SECTION-4

CONCRETE

Indian Standards

The following IS with latest revision apply to this section:

<table>
<thead>
<tr>
<th>I.S. No</th>
<th>Subject</th>
</tr>
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<tbody>
<tr>
<td>10262-1982</td>
<td>Recommended Guide Lines for Concrete Mix Design</td>
</tr>
<tr>
<td>383-1970</td>
<td>Specification for coarse and fine aggregates from natural sources for concrete (Second revision)</td>
</tr>
<tr>
<td>516-1959</td>
<td>Method of test for strength of concrete.</td>
</tr>
<tr>
<td>1199-1959</td>
<td>Method of sampling and analysis of concrete.</td>
</tr>
<tr>
<td>2185 (part-I)-1979</td>
<td>Specification for load bearing, hollow concrete blocks (second revision)</td>
</tr>
<tr>
<td>2185 (Part-II)-1983</td>
<td>Specification for concrete masonry units Hollow and solid light weight concrete blocks (first revision)</td>
</tr>
<tr>
<td>2185 (Part-III)-1984</td>
<td>Specification for concrete masonry units Auto cleaved cellular (aerated) concrete blocks (first revision)</td>
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<tr>
<td>2645-1975</td>
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<td>4926 - 2003</td>
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<td>Code of practice for extreme weather concreting Part 1-Recommended Practice for hot weather concreting</td>
</tr>
<tr>
<td>8112-1989</td>
<td>Specification for 43 Grade Ordinary Portland Cement</td>
</tr>
<tr>
<td>12269 - 1987</td>
<td>Specification for 53 Grade Ordinary Portland Cement</td>
</tr>
</tbody>
</table>

MATERIALS:

Cement:

Unless otherwise indicated, cement used shall be Ordinary Portland Cement 43 grade confirming to IS 8112 of approved make. Use of any other grade of cement in case of extreme emergency shall be with the specific approval from the consultant and Engineer – in – Charge. Cement older than 3 months from the date of manufacturing shall not be used for the work.

Storage:

Cement in bags shall be stored in dry waterproof sheds to protect the cement from dampness and to minimize warehouse deteriorations. Where cement has been stored and for any reason the stored cement shows signs of deterioration or contamination, it may be tested before use for its strength, setting time, etc., cement which has fully or partially set shall not be used.

Storage of cement at the site of work shall be at the contractor’s expense and risk. In the event of any damage occurring to cement due to faulty storage in contractor's sheds or on account of negligence on his part, such damage shall be the liability of the contractor. The storage shall be planned considering optimum utilization as per planned progress and shall not allow storage of cement for longer period than the specified.

Precautions in storage:
Cement bags shall not be piled against the wall. A space of 60 cm all round shall be left between the walls and the piles, bags shall be piled off the floor on wooden planks. Bags shall be kept close together in the pile to reduce circulation of air as much as possible and shall not be piled more than 10 bags high to avoid lumping under pressure. The width of pile shall not be more than about 3m. For extra safety during the monsoon, or when it is expected to store the cement for an unusually long period, the pile shall be completely enclosed by a waterproof membrane such as polythene, tarpaulin etc. Each consignment of cement shall be stacked separately to permit easy access for inspection and facilitate removal. Cement shall be used in the order in which it is received.

Aggregates from Natural Sources:

Sources: Quality of Aggregates:

Aggregates from natural sources shall consist of (crushed or uncrushed) stones, gravel and sand or combination thereof conforming to IS 383. Specification for coarse and the fine aggregates from natural sources used for concrete. They shall be hard, strong, dense, durable, clean and free from veins and adherent coatings and free from injurious amounts of disintegrated pieces, alkali, vegetable matter and other deleterious substances. As far as possible, flaky and elongated pieces shall be avoided. Aggregated shall be obtained from approved sources as indicated.

Coarse aggregates shall be obtained from crushed granite, trap, basalt or similar stones from approved quarry. Sampling and testing shall be as per IS : 2386.

Deleterious Materials:

Aggregates shall not contain any harmful material, such as pyrites, coal, lignite, mica, shale or similar laminated material, clay, alkali, organic impurities, soft fragments, sea shells, etc., in such quantities as to affect the strength or durability of the concrete. Aggregates to be used for reinforced concrete shall not contain any material liable to attack the steel reinforcement. Aggregates, which are chemically reactive to alkalis in cement, shall not be used in cement concrete.

Limits of Deleterious Materials:

The maximum quantities of deleterious materials in the aggregates shall not exceed the limits laid down in IS 383.

4.3.3.1 If the quantities of deleterious materials in the aggregates exceed the limits mentioned above the aggregates shall be washed in fresh and clean water to the satisfaction of E.I.C before use.

4.3.3.2 Use of sea-sand shall not be allowed for any description of mortar and concrete works, in any location.

4.3.4 Aggregate Crushing Value:

The aggregate crushing value shall not exceed 45 percent for aggregate used for concrete other than for wearing surfaces and 30 percent for concrete for wearing surfaces such as runways roads and pavements.

4.3.5 Aggregate Impact Value:

As an alternative to aggregate crushing value, the aggregate impact value shall not exceed 45 percent by weight for aggregates used for concrete other than for wearing surfaces and 30 percent by weight for concrete for wearing surfaces, such as runways roads and pavements.

4.3.6 Aggregate Abrasion Value:

The abrasion value of aggregate, using Los Angeles machine shall not exceed the following value:

a) For aggregates to be used in concrete for wearing surfaces-30 percent

b) For aggregates to be used in other concrete-50 percent

4.3.7 Size and Grading of Aggregates:
Grading of Coarse Aggregate:

<table>
<thead>
<tr>
<th>IS Sieve Designation</th>
<th>Percentage Aggregate</th>
<th>Passing for graded of nominal size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>40 mm</td>
<td>20 mm</td>
</tr>
<tr>
<td>80 mm</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>63 mm</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>40 mm</td>
<td>95-100</td>
<td>100</td>
</tr>
<tr>
<td>20 mm</td>
<td>30-70</td>
<td>95-100</td>
</tr>
<tr>
<td>12.5 mm</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>10 mm</td>
<td>10-35</td>
<td>25-55</td>
</tr>
<tr>
<td>4.75 mm</td>
<td>0-5</td>
<td>0-10</td>
</tr>
</tbody>
</table>

Grading of Fine Aggregate:

(2) Fine Aggregate (Sand): - The grading of fine aggregates shall be within the limits given in the following table and shall be described as fine aggregates Grading zone I, II, III & IV. Where the grading falls outside the limits of any particular grading zone of sieves other than 600 micron I.S. Sieve, by a total amount not exceeding 5 percent, it shall be regarded as falling within that Grading Zone. This tolerance shall not be applied to percentage passing the 600 micron I.S. Sieve or to percentage passing any other size on the coarser limit of grading Zone I or the finer limit of Grading Zone IV.

<table>
<thead>
<tr>
<th>IS Sieve Designation</th>
<th>Percentage passing for</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grading Zone I</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>10 mm</td>
<td>100</td>
</tr>
<tr>
<td>4.75 mm</td>
<td>90-100</td>
</tr>
<tr>
<td>2.36 mm</td>
<td>60-95</td>
</tr>
<tr>
<td>1.18 mm</td>
<td>30-70</td>
</tr>
<tr>
<td>600 micron</td>
<td>15-34</td>
</tr>
<tr>
<td>300 micron</td>
<td>5-20</td>
</tr>
<tr>
<td>50 micron</td>
<td>0+10</td>
</tr>
</tbody>
</table>

**NOTE 1:** For crushed stone sands the permissible limit on 150 micron I.S. Sieve shall be increased to 20 percent. This does not affect the 5 percent allowance, as already permitted, applicable to other sieve sizes.

**NOTE 2:** Fine aggregate conforming to Grading Zone IV shall not be used in reinforced concrete, unless tests (which shall be recorded) have been made to ascertain the suitability of proposed mix proportions and prior written approval of EIC for use of such fine aggregate is obtained.

(3) All-in Aggregate: - Grading of all in aggregate shall be within the limits given in the following table:

<table>
<thead>
<tr>
<th>IS Sieve Designation</th>
<th>Percentage passing for All-in Aggregate of nominal size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>40 mm</td>
</tr>
<tr>
<td>80 mm</td>
<td>100</td>
</tr>
<tr>
<td>40 mm</td>
<td>95-100</td>
</tr>
<tr>
<td>20 mm</td>
<td>45-75</td>
</tr>
<tr>
<td>4.75 mm</td>
<td>25-45</td>
</tr>
<tr>
<td>600 micron</td>
<td>8-30</td>
</tr>
<tr>
<td>150 micron</td>
<td>0-6</td>
</tr>
</tbody>
</table>
NOTE: For carrying out tests on all-in-aggregates, the fractions passing through 4.75 mm IS sieve and the fractions retained on 4.75 mm IS sieve shall be first separated and there shall comply with the requirements (except grading) specified for fine aggregates and coarse aggregate respectively.

44 Water Proofing Compound:

Integral cement waterproofing compound where indicated shall be used and the same shall confirm to the requirements of IS 2645-1975. Specifications for integral cement water proofing compound or as specified in the BOQ.

45 Water:

Water used for mixing and curing shall be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete or steel. The pH value of water shall generally be not less than 6. Potable water is generally considered satisfactory for mixing concrete. Water found satisfactory for mixing is also suitable for curing concrete. However, water used for curing should not produce any objectionable stain or unsightly deposit on the concrete surface. The presence of tannic acid or iron compounds is objectionable.

WORKMANSHIP

4.6 Plain and Reinforced Cement Concrete:

4.6.1 Cement Concrete:

Cement concrete shall be of the specified Grade or volumetric mix as indicated. Cement concrete and reinforced cement concrete shall be provided in accordance with IS 456-2000, code of practice for plain and reinforced concrete, except as otherwise stated.

4.6.2 Concrete Mix Proportioning:

Where concrete is specified by its Grade i.e., characteristic compressive strength, determination of proportions of cement, aggregates and water to attain the required strength shall be made by designing the concrete. Mix (Design mix concrete).

Design Mix Concrete:

The mix shall be designed to produce the grade of concrete having the required workability and the characteristic strength not less than that specified. The contractor shall conduct all necessary tests and analysis of the materials and provide necessary test/analysis data required for design of the concrete mix. The contractor shall also make trial mixes of concrete and conduct necessary tests to arrive at the approved mix proportioning and strength at his cost. As long as the quality of materials does not change a mix design done earlier may be considered adequate for later work. The mix design shall be done/tested from the Government Laboratories preferably located at NASIK.

4.6.2.1 MINIMUM CEMENT CONTENTS:

The minimum cement contents for design mix concrete of various grades shall be as indicated.

Volumetric Mix Concrete:

Where indicated concrete will be of the specified volumetric mix. For volumetric mix concrete, the proportions of cement and aggregates are defined by bulk. Volumetric mix shall be designated as 1:4:8, 1:3:6 etc., the figures denote the relative proportions of cement, fine aggregate in dry condition and graded coarse aggregate respectively. If fine aggregate is moist, necessary allowance shall be made for bulking. To determine bulk, 50 kg of cement shall be taken as equal to 0.035 cum. Quantities of fine and coarse aggregates shall be determined by Volume separately and accurately in proper gauge boxes. The gauge boxes shall be of such dimensions that 50 kg of cement forms a unit. The equivalent size of a box for 50 kg cement bag will measure 40x 35x 25 cm internally. Consolidation of aggregates in the gauge boxes by ramming or shaking shall not be allowed.
4.6.3 Batching:
In proportioning design mix concrete, the quantity of both cement and aggregates shall be determined by weight. Water shall be either measured by volume in calibrated tanks or weighed. All measuring equipment shall be maintained in a clean serviceable condition and their accuracy periodically checked. All materials for controlled concrete shall be batched as per approved design in suitable weigh batcher of adequate capacity and of approved design.

4.6.3.1 The material shall be stockpiled for several hours, preferably a day before use. The grading of coarse and fine aggregates shall be checked as frequently as possible, the frequency for a given job being determined by the EIC to ensure that the specified grading is maintained.

4.6.3.2 Where the aggregates supplied are not graded, different sizes shall be blended in right proportions; the different sizes being stacked in separate stock piles.

4.6.3.4 Water cement ratio shall be maintained at its correct value.

4.6.3.5 No substitutions in the materials used on the work or alterations in the established proportions shall be made without additional test to show that the quality and strength of concrete are satisfactory.

