full duplex, RJ45
- Protocols: RTP, UDP, TCP, IP, HTTP, HTTPS, FTP, DHCP, IGMP, ICMP, SMTP, SNMPv1, RTSP, iSCSI, UPnP, IPv4, IPv6, QoS.
- Ingress Protection Rating: Standard-IP66,NEMA 4X
- Operating Temperature 0°C to 50°C
- Humidity: 0% to 90% or better
- Mount: Pendant arm mount and pole mount adapter
- The camera must be of ONVIF standard and have UL and FCC Certifications.
- Camera Housing & Lens shall be from the same OEM.



- Enclosure (housing for cameras) must be vandal resistant.
- Camera housing(indoor/outdoor), Mount Adapter, Adds H/V adjustability Wall Mount for housing must be provided.

6.19.3 Single Mode Fiber Optic cable

- 6/24 Core - 9/125 Micron Single Mode Outdoor Fiber Cable
- Type of Cable: OS1 Single mode
- Optical Properties
- Attenuation
 - at 1310 nm $\leq$ 0.34 dB/KM
 - at 1550nm $\leq$ 0.22 dB/KM
- Maximum Tensile Strength Short term: 1000N
- Maximum Crush resistance short term: 2000N/10CM
- Operating Temperature: -10° C to + 70°C
- Sheath: UV Stabilized HDPE
- Overall, Cable Diameter: 9.5 mm- 10 mm
- Fibre Tube Identification: Single Tube
- No. Of Elements: 5
- Fibre Protection (Tubes): Polybutylene terephthalate (PBT)
- Peripheral Strength Member: Two Steel Wires
- Mass (Nominal): 95 Kg/Km
- Core Wrapping: Polyethylene Terephthalate
- Inner Sheath: Polyethylene
- Armouring: Copolymer Steel tape Armor
- Sheath: HD Polyethylene (UV Stabilized)
- Water Blocking: Thixotropic Gel
- ROHS Complaint
- ISO/IEC 11801: 2002 -2nd Edition, Type OS1
- ITU-T REC G 652D spec for Low Water Peak fibre, TIA 568, EIA 455
- AS/ACIF S008; AS/NZS 3080
- Max. Bending Radius (during installation): 20D
- Max. Bending Radius (during full load): 10D



- Life of Cable: The minimum expected life of the cable is not less than 25 years.

The complete surveillance system shall include the testing and commissioning to satisfaction of the Employer.

6.20 Underground Conduits for Cables & Wires for Electrical, Telecommunication and CCTV

This specification have been furnished in respect of underground conduits for cabling & wiring works to be executed through the license electrical Contractor.

The route of the conduits for cables & wires shall be as shown on the drawings.

The materials referred to in the specifications of various works dealt in this section shall conform to the latest Indian Standards, as detailed below:

PVC conduit pipes: IS 9537

Other materials shall conform to the relevant Indian Standards specifications wherever applicable.

The work shall include digging of trench of required width and depth for laying the cables in PVC conduits over the plain cement concrete bedding and refilling the trench and consolidating the soil to the satisfaction of the Engineer-in-charge.

The work shall also include supplying, fixing and wiring earth electrodes for grounding conduits, IC cut outs and other equipment using 40 mm diameter, 2.9 mm thick G.I. pipe 25m long buried in a pit. The pit shall be filled in with equal proportion of salt and charcoal 150 mm around the pipe to complete depth. The connection from the pipe to the conduit etc is to be established through G.I. wire of adequate size using 12 mm diameter bolts, nuts, washer, and check-nuts etc. The pipe shall have 16 through holes of 12 mm diameter. Wherever the specified ground resistance (as per IS 3043) is not obtained by the grounding, extra grounds are to be provided until the required resistance value is obtained.

6.20.1 Trench Width and Depth

All buried conduits for cables & wires shall be minimum 1.05 meter +/- 0.15 mtr below ground level or unless otherwise stated / shown on the drawings or unless other depths are approved by the engineer in charge. The trench width for respective conduit diameters permissible as required under respective IS code for cable laying and installation.

The trench width shall be constant throughout the trench depth, which will provide a clearance of about 0.30 m on either side of the conduit line.

The contractor may, for the facility of work or similar other reasons, excavate and also backfill later, if so, approved by the Engineer-in-Charges, at his own cost, outside the allowable trench width specified above. Should any excavation be taken below the specified trench bottom, contractor shall fill it up to required level, at his own cost, with the same material available at the trench bottom including watering and compaction.

The excavation shall be taken down to such depths as shown in drawings. Excavation for extra depth equal to the thickness of proposed conduit bedding shall be done below conduit soffit level for providing bedding below conduit line wherever bedding is required. The trench bottom shall be excavated to proper grade as shown on drawings. The contractor shall provide site rails and levelling instruments required for checking the



grade during excavation, bottom bedding and pipe laying Projections in rock excavation shall be removed by chipping.

The minimum cover on pipe is to be maintained 1.05 meter+/- 0.15 mtr. However, the cover on conduit may be modified to suite gradients and site conditions as per direction of Engineer-in-Charge.

The laying of conduits for cables & wires shall be in accordance with Indian Electricity rules, other relevant Indian Standards and Good Industry Practice including, but not limited to, the following:

- Trench Excavation, reuse of surface material, stacking/disposal of excavated material.
- Site Clearance
- Alignment marking
- PCC/Sand bedding below conduits
- Refilling the trenches & consolidation
- Jointing of the cables & wires
- Construction of masonry chambers with heavy duty covers.
- Testing & Commissioning

6.21 High Density Polyethylene (HDPE) Pipes for Water Supply

The High-Density Polyethylene (HDPE) pipes for water supply system shall be conforming to IS 4984 for buried water mains and services. High density polyethylene materials for mouldings and extrusion shall be in accordance with IS 7328. Injection moulded HDPE fittings for potable water supplies shall be in accordance with IS 8008.

Unless otherwise stated / shown in the drawings, the designation of HDPE pipes shall be PE 80 PN 10 DN 63, which indicates a pipe pertaining to material grade 80, pressure rating 1.0 MPa and outside nominal diameter 63 mm.

The specified base density shall be between 940.5kg/m³ and 946.4 kg/m³ (both inclusive) when determined at 27 OC according to ~procedure prescribed in Annex A of IS 7328: 1992. The value of the density shall also not differ from the nominal value by more than 3 kg/m³ as per 5.2.1.1 of IS 7328: 1982.

6.21.1 Excavation for Pipe Line Trenches

6.21.1.1 *Excavation for Pipeline Trenches*

The excavation shall be carried out as per the Project Technical Specifications pertaining to Excavation and the tendered rate is supposed to cover cost of all such means.

6.21.1.2 *Site Clearance*

The pipeline alignment shall be cleared of all bushes, shrubs, roots, grass, weeds and if required trees, coming in the alignment of pipeline in the trench width portion. The rates for excavation shall cover all such site clearance work and no extra payment shall be allowed on this account.

6.21.1.3 *Alignment marking*

After the work site is cleared as above, pipeline alignment with required trench width shall be marked on the ground with apex points, curves etc, as shown on the drawings or as directed by the Engineer-in-Charge in charge for the stretch where the work is to be started. The contractor shall provide all labour, survey instruments, and materials such as strings, pegs, nails, bamboos, stones, mortar, concrete etc. required for setting out and establishment of benchmarks. The contractor shall be responsible for the maintenance of benchmarks and other marks and stakes as long as they are required for the work in the opinion of the Engineer-in-Charge.