4.6.4 Workability of concrete:
The concrete shall be of adequate workability for the placing condition of the concrete and proper compactions with the means available. Suggested ranges of values of workability of concrete for some placing conditions, measured in accordance with IS 1199-1959, are given below:

<table>
<thead>
<tr>
<th>Placing conditions</th>
<th>Degree of workability</th>
<th>Values of Workability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Concreting of shallow sections with vibration</td>
<td>Very low</td>
<td>20-10 seconds vee-bee time OR 0.75-0.80 compacting factor</td>
</tr>
<tr>
<td>Concreting of lightly Low reinforced sections with vibration</td>
<td>Low</td>
<td>10-5 seconds vee-bee time OR 0.80-0.85 compacting factor</td>
</tr>
<tr>
<td>Concreting of lightly reinforced sections without vibration, or heavily reinforced section with vibration</td>
<td>Medium</td>
<td>5-2 seconds vee-bee time OR 0.85-0.92 compacting factor OR 6-25mm slump for 12.5 mm aggregate OR 25-75mm slump for 20 mm aggregate</td>
</tr>
<tr>
<td>Concreting of heavily reinforced section without vibration</td>
<td>High</td>
<td>Above 0.92 compacting factor OR 75.;125mm slump for 20 mm aggregate</td>
</tr>
</tbody>
</table>

4.6.5 Mixing:
Concrete shall be mixed in a mechanical mixer. The mixing shall be continued until there is a uniform distribution of the materials and the mass is uniform in color and consistency. If there is segregation after unloading from the mixer, the concrete shall be re-mixed. The mixing time may be taken as 1-1/2 to 2 minutes.

4.6.6 Form
Work: 4.6.6.1

General:
The formwork shall be designed and constructed to the shapes, lines and dimensions shown on the drawings. All forms shall be sufficiently watertight to prevent leakage of mortar. Forms shall be constructed so as to remove in sections. Formwork shall be provided finished fair and even as specified in section 7-
Woodwork. The formwork shall be properly designed so that it is rigid enough to remain free from bulging, sagging or displacement while placing the concrete and consolidation.

### 4.6.6.2 Cleaning and Treatment of Forms:

All rubbish particularly chippings; shavings and sawdust shall be removed from the interior of the forms before the concrete is placed. The formwork in contact with the concrete shall be cleaned and thoroughly wetted or treated with an approved composition to prevent adhesion between formwork and concrete. Care shall be taken that such approved composition is kept out of contact with the reinforcement.

### 4.6.6.3 Stripping Time:

Forms shall not be struck until the concrete has attained strength at least twice the stress to which the concrete may be subjected at the time of removal of formwork. The strength referred to shall be that of concrete using the same cement and aggregates, with the same proportions and cured under conditions of temperature and moisture similar to those existing of the work. Where so required formwork shall be left longer. In normal circumstances and where ordinary Portland cement is used, forms may generally be removed after the expiry of the following periods: For other cement stripping time shall be indicated:

| (a) | Walls, columns and vertical faces of all structural members | 2 days |
| (b) | Slabs (props left under) | 3 days |
| (c) | Beam Soffits (props left under) | 7 days |
| (d) | Removal of props under slabs |
| 1) | Spanning up to 4.5 m | 7 days |
| 2) | Spanning over 4.5 m | 14 days |
| (e) | Removal of props under beams and arches |
| 1) | Spanning up to 6 m | 14 days |
| 2) | Spanning over 6 m | 21 days |

In case of bad weather these periods may be increased at the direction of EIC.

The number of props left under, their sizes and disposition shall be such as to be able to safely carry the dead load of slab, beam or arch as the case may be together with any live load likely to occur during curing or further construction.

### 4.6.6.4 Removal of Form work:

Formwork shall be removed in such a manner as would not cause any shock or vibration that would damage the concrete. Before removal of soffits and props concrete surface shall be exposed to ascertain that the concrete has sufficiently hardened.

### 4.6.6.5 Where the shape of the element is such that formwork has re-entrant angles, the formwork shall be removed as soon as possible after the concrete has set, to avoid shrinkage cracking occurring due to the restraint imposed.

### REINFORCEMENT:

#### 4.6.7 Assembly of Reinforcement:

Reinforcement shall be bent and fixed as specified in section 10 Steel and Iron work. All reinforcement shall be placed and maintained in the position shown in the drawings during concreting. Crossing bars shall not be tack welded for assembly of reinforcement, unless otherwise indicated. All Reinforcement shall be of tested Quality and specified Diameter as per the design. Test reports shall be submitted to Engineer – in – Charge / Consultant for approval.

#### 4.6.7.1 Tolerance on Placing of Reinforcement:

Unless otherwise directed, reinforcement shall be placed within the following tolerance:

(a) For effective depth 200 mm or less + 10 mm
4.6.7.2 Welded joints or mechanical connectors:

Welded joints in reinforcement may be used where indicated / directed but in all cases of important connections, tests shall be made to prove that the joints are of the full strength of the bars connected.

4.6.8 Cover to Reinforcement:

4.6.8.1 Reinforcement shall have concrete cover and the thickness of such cover (exclusive of plaster or other decorative finish) shall be as follows, unless otherwise indicated:

a) At each end of reinforcing bar, not less than 25 mm or less than twice the diameter of such bar;

b) For a longitudinal reinforcing bar in a column not less than 40 mm nor less than the diameter of such bar. In the case of columns of minimum dimension of 200 mm or under whose reinforcing bars do not exceed 12 mm, a cover of 25 mm may be used;

c) For longitudinal reinforcing bar in a beam, not less than 25 mm nor less than the diameter of such bar;

d) For tensile, compressive, shear, or other reinforcement in a slab, not less than 15 mm nor less than the diameter of such bar; and

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

4.6.8.2 Increased cover thickness may be provided when surfaces of concrete members are exposed to the action of harmful chemicals acid vapour, saline atmosphere sulphurous smoke, etc., and such increase of cover may be between 15mm and 50mm beyond that specified in 4.6.8.1, as indicated.

4.6.8.3 In all cases the cover shall not exceed 75 mm.

4.6.9 Transporting:

Concrete shall be transported from the mixer to the formwork as rapidly as possible by methods, which will prevent the segregation or loss of any of the ingredients and maintaining the required workability. During hot or cold weather, concrete shall be transported in deep containers. Other suitable methods like transporting by transit mixers may be adopted. Special care should be taken to reduce loss of water by evaporation in hot weather and heat loss in cold weather during transportation. Sufficient numbers of transit mixtures shall be employed for maintaining continuity of concreting process.

Concrete line-pumps of suitable capacity and sufficient numbers shall be engaged for pouring concrete in pavements.

4.6.10 Placing:

The concrete shall be deposited as nearly as practicable in its final position to avoid rehandling. The concrete shall be placed and compacted before setting commences and should not be subsequently disturbed. Methods of placing should be such as to preclude segregation. Care shall be taken to avoid displacement of reinforcement or movement of formwork. The concrete, which is deposited or otherwise disturbed after initial setting commences shall be immediately removed from the site.

4.6.10.1 Before placing the concrete in trenches or on sub-grade or sub-base, the sub-grade / sub-base shall be cleaned of all injurious or foreign matter, watered and well consolidated, if necessary.

4.6.10.2 The final layer of concrete shall be laid to such levels and falls as may be directed.

4.6.10.3 When concrete has to be lowered to any depth below 15m, it shall be conveyed in suitable receptacles or by chute. The delivery end of the chute shall be as close as possible to the point of deposit. The chutes shall be thoroughly flushed with water before and after each working period, the water for this purpose shall be -discharged outside the formwork.
4.6.11 Compaction:

Concrete shall be thoroughly compacted and, fully worked around the reinforcement, around embedded fixtures and into the corners of the formwork. Mechanical vibrators shall be employed for compacting concrete. Over vibration or vibration of very wet mixes is harmful and shall be avoided; under vibration is also to be avoided. Sufficient numbers of reserve / vibrators in good working condition shall be kept at all times so as to ensure that there is no slacking / interruption in compacting. Vibrators of specified sizes shall be used depending upon the quantum of concreting.

4.6.11.1 Where vibration is to be applied externally, the design of formwork and the disposition of vibrators shall be such as to ensure efficient compaction and to avoid surface blemished.

4.6.12 Construction Joints:

Concreting shall be carried out continuously up to construction joints the position and arrangement of which shall be as indicated or directed by the consultant and Engineer – in – charge.

4.6.12.1 When the work has to be resumed on a surface which has hardened, such surface shall be roughened. It shall then be swept clean and thoroughly wetted. For vertical joints neat cement slurry at the rate of 2.50 kg of cement per sqm shall be applied on the surface before it is dry. For horizontal joints surface shall be covered with a layer of mortar about 10 to 15 mm thick composed of cement and sand ratio as the cement and sand in the concrete mix. The layer of cement slurry or mortar shall be freshly mixed and applied immediately before placing of concrete.

4.6.12.2 Where the concrete has not fully hardened, all laitance shall be removed by scrubbing the wet surface with wire or bristle brushes. Care being taken to avoid dislodgement of particles of aggregate. The surface shall be thoroughly wetted and all free water removed. The surfaces shall then be coated with neat cement slurry. On this surface, a layer of concrete not exceeding 150mm in thickness shall first be placed and shall be well rammed against old work; particular attention being paid to corners and close spots; work thereafter shall proceed in the normal way.

4.6.12 Curing:

Exposed surfaces of concrete shall be kept continuously in a damp or wet condition by covering with a layer of sacking, canvas, Hessian or similar materials or a layer of sand or by ponding for at least seven days from the date of placing of concrete. Approved curing compounds may be used in lieu of moist curing with the permission of EIC. Such compounds shall be applied to all exposed surface of the concrete as soon as possible after the concrete has set.

4.6.13 Protection:

The concrete shall be carefully protected after it is laid against the action of frost and shielded from exposure to sun to avoid rapid drying. Care shall be taken to protect the concrete from all shaking and other disturbances during construction. No traffic shall be allowed on the finished concrete surface for at least 7 days. This period may be increased or decreased at the discretion of EIC

4.6.14 Inspection :

Immediately after stripping the formwork, all concrete shall be carefully inspected for any defective work and defects either removed or made good before the concrete has thoroughly hardened.

4.6.15 Exposed Surfaces :

4.6.15.1 The contractor shall use proper formwork so that the concrete in contact with removal of formwork present an even surface. Concrete while being poured against formwork shall be adequately tamped, or vibrated where directed, so that fines are drawn towards the surface and honey combing is avoided.

4.6.15.2 Exposed surfaces of concrete shall be "Finished fair and Even in Forms".

Exposed surfaces after striking off formwork shall be such as to present a fair and even surface and shall not be plastered unless otherwise specified. The surface shall be presentable without any further treatment.
Any irregularities and protruding formwork marks shall be removed and minor honeycombing made good with cement and sand mortar 1:3. Lines along the formwork joints may however show.

4.6.15.3 Exposed surfaces of concrete which are indicated/required to be plastered shall be roughened with wire brushes and hacked out closely immediately after removal of formwork.

4.6.15.4 Openings and Inserts:

Openings and Positions of Inserts shall be made as per the drawing or as directed by the Consultant and EIC. This shall be done with utmost accuracy/precision and any deviation from the Drawing or instruction by the Consultant or EIC, the same shall be rectified by the Contractor at his own cost. No Extra payment shall be admissible for making openings/inserts etc.

4.6.16 Sampling and testing of concrete:
Samples from fresh concrete shall be taken as per IS 1199-1959. Method of sampling of concrete and cubes shall be made, cured and tested at 28 days in accordance with IS 516-1959, Method of test for strength of concrete.

4.6.16.2.1 Where indicated, tests on beams for modulus of rupture at 72 ± 2hrs or at 7 days, or compressive strength tests at 7 days may be carried out in addition to 28 days compressive strength alone shall be the criterion for acceptance or rejection of the concrete.

4.6.16.3 Test Specimen:
Three test specimens shall be made from each sample for testing at 28 days. Additional cubes may be required for such purpose as to determine the strength of concrete at 7 days or to check the testing errors.

4.6.16.4 Test Strength of samples:
The test strength of the sample shall be the average of the strength of three specimen. The individual variation shall not be more than +/- 15 percent of the average.

4.6.16.5 Acceptance Criteria:
The concrete shall be deemed to comply with the strength requirement when both the following conditions are met:
   a) The mean strength determined from any group of four consecutive test results complies with the appropriate limits in Column No. 2 Table – 11 of IS 456 -2000
   b) Any individual test results complies with the appropriate limits in column No.3 of Table -11 of IS 456-2000.

If the concrete is deemed not to comply pursuant to acceptance criteria, it shall be dismantled and redone at the contractor’s expenses.