6.21.1.4 *Working survey*

Working survey of the pipeline alignment shall be carried out by the contractor before start of the excavation work. The contractor shall provide all the instruments such as levelling instruments, steel tape, ranging rods, strings, pegs etc for carrying out the survey. Based on the working survey, the alignments, L-section (depth of laying), grade, and location of specials, valves and chambers shall be finalized and got approved from the engineer in charge. The gradient and alignment shall be such that minimum horizontal and vertical bends shall be required.

6.21.1.5 Use of Machinery

All excavations shall be carried out by mechanical equipment / machinery unless, in the opinion of the Engineer-in-Charge, the work involved and time schedule permit manual excavation.

6.21.1.6 Trench Width and Depth

All buried pipelines shall be minimum 0.9 meter to 1.0 mtr below ground level to maintain proper grade unless other depths are approved by the engineer in charge. The trench width for respective pipe diameters permissible as required under respective IS code for Pipeline laying and installation.

The trench width shall be constant throughout the trench depth, which will provide a clearance of about 0.30 m on either side of the pipeline.

The contractor may, for the facility of work or similar other reasons, excavate and also backfill later, if so, approved by the Engineer-in-Charges, at his own cost, outside the allowable trench width specified above. Should any excavation be taken below the specified trench bottom, contractor shall fill it up to required level, at his own cost, with the same material available at the trench bottom including watering and compaction.

The excavation shall be taken down to such depths as shown in drawings. Excavation for extra depth equal to the thickness of proposed pipe bedding shall be done below pipe soffit level for providing bedding below pipeline wherever bedding is required. The trench bottom shall be excavated to proper grade as shown on drawings. The contractor shall provide site rails and levelling instruments required for checking the grade during excavation, bottom bedding and pipe laying. Projections in rock excavation shall be removed by chipping.

The contractor shall carryout extra excavation at the pipeline joints to be fusion welded in the trench, as required (minimum 0.6 m deep and 0.9 m lengthwise, all around the pipe), for facilitating proper welding of the bottom joint from outside. The work of trench excavation should be commensurate with laying and jointing of the pipeline. It should not be dug in advance for a length greater than 500 m ahead of work of laying and jointing of pipeline unless otherwise permitted by the Engineer-in-Charge.

The minimum cover on pipe is to be maintained 0.9 meter to 1.0 meter. However, the cover on pipe may be modified to suite gradients and site conditions as per direction of Engineer-in-Charge.

6.21.1.7 Barricading and Guarding

To protect persons from injury and to avoid damage to property, adequate barricades, construction signs, red lanterns and guards as required shall be placed and maintained.

During the progress of work, till filling of the trenches after pipes are laid and jointed. The lighting, barricading, guarding of the trenches and the maintenance of watchman shall be done by the contractor at his cost.

All precautions shall be taken during excavation and laying operation to guard against possible damage to any existing structures, underground cables, pipelines of water, gas,

sewage etc. Any damage done to such properties will have to be repaired / rectified by the contractor at his cost. The Contractor has to ensure the following:

- safety protections as mentioned above have to be incorporated in the work process.
- hindrances to the public have to be minimized.
- the trench must not be eroded before the pipes are laid.
- the trench must not be filled with water when the pipes are laid.
- the trench must not be refilled before laying of the pipes.

The bed for the laying of the pipes has to be prepared according to the L-Section immediately before laying of the pipes.

6.21.1.8 Reuse of surface material

All surface materials, which in the opinion of the Engineer-in-Charge, suitable for reuse in restoring the surface shall be kept separate from the general excavation material, as directed by the Engineer-in-Charge.

6.21.1.9 Stacking of excavated material

All excavated materials shall be stacked in such a manner that it does not endanger the work and avoids obstructing foot paths and roads. Hydrants under pressure, surface boxes, fire and other utility controls shall be left unobstructed and accessible until the work is completed. Gutters shall be kept clean or other necessary provisions made for street drainage and natural water courses shall not be obstructed. All the excavated material shall be the property of the Employer and shall be stacked or disposed off as directed by the Engineer-in-Charge.

6.21.1.10 Maintenance of traffic

The work of excavation and pipe laying shall be carried in such a manner that it causes the least interruption to traffic and the road / street may be closed in such a manner that it causes the least interruption to the traffic. Where it is necessary for traffic to cross open trenches, suitable bridging arrangement shall be provided. When the street is closed for traffic, suitable signs indicating that street is closed shall be placed and necessary detour signs for proper maintenance of traffic shall be provided.

6.21.1.11 Structure protection

Temporary support, adequate protection and maintenance of all underground and surface structures, drains, sewers and other obstructions encountered in the progress of work shall be furnished under the direction of the Engineer-in-Charge. The structures which have been disturbed shall be restored upon completion of work.

6.21.1.12 Protection of property

Trees, shrubbery fences, poles and all other property shall be protected unless their removal is allowed by the Engineer-in-Charge. When it is necessary to cut roots and tree branches, such cutting shall be done under the supervision and direction of the Engineer-in-Charge.

6.21.1.13 Avoidance of existing services

As far as possible, the pipeline shall be laid below existing services, such as water and gas pipes, cables, cable ducts and drains but not below sewers. Excavation of the trenches shall be carried out to the required depth accordingly. If it is unavoidable, the pipeline shall be suitably protected and lesser trench depth in such cases can be allowed. A minimum clearance of 150 mm shall be provided between the pipeline and such other services. When thrust or auger boring is proposed for laying pipeline across roads, railway or other utilities, larger clearance as required shall be provided. Adequate arrangements shall be made to protect and support the other services during excavation and pipe laying operations. The work shall be so carried out as not to obstruct access to the other services for inspection, repair and replacement. When such utilities are met with during excavation, the authority concerned shall be intimated and arrangements made to support the utilities in consultation with them.

6.21.1.14 Bailing out of Water

During the excavation if subsoil water is met with, contractor shall provide necessary equipment and labour for dewatering the trenches. If pumping out subsoil water is found necessary, contractor shall provide sufficient number of pumps for the same. The tendered rate shall cover all costs for bailing out of water including hire charges of pumps, cost of diesel and labour etc and hence, no extra payment shall be allowed.

6.21.1.15 Disposal of loose boulders etc

All loose boulders, semi detached rocks, (along with earthy stuff which might move therewith), not directly in the excavation but close to the area to be excavated, as to be liable, in the opinion of the Engineer-in-Charge, to fall or otherwise endanger the workman equipment, or the work etc, shall be stripped off and removed away from the area of the excavation. The method used shall be such as not to shatter or render unstable or unsafe the portion which was originally sound and safe. The tendered rate is supposed to cover this job and no extra payment will be allowed on this account.

6.21.1.16 Disposal of Excavated Material

All the excavated surplus material shall be disposed off on low lying Government land or as directed by the engineer in charge.

6.21.1.17 Moorum / Sand Bedding below Pipeline

In case of hard rock and black cotton soil, before lowering of the pipes in trenches, a layer of selected moorum, available from excavated material under the same contract shall be provided below the pipeline to act as bedding. The bedding shall be compacted properly including required watering and the thickness of well compacted layer shall not be less than 150 mm. The bedding shall be provided for full trench width with proper grade as shown on drawings.

6.21.2 Refilling the trenches

6.21.2.1 Use of selected excavated material

Filling of excavated material in trenches shall be commenced as soon as the joints of pipes and specials have been tested and passed. The backfilling material shall be



properly consolidated by watering and ramming, taking due care that no damage is caused to the pipes and the outer coating.

Selected surplus spoils from excavated material shall be used as backfill. Fill material shall be free from clods, salts, sulphate, organic or other foreign material. All clods of earth shall be broken or removed. Where excavated material is mostly rock, the boulders shall be broken into pieces not larger than 150 mm size, mixed with properly graded fine material consisting of murum or earth to fill up the voids and the mixture used for filling.