Concrete of each grade shall be rejected if it is porous or honey-combed; its lacing has been interrupted without providing a proper construction joint; the reinforcement has been displaced beyond the tolerances specified or construction tolerances have not been met. However, the hardened concrete may be accepted after carrying out suitable remedial measures to the satisfaction of the Engineer-in-charge

4.6.16.5 Standard Deviation:
Standard deviation of concrete of each grade shall be determined separately as stated below. When result of sufficient number of tests (at least 30) are not available, than depending on the degree of quality control expected to be exercised at the site, the value of standard deviation given in the following table may be adopted for guidance. Grade of Concrete Suggested Values of S.D

<table>
<thead>
<tr>
<th>Grade of Concrete</th>
<th>S.D. for different degree of control in N/mm²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Very Good</td>
</tr>
<tr>
<td>M 10</td>
<td>2</td>
</tr>
<tr>
<td>M 15</td>
<td>2.5</td>
</tr>
<tr>
<td>M 20</td>
<td>3.6</td>
</tr>
<tr>
<td>M 25</td>
<td>4.3</td>
</tr>
</tbody>
</table>
Control expected for this work is "Very Good" and the contractor shall deploy weigh batcher as required to attain the required control.

47 **Waterproof Concrete:**

Where indicated, cement concrete shall be waterproofed by adding integral waterproofing compound conforming to IS 2645-1975. Specification for integral cement waterproofing compounds at the time of making concrete as per the manufacturer's instructions. The quality of waterproofing compound shall be as indicated but in no case shall be less than the quality recommended by the manufacturers and not exceeding 3 percent by weight of cement.

48 **Work in Extreme Weather Concreting:**

Concreting during hot and cold weather shall be done as per the procedures set out in IS: 7861 (part-I) Code of practice for extreme weather concreting; part I Recommended practice for hot weather concreting, or IS7861 (part-II)-1981 Code of practice for extreme weather concreting; Part II Recommended practice for cold weather concreting.

49 **Reinforced Concrete Work in water Retaining Structure:**

4.9.1 Special care shall be taken to get the most suitable grading of aggregate so as to produce the densest possible concrete. Mix proportion shall be indicated. Water cement ratio shall be controlled consistent with the requirements of workability to produce impervious concrete.

4.9.2 The concrete between the reinforcement and the formwork on the water face shall be well compacted and the board joints tight, so as to produce a face free from honey-combing or pores. External vibrators viz. shutter vibrators at the rate of one vibrator per 2.5 m² of shutter area shall be used to produce a compact concrete with a dense skin which shall not, however, contain an excess of cement, wherever it is not possible to use shutter vibrator, pin vibrator shall be used after the approval of EIC.

4.9.3 **Construction, Contraction & Expansion Joints.**

4.9.3.1 All vertical, horizontal construction and expansion joints in water retaining structures shall be located and executed as shown in the drawings and no deviation shall be permitted without the specific permission of EIC. Where days' work joints are formed whether horizontally or vertically, they shall be rebated as called out on drawings. Care shall be taken to remove from the earlier lift over all loose pieces of gravel, stone chips, wooden chips, country nails or any other foreign materials. All laitance shall also be thoroughly removed. If necessary, the face of the old concrete shall be well hacked to expose the aggregate and after washing the surface, a thin coat of mortar or grout (1 cement: 1 sand) shall be applied immediately before resuming concreting.

4.9.3.2 Water bar installation along the joints shall be done by embedding one half of the water bar in each side of the joint by suitable jigs / supporting arrangements between the adjacent sections of the concrete as per the manufacturer's specifications and directions of the EIC. Water bars shall be properly aligned and placed in position during embedding. To achieve the continuity of the water bar all along the joint at crossing and at change of alignment, the water stops shall be welded (in T, X or L shapes as the case may be) as per manufacturer's specifications and directions of EIC. Suitable jigs manufactured out of reinforcing bars may be used for fixing the water bars.

4.9.3.3 **Fittings:**

Pipes and outer fittings passing through the walls and bottom shall be well embedded in the concrete and shall be provided with normal puddle flanges. Opening in the walls, and floor slabs if any shall be provided as per the relevant drawings.

4.9.4 **Curing:**

Concrete in water retaining portion shall be cured minimum for 21 days.
4.9.5 Hydraulic Testing:

Structures shall be tested strictly in accordance with IS: 3370 (Part I) for water tightness. For underground tank, the total maximum drop in water surface level over seven days shall not exceed 40 mm.

4.10 Pre-cast Reinforced Concrete—Generally

4.10.1 Pre-cast reinforced concrete articles such as manhole cover and frame, columns, fencing posts, door and window frames, lintels, chajjas, copings, sills, shelves, slabs, louvers etc. shall be of the grade or mix as indicated and cast in forms or moulds. The forms shall be of timber or of steel for better finish. Provisions shall be made in the forms and moulds to accommodate fixing devices such as nibs, clips, hooks, bolts and forming of notches and holes. The contractor may precast the units on cement or steel platform that shall be adequately oiled provided the surface finish is of the same standard as obtained in the forms. Each unit shall be cast in one operation.

4.10.2 Concrete shall be proportioned, mixed, placed and thoroughly compacted by vibration or tamping to give a dense concrete free from voids and honeycombing.

4.10.3 Precast articles shall have a dense surface finish showing no coarse aggregate and shall have no cracks or crevices likely to assist in disintegration of concrete or rusting of steel or other defects that would interfere with the proper placing of the units or to impair the strength or the performance of construction. All angles of the precast units with the exception of the angles resulting from the splayed or the chamfered faces shall be true right angles. The rises shall be clean and sharp except those specified to be rounded. The wearing surface shall be true and out of winding. On being fractured, the interior of the units shall present a clean, homogeneous appearance.

4.10.4 The longitudinal reinforcement shall have a minimum cover of 12 mm or twice the diameter of the main bar, whichever is more, unless otherwise directed.

4.10.5 Curing:

After placing, the concrete shall be adequately protected during setting and in first stages of hardening from shocks and from the harmful effects of sunshine, drying winds and cold. The concrete shall be cured for at least 7 days.

4.10.6 Maturing:

From the date of casting, the precast articles shall be matured for 28 days before erection or being built up. 4.10.7 Concrete shall have sufficient strength to prevent damage to units when first handled.

Flyash:

Addition of flyash may be considered to the extent of 10% only and not more for footings, pedestals, columns, slabs and beams. Flyash shall not be used for Pavements and floors.

Nevertheless of what is specified herein above or not, IS – 456,516,10262 and 1199 shall be followed related to all the matters of concrete specified therein.

4.10.8 Marking:

Precast articles shall be clearly marked to indicate the top of member and its location and orientation in the structure. While the concrete is still green, each unit shall be marked with the date of casting. Precast units shall be stored, transported and placed in position in such a manner that they will not be over stressed or damaged.

4.11 Epoxy resin concrete bonding agent Scope of work.

For bonding new cementitious materials to existing cementitious surfaces. For use on horizontal surfaces and on vertical surfaces where mortar or concrete can be supported by formwork. Where extension to existing structure or similar work is ordered. The following strengths should be achieved as Per table
### Adhesive strength to concrete: In general the bond strength will always exceed the tensile strength of M30 concrete.

The Tests shall be carried out at manufacturers laboratory and results shall be submitted to the consultant / EIC for approval

#### Specification clauses

The bonding agent shall be an epoxy based two component resin system pre packed in distinct colours to give visual evidence for proper mixing. The bonding agent should remain in tacky state after application for a minimum period of 6 hours at 30°C. There shall not be bond failure of the specimen when tested by slant shear method according to BS 6319 pt 4.

#### Application

**Preparation**

All surfaces to be treated must be firm, dust free and clean. All laintence should be removed by etching with Reebaklen and wire-brushing. Where ever necessary, the existing concrete must be chipped to a sound substrate. Where surfaces are contaminated with oil or grease, this should be removed by using a strong industrial detergent or organic degreaser. Surface should be washed thoroughly with water and dried before the application.

**Mixing**

The entire contents of the hardener shall be poured into the resin container and the two materials thoroughly mixed until a uniform colour is obtained. To facilitate application at temperatures below 10 °C the separate components should be warmed in hot water to a maximum of 25 °C before mixing.

**Coating**

Mixed Epoxy resin bonding agent should be brush applied to the prepared surface. The new concrete should be placed within 6 hours at 30°C to the coated substrate, when it is in a tacky state.

#### Rate

The rate shall include the cost of all labour and materials involved in all the above operations and testing (including surface preparation) described above. No Extra Payment shall be made for Testing.

4.12 **High strength, non-shrink, cementitious grout**

**Description of work:** It is used for grouting of base plates of Columns, stanchions, and similar applications etc.,

**Description of material:** This material is supplied as a ready to use dry powder. The addition of a controlled amount of clean water produces a free flowing, non-shrink grout for gap thicknesses up to 100mm.

This material is a blend of Portland cement, graded fillers and chemical additives which impart controlled expansion in the plastic state whilst minimizing water demand. The low water demand ensures high early strength. The graded fillers are designed to assist uniform mixing and produce a consistent grout.
The Tests shall be carried out at approved Govt. laboratory and results shall be submitted to the consultant / EIC for approval.

**Specification Clauses**

**Performance specification**

All grouting shown on the drawing must be carried out with a pre packed cement based product which is chloride free. It shall be mixed with clean water to the required consistency. The grout must not bleed or segregate. A positive volumetric expansion shall occur while the grout is plastic by means of gaseous system. The compressive strength of the grout must exceed 50 N/mm\(^2\) at 7 days and 60 N/mm\(^2\) at 28 days as per Code (BS 1881 - Part 116: 1983). The flexural strength of grout must exceed 9N/mm\(^2\) @ 28 days as per Code (BS 4551, 1998). The fresh wet density of the mixed grout must exceed 2150 kg/m\(^3\).

The storage, handling and placement of the grout must be in strict accordance with the manufacturer's instructions.

**Application instructions**

**Preparation Foundation**

**surface**

The substrate surface must be free from oil, grease or any loosely adherent material. If the concrete surface is defective or has laitence, it must be cut back to a sound base. Bolt holes and fixing pockets must be blown clean of any dirt or debris.

**Pre-soaking**

Several hours prior to placing, the concrete substrates should be saturated with fresh water. Immediately before grouting takes place any free water should be removed with particular care being taken to blow out all bolt holes and pockets.

**Base plate**

It is essential that this is clean and free from oil, grease or scale. Air pressure relief holes should be provided to allow venting of any isolated high spots. Leveling shims If these are to be removed after the grout has hardened, they should be treated with a thin layer of grease.

**Formwork**

The formwork should be constructed to be leak proof. This can be achieved by using foam rubber strip or mastic sealant beneath the constructed formwork and between joints. In some cases it is practical to use sacrificial semi-dry sand and cement formwork. The formwork should include outlets for pre-soaking.

**Unrestrained surface area.**

This must be kept to a minimum. Generally the gap width between the perimeter formwork and the plate edge should not exceed 150mm on the pouring side and 50mm on the opposite side. It is advisable, where practical, to have no gap at the flank sides.

**Mixing and placing**

**Mixing**

For best results a mechanically powered grout mixer should be used. When quantities up to 50kg are used, a heavy duty slow speed drill (400-500 rpm) fitted with a paddle is suitable. Larger quantities will require a heavy duty mixer.

To enable the grouting operation to be carried out continuously, it is essential that sufficient mixing capacity and labour are available. The use of a grout holding tank with provision to gently agitate the grout may be required.
Consistency of grout mix

The quantity of clean water required to be added to a 25kg bag to achieve the desired consistency as given in table below:

<table>
<thead>
<tr>
<th>Consistency</th>
<th>Quantity (litres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pourable</td>
<td>4.125</td>
</tr>
<tr>
<td>Flowable</td>
<td>4.500</td>
</tr>
</tbody>
</table>

Placing

At 30°C place the grout within 20 minutes of mixing to gain full benefit of the expansion process. Grouting material can be placed in thicknesses up to 100mm in a single pour when used as an under plate grout.

For thicker sections it is necessary to fill out grouting material with well graded silt free aggregate to minimize heat buildup. Typically a 10mm aggregate is suitable. 50 - 100% aggregate weight of grouting material can be added.

Rate

The rate shall include the cost of all labour and materials involved in all the above operations and testing as described above. No Extra Payment shall be made for Testing.