6.21.2.2 Filling zones

For the purpose of back-filling, the depth of the trench shall be considered as divided in to the following three zones from the bottom of the trench to its top:

Zone A:

From the bottom of the pipe (top of bedding) to the level of the centre line of the pipe Back-filling by hand with selected approved material available from excavation, placed in layers of 150 mm and compacted by tamping. The back-filling material shall be deposited in the trench for its full width on each side of the pipe, specials, and appurtenances simultaneously. Special care shall be taken to avoid damage of the pipe and the coating or moving of the pipe.

Zone B:

From the level of the centre line of the pipe to a level 300 mm above the top of the pipe Back-filling and compaction shall be done by hand or approved mechanical methods in layers of 150 mm; special care shall be taken to avoid damage of the pipe and the coating or moving of the pipe.

Zone C:

Back-filling shall be done by mechanical methods in 15 cm.

All excavations shall be backfilled to the level of the original ground surfaces unless otherwise shown on the drawings or ordered by the Engineer-in-Charge in Charge, and in accordance with the requirements of the specification. The material used for backfill, the amount thereof, and the manner of depositing and compacting shall be subject to the approval of the Engineer-in-Charge in Charge, but the Contractor will be held responsible for any displacement of pipe or other structures, any damage to their surfaces, or any instability of pipes and structures caused by improper depositing of backfill materials.

The back filled layers shall be wetted and compacted to a density of not less than 90 percent of the maximum dry density at optimum moisture content of the surrounding material. Any deficiency in the quantity of material for backfilling the trenches shall be supplied by the Contractor at his expense.

The Contractor shall at his own expense make good any settlement of the trench backfill occurring after backfilling and until the expiry of the defects liability period.

On completion of pressure and leakage tests exposed joints shall be covered with approved selected backfill placed above the top of the pipe and joints in accordance with

the requirements of the above specifications. The Contractor shall not use backfilling for disposal as refuse or unsuitable soil.

6.21.2.3 Fillings of the trench excavated in rock

In case of excavation of trenches in rock, the filling up to a level of 30 cm above the top of the pipe shall be done with fine materials, such as soft soil, murrum etc. The filling up of the level of the centre line of the pipe shall be done by hand compaction in layers not exceeding 15 cm, whereas the filling above the centre line of the pipe shall be done by hand compaction or mechanical means in layers not exceeding 15 cm. The filling from a level of 30 cm above the top of the pipe to the top of the trench shall be done by mechanical methods with broken rock filling of size not exceeding 15 cm mixed with fine material as available to fill up the voids.

6.21.2.4 Consolidation

The consolidation of the filled material shall be done to attain 95 % proctor density. The density of the filled and compacted material shall be tested regularly, and record maintained accordingly.

6.21.2.5 Road Restoration

The contractor shall be restoring the road after laying & jointing of pipe & refilling of trench. The restoration work shall include WBM & Bituminous/cc surface of thickness & design mix as directed by EIC.

6.21.3 Supply, laying and jointing of High Density Polyethylene (HDPE) Pipes and fittings

6.21.3.1 Scope

This specification covers the requirements for successfully designing, manufacturing, supplying, laying, jointing, and testing at works and site of High-Density Polyethylene Pipes used for water supply. Use of HDPE Pipes of various diameters shall be as per relevant BIS /other standards marked with Pressure class of PN 6.

6.21.3.2 Applicable Codes

The manufacturing, testing, supplying, laying, jointing and testing at work sites of HDPE pipes shall comply with all currently applicable statutes, regulations, standards and Codes. In particular, the following standards, unless otherwise specified herein, shall be referred. In all cases the latest revision of the Codes shall be referred to. If requirements of this Specification conflict with the requirements of the standards / Codes, this Specification shall govern.

Other Codes not specifically mentioned here but pertaining to the use of HDPE pipes form part of these Specifications.

Code No.	Title/Specification
IS 4984	High Density Polyethylene Pipes for Water Supply
IS 2530	Methods of test for polyethylene moulding materials and polyethylene compounds DI K7 Pipes, Joints and Fittings for use for Potable Water Supply



Code No.	Title/Specification
IS 5382	Rubber sealing rings for gas mains, water mains and sewers.
IS 4905	Methods for random sampling
IS 7328	High density polyethylene materials for moulding and extrusion
IS 7634	Laying & Jointing of Polyethylene (PE) Pipes
IS 9845	Method of analysis for the determination of specific and/or overall migration of constituents of plastics material and articles intended to come into contact with food stuffs
IS 10141	Positive list of constituents of polyethylene in contact with food stuffs, pharmaceuticals and drinking water.
IS 10146	Polyethylene for its safe use in contact with foodstuff, Pharmaceuticals and drinking water.

6.21.3.3 **Designation**

Pipes shall be designated as per IS 4984, according to the grade of material, followed by pressure rating and nominal diameter, for example, PE 100 PN 10 DN 200 indicates a pipe pertaining to material grade 100 having a pressure rating 1.0 MPa and outside nominal diameter 200 mm.

6.21.3.4 **Colour**

The colour of the pipe shall be black.

6.21.3.5 **Materials**

The material used for the manufacturer of pipes should not constitute toxicity hazard, should not support microbial growth, should not give rise to unpleasant taste or odour, cloudiness or discoloration of water. Pipe manufacturers shall obtain a certificate to this effect from the manufacturers of raw material by any internationally reputed organization as per the satisfaction of the Engineer-in-Charge in charge.

6.21.3.6 **Raw Material**

- Raw material used to manufacture the HDPE pipes shall be PE 100, pre-compounded PE resin confirming to IS: 4984, IS: 7328 and ISO: 4427-2007. For this a certification has to be given by the resin manufacturer as per clause 3.2.3 of IS: 4984. The resin proposed to be used for manufacturing of the pipes should also comply with the following norms as per ISO 9080-2003.
- The resin should have been certified by an independent laboratory of international repute for having passed 10,000-hour long term hydrostatic strength (LTHS) test extrapolated to 50 years to show that the resin has a minimum MRS of over 10 MPa for PE 100 resin. Internal certificate of any resin manufacturer will not be acceptable.
- Certificate from reputed organization OR Raw material supplier for having passed the full-scale rapid crack propagation test as per ISO 13478. High density Polyethylene (HDPE) used for the manufacture of pipes shall conform to designation PEEWA-50-T-003 of IS 7328. HDPE conforming to designation PEEWA-50- T-003 of IS 7328 may also be used with the exception that melt flow

rate (MFR) shall not exceed 1.10 g/10 min. In addition, the material shall also conform to clause 5.6.2 of IS 7328.

- d) The specified base density shall be between 940 kg/ m³ and 958 kg/ m³ (both inclusive) when determined at 27°C according to procedure prescribed in IS 7328. The value of the density shall also not differ from the nominal value by more than 3 kg/ m³ as per 5.2.1.1 of IS 7328. The MFR of the material shall be between 0.20 and 1.10 (both inclusive) when tested at 190°C with nominal load of 5 kgf as determined by method prescribed in IS 2530. The MFR of the material shall also be within ± 20 percent of the value declared by the manufacturer.
- e) The resin shall be compounded with carbon black. The carbon black content in the material shall be within $2.5 \pm 0.5\%$ and the dispersion of carbon black shall be satisfactory when tested as per IS 2530.

6.21.3.7 Anti-oxidant

The percentage of antioxidant used shall not be more than 0.3 percent by mass of finished resin. The antioxidant used shall be physiologically harm less and shall be selected from the list given in IS 10141

6.21.3.8 Reworked Material

No addition of Reworked/ Recycled Material from the manufacturer's own rework material resulting from the manufacture of pipes is permissible and the vendor is required to use only 100% virgin resin compound.

6.21.3.9 Maximum Quality of Pipe

The outside diameter of pipes, tolerance on the same and quality of pipe shall be as given in table 2 of IS 4984. Quality shall be measured as the difference between maximum outside diameter and minimum outside diameter measured at the same cross section of the pipe, at 300 mm away from the cut end. For pipes to be coiled the quality shall be measured prior to coiling. For coiled pipes, however, re-rounding of pipes shall be carried out prior to the measurement of quality.

6.21.3.10 Detectability

HDPE Pipes should be detectable when buried underground, by providing a copper wire of 1.50 sq.mm +/- 0.2 sq. mm, co-extruded or fixed on to the pipe with the help of superior quality adhesive tape on the outer surface as provided in IS 7634 part II in such a way that in no way it affects the pipes' conformity to relevant BIS codes.

6.21.3.11 Length of Straight Pipe

The length of straight pipe used shall be minimum 6 mtr or as agreed by Engineer-in-Charge. Short lengths of 3 meter (minimum) up to a maximum of 10% of the total supply may be permitted.

6.21.3.12 Coiling

The pipes supplied in coils shall be coiled on drums of minimum diameter of 25 times the nominal diameter of the pipe ensuring that kinking of pipe is prevented. Pipe beyond 110mm dia shall be supplied in straight length not less than 6m.

6.21.3.13 Workmanship / Appearance

Pipes shall be free from all defects including indentations, delaminating, bubbles, pinholes, cracks, pits, blisters, foreign inclusions that due to their nature degree or extent detrimentally affect the strength and serviceability of the pipe. The pipe shall be as uniform as commercially practicable in colour opacity, density and other physical properties as per relevant IS Code or equivalent International Code. The inside surface of each pipe shall be free of scouring, cavities, bulges, dents, ridges and other defects that result in a variation of inside diameter from that obtained on adjacent unaffected portions of the surface. The pipe ends shall be cut clearly and square to the axis of the pipe. IS 4984 :1995 will be followed for visual appearance.

6.21.3.14 Handling, Transportation Storage and Lowering of pipes

During handling, transportation, storage and lowering, all sections shall be handled by such means and in such a manner that no distortion or damage is done to the section or to the pipes as a whole.

The following procedures should be followed so as to eliminate potential damage to pipes and fittings and to maintain maximum safety during unloading, lifting and lowering.

- Pipes must not be stored or transported where they are exposed to heat sources likely to exceed 60oC.
- Pipes shall be stored such that they are not in contact with direct sunlight, lubricating or hydraulic oils, petrol, solvents and other aggressive materials.
- Scores or scratches to a depth of greater than 10% or more of wall thickness are not permissible; any pipes having such defects should be strictly rejected.
- PE pipes should not be subjected to rough handling during loading and unloading operations. Rollers shall be used to move, drag the pipes across any surface.
- Only polyester webbing slings should be used to lift heavy PE (>315mm) pipes by crane. Under no circumstances, chains, wire ropes and hooks be used on PE pipes.
- Pipes shall not be dropped to avoid impact or bump. If any time during handling or during installation, any damage, such as gouge, crack or fracture occurs, the pipe shall be repaired if so, permitted by the competent authority before installation.
- During coiling care should be taken to maintain the coil diameter at or above the specified minimum to prevent kinks. Coiling shall be done when the pipe attains the ambient temperature from the extruder. In uncoiling or recoiling care should be taken that sharp objects do not scour the pipe.
- When releasing coils, it must be remembered that the coil is under tension and must be released in a controlled manner. The end of the coil should be retained at all times, then the straps released steadily, one at a time. If the coil has bands at different layers of the coil, then they should be released sequentially starting from the outer layers. The amount of the energy locked up in the coil will depend on the size of the pipe, the SDR of the pipe, and the size of the coil.
- Straight lengths should be stored on horizontal racks giving continuous support to prevent the pipe taking on a permanent set.

- Bare coils shall be wrapped with hesian cloth for long distance (> 300Kms) transportation. The truck used for transportation of the PE pipes shall be exclusively used of PE pipes only with no other material loaded - especially no metallic, glass and wooden items. The truck shall not have sharp edges that can damage the Pipe.
- Pipes manufactured at factory are to be carried to the site of work directly or stacked suitably and neatly along the alignment/roadside/elsewhere near by the work site or as directed by the Engineer-in-Charge.
- Damages during transit, handling, storage will be to the Contractor's account and replacement for such pipes has to be made by the Contractor without any extra cost as directed by the Engineer-in-Charge.

6.21.3.15 Lowering, Laying of Pipes

- Each pipe shall be thoroughly checked for any damages before laying and only the pipes which are approved by the Engineer-in-Charge shall be laid.
- While installing the pipes in trenches, the bed of the trench should be level and free from sharp edged stones. In most cases, the bedding is not required, as long as the sharp and protruding stones are removed, by sieving the dug earth, before using the same as backfill material. While laying in rocky areas suitable bed of sand or gravel should be provided. The fill to about 10 to 15 cm above the pipe should be fine sand or screened excavated material. Where hard rock is met with, bed concrete M15, 15 cm or 20cm thick sand bed as approved by the Engineer-in-Charge may be provided.
- As PE pipes are flexible, long lengths of Electro/Butt-fusion jointed pipes having joints made above ground can be rolled or snaked into narrow trenches. Such trenches can be excavated by narrow buckets.
- During the pipe laying of continuous Electro/Butt-fusion jointed systems, due care and allowance should be made for the movements likely to occur due to the thermal expansion/contraction of the material. This effect is most pronounced at end connections to fixed positions (such as valves etc) and at branch connections. Care should be taken in fixing by finishing the connections at a time the length of the pipe is minimal (lower temperature times of the day.)
- For summer time installations with two fixed connection points, a slightly longer length of PE pipe may be required to compensate for contraction of the pipe in the cooler trench bottom.
- The final tie-in connections should be deferred until the thermal stability of the pipeline is achieved.
- The flexibility of polyethylene pipes allows the pipe to be cold bend. The fusion jointed PE pipe is also flexible as the plain Pipe. Thus, the total system enables directional changes within the trench without recourse to the provision of special bends or anchor blocks. However, the pipe should not be cold bend to a radius less than 25 times the OD of the pipe.
- The Installation of flanged fittings such as connections to sluice/air/gate valves and hydrant tees etc., requires the use of stub ends (collars/flange adaptors complete with backing rings and gaskets. Care should be taken when tightening these flanges to provide even and balance torque.



- Provision should be made at all heavy fittings installation points for supports (such as anchoring of the flange in the soil) for the flange joint to avoid the transfer of valve wheel turning torque on to the PE flange joint.
- PE pipe is lighter than water. Hence care should be taken for normal installations where there could be a possibility of flooding of the trench thus the trench shall be kept free of water till the jointing has been properly done.
- When flooded, some soils may lose cohesiveness, which may allow the PE pipe to float out of the ground. Several design checks are necessary to see if groundwater flotation may be a concern. Obviously, if the pipeline typically runs full or nearly full of liquid, or if groundwater is always below the pipe, flotation may not be a significant concern.
- However, weights by way of concrete blocks (anchors) are to be provided so that the PE pipe does not float when suddenly the trench is flooded and the soil surrounding the pipe is washed away. Thus, site conditions study is necessary to ensure the avoidance of flotation.
- Pipe embedment backfill shall be stone-free excavated material placed and compacted to the 95% maximum dry density.

The pipe ends shall be suitable for Electro-fusion/ Butt- Fusion jointing system that shall provide for fluid tightness for the intended service conditions.