BATCH MIXING PLANT

Central Mixed Concrete Batching Plant specified capacity in General Conditions of Contract (Volume I) shall be set up by the contractor

4.13 READY MIX CONCRETE

(If Specifically Permitted by Engineer in Charge on Emergency)

SPECIFICATIONS for RMC:

Contractor shall make ready mixed concrete with who is expert in the field, would supply designed mix. The RMC producer accepts the responsibility for the design of the mixture for the desired performance. The contractor shall specifies aggregate size, slump, air content, cement content, or weight of cement per cubic meter of concrete, maximum water content and admixtures required. The contractor shall accept the responsibility for concrete strength and its performance.

PROPORTIONING OF RMC:

The proportioning of an RMC aims at obtaining the properties, such as workability, strength, durability and appearance. The following basics of a good concrete mix should be considered while proportioning RMC. Concrete aggregates should be clean, strong and durable. Fly ash or other supplementary cementitious materials added as directed if necessary by EIC to RMC to enhance concrete properties. Admixtures are commonly used to improve the rate of setting and strength of development of concrete as directed by EIC.

CENTRAL- MIXED CONCRETE:

Concrete batch plants include a stationary, plant mounted mixer that mixes the concrete before it is discharged into a truck mixer. While traveling to the job site the drum is turned at agitating speed (slow speed). After arriving at the job site, the concrete is completely mixed. The drum is then turned for 70 to 100 revolutions, or about 5 minutes, at mixing speed. Concrete mixed in the yard or central batching plant: The drum is turned at high speed or 12-15 rpm for 50 revolutions. This allows quick check of batch. The concrete is then agitated slowly while driving to the job site. Concrete mixed in transit: The drum is turned at medium speed or about 8 rpm for 70 revolutions while driving to the job site.

DELIVERY OF RMC:

Ready mix concrete can be delivered to the construction site in truck-mounted, rotating drum mixers. Truck mixers have a revolving drum with the axis inclined to horizontal. To load or charge the raw materials from
a transit mixed plant or central mixed plant into the truck, the drum must be turned very fast in the changing direction. After the concrete is loaded and mixed, it is normally hauled to the job site with the drum turning at the speed of less than 2 rpm. The truck mixer shall have discharge units to convey through the pump to desired location in the site.

INSPECTION AND TESTING:

Specific control tests and evaluations are required during the manufacturing process to produce predictable high quality concrete. The concrete shall undergo all the specified test for concrete as per IS codes.

4.14 Plasticizer

Scope of work
To produce high workability concrete without loss of strength and to promote high early and ultimate strengths by taking advantage of water reduction whilst maintaining workability. To produce high quality concrete of improved durability and impermeability. At higher dosages, advantages can be taken of the retardation of initial setting time of concrete especially in large pours.

Standards compliance

Plasticizer should conform to IS: 9103-1999 and carries license from Bureau of Indian Standards. It should complies with IS 2645: 1975 and BS 5075 Part 3 and ASTM C494 Type F and chloride content should be nil as per IS 456

Description of material

Plasticizer is based on a blend of specially selected organic polymers and disperses the cement particles effectively in the concrete mix and hence exposes a larger surface area to the hydration process. This effect is used either to increase the strength or to produce high workability concrete or reduce cement content of concrete or to retard the setting time of concrete

Application instructions

Application process as per manufacturer’s specifications and contractor should submit the technical literature & get approval from the EIC and the material should be used within the shelf time.

SECTION-10

STEEL, IRON AND ALUMINIUM WORK

10.1 Indian Standards The following IS with latest revision apply to this section:

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Subject</th>
</tr>
</thead>
<tbody>
<tr>
<td>210-1993</td>
<td>Specification for Grey Iron casting (Fourth revision)</td>
</tr>
<tr>
<td>277-2003</td>
<td>Specification for Galvanised Steel sheet (plain and corrugated)</td>
</tr>
<tr>
<td></td>
<td>(Sixth revision)</td>
</tr>
<tr>
<td>278-2001</td>
<td>Specification for Galvanised Steel Barbed wire for fencing (Third revision)</td>
</tr>
<tr>
<td>280-2006</td>
<td>Specification for mild steel wire for general engineering purposes.</td>
</tr>
<tr>
<td></td>
<td>(Fourth revision)</td>
</tr>
<tr>
<td>412-1975</td>
<td>Specification for expanded metal steelsheets for general purposes</td>
</tr>
<tr>
<td></td>
<td>(Second revision)</td>
</tr>
<tr>
<td>432 (part I) 1982</td>
<td>Specification for mild steel and medium tensile steel bars (Third revision)</td>
</tr>
<tr>
<td>432 (Part 2) 1982</td>
<td>Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement. Part-II, Hard drawn steel wire (Third revision)</td>
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<tr>
<td>733-1983</td>
<td>Specification for wrought aluminium and aluminium alloys bars, rods and sections (for general engineering purposes). (Third revision)</td>
</tr>
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<td>737-1986</td>
<td>Specification for wrought aluminium and aluminium alloys sheet and strip for general engineering purposes (Third revision)</td>
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<tr>
<td>800-1984</td>
<td>Code of practice for general construction in steel (Second revision).</td>
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<td>806-1968</td>
<td>Code of Practice for use of steel tubes in general building construction</td>
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<td>808-1989</td>
<td>Dimensions for hot rolled steel beam, column, channel and angle sections. (Third revision)</td>
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<td>Cold formed light gauge structural steel section. (Revised)</td>
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<td>814-2004</td>
<td>Specification for covered electrodes for manual metal arc welding of carbon and carbon manganese steel (sixth revision)</td>
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<td>816-1969</td>
<td>Code of practice for use in metal arc welding for general construction in mild steel (First revision)</td>
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<td>818-1968</td>
<td>Code of practice for safety and health requirement in electric and gas welding and cutting operations (First revision)</td>
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<td>822-1970</td>
<td>Code of procedure for inspection of welds</td>
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<tr>
<td>1038-1983</td>
<td>Specification for steel doors, windows and ventilators (Third revision)</td>
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<tr>
<td>1081-1960</td>
<td>Code of practice for fixing and glazing of metals (steel and aluminium) doors, windows and ventilators</td>
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<tr>
<td>1148-1982</td>
<td>Specification for hot rolled rivet bars (up to 40mm diameter) for structural purposes (Third revision)</td>
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<td>1173-1978</td>
<td>Hot rolled slotted steel tee bars (Second revision)</td>
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<td>1252-1991</td>
<td>Dimension of hot rolled steel bulb angles (First revision)</td>
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<td>1285-2002</td>
<td>Specification for wrought aluminium and aluminium alloys extruded round tube and hollow sections for general engineering purposes (Third revision)</td>
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<td>1361-1978</td>
<td>Specification for steel windows for industrial buildings (First revision)</td>
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<tr>
<td>1363-2002</td>
<td>Hexagon head bolts, screw and nuts of product grade ‘C’ - Part-I, Hexagon head bolts (Part 1) (Size range M5 to M64) (Fourth revision)</td>
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<tr>
<td>1363-2002</td>
<td>Hexagon head bolts, screw and nuts of product grade ‘C’ - Part-II, Hexagon (Part 2) head screws (Size range M 5 to M 64) (Fourth revision)</td>
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<td>1363-1992</td>
<td>Hexagon head bolts, screw and nuts of product grade ‘C’ - Part-III, Hexagon (Part 3) nuts (Size range M 5 to M 64) (Third revision)</td>
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<td>1367 (Parts 1 to 20)</td>
<td>Technical supply conditions for threaded fasteners</td>
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<td>Specification for hard drawn steel wire fabric for concrete reinforcement (Second revision)</td>
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<td>Dimensions for steel plates, sheets, strips and flats for general engineering purposes (Second revision)</td>
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<td>1732-1989</td>
<td>Dimensions for round and square steel bars for structural and general engineering purposes, (Second revision)</td>
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<tr>
<td>1768-1985</td>
<td>Specification for high strength deformed steel bars and wires for concrete reinforcement (Third revision)</td>
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<td>1852-1985</td>
<td>Rolling and cutting tolerances for hot rolled steel products (Fourth revision)</td>
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<td>1868-1996</td>
<td>Specification for anodic coating on aluminium and its alloys (Third revision)</td>
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<td>1948-1961</td>
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<td>1949-1961</td>
<td>Specification for aluminium windows for industrial buildings</td>
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<td>2016-1967</td>
<td>Specification for plain washers (First revision).</td>
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<td>2062-2006</td>
<td>Specification for hot rolled low, medium and high tensile structural steel (Sixth revision)</td>
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<tr>
<td>2314-1986</td>
<td>Specification for steel sheet piling sections (First revision).</td>
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<tr>
<td>2751-1979</td>
<td>Code of practice for welding of mild steel bars used for reinforced concrete construction (First revision).</td>
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<td>3016-1982</td>
<td>Code of practice for fire precautions in welding and cutting operations (First revision)</td>
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<tr>
<td>3063-1994</td>
<td>Specification for single coil rectangular section springs lock washers. (Second revision)</td>
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<td>3443-1980</td>
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<td>3502-1994</td>
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<td>Hot rolled steel channel sections for engineering purposes - dimensions (First revision)</td>
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<td>4948-2002</td>
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<td>5384-1985</td>
<td>Aluminium I Beam (First revision)</td>
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<td>5523-1983</td>
<td>Method of testing for anodic coating on aluminium and its alloys (First revision)</td>
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<tr>
<td>6248-1979</td>
<td>Specification for metal rolling shutters and rolling grills (First revision)</td>
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<td>6445-1985</td>
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<td>6639-2005</td>
<td>Specification for hexagon head bolts for general steel structures. (First revision)</td>
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<td>7205-1974</td>
<td>Safety code for erection of structural steel work.</td>
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<td>7215-1974</td>
<td>Tolerances for fabrication of steel structures.</td>
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<td>Specification for hot rolled steel sections for doors, windows and ventilators. (Second revision)</td>
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<td>9595-1996</td>
<td>Recommendation for metal arc welding of carbon and carbon manganese steel (First revision)</td>
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<td>10019-1981</td>
<td>Specification for mild steel stays and fasteners</td>
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<td>10521-1983</td>
<td>Specification for collapsible gate</td>
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<tr>
<td>12753-1989</td>
<td>Electro galvanized coatings on round steel wire - specifications.</td>
</tr>
<tr>
<td>12778-2004</td>
<td>Hot rolled parallel, flange steel sections for beams, columns and bearing piles dimensions and section properties. (First revision)</td>
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<tr>
<td>12843-1989</td>
<td>Tolerances for erection of steel structure</td>
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<tr>
<td>13871-1993</td>
<td>Specification for powder coatings</td>
</tr>
</tbody>
</table>

**CAST IRON WORK**

**10.2 Cast Iron Work**

Casting shall be from cast iron of grade FG 150 conforming to IS: 210-1978, specification for grey iron castings. The castings shall be sound, clean and free from porosity, blowholes, hard spots, cold shuts (i.e.,

SIGNATURE OF TENDERER WITH SEAL

EMPLOYER

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irregularities due to casting at too low a temperature), distortion and other harmful defects. They shall be well dressed and fettled; accurately moulded in accordance with the pattern / drawing and shall be of uniform thickness except where the design necessities variation. Abrupt changes in the section: of adjoining members shall be voided as far as possible. Unless otherwise indicated edges of castings shall be rounded and integral angles finished with an angle fillet. No welding or repairs shall be carried out, unless otherwise indicated.

10.3 Structural Steel Work

Structural steel shall conform to

(a) Structural steel (fusion welding quality) ‘fe 410-W' conforming to IS 2062-2006, Specification for structural steel (fusion welding quality). Fe 310-0 steel may be used for general purpose such as door and window frames, window bars, grills, steel gates, handrails, tie bars etc.

10.3.1 Freedom from Defects:

All finished steel shall be well and cleanly rolled to the dimensions, sections and weights specified. The finished material shall be reasonably free from cracks, surface flaws, laminations, rough, jagged and imperfect edges, and all other harmful defects. Minor surface defects may be removed by the manufacturer by grinding provided that the thickness is not locally by more than 4 percent with a maximum of 3 mm.

10.3.2 Structural steel of different sections, sizes and lengths shall be stacked separately. For each classification of steel separate areas shall be earmarked. Steel shall be marked with distinct painting marks for easy identification. All steel shall be so stored that it is always at least 15 cm above the ground level In case of long storage suitable protective measures shall be taken to prevent scaling and rusting.

10.3.3 Tolerances

Rolling and Cutting tolerances shall be as per IS 1852.

10.4 Chequered Plates

Chequered plates shall be as per requirements given in IS 3502-1994 Specification for steel chequered plates, Pattern of chequered plates shall be as directed. Plates shall be cleanly rolled and shall be reasonably free from harmful surface defects such as cracks, surface flaws, imperfect edges, etc. thickness of chequered plates specified shall be exclusive of the raised portion.