6.21.4 Bedding, Backfilling and Compaction

6.21.4.1 **Bedding**

In case of sandy strata, no separate bedding is required. However, the bottom face / trench bed where pipe shall be placed shall be compacted to provide a minimum compaction corresponding to 95% of maximum dry density. The pipe bedding should be placed so as to give complete contact between the bottom of the trench and the pipe. The minimum cover over buried pipe should be 1 m.

6.21.4.2 **Back Filling**

Backfilling should be placed in layers not exceeding 15cm thickness per layer and should be compacted to a minimum of 95% maximum dry density. The refilling should be done on both sides of pipe together & height difference in earth-fill on each side should not be more to cause lateral movement of pipe.

Most coarse-grained soil are acceptable. This may comprise of gravel or sand. However silty sand, clayey sand, silty and clayey gravel shall not be used unless proposed to be used in conjunction with gravel or clean sand.

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

Heavy earth moving equipment used for backfilling should not be brought until the minimum cover over the pipe is 90 cm in the case of wide tracked bulldozers or 120 cm in the case of wheeled roaders or roller compactors.



6.21.4.3 *Compaction*

Vibratory methods should be used for compaction. Compaction within distances of 15 cm to 45 cm from the pipe should be usually done with hand tampers. The backfill material should be compacted not less than 95% of maximum dry density.

6.21.4.4 *Thrust Block*

RCC thrust blocks, if required, should be suitably designed & provided at bends and at places of reduction in cross section to take care of thrust as required as per the provisions of relevant standards/codes.

6.21.4.5 *Fittings & Specials*

All HDPE fittings/ specials shall be of minimum PN 6 or above Pressure class, fabricated in accordance with IS: 8360 (Part I & III). PE Injection moulded fittings shall be as per IS: 8008 (Part I to IX). All fittings/specials shall be fabricated or moulded at factory only. No fabrication or moulding will be allowed at site, unless specifically permitted by the Engineer-in-Charge. Fittings will be Butt welded on to the pipes or other fittings by use of Electro/Butt fusion process. Recommended makes for PE / PP fittings / specials are Georg-Fischer / Glynwed / Frialen / Durafuse if purchased or should be manufactured by the manufacturer himself to have consistency with pipe material/grade.

6.21.4.6 *Bends*

HDPE bends shall be plain square ended conforming to IS: 8360 Part I & III Specifications. Bends shall be moulded.

6.21.4.7 *Tees*

HDPE Tees shall be plain square ended conforming to IS: 8360 Part I & II Specifications. Tees may be equal tees or reduced take off tees. Tees shall be moulded or fabricated from pipe elements.

6.21.4.8 *Reducers*

HDPE Reducers shall be plain square ended conforming to IS: 8008 Part I & VII Specifications. Reducer must be moulded.

6.21.4.9 *Flanges/ HDPE Pipe Ends*

HDPE Stub ends shall be square ended conforming to IS: 8008 Part I & VI Specifications. Stub ends will be welded on the pipe. Flange will be of slip-on flange type as described below.

6.21.4.10 *Slip-On Flanges*

Slip-on flanges shall be metallic flanges covered by epoxy coating or plastic powder coating. Slip-on-flanges shall be conforming to standard mating relevant flange of valves, pipes etc. Nominal pressure rating of flanges will be PN10.

6.21.4.11 Fusion Welding Procedure

Jointing between HDPE pipes and specials shall be done as per the latest IS: 7634 part II. Method of jointing between the pipes to pipes and pipes to specials shall be with Electro or Butt-fusion welding using automatic or semi-automatic, hydraulically operated, superior quality Electro/Butt-fusion machines which will ensure good quality welding of HDPE pipes.

Normally Electro/Butt fusion welding shall include following activities:

- Aligning of pipe on welding M/C
- Surface preparation for welding.
- Heating of pipes/ ends
- Holding pipes for welding
- Cooling etc.

6.21.4.12 Hydraulic Testing

Pipes shall be given different hydraulic tests for ensuring quality of manufacture as per Standard Specification.

6.21.4.13 Site Fabrication of PE Fittings

Two or more PE specials coming at one place (like PE Tee, Reducer, Flanged end etc.) shall be jointed at contractor's workshop and transported to the site of works for final installation with proposed PE pipelines. In no case, jointing of three or more welds in one place, at site will be allowed.

6.21.4.14 Training

The Contractor shall provide on-site training on PE pipe laying, jointing, testing and maintenance etc., to the personnel authorized by EMPLOYER.

6.21.4.15 Manuals

Technical Manual on PE pipes including precautions to be taken during operation of the pipeline shall be prepared and submitted by the contractor immediately on completion of work.

6.21.4.16 Flanges

All flanges employed in the project must be compatible whatever material used.

6.21.4.17 Marking

All pipes shall be marked at maximum interval of 1 m. The marking shall indicate at least the following information.

1. Manufacturer's name & / or trademark.
2. The dimensions (nominal outside diameter X nominal wall thickness)
3. The outside diameter tolerance (A or B)
4. The designation of pipes material (PE 100, PE 80 etc)



5. The nominal pressure (PN)
6. The production period (date or code)
7. The number of the international standard.
8. The word "Water" shall also be included.
9. Lot number/Batch Number

6.21.4.18 Packing & Transport

The pipes should be preferably transported by road from the factory and stored as per the manufacturer specifications to protect damage.

6.21.4.19 Summary of Quality Tests

1. Quality Mark: Pipe: IS 4984
2. Material: As per IS 4984. However only virgin resin is allowed, reworked material is not allowed.
3. Grade of Material: PE 100 as per IS 4984 (Certificate from raw material manufacturer is required).
4. Pressure Rating: Minimum PN 6 or above as per requirement.
5. Colour: as per IS 4984
6. Dimensions:

Diameter:	The nominal diameter (outside)
Wall thickness:	As per IS 4984.
Length:	
i.	For diameter up to 110 mm: min 6 mtr max. 100 meters
ii.	For diameter more than 110 mm: minimum 6 meter.

(Tolerance as per IS 4984)

7. Visual Appearance: as per IS 4984.
8. Test and sampling: as per IS 4984.
9. Special Test:

Notch hydraulic Test for the HDPE pipe made from PE-100 grade raw material as per ASTM 1474 OR ISO 13479 at manufacturers laboratory or independent laboratory and should pass the Hydraulic test as per IS: 4984:1995 for a minimum 165 Hours. The test reports shall not be more than three months old.

Pipe shall convey water under variable temperature conditions ranging from 4 degree centigrade to 45 degrees centigrade.

10. Jointing of pipes (pipe end): For diameters up and more than 110 mm diameter: Butt or Electro-fusion Process
11. Quality Assurance: Quality Assurance Plan shall be got approved from the employer before production start.

6.21.4.20 BIS License

The pipe manufacturer who is going to supply the pipes for the project has to have a valid BIS license. The Bidders shall include this valid license along with the Tender from the proposed pipe/ Fittings manufacturer.

6.21.4.21 **Performance requirements**

The pipe supplied should have passed the acceptance tests as per clause given in specified standards. The manufacturer should provide the test certificates for the tests conducted, as required in specified standards along with the supply of pipes. These acceptance tests can be performed in the in-house laboratory of the pipe manufacturer. The Employer will depute one person to be positioned at the pipe manufacturing facility of the successful Contractor. This deputed person will check and approve each lot of the pipes manufactured before they leave the factory after ensuring that they are meeting the required specifications.

Note: All remaining parameters / specifications shall be as per respective IS.

6.21.5 **Field Hydraulic testing of the pipelines**

a. Sectional tests

After laying and jointing the pipeline shall be tested for tightness of barrels and joints, and stability of thrust blocks in sections approved by the Engineer-in-Charge in Charge. The length of the sections depends on the topographical conditions. Preferably the pipeline stretches to be tested shall be between two chambers (air valve, scour valve, bifurcation, other chamber). At the beginning, the Contractor shall test stretches not exceeding 1 km. After successful organization and execution of tests the length may be extended to more than 1 km after approval of the Engineer-in-Charge in Charge. The hydraulic testing shall have to be commenced immediately after laying and jointing of 1 km reach is completed.

The water required for testing shall be arranged by the contractor himself. The Contractor shall fill the pipe and compensate the leakage during testing. The Contractor shall provide and maintain all requisite facilities, instruments, etc. for the field testing of the pipelines. The testing of the pipelines generally consists in three phases: preparation, pre-test/saturation and test, immediately following the pre-test.

6.21.6 **Flushing and disinfecting of pipelines**

After testing and commissioning the contractor shall flush the pipes with a velocity not less than 1 m/s or as approved by the Engineer-in-Charge in Charge. Disinfection of drinking water pipelines should be done by Contractor.

6.21.7 **Above ground pipeline**

DI K9 pipe of appropriate size, conforming to IS: 8329 or MS pipes of appropriate size and thickness, conforming to IS :3589 will be used wherever the pipeline is laid above ground. MS pipes will be in-lined and out-coated with 15 mm thick Cement concrete mortar or Epoxy coating of 400 Micron DFT.

6.21.8 **Flow measuring devices**

Electromagnetic Flow Meter of appropriate size shall be provided along with 8-hour Battery back-up, at inlet and outlet of the Raw water and Clear water pipeline and Feeder pipeline outlet at RCC Overhead tanks; to check losses and measure the quantity of



water. Reading display of all the Flow meters, along with data logging instruments should be made available at single point, wherever decided by the Engineer-in-charge.

All the Electromagnetic Flow meters shall have the same make and salient features as under.

Coil housing of the Electromagnetic flow meters of fully welded SS-316 and Flow-tube lining of PTFE / EPDM / Neoprene.

Recommended make: Krohne-Marshall / Yokogawa / Emerson- Rosemount.

6.21.9 Technical Qualifications for procurement of pipes during construction

6.21.9.1 H.D.P.E. Pipe

The Pipe manufacturer should have an annual installed production capacity of quantity equal to this TENDER.

The manufacturer should hold valid IS license under IS:4984 consecutively for last five years to manufacture ISI marked pipes.

The Pipe manufacturer should have manufactured and supplied in India at least HDPE Pipe of minimum 110 mm or above dia. More than required in this TENDER during past 3 years ending 2017. Self-certified document from HDPE Pipe Manufacturer to be attached along with technical Tender.

6.21.10 Technical Qualifications for Bidder

The Bidder should have successfully executed one job of Supply, laying and commissioning of ISI marked HDPE Pipeline, complete in all respects.

6.21.11 Installation and Commissioning of HDPE pipes

6.21.11.1 Installation

- a) Supplying, laying, jointing, testing and commissioning of pipes shall conform to relevant IS codes, as applicable.
- b) The alignment of pipelines shown in drawings of the TENDER documents is only indicative and the exact alignment will be as per drawings and/or as directed by the Engineer or his representative.
- c) The HDPE Pipes shall be laid in accordance with the latest IS 7634 Part-2

6.21.12 Field Hydraulic Test

- a) The Sectional Hydraulic Test shall be carried out after the pipeline section to be tested has been laid jointed and backfilled to a depth sufficient to prevent floatation.
- b) Each length of the pipeline to be tested shall be capped or blanked off at each end and securely struted or restrained to withstand the forces which will be exerted when the test pressure is applied.
- c) Proposals for testing where thrusts on structures are involved, even where thrust flanges on the piping are installed, shall be with the prior approval of the Engineer.

- d) The proper method of filling the pipeline with water shall be used. The length under test shall be filled making certain that all air is displaced through an air valve or any other appropriate mechanism. The test length shall then remain under constant moderate pressure as per testing method given in the IS 7634.
- e) As per IS code water required to built up allowable drop in pressure during test will be treated as a make up water.
- f) The maximum allowable test pressure shall be 1.5 times the system design pressure or pipe rating whichever is higher.
- g) Notwithstanding the satisfactory completion of the hydraulic test, if there is any discernible leakage of water from any pipe or joint, the Contractor shall, at his own cost, replace the pipe, repair the pipe or re-make the joint and repeat the hydraulic test with cost including the cost of water.
- h) Test pressures are to be measured in kg/cm^2 at the centre of the blank flange situated at the lowest end of the pipeline under test. Unless otherwise specified the test pressure shall be as stated below.

6.21.13 Installation of Valves

General

The installation of valves shall be made according to the instructions of the manufacturer and the Engineer.

Installation of valves

Butterfly/Sluice valves shall be installed between flanges according to the instructions of the manufacturer.

Valves shall be placed on a support of concrete so that no shear stress is in the flanges. In case of axial thrust due to closure of a valve against pressure the valve shall be anchored in the support in a suitable manner to transfer the thrust into the floor slab of the chamber.

Air valves shall be installed on top of air valve tees.

SLUICE VALVES

DESIGN REQUIREMENT

A. Sluice valves shall generally conform to IS 14846/BS EN 1171/DIN 3352. Additionally, they should also meet specific requirement as stated.

B. Spindle, thrust collar and operating arrangement including hand wheel should be designed in such a way that one adult male is able to operate the valve against full differential pressure by exerting no more than 8 kgf effort (pull and push) on the hand wheel.

FEATURES OF CONSTRUCTION

- a. Valves shall have inside screw, non-rising spindle.
- b. Valves shall be with appropriate bushing arrangement for replacement of packing without leakage (350 mm $\varnothing$ and above), up to 350 mm $\varnothing$ valves shall be glanduss.

- c. Valves 450 mm ϕ & above shall be provided with an antifriction device / ball thrust bearing arrangement to minimize friction between spindle collar and casting. These should be housed away from wet chamber and should have facility for periodic greasing.
- d. Valves of size 450 mm ϕ and above shall be provided with enclosed, grease packed spur gear box.
- e. Valves 450 mm ϕ and above shall be provided with a drain and air plug.
- f. All valve doors when fully closed would ensure door faces are riding on body seat ring by at least 50% of the width of seat ring and there is sufficient room for wear travel. Applicable for valves 350 mm and above., up to 300 mm valves shall be resilient seated.
- g. All face and seat rings will be force/press fitted and additionally riveted (300 ϕ & above) to the recess in the CI casting. No screws are allowed.
- h. Spindle, thrust collar and operating arrangement including hand wheel should be designed in such a way that one adult male is able to operate the valve against full differential pressure by exerting no more than 80 N effort (pull and push) on the hand wheel. Only single start, square threads with a pitch not exceeding 12 mm in the spindle be used.
- i. Manufacturer to give details of gear box proposed - no. of spur pair, ratio, efficiency etc.
- j. Manufacturer to justify with calculation that the valve proposed is operable within the effort parameters specified and no. of turns to ensure the time required to operate the valve from full open to full close is within reasonable limits. This is a vital requirement.
- k. Nominal size of the valve shall be cast on the body of the valve.