10.5 BLANK

10.6 Bolts Nuts and Washers

10.6.1 Bolts and nuts shall be conforming to the relevant requirements given in the following IS specifications and as indicated:

(a) IS1363-2002 (Parts 1 to 3) Of product grade ‘C’ (Size M5 to M64)

(b) IS 1367 (Parts 1 to 20) Technical supply conditions for threaded fasteners.

(c) IS 6639-2005 Specification for hexagon head bolts, for steel structures

10.6.2 The heads shall be forged, in one piece with the bolts and the nuts shall, be neatly made with the hole truly in the centre. The threads shall be full, true and deep. The heads and nuts shall be hexagonal unless square heads and nuts are specially indicated. Bolts and nuts Shall be cleanly finished and shall be sound and free from defects, which may affect their serviceability. Bolts and nuts shall be suitably protected against corrosion.

10.6.3 Washers :

Plain washers shall be of steel conforming to IS 2016-1974. Specification for plain washers: Spring washers shall conform to IS 3063-1994, specification for single coil, rectangular section spring washers for bolts; nuts and screws. The washer shall be free from cracks, burns, pits to other defects. The hole shall be reasonably concentric, with the outer periphery. All sharp edges shall be removed.
10.7 Electrodes

Electrodes for metal arc welding of mild steel shall be as per IS 814-2004, Specification for covered electrodes for metal arc welding of structural steel joints in materials above 20 mm thick and all-important connections shall be made with low hydrogen electrodes. The mechanical properties of the weld deposit shall be such as to satisfy all the requirements such as tensile strength, elongation and impact strength of the parent metal.

10.8 Workmanship Generally

Structural steel work riveted, bolted or welded shall be carried out described in IS 800-1984, code of practice for use of structural steel in general building construction.

Note: The Contractor shall prepare the shop Drawings indicating all details regarding cutlength, weld, bolts, joints, splicing, position etc., for the approval of the consultant before providing for any fabrication. All connections, bolts, welds etc., shall be neatly described in the drawing. Approval of shop Drawings by the consultant shall not relieve the Contractor from the responsibility for correctness of the dimensions and adequacy.

10.8.1 Straightening and bending:

All material shall be straight and if necessary, before being worked shall be straightened and flattened by pressure, unless required to be of curvilinear form and shall be free from twists. Straightening of steel by hammer blows is not permitted. All bending and cutting shall be carried out in cold condition, unless otherwise directed, in such manner as not to impair the strength of the metal.

10.9 Cutting and Machining

Member shall be cut mechanically by saw or shear or by oxyacetylene flame. All sharp rough or broken edges and all edges of joints which are subjected to tensile or oscillating stresses shall be grounded. No electric metal arc cutting shall be allowed. All edges cut by oxyacetylene pores shall be cleaned of impurities and slag prior to assembly. Cutting tolerance shall be as follows:

(a) For member connected at ends +/- 1 mm.

(b) Elsewhere +/- 3 mm.

10.9.1 When compression members depend upon contact surfaces for stress transmission, then ends of columns, caps and bases together with gussets, angles and channels (after riveting/welding together) shall be accurately machined so that the parts connected butt over the entire surfaces of contact. Columns at bases or at caps or at butt joints need not be machined.

10.10 Holes

All holes shall be accurately marked and drilled. Holes through more than one thickness shall preferably be drilled together after the members are assembled and tightly clamped or bolted together. In such cases, if required, these parts shall be separated after drilling and burrs removed. For thickness of materials less than 16 mm the holes may be punched 3 mm less in diameter than the required size and be reamed to the full diameter after assembly. Finished holes for rivets and black bolts shall be not more than 1.5 mm (2.0 mm for rivets and bolts or diameter more than 25 mm) in diameter larger than the diameter of rivets and bolts passing through them. All matching holes for rivets shall be so prepared that a gauge 0.8 mm diameter less than the hole can pass steeley through the members assembled for riveting. Holes other than those required for close tolerance may be punched full size through material not over 12 mm thick.

10.10.1 All holes shall have their axis perpendicular to the surface bored through. Holes through two or more members shall be truly concentric. No rivet or bolt hole shall be nearer the edge of the member than distance equal to its own diameter. Holes shall not be formed by gas cutting process.

10.11 Assembly

Before assembly the contact surfaces shall be painted with a heavy coat of pure zinc chromate red oxide primer including surface preparation.

10.11.1 Laying Out:
Steel structure shall be laid out on a level platform to full scale and to full size or in parts as shown on working drawings or as directed by EIC. Wooden templates 12 mm to 19 mm thick or metal sheet templates shall be made to correspond to each member and part, rivet holes shall be marked accurately on them and drilled. The templates shall be laid on the steel members and holes for riveting and bolting marked on them. The ends of the steel members shall also be marked for cutting. The base of steel columns and the positions of anchor bolts shall be carefully set out.

10.11.2 The component parts shall be assembled in such a manner that they are neither twisted nor otherwise damaged and shall be so prepared that the specified cambers, if any, are provided. All box sections shall be carefully set out.

10.11.3 Assembly shall be done by using assembly fixtures, jigs and stands, which facilitate high quality assembly with proper safety. Mis-alignment and distortion of parts after assembly shall not be allowed; only thoroughly straightened parts free from burrs, grease, rust, etc, shall be allowed for assembly.

10.11.4 Temporary connection of parts during assembly shall be done in the following way:

(a) For welded structures joining shall be done by means of tack weld, fastening devices and fixtures.

(b) For riveted and bolted structures joining shall be done by adequate number of bolts. If tack welding is permitted, in such cases the same shall be removed after the work is over.

(c) For riveted structures in which holes are to be drilled after assembly, joining shall be done by appropriate fixtures.

10.11.5 Tack welding shall be done on the sides and along the line of the weld. Tack weld dimension shall be minimum. Tack welding shall be carried out with similar electrodes as the final welding and the tacks shall completely fuse with the final weld metal.

10.11.6 In case splicing is necessary, the individual members shall be spliced first before assembly and before final welding with other members.

10.11.7 For riveted structures, members shall be well tightened by assembly bolts in every third hole maximum distance between bolts shall not exceed 500 mm. To prevent stiffening, drift pins shall be used 30 percent of the assembly bolts. After tightening, the gap between members to be jointed shall be checked by 0.2 mm thick feeler gauge which should not go inside by more than 2 mm, looseness of bolts shall be checked by tapping with a test hammer.

10.13 Bolting

Bolt head and nuts shall be of such length as to project one clear thread beyond the nuts when fixed in position, and these shall fit in the holes without any shake. The nuts shall fit in the threaded ends of bolts properly.

10.13.1 Round washers shall be placed under the heads and nuts of permanent bolts. Maximum two washers for one nut and one for each bolt head shall be used. Bolt threads shall be outside the limits of joining members and unthreaded portion of bolt shall not be outside the washer.

10.13.2 Where there is risk of the nuts being removed or becoming loose due to vibration or reversal of stresses, these shall be secured from slackening by the use of lock nuts or spring washers, as directed by the EIC.

10.13.3 Bolts, nuts and washers shall be thoroughly cleaned and dipped in double linseed oil before use.

10.13.4 Quality of tightening of bolts shall be inspected by taping them with a hammer. The bolt shall not be shaken or shifted.

10.13.5 The bolts shall be tightened starting from center of the joint towards the edge.

10.14 Welding
10.14.1 Welding shall be done by metal arc process unless otherwise permitted by the EIC, in writing, in accordance with IS 816-1969 Code of practice for use of metal arc welding of general construction. in mild steel, and IS 9595-1996 Recommendation of Metal .arc welding, regarding workmanship welding method, welding procedure with suitable electrodes and wire flux, combinations, quality of welds, correction of weld faults etc.

10.14.2 Preparation of members for welding:

10.14.2.1 Assembly of structural members shall be made with proper jigs and fixtures to ensure correct positioning of members (angles, axis, nodes etc)

10.14.2.2 Sharp edges, rust of cut edges, notches, irregularities and fissures to ensure due to faulty cutting shall be chipped or ground or filed over the length of the affected area deep enough to remove faults completely.

10.14.2.3 Edge preparation for welding shall be carefully and accurately made so as to facilitate a good joint.

10.14.2.4 Generally, no special edge preparation shall be required for members under 8 mm thick.

10.14.2.5 Edge preparation (beveling) denotes cutting of the same so as to result in V, X, K or U seam shapes as per IS 9595.

10.14.2.6 The members to be assembled shall be clean and dry on the welding edges. Under no circumstances shall wet, greasy, rust of dirt-covered parts be assembled. Joints shall be kept free from any foreign matter, likely to get into the gaps between members to be welded.

10.14.2.7 Before assembly, the edges to be welded as well as adjacent areas extending for at least 20 mm shall be cleaned (until metallic polish is achieved)

10.14.2.8 When assembling members proper care shall be taken of welding shrinkage and distortions, as the drawing dimensions cover finished dimensions of the structures.

10.14.2.9 The elements shall be got checked and approved by the EIC before assembly.

10.14.2.10.1 The permissible tolerances for assembly of members preparatory to welding shall be as per IS 9595.

After the assembly has been checked, temporary tack welding in position shall be done by electric welding, keeping in view finished dimensions of the structure.

Preheating of members to be joined to be carried out as per standards wherever necessary.

Butt Welds:

The form of joint, angle between fusion faces, gap between parts and the welding procedure shall be such that welded joint shall comply with the design requirements. The ends of butt joints in plate shall be welded so as to provide full throat thickness. In the gas-welded condition, the weld face shall be proud of the surface of the parent metal. Where a flush surface is required, the excess metal shall be dressed off. Where no dressing is to be carried out, the permissible weld profile shall be as specified in the relevant IS.

For butt weld, where these are to be welded for both sided, certain welding procedures allow this to be done without back going, but where complete penetration cannot be achieved, the back of the first run shall be gouged out to clean sound metal before welding is started on the gouged outside.

Fillet Welds:

A fillet weld as deposited shall be not less than the specified dimensions indicated as throat thickness and/or leg thickness taking into account penetration process or partial penetration. For concave fillet welds the actual throat thickness shall be not less than 0.7 times the specified leg length. For convex fillet welds,
the actual throat thickness shall be not less than 0.9 times the specified leg length.

**Preparation of joint Faces:**

If preparation or cutting of material is necessary, this shall be done by shearing, chipping, grinding, machining, thermal cutting. When shearing is used the effect of work hardening shall be taken care of to ensure that there is no cracking of the edges. Removal of 1 mm to 2 mm from a cut face normally eliminates the layer of hardness.

**Fusion Faces:**

Fusion faces and adjustment surfaces shall be free from cracks, notches or other irregularities which might be the cause of defects or would interfere with the deposition of the weld. They shall also be free from heavy scale, moisture, oil, paint and any other substances which might affect the quality of weld or impede the progress of welding.

**Assembly for Welding:**

Jigs and manipulators should be used, where practicable, so that the welding can be carried out in the most suitable position. Jigs shall maintain the alignment with the minimum restraint so as to reduce the possibility of lock-in stresses.

**Alignment of Butt Joint:**

The root edges or root faces of butt joints shall not be out of alignment by more than 25 percent of the thickness of the thinner material for material up to 12 mm thick or by more than 3 mm for thicker material. For certain applications closer tolerances may be necessary for proper alignment.

**Fit up of parts jointed by fillet welds:**

The edges and surfaces to be jointed by fillet welds shall be in close contact as possible since any gap increases the risk of cracking but in no case should be gap exceed 3 mm.

10.14.10 **Tack Welds:**

Tack welds shall be not less than the throat thickness or leg lengths of the root run to be used in the joint. The length of the tack weld shall not be less than four times the thickness of the thicker part or 50 mm whichever is smaller. If smaller tack welds are desired, these shall be so indicated.

Where a tack weld is incorporated in a welded joint, the shape of the tack shall be suitable for incorporation in the finished weld and it shall be free from cracks and other deposition faults.

10.14.11 **Protection from Weather.**

Surface to be welded shall be dry. When rain or snow is falling or during periods of high wind, necessary precautions shall be taken for outdoor welding. Warming shall be carried out at all ambient temperatures below 10°C.

10.14.12 **Inter-Run Cleaning:**

Each run of weld bead and each layer of weld shall be thoroughly cleaned of slag, spatters, etc., before depositing subsequent bead or weld with particular reference to thorough cleaning of toes of the welds. Visible defects such as cracks, cavities and other deposition faults, if any, shall be removed to sound metal before depositing subsequent run or layer of weld.