Sr. No.	Data	Description
1	Size	300 mm to 1000 mm
2	Rating (Kg/sq.cm)	PN 1.0
3	Drilling	IS 1538 Table 4 & 6 / relevant ISO with latest amendments/ BS EN 1092-2
4	Material of construction	
5	Body	DI IS 1865 Gr. 500/7; 400/15 or CI IS 210 Gr. FG 200 for PN 1.0 (all sizes)
6	Wedge	DI IS 1865 Gr. 500/7; 400/15 (fully rubber lived EPDM, upto 300 mm) or CI IS 210 Gr. FG 200 for PN 1.0
7	Spindle	St. St. AISI 410 / 316 / relevant ISO with latest amendments
8	Seat & face rings	Bronze IS 318 LTB II 6 / relevant ISO with latest amendments (for 350 mm above)
9	Drain & air plug	Bronze IS 318 LTB II 6 / relevant ISO with latest amendments
10	Ball thrust bearing	SKF or equivalent
11	Bushing arrangement	Halprene on bronze
12	Rivets	Soft annealed brass
13	Gland packing	Teflon coated / graphited asbestos / hemp

14	Fasteners	Carbon Steel
15	Shop Testing: Hydrotest	
16	Seat leakage	10 Kg/cm ² (5 min) - for PN 1.0
17	Back seat leakage	5 Kg/cm ² (2 min) - for PN 1.0
18	Body	15 Kg/cm ² (5 min) - for PN 1.0
19	Approved Make	Ivc / Kirloskar / Vag / Fouress/Ivi

BUTTERFLY VALVES

- a. Butterfly valves shall be of double eccentric and resilient sealed type generally as per BS EN 593, BS 5155 and IS 13095. Valves shall be installed in valve chambers. Valves shall be provided with stainless steel extension spindle so that valves can be operated from ground level and without entering the chamber.
- b. Material of construction of butterfly valves shall comply with following requirements:

Item	PN 1.0 Valves
Body	Ductile IRON DIN 1693 - GGG40/spheriodal graphite icon IS 1865 Gr 400/12
Disk	Ductile IRON DIN 1693 - GGG40/spheriodal graphite icon IS 1865 Gr 400/12
Shaft	Stainless steel BS 970 Grade 431 S 29
Body Seat	Nickel weld overlay micro finished
Disc Seal	EPDM
Seal retaining ring	Ductile iron DIN 1693 - GGG40
Shaft bearing	Bronze with EPDM 'O' ring seal
Internal Fasteners	Stainless steel SS 316
Nuts, Bolts & washers for pipe flanges	High Tensile steel hot dip galvanized for valve in chamber. Stainless steel SS 316 for buried valves
Coating	Internal and external with power of liquid epoxy coating with minimum dry film thickness of 250 microns

- c. Butterfly valves shall be suitable for mounting in any position. The valve shall be free from induced vibration.
- d. Butterfly valve shall be suitable for bidirectional pressure testing with dead tight shut off even after long period of operation of 5 years. The valves shall be of double flanged long type.
- e. The valve seal shall be of replaceable design. When the valve is fully closed, the seal shall seat firmly. The seat surfaces shall be machined smooth to provide a long life for the seal. All fasteners shall be set flush so as to offer the least resistance possible to the flow through the valve.
- f. The shaft shall be stainless steel with bronze or equivalent seal with self-lubricating bearings. Disc pin shall be stainless steel. Ring shall be Tender directional seal adjusting suitable for pressure and vacuum service. Removal and replacement of steel shall be possible without removing the operating mechanism, valve shaft and

without removing the valve from the pipeline. Valve shaft shall be of one-piece unit extending completely through the valve disc hubs.

- g. All valve spindle and head wheels shall be positioned to give access for operational personnel. Valves shall be provided with enclosed gear arrangement for ease of operation. The gear box shall be worm and worm wheel design type totally enclosed grease filled and weatherproof. The operation with gearing shall be such that they can be opened and closed by one man against an unbalanced head of 1.15 times the specified ratings. Valves and gearing shall be such as to permit manual operation in a reasonable time and not exceed a required rim pull of 200 N. The valve disc shall be 90 deg turn.
- h. The disc shall be designed to withstand the maximum pressure differential across the valve in either direction of flow. The disc shall be contoured to ensure the lowest possible resistance to flow and shall be suitable for throttling operation.
- i. It should be possible to open the valve with upstream pipe fully filled and downstream pipe fully empty. The shaft shall be designed to withstand the maximum torque that will be imposed by the operator. It shall be secured to the disc by tapered stainless steel cotter pins.
- j. Valve shall be provided with mechanism position indicator to show the position of the disc mounted on the driven shaft end.
- k. Rigid adjustable stop mechanism shall be provided within the gear box or elsewhere on the valve to prevent movement of the disc beyond the fully opened or closed position (i.e., set points).
- l. Valve shall be capable of closing against the maximum flow that can occur in practice. The break way torque against maximum differential head conditions shall be within the manufacturers limits.
- m. All hand wheels shall be arranged to turn in a clockwise direction to close the valve, the direction of rotation for opening and closing being indicated on the hand wheels.
- n. All hand wheels shall be provided with an internal locking device to prevent operation device by unauthorized person.

AIR VALVES

A SCOPE AND GENERAL DESIGN FEATURE

This section covers the requirements of double orifice type air valves with tamper proof cover to be used for evacuation of accumulation of air in water mains under pressure, for the exhaust of air when such mains are being charged with water and for inlet of air when they are emptied of water.

The working pressure of the air valves shall be 10 kg/cm² (PN 1).

B FUNCTION

Automatic air valves generally conforming to IS 14845 / relevant ISO with latest amendments are to be used for evacuation of accumulated air in water mains under pressure, for the exhaust of air when such mains are being charged with water and for ventilating the mains when they are being emptied of water.

C DESIGN FEATURES

- a) Air valves shall be double orifice type and tamper proof unless otherwise directed by Engineer. A buoyant rigid float shall seal the large orifice and the chamber



housing shall be designed to avoid premature closing of the valve by the air whilst being discharged. Small orifice shall discharge small air volume during operation under full internal pressures. All air valves shall be provided with isolating sluice valves and flanged end connection.

- b) The valve shall be capable of exhausting air from pipe work automatically when being filled, the air being released at a sufficiently high rate to prevent the restriction of the inflow rate. Similarly, the valve shall be capable of ventilating pipe work automatically when being emptied or under water hammer condition, the air inflow rate being sufficiently high to prevent the development of a vacuum in the pipelines. The valve shall also automatically release air accumulating in pipe work during normal working conditions.
 - c) The valves shall be designed to prevent premature closure prior to all air having been discharges from the line. The orifice shall be positively sealed in the closed position with the float only raised by the liquid and not by a mixture of air and liquid spray. The seating shall be so designed to prevent the float sticking after a long period in the closed position.
 - d) Air valves shall thus be designed to automatically operate so that they will.
- Positively open under internal pressure less than atmospheric pressure to admit air in bulk during pipeline draining operation.
 - Exhaust air in bulk and positively close as water, under low head, fills the body of the valve during filling operation.
 - Not blow shut under high velocity air discharge; and
 - Exhaust accumulated air under pressure while the pipe is flowing full of water.

D CONSTRUCTION FEATURES

Material of construction of air valves shall comply with following requirements:

- a) All air valves shall be constructed so that internal working parts which may become necessary for repairs shall be readily accessible, removable, and replaceable without used special tools and removing the valve from the line.
- b) Valves with air intake or exhaust facilities shall have an integral protecting cover top shall be supplied to prevent dirt and debris from entering the outlet of the valve.
- c) The contractor shall verify with the supplier of the valves that the valves have the capacity to sustain the pipeline test pressure prior to testing. In the event that the valves do not sustain the pressure they shall be removed and the stub pipes from the main pipeline blanked off before pressure testing the pipeline.