10.14.13 **Welding Procedure:**

10.14.13.1 Welding shall be carried out only by fully trained and experienced welders as tested and approved by the EIC.

10.14.13.2 Qualification tests for welders as well as tests for approval of electrodes will be carried out as per IS 823. The nature of test for performance qualification for welders shall be commensurate with the
quality of welding required on this work as judged by the EIC.

10.14.13.3 The steel structures shall be automatically, semi-automatically or manually welded.

10.14.13.4 Welding shall be done only after the checks shown under clause 10.15 have been carried out.

10.14.13.5 Welding procedures and tests for welders shall be conducted as per IS 9595 and approved by the EIC.

10.14.13.6.1 The welder shall mark with his identification mark on each element welded by him.

10.14.13.7 When welding is carried out in open air steps shall be taken to protect the places of welding against wind or rain. The electrodes wire and parts being weld on shall be dry.

10.14.13.8 Before beginning the welding operation each joint shall be checked to assure that the parts to be welded are clean and root gaps provided as per IS 9595.

10.14.13.9 For continuing the welding of seams discontinued due to some reasons the end of the discontinued seam shall be melted in order to obtain a good continuity. Before resuming the welding operation the groove as well as the adjacent parts shall be well cleaned for a length of approximately 50 mm.

10.14.13.10 For single butt welds (in V, 1/2V or U) and double butt welds (in K, double U, etc) the rewelding of the root butt is mandatory but only after the metal deposition on the root has been cleaned by back gouging or chipping.

10.14.13.11 The welding seams shall be left to cool slowly. The contractor shall not be allowed to cool the welds quickly by any method.

10.14.13.12 For multi layer welding before welding the following layer, the formerly -welded layer shall be cleaned metal bright by light chipping and wire brushing. Backing strips shall not be allowed.

10.14.13.13 The order and method of welding shall be so that:

(a) No unacceptable deformation appeared in the welded parts

(b) Two. margin is provided to compensate for contraction due to welding in order to avoid any a high permanent stresses.

10.14.13.14 The defects in welds shall be rectified to IS: 9595 and as per instruction of EIC.

All weld shall be inspected by Dye Penetration before painting, any weld found to be defective shall be cut by using either chipping hammer or any other means in such a manner that the adjacent material is not damaged.

10.14.14 Approval and Testing of welders:

The contractors shall satisfy the EIC that the welder is suitable for the work up on which they will be employed.

10.14.15 Weld instruction:

The weld seams shall satisfy the following:

a. shall correspond to design, shapes and dimensions

b. Shall not have any defects such as cracks, incomplete penetration and fusion under cuts, rough surfaces, burns, blow holes, and porosity etc beyond permissible

10.14.15.1 During the welding operation and approval-of finished elements inspection ant test shall be made as shown in table 1 below

<table>
<thead>
<tr>
<th>SL No</th>
<th>Inspection of test</th>
<th>Coverage</th>
<th>Procedure</th>
<th>Evaluation and remedy of defects</th>
</tr>
</thead>
</table>

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10.14.15.2 The mechanical characteristics of the welded joints shall be as in IS: 9595

10.14.16 Quality of welds and corrections:

Welded joints shall be free from defects that would impair the service performance of the construction. All welds shall be free from incomplete penetration, incomplete fusion; slag inclusion, burns, unwelded craters, undercuts and cracks in the weld metal or in the heat affected zone, porosity, etc. Unacceptable undercutting shall be good by grinding. In case of shrinkage cracks, cracks in parent plate and crater, defective portions shall be removed down to sound metal and re-welded. Whenever corrections necessitate the deposition of additional weld metal, electrode of a size not exceeding 4mm may be used. Rectification of welds by caulking shall not be permitted.

10.15.17 Cleaning
All welds shall be cleaned of slag and other deposits after completion; till the work is inspected and approved, painting shall not be done.

10.15.18 Plaining of Ends:

10.15.18.1 Plaining of ends of member like column ends shall be done by grinding where so specified.

10.15.18.2 Plaining of butt welded member shall be done after these have been assembled and the edges be removed with grinding machine or file.

Shop Painting: Entire steel work with exception of bolts, nuta and machined surfaces after being thoroughly cleaned and shall be given shop coat of zinc chromate primer. Welds and adjacent parent material shall not be painted prior to the deslagging, inspection and approval.

10.15.18.3 The following tolerances shall be permitted on members that have been plained:
(a) The length of member having both end plained max + 2mm with respect to design.
(b) Level difference between plained surface = 0.3mm.
(c) Deviation between plained surface and member axis= max 1/5000.

10.15.19 Safety and Health
The Contractor shall ensure that the safety requirements and health provisions laid down in IS : 818-1968, Code of Practice for safety and health requirements in electric and gas welding and cutting operations, are complied with during welding operations. The Contractor shall also provide equipment for eye and face protection during welding as laid down in IS: 1179-1967. Fire precautions shall be taken in accordance with IS 3016-1982, Code of practice for fire precautions in welding and cutting operations.

10.15 Erection:

10.15.1 Erection work shall be performed in accordance with the general construction schedule. A scheme shall be worked before the commencement of the erection which shall also contain rules for safety precautions as detailed in IS: 7205-1974. Safety code for erection of structural steel works.
10.15.2 Anchor bolts for fastening of steel structures shall be set in designed positions and grouted along with foundations. Alternatively anchor bolts should be provided in the concrete foundation with bolt boxes and anchor channels for the purpose of flexibility and grouted after final alignment and levelling Column.

10.15.3 The gaps between the bearing surface of foundation and bottom of the structure to be erected shall be filled properly by cement grouting. Grouting shall be done after the verification and proper positioning of the structures but before encasing the structures with concrete if specified.

10.15.4 Damaged structural members shall be examined and rectified or replaced as directed.

10.15.5 The erected parts of the structures shall be stable during all the stages of erection; and structural elements to be erected shall be stable and strong to bear erection loads.

10.15.6 Working on the already erected structures is permitted only after they are finally fixed. Erection of structures of each tier for high structures shall be executed only after fastening of lower tier by the permanent or temporary fastening devices as per schedule of execution of work and certified for safety.

10.15.7 The joint and mating surface including the mating planes, strips and filler or spacers shall be cleaned of dust, rust and water.

10.15.8 Erected structural members shall be firmly fastened by bolts and drifts, permanent or provisional tacking, crossing bars and so on before the erection crane hook is removed.

10.15.9 The trusses shall be lifted only at nodes. The trusses above 12 m span shall not be singed at the apex, as it will develop compression stresses in the bottom tie member. It shall be lifted by slinging at two mid points of rafters, which shall be temporarily braced by a wooden member of suitable section. After the trusses are placed in position purlins and wind bracings shall be fixed as soon as possible. The end of truss which faces the prevailing winds shall be fixed with holding down bolts and the other end kept free to move. In case of small truss of span say up to 12 mm the free end of the truss shall be laid on steel plate as per design and the holes for holding down bolts shall be made in the form of oblong slot as to permit the free movement of the truss end. For large spans, the free end of the truss shall be provided with suitable rocker and roller bearing where indicated.

10.15.10 Erection Joints:

While erecting, holes to be riveted shall be fitted with temporary bolts and drifts of diameter equal to those of the holes. It is necessary to install drifts for accurate matching of holes. Number of bolts and drifts shall not be less than 40 percent of total number of holes. Forces applied to drifts shall be same as approved for rivets. Number of drifts shall be 10 percent of number of holes.

10.15.11 The number, size and length of tack welds in erection forces shall be as indicated. For the erection joints which do not bear the erection forces the length of tack welds shall be minimum 10 percent of tube designed weld length of the joint.

10.15.12.1 Welding, riveting and final fastening of permanent bolts shall be done only after the inspection of the structural elements for their positions. Head bolts and nuts shall perfectly be in touch with the surfaces of structures and washers.

10.15.13 Tolerance Allowed in Erection;

10.15.13.1 Building without crane;

The maximum tolerance for-line and level of steel structure shall be ±3 mm on any part of the structure. The structure shall not be out of plumb more than 5 mm on each 10 meter section in height and not more than 8 mm per 30 metre section. These tolerances shall apply to all parts of structure unless otherwise specified.

10.15.13.2 Tolerance allowed in erection of steel structure containing cranes shall be as per following table:
### Component: Main Columns and Roof Posts

<table>
<thead>
<tr>
<th>Component</th>
<th>Table</th>
<th>Tolerance Allowed</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Shifting of column's axis at foundation level with respect to building line: (i) In longitudinal direction (ii) In lateral direction</td>
<td>+/-5 mm</td>
<td>+/-5 mm</td>
</tr>
<tr>
<td>(b) Deviation of both major column axis from vertical between Foundation and other member connection levels: (i) For a column upto and including 10m height, (ii) For a column greater than 10m but less than 40m height</td>
<td>+/-5.00 mm from true vertical</td>
<td>+/-5 mm from true vertical for any 10M length measured between connection levels but not more than +/-8.00mm for 30 M length</td>
</tr>
<tr>
<td>(c) For adjacent pairs of columns across the width of the building prior to placing of truss.</td>
<td>+/-5.00 mm on true span</td>
<td></td>
</tr>
<tr>
<td>(d) For any individual column deviation of any bearing or resting level from levels shown on drawings.</td>
<td>+/-5.00 mm</td>
<td></td>
</tr>
<tr>
<td>(e) For adjacent pairs of columns either across the width of buildings or longitudinally level difference allowed between bearing or seating level supposed to be at the same level.</td>
<td>+/-5.00 mm</td>
<td></td>
</tr>
</tbody>
</table>

### Component: Truss

<table>
<thead>
<tr>
<th>Component</th>
<th>Table</th>
<th>Tolerance Allowed</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Deviation at centre of span of upper chord member from vertical plane running though centre of bottom chord. (b) Lateral displacement of top chord at centre of span from vertical plane running through centre of supports.</td>
<td>1/500 of the span or 10mm whichever is less</td>
<td>1/250 of depthon truss or 20mm whichever is less</td>
</tr>
</tbody>
</table>

### STEEL REINFORCEMENT

#### 10.16 Steel Reinforcement for concrete

Steel Reinforcement shall be of mild steel plain bars, high strength deformed bars manufactured by thermo mechanical treatment process (TMT), steel wire fabrics and of grade / types as indicated.

10.16.1 Mild steel plain bars shall be grade I or grade II as indicated and conforming to IS 432 (part I) - 1982, Specification for mild steel and medium tensile steel bars. Alternatively mild steel bars shall be of grade E 250 conforming to IS 2062.

10.16.2 High strength Deformed Bars shall be produced by thermo mechanical treatment process (TMT) and shall be of grade Fe 415, Fe 500 or Fe 550 as indicated meeting all requirements confirming to IS 1786 - 1985 Specification for high strength deformed bars and wires for concrete reinforcement.


#### 10.16.4 Tolerance on size of Reinforcement Bars:

The tolerance on diameter of the mild steel bars will be +/- 0.5mm for bars upto and including 25mm dia with a total margin of 1 mm, and +/- 0.75mm for bars above 25mm dia with total margin of 1.5mm. The tolerance on the diameter in the case of coiled round bars shall be +/- 0.5mm upto and including 12mm diameter with a total margin of 1 mm Measurement shall be taken at point sufficiently away from the ends ensuring exclusion of heavy ends.

#### 10.16.5 Tolerance on Weight:

The tolerance on weight of plain and deformed round shall be ±4 percent with a total margin of 8 percent
for bars up to and including 8 mm diameter and +/-2.5 percent for bars over 8 mm diameter with a total margin of 5 percent.

Tolerances on weight of fabric reinforcement shall be +/- 6 percent

10.16.6 Freedom from defects:

All finished bars shall be well and cleanly rolled to the dimensions and weights specified: these shall be sound and free from cracks, surface flaws, laminations and rough, jagged and imperfect edges and other defects and shall be finished in a workmanlike manner.

10.16.7 Steel reinforcement shall be stored as to prevent distortion and corrosion. Any reinforcement that has "deteriorated or corroded or is considered defective by the EIC shall not be used in the work. Bars of different classification, sizes, and lengths shall be stored separately to facilitate use in such sizes and lengths so as to minimize wastage in cutting from the standard lengths

10.17 Bends and Hooks forming end Anchorages

10.17.1 In the case of binders, stirrups, links, etc the straight portion beyond a curve at the end shall be not less than 8 times the nominal size of the bar.

10.17.2 Bars specified to be formed to radii exceeding those given in the table X of IS2502 Code of practice for bending and fixing of bars for concreting need not be bent but the required curvature may be obtained during the placing.