E DATA

A	Valve size	300 to 1000 mm dia
B	Suitable for max. differential pressure (kg/cm ²)	10
C	Material of construction	
	Body and cover	CI IS 210 Gr FG 200 or SG iron 1865 Gr 400/12 or grade GGG40
	Float	Rubber coated timber or Polycarbonate up to 50 NB/ SS 304 above 50 NB



	Internal Linkages	SS 304
	Seat Ring	Dexine (Nitrile Rubber) or bronze seat
	Isolating Sluice Valve	Generally conforming to IS 14846/relevant ISO with latest amendments
	Spindle for Sluice Valve	St. St. AISI 410
	Bolts & Nuts	M.S.

TESTING AND PERFORMANCE

- a) When tested as per clauses 11.6.d.1, the air passage and the function of ball floats in a valve shall be satisfactory, and the valve shall work smoothly.
- b) Hydrostatic test of valve body, when tested in accordance with 11.6.d.4 there shall be no leakage through pressure sustaining components and joints. There shall be no permanent deformation of any part.
- c) Valve seat and cock, when tested in accordance with 11.6.d.2 and 11.6.d.3 shall not show any leakage.
- d) Function and Performance Test
 - i. The valve shall be fitted on a test bench.

The pressure of the water in pipe shall be developed to working pressure, and the main valve shall be gradually opened to check the air release and float function. Compressed air shall then be slowly put into the valve through underside of the valve and check the function of floats.

- ii. High Pressure Orifice Seat Test

Subsequent to high pressure orifice performance test, hydraulic pressure shall be reduced up to half of the working pressure to check leakage of orifice seat for a duration of three minutes.

- iii. Low Pressure Orifice Seat Test

Subsequent to high pressure orifice performance test, hydraulic pressure shall be reduced up to half of the working pressure to check leakage of orifice seat for a duration of three minutes.

- iv. Body Test

The valve body (without cover and ball floats) shall be covered by a blank flange, keeping isolating valve open. Hydrostatic pressure of 1.5 times the pressure class of the valve shall be applied for duration of 5 minutes to check the water tightness of the body.

6.21.14 Valve Chambers

Valve chambers shall be constructed according to the typical drawings suitable for the respective valve and special arrangement if any shall be approved by Engineer. They shall be constructed in brick masonry as shown in the drawing. The chambers shall be constructed after the laying of the pipes and the assembly of specials and valves. The size of the chambers shall be according to the following criteria/ as per direction of Engineer.



- Minimum distance of flanges from walls: 45 cm
- Minimum distance of sockets from walls: 45 cm
- Minimum distance between highest point of equipment and roof slab: 30 cm
- Maximum distance between highest point of equipment and roof slab: 50 cm

Pipes passing through walls should be coated by two layers of soft material (Hessian felt) to allow for differential settling and longitudinal expansion if directed by Engineer. Only metallic pipes may be cast into the walls for anchoring purposes.

The work shall include excavation, consolidation, levelling, lean concrete as per drawing in foundations, finishing, refilling. It shall include all labour and material required for the complete chamber.

6.21.15 Dismantling Joints

Double flanged Dismantling joints shall be of Cast Iron in such a manner that valves (300 mm and above diameter) can be dismantled without stress to the joints. These shall be for working pressures of 10 kg/cm² (1 Mpa) and shall be completely leak proof with proper gasket arrangement. Flange dimensions shall conform to IS 1538 (part I to XXII). Flanged specials shall be supplied with required nuts, bolts, and rubber gaskets. The nuts and bolts shall be of best quality carbon steel, machined on the shank and electro-galvanized. Rubber gasket shall be as per IS 5382. Dimensions and drilling of flat gasket will be as per IS 1538: 1993, suitable for making flanged joint. The dismantling pieces shall provide minimum clearance of + 25 mm (total distance 50 mm). The dismantling joint shall be internally and externally coated with hot applied (dip) bituminous paint.

6.21.16 Thrust Blocks

The thrust blocks shall be of plain/reinforced cement concrete on site as per design and drawings to be given by the Contractor and approved by the Engineer in Charge. The thrust blocks shall be cast directly against the undisturbed soil.

6.21.17 Other Services

Contractor shall take the necessary precautions to avoid the damage to other services such as water supply lines, telephone cables, electrical cables, storm water drains etc. In case of any damages to any of the services, contractor shall be responsible for restoring the facilities in bare minimum time at his own cost.

6.21.18 Reinstating The Pavement / Road Surface

Pavement / Road restoration should be done just after proper backfilling of trenches. About 100 mm thick layer of stone dust/zeera gitti should be filled in trenches and making with adjacent road. Any settlement in trench should be immediately filled with stone dust/zeera gitti. WBM/Bituminous surface shall be made as directed by Engineer in Charge.

6.22

Construction of Toilet Block

Construction of Toilet Block building shall be conforming to the requirements of National Building Code of India (NBC). All the items covered under the construction of toilet block, however, shall comply the corresponding Indian Standards & Codes of Practice. It shall include, but not limited to, the following items complete as per the drawings and technical specifications.

- Earthwork - Excavation & Backfilling
- Foundation, Footing & Plinth works.
- Plain & Reinforced Concrete works
- Brick, Stone, or Concrete Block Masonry works.
- Waterproofing & Anti-termite Treatment
- Internal & External Plastering & Painting works (Make: Asian Paint)
- Internal & External Flooring, Dado & Paving works
- Door, window, ventilators & Partition works
- Internal & External Electrification & Lighting works, luminaires, fixtures, fittings, fans, exhaust fans, wiring, cabling, switch boards, panels, distribution boards, MCB, ELCB, etc (Make: Cable – RR, Exhaust fan – Havel's, Switch Board-Crab tree)
- Internal & External Storm water drainage
- Internal & External Water supply, plumbing & sanitary works, underground water tank, high density polyethylene UV stabilized overhead water storage tank conforming to IS 12701 of Sintex or equivalent brand with accessories, connections, testing etc complete.
- UPVC piping, fittings & accessories (Make – Astral)
- Bib cock, stop cock, angle cock, flush cock, ball cock, health faucets, etc (Make - Jaguar / Hindware)
- Nahani trap, gully trap, inspection chamber, interseptic chambers, Manholes, etc complete
- Cast iron, Saltglazed stoneware/NP2 class precast concrete/UPVC/HDPE sewage/waste water pipes, fittings & collars etc complete.
- Water Closets - Indian, Orrissa, European including P or S trap, flush cock, health faucet, flusing cistern, bib cock, etc (Make – Hindware)
- Urinals with angle cocks, flush cocks, traps, marble/granite/glass partitions, etc (Make – Hindware)
- Wash hand basins with pillar cocks, traps, pilished marble/granite counter top, mirrors, etc (Make – Hindware)
- All toilet accessories & ladders, Portable fire extinguishers, miscellaneous items as required.

- Septic tank and soak well.

Schedule of Finishes

The various items involved in the construction of the toilet block shall have, at the minimum, the following types of finishes.

Sr. No.	Item Description	Type of Finishes
1	Masonry works	Burnt Clay Bricks or Fly-ash bricks or Stone blocks or Precast concrete blocks
2	Footings, beams, columns, slabs, chajjas, etc	Reinforced Concrete
3	Plinth protection	Concrete M30 grade with M15 PCC below;
4	Internal Plaster	Double coat mala plaster
5	External Plaster	Double coat sand face plaster
6	Flooring Tiles & Dado	Vitrified ceramic tiles (Varmora/Kajaria/Somany Make)
7	Internal painting	Acrylic paint, Oil paint or Flat paint
8	External painting	Weather coat acrylic paint
9	Door, windows, vents	Anodized Aluminium framing with 5mm thick plain glass
10	Stone partitions & counter tops	Polished marble or granite
11	Switch boards	Modular acrylic switch boards
12	Sanitaryware	White or ivory finished vitrified ceramic
13	Sanitary fixtures & faucets	Chrome plated brass