10.17.3 Bending of bars:

Bars shall be bent to shape cold except that bars larger than 25 mm in size may be bent hot at cherry red heat (not exceeding 850°C) Hot bar shall not be cooled by quenching. A bar which shows any sign of cracks at a bend shall be rejected.

10.18 Splicing:

Where bars required are longer than those carried in stock, splices shall be provided as far as possible, away from the section of maximum stress and be staggered. Lap splices shall be considered as staggered if the centre to centre distance of the splices is not less than 1.3 times the lap length. The use of short length bars shall not be permitted. IS 456-1978, Code of practice for plain and reinforced concrete, recommends that splices in flexural members should not be at section where the bending moment is more than 50 percent of the moment of resistance; and not more than half the bars shall be fed at a section.

10.18.1 Lap Splices:

Lap splices shall not be used for bars larger than 36 mm dia, larger diameter bars may be welded, in cases where welding is not practicable, lapping of bars larger than 36 mm dia may be permitted in which case additional spirals shall be provided around the lapped bars.

10.18.2 Lap length including anchorage value of hooks for bars in flexural tension shall be not less than development length (calculated as per IS 456) or 30 diameter whichever is greater and for direct tension shall be not less than two times development length (calculated as per clause 26.2.1 of IS 456) or 30 diameter whichever is greater. Lap length in compression shall be not less than development length in compression (calculated as per IS 456) or 24 diameter whichever is greater. When bars of two different diameters are to be spliced the lap length shall be calculated on the basis of diameter of the smaller bar. Other provisions of IS 456 shall also be followed.

10.18.3 End bearing splices shall be, used only for the bars in compression. The ends of the bars shall be square cut and concentric bearing ensured by suitable devices.

10.18.4 When larger diameter bars have to be welded to avoid congestion rather than lapped for splicing, the method of welding shall be as directed. The location of staggered weld at heights or position shall be convenient for welding.

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10.18.5 Spiral Reinforcement:

Spirals shall be provided with one and a half extra turns at both top and bottom. Where necessary to splice the spiral it shall be done by a lap of one and a half turns or by shop welding.

10.18.6 Placing and fixing of bars

Reinforcement shall be placed in position as per detailed design drawing and shall be secured at that position. In case of delay occurring between fixing of reinforcement and concreting, the position of the reinforcement shall be checked prior to concreting. Bars crossing each other shall be secured by binding wire (annealed) of size not less than 0.9 mm and conforming to IS 280-1978. Specification for mild steel wire, in such a manner that they will not slip over each other at the time of fixing and concreting. Every compression bar shall be tied at least in two perpendicular directions.

10.19.1 Cover Blocks:

Cover blocks generally of PVC or cement mortar shall be used to ensure the required cover for the reinforcement. The mortar or concrete used for the cover blocks or rings shall not be leaner than the mortar or concrete in which they would be embedded.

10.19.2 Spacers:

Where multiple rows of reinforcement are provided distances between successive rows shall be properly maintained while concreting by providing suitable spacer bars.

10.19.3 Placing Reinforcement:

All mill scale, loose or scaly rust, oil and grease or any coating that will destroy the bond shall be thoroughly cleaned off the steel reinforcement with a stiff wire brush or approved means before it is placed in forms. Steel reinforcement when placed in the forms shall be properly braced, supported, or otherwise held firmly in position so that placing and ramming/vibrating of concrete does not displace it.

10.19.4 It shall be ensured that all reinforcement can be properly placed. Congestion of steel shall be avoided at points where members intersect.

10.19.5 Tolerance in Placing of reinforcement:

Unless otherwise indicated, reinforcement shall be placed within following tolerance.

a) For effective depth 200 mm or less = +/-10mm

b) For effective depth more than 200 mm = +/-15mm

The cover shall in no case be reduced by more than 1/3 of specified cover or 5 mm whichever is less.

10.20 Steel Wire Fabric Reinforcement

Hard drawn steel fabric shall conform to IS 1566-1982 specification for hard drawn steel wire fabric for concrete reinforcement, MESH size, weight, size of wire for square and oblong welded wire fabric shall be indicated. The fabric shall be formed by spacing the main and the cross wire, which shall be fixed at the point of inter-section by electric welding.

"Since fabric is supplied in long rolls it is rarely necessary to have a joint of the main wires. In structural slab laps in regions, of maximum stress shall be avoided. When splicing of welded wire fabric is to be carried out, lap splices of wires shall be made so that overlap measured between the extreme cross wires shall be not less than the spacing of Cross wires plus 10 cm. For edge laps a lap of 5 cm shall be provided.

10.21 Welding of Reinforcement

Welding of bars where indicated or agreed to by the EIC, in writing, in lieu of lapping shall be done in accordance with IS 2751-1979 code of practice for welding of concrete construction. Welding in general shall be done as described for structural steel work.
10.21.1 Bars up to and including 20 mm dia shall be lap welded and those larger than 20 mm dia shall be butt- welded. In case of lap welds, the length of lap shall be five times the dia or 100 mm whichever is greater. The throat thickness shall not be less than 3 mm for bars up to 16 mm dia and 5 mm for bars over 16 mm dia and up to 20 mm dia.

**Butt Welding**

Where it is not possible to rotate bars for welding in flat position the axis of the bars shall be horizontal and the respective axis of the welds shall be vertical. The edge preparation for inclined bars shall be such that welding is done only on sides. All the bars to the butt-welded shall be aligned and set up in position with their axis in one straight line. This may be done in a jig or by means of a clamp or by using guides. Rotation of the bars shall be avoided, until they are adequately welded.

**Lap Welding**

Edge preparation is not necessary for lap welds.

**Finish:**

The profile of the welds shall be uniform, slightly convex and free from overlap at the toes of the welds. The weld face shall be uniform in appearance throughout its length. The welded joint shall be free from undercut. The joints in the weld run shall be as smooth as practicable and shall show no pronounced hump or crater in the weld surface. The surface of the weld shall be free from porosity, cavities and trapped slag.

**Steel Rolling Shutters**

Steel rolling shutters shall be of approved make and shall conform to the requirements of IS 6248-1979 specification for metal rolling shutters and rolling grills. The size of the rolling shutters (denoted by clear width and clear height) shall be as indicated. The position of fixing of the rolling shutter shall be as indicated viz inside or outside or within jambs; with projecting or embedded guide channels and above or below the soffits.

Rolling shutters shall be gear operated type with bevel gear box and crank handle.

**Curtain**

The curtain shall be built up of inter-locking lath sections formed from cold rolled steel strips 1.20 mm thick for all shutters unless otherwise specified. The lath section shall be rolled so as to have interlocking curls at both edges and a deep corrugation at the center with a bridge depth of not less than 12 mm. Each lath section shall be continuous single piece without any welded joint. When interlocked, the lath sections shall have a distance of 75 mm between rolling centers, unless otherwise specified. Each alternate lath section shall be fitted with malleable cast iron or mild steel clips securely riveted at either ends.

**Lock Plate:**

A fabricated lock plate of riveted construction made of mild steel sheet of not less than 3.15 mm thickness, reinforced with mild steel angle section of not less than 35x35x5 mm size at the bottom, shall be interlocked with bottom most lath Section of curtain so as to provide contact against the sill, when closed. The lock plate shall be fitted with sliding bolts, with arrangements for locking with pad locks and also pulling handles of mild steel, one handle for width upto 2.5 m and two handles for widths of above 2.5 m pulling handle shall be fixed on both the interior and exterior side of the lock plate.

**10.22.4 Guide Channels:**

The guide channels shall be of mild steel deep channel section and of rolled, pressed or built up construction. Thickness of sheet shall not be less than 3.15 mm. The curtain shall project into the guide channel at least 40 mm upto 3.5 mm width and 60 mm for greater widths. There shall be a clearance of 10 mm minimum between the guide wall and end clips of the curtain. Minimum depth of the guide channels shall be as under:
### Clear width of shutter vs Depth of guide Channels

<table>
<thead>
<tr>
<th>Clear width of shutter</th>
<th>Depth of guide Channels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upto 3.5 m</td>
<td>65 mm</td>
</tr>
<tr>
<td>3.5 m and upto 8 m</td>
<td>75 mm</td>
</tr>
<tr>
<td>8 m and above</td>
<td>100 mm</td>
</tr>
</tbody>
</table>

Width of guide channel shall be 25 mm for the lath section with bridge depth upto 12 mm or near about.

Each guide channel shall be provided unless otherwise specified, with a minimum of three fixing cleats or supports for attachment to the walls or column by means of bolts or screws. The spacing of cleats shall not exceed 0.75m. Alternatively, the guide channel may also be provided with suitable dowels, hooks or pin for embedding in the walls.

The guide channels shall be attached to the jambs, plumb and true, either in the overlapping fashion projecting fashion or embedded in grooves, depending on the method of fixing. The guide channels shall have a box welded on at the bottom to conceal the end of the sliding bolt, when fixed on side.

#### 10.22.5 Bracket Plate:

It shall be fabricated out of mild steel sheet of 3.15 mm minimum thickness in case of manually operated shutters, and 6 mm minimum thickness in case of mechanically operated shutters. The bracket plate may be of hexagonal square or circular contour. In case of manually operated shutter, extra tying in the bracket plate to the guide channel shall be provided by means of a square bar not less than 20 mm size. An angle iron 40x 40x 6 mm split at one end shall be firmly riveted or welded at the top line of the bracket. The angle shall extend at least 20 cm from the edge of the bracket plate. This angle shall be grouted firmly into the wall with the split end of the angle well buried in concrete. A stopper made out 40x6 mm M.S flat is bolted on to the square bar so that the lock plate be arrested, nom going beyond the limit.

#### 10.22.6 Roller

Recommended size, of pipes for suspension shafts for various widths of rolling shutter are as follows:-

<table>
<thead>
<tr>
<th>Width</th>
<th>Size of pipe (nominal bore)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upto 2 m</td>
<td>32mm</td>
</tr>
<tr>
<td>Upto 3 m</td>
<td>40mm</td>
</tr>
<tr>
<td>Upto 6 m</td>
<td>50 mm</td>
</tr>
</tbody>
</table>

The suspension shaft shall be provided with steel or preferably cast iron pulleys and helical wire spring or flat spiral springs for counter balancing the weight, of the shutter adequately. When the width of shutter is greater than 3.5 m the pulleys shall be interconnected with a cage formed out of MS flats of at least 32x 6 mm and MS dummy ring made of similar flats so that the torque is distributed uniformly. In such cases self aligning two row-ball bearing shall be provided with special cast iron casting at the extreme pulleys at either ends, where indicated.

The caging rings shall have a minimum spacing of 15 cm and there shall be at least 4 nos. flat running through length of the roller.

#### 10.22.7 Hood Covers:

Hood covers shall be made of mild steel sheets 1 mm thick. They shall be hexagonal square or circular contour depending on the contour of the bracket plate. The cover shall be properly stiffened with angle / flat stiffeners at top and bottom edges. The hood covers shall be fixed to the bracket plate.

#### 10.22.8 Gears, Worms etc:

All gears, worms etc, used in the assembly of the rolling shutters shall be machine cut. Worm gear wheel shall be of high-grade cast iron or mild steel The worms shall be of mild steel.

#### 10.22.9 Safety Devices:

For width upto 2.5 m a properly fabricated and reinforced bottom, lock shall be provided to give protection. For width above 2.5 m in addition, both anchoring rods and central hasp and staples shall be provided. The pipes for the anchoring rods shall be embedded in the sill so as not to project above the sill surface.
Anchoring rods shall be provided at the rate of one per extra 2.5 m width or a part thereof of above a clear width of 2.5 m. The hasps shall be grouted on the ground so as to be level with the sill.

10.22.10 Wicket Doors:

Where indicated, wicket door of 600x1200 mm size for ordinary use and 900x 1800 mm size for large installation shall be provided in the rolling shutters. The wicket door shall be robust construction and shall be fitted with a good lever lock operated by key, lockable both from inside and outside. The wicket doors shall be erected in such a way as not to foul with the main rolling shutters when opening or closing. The wicket door shall be swung clear of the opening before the rolling shutter is raised or lowered.

10.22.11 Safety Lever Locks:

Where indicated one pair of safety lever locks may be fitted on either ends of the bottom lock plate.

10.23 Rolling Grill

In situation where certain amount of ventilation combined with safety is required, for example transformer room, substation etc, the rolling shutter may have a small rolling grill portion either at top or at bottom or at both places as indicated. Rolling grill shall be built of cold rolled steel sheet links of 0.9 mm thickness assembled on tubes or rods. Grill may also be manufactured out of 8 mm dia MS round bars. Design of grill shall be as indicated.

10.24 Blank

10.25 Steel windows

Steel doors, windows and ventilators shall comply with IS 1038-1983, Specification or steel doors, windows and ventilators; except with regard to sizes, which shall be as indicated; and shall be of approved make. Rolled steel sections for fabrication shall conform to IS 7452-1990.

10.25.1 Fabrication:

Both fixed and opening frames shall be constructed of sections mixed at corners. The corners of frames shall be welded to form a solid fused welded joint. All frames shall be square and flat. The process of welding adopted may be flash butt welding or any other suitable method which complies with the requirements listed in the IS. Subdividing bars of the units shall be tenoned and riveted to the frames. Casements shall be fitted to their frames so as to provide continuous contact to weathering on the inside and outside and shall be secured in closed position by the fittings which shall have been properly adjusted. Windows and doors may have holes in the web of bars other than those required during manufacture and fixing. Fixing lugs shall have standard slot of 8mm wide for MS screw of 6 mm dia and 12 mm long with square nuts.

10.25.2 For fixing steel hinges, slots shall be cut in the fixed frame and the hinges inserted inside and welded to the fame. The hinges shall be projecting type and not less than 65mm and not more than 75mm wide. The hinge pin shall be of electro-galvanised steel of suitable thickness. Where indicated, friction hinges shall be provided for side hung windows.

10.25.3 Side hung shutters

The handles for side hung shuters shall be of steel or of hot pressed brass, where indicated and shall be mounted on a steel handle plate. Thickness of handle shall not be less than 3 mm for mild steel and brass. The handle shall have a two point nose which shall engage with a steel/brass striking plate on the fixed frame in a slightly. open position as well as in a fast position. The boss of the handle shall incorporate a friction device to prevent the handle from dropping under its own weight and the assembly shall be so designed that the rotation of the handle may not cause it to unscrew from the pin. The strike plate shall be so designed and fixed in such a position in relation that with the latter bearing against its stop, there shall be adequate tight fit between the casement and the outer frames.
10.25.4 In cases where non-friction type hinges are provided, the windows shall be fitted with peg stays which shall be of steel and shall be 300 mm long with steel peg and locking brackets riveted or welded to the fixed frames. Side hung casement fitted with friction hinges shall not be provided with peg stays.

10.25.5 Top Hung Ventilators
Steel butt hinges for top hung ventilators shall be riveted to fixed frame or welded to it after cutting a slot in it. Hinges to the opening frame shall be riveted or welded and cleaned off. Top hung casements shall be provided with a peg stay with three holes which when closed shall be held tightly by the locking bracket. The locking bracket shall either be fitted to the fixed frame or to the window.

10.25.6 Centre Hung Windows and Ventilators
Centre hung windows and ventilators shall be hung on two pairs of brass cup pivots, riveted to the inner and outer frames of the window to permit the window to swing to an angle of approximately 85 degree. The opening portion of the window shall be so balanced that it remains open at any desired angle under normal weather conditions. A brass spring catch shall be fitted in the centre of the top bar of the centre hung window and shall close into a mild steel or malleable iron catch plate. A brass cord pulley wheel in galvanized mild steel or malleable iron bracket shall be fitted at the sill of the window.

10.25.7 Door
Steel hinges unless otherwise indicated, shall be 50 mm projecting type. The hinge pin shall be of electrogalvanised steel. A mortice lock with not less than 4 levers shall be provided in the door where indicated. In the double leaf shutter concealed bolts at the top and bottom shall be of steel.

5.8 Weather Bar
Where fixed light occurs over external opening shutter, a push fit weather bar shall be provided.

10.25.9 Position of Holes
Outer frames shall be provided with fixing holes centrally in the web of the section.

10.25.10 Composite Units
Composite units shall consist of two or more units of doors, windows and ventilators jointed together with coupling sections made from MS sheet 1.6 mm thick and of dimensions given in the IS. Mastic cement shall be applied between the junctions with the coupling sections to make the joints watertight.

10.25.11 Fixing steel Doors, Windows or Ventilators
Steel doors, windows or ventilators shall be fixed into prepared opening. They shall not be built-in as the walls go up. In case of brick work holes for fixing the lugs or holdfasts shall be cut 5 cm square and 5 cm to 10 cm deep, unless it is possible to put slotted lugs into joints. In the case of concrete or stone masonry, fixing lugs are recommended to be embedded in the masonry during construction at the appropriate places. Steel door, window and ventilator units shall be checked to ensure that they are square and working satisfactorily. The unit shall then be set in its opening by using wooden wedges at jambs, head and sill and shall be plumbed. The frame shall be squared and true and free from any warp and twist. The unit shall be put in position and the lugs screwed on tight. Every hole in the frame need not be fixed with a lug; some holes are incidental to manufacture and are not necessarily fixing holes. Lugs shall be placed in the specified position and then grouted into their holes with cement sand mortar 1:3; wedges round the frame shall be left in position until this cement has hardened and the lugs firmly set in. The gap between unit and surround shall then be filled with cement mortar 1:3. When fixing to flush surround without rendering, the 3 mm clearance round the frame shall be pointed with cement mortar 1:3. The plaster shall be applied to surrounds after the lugs have firmly set taking care to keep plaster clear of hinges and not to bring it too close to the opening frame of casement. Before applying the rendering, the joint of unit and mortar shall be pointed from the outside. Other details of fixing and the fixing procedure for composite doors, windows and ventilators shall generally be as described in IS 1081-1960, Code of practice for fixing and glazing of metal (steel & aluminium) doors, windows and ventilators.

10.27 Pressed steel frames

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EMPLOYER
10.27.1 Steel frames for wooden shutters shall be pressed out of cold rolled mild steel sheets of 1.25 mm or 1.60 mm thickness as indicated and shall comply with requirements of IS 4351-2003, Specifications for steel door frames. Cold rolled mild steel sheet shall conform to IS 513. The size, type (profile) and dimensions of the frames shall be as indicated. Tolerance in the size of frames shall not vary by more than +/- 2 mm. The tolerance over the profile size shall be +/- 1 mm. Steel frames shall be of approved make.

10.27.2 Frames shall be either painted with two coats of ready mixed paint or power coated (conforming to IS 13871) as indicated.

10.27.3 Frames shall be filled with PCC 1:3:6.

**Mode of measurements:**

The length shall be measured in running meters correct to a cm. out to out of the frames including the embedded portion.

10.28 Tee or Angles Iron Door, window and ventilator frames

Tee or angles iron frames shall be made from mild steel tee or angle sections of the size as indicated. Steel shall be of grade E - 165 conforming to IS 2062-2006. The frame shall be fabricated in sections which have been cut and mitered. The corners of the frames shall be butt welded to form a true right angle. All frames shall be square and flat. Requisite number of the holes shall be made in the frame for fixing of fittings. Nuts shall be welded to the frame. Frames shall be fixed in the masonry opening with the lugs or any other arrangements as indicated.

10.29 Steel sheeting, plain and corrugated

Galvanized steel sheet, plain or corrugated shall comply with the requirements of IS 277-2003, specification for galvanized steel sheets, plain or corrugated. The grade of galvanizing shall be as indicated:

<table>
<thead>
<tr>
<th>Grade of coating</th>
<th>Minimum average mass of coating (Total both sides) (Triple spot test) gm/ m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>600</td>
<td>600</td>
</tr>
<tr>
<td>450</td>
<td>450</td>
</tr>
<tr>
<td>350</td>
<td>350</td>
</tr>
<tr>
<td>275</td>
<td>275</td>
</tr>
<tr>
<td>220</td>
<td>220</td>
</tr>
<tr>
<td>200</td>
<td>200</td>
</tr>
<tr>
<td>180</td>
<td>180</td>
</tr>
<tr>
<td>120</td>
<td>120</td>
</tr>
</tbody>
</table>

The following are recommended grades of zinc coating for the various thickness of sheets:

<table>
<thead>
<tr>
<th>Thickness</th>
<th>Grade of coating</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.18 to 0.28mm</td>
<td>200</td>
</tr>
<tr>
<td>0.30 to 0.55mm</td>
<td>220</td>
</tr>
<tr>
<td>0.63 to 1.0mm</td>
<td>275</td>
</tr>
<tr>
<td>Above 1.0 mm</td>
<td>350</td>
</tr>
</tbody>
</table>

**Note:** The recommended thickness for roofing application in IS is 0.63 mm and corresponding recommended grade of coating is minimum 275 gm/ m².

10.29.1 Plain sheets shall be reasonably flat and free from twist. Corrugated sheets shall be free from twist or buckle and shall have uniform corrugation, true in depth and pitch, and parallel to the sides of the sheets. The galvanized coating shall be clean, even and free from ungalvanised spots and other defects. The tolerance on weight of an individual sheet shall be +/- 10% and tolerance on a bundle of sheet shall be +/- 5%.

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10.30 Barbed Wire

Galvanised steel barbed wire for fencing shall confirm to IS 278-2001, Specification for galvanized steel
barded wire for fencing. The galvanized barbed wire shall be manufactured from galvanized mild steel wire conforming to IS 280-2006, Galvanized coating of steel wire shall conform to the requirements as laid down for medium coated wire in IS 4826, Hot dipped galvanized coatings on round steel wires. The barbed wire shall consist of two line wire 2.24 mm nominal dia, one or both containing 2 mm dia barbs at 75 mm centre to centre and weighing 97 to 106 Kg per Km. The barbs shall have a length of not less than 13 mm and not more than 18 mm. The points shall be sharp. The line and point wires shall be circular in section, free from scales and other defects and shall be uniformly galvanized. The line wire shall be in continuous lengths and shall not contain any welds other than those in the rod before it is drawn.

10.30.1 Barbed wire shall be stretched and fixed in specified number of rows and diagonals. The diagonals wires will be interwoven with horizontal wires by fixing the old rows of wires, then the diagonal cross wires and lastly the even rows of wires. The barbed wires shall be held to the RCC posts by means of GI staples fixed to wooden plugs or GI binding wire tied to 6 mm bar nibs fixed while casting the posts. The barbed wire shall be fastended to the ballies/timber posts by means of GI staples, driven into the post. Turn buckles and straining bolts shall be used at the end posts where indicated.

10.31 Mild Steel Wire

Mild steel wire for fencing, mattresses shaped nets, etc. shall be galvanized and shall conform to IS 280-2006, specification for mild steel wire for general engineering purposes. All finished steel wire shall be well and cleanly drawn. Wires shall be sound and free from splits, surfaces flaw, rough jagged and imperfect edges and other harmful surface defects. Zinc coating shall be smooth, even and bright. Fixing arrangements shall be as directed.

10.33 Welded Steel Wire Fabric.

Wire fabric for general use such as fencing, windows grills etc. shall confirm to IS 4948 – 2002, specification for welded steel wire fabric for general use. The longitudinal and transverse wire shall be securely connected at every intersection by process of welding. Wire fabric shall be rust proof and free from injurious defects. The mesh size and the size of wires shall be as indicated. Steel wire fabric in each panel shall be in one whole piece. Wire fabric shall be fixed with wooden beads or MS flats as indicated.

10.33.1 The welded steel wire fabric in fencing shall be stretched and fixed to the posts by means of G.I staple fixed to wooden plugs or G.I binding wire tied to 6 mm bar nibs, fixed while casting the posts 25 cm apart or as indicated.

10.35 Fan Clamps

Circular cast iron box for ceiling fan clamps shall be fixed during the laying of RCC slabs. The sizes of the box shall be 10 cm overall dia, 75 mm height, with rim thickness of 5 mm. Bottom and top lid shall be 1.5 mm thick mild steel sheet with its top surface hacked for proper bonding with the concrete. Lid shall be screwed to the box. Fan clamps shall be made of 12 mm dia mild steel bar bent to shape with its end bent as directed.

10.36. ALUMINIUM WORK

Aluminium Sections:

Aluminium sections used for fixed/openable windows, ventilators, partitions, frame work & doors etc. shall be suitable for use to meet architectural designs to relevant works and shall be subject to approval of the Engineer-in-Charge for technical, structural, functional and visual considerations. Chemical and mechanical properties of sections shall comply with requirements given in IS 733-1983, Specification for wrought aluminium and aluminium alloys bars, rods and sections, IS 737-1986, Specification for wrought aluminium and aluminium alloys sheet and strip for general engineering purposes and IS 1285-2002, Specification for wrought aluminium and aluminium alloys extruded round tube and hollow sections for general engineering purposes. The stainless steel screws shall be of grade AISI 304, Joining of sections, providing fittings, lugs, method of fixing etc shall be as per IS 1948 - 1961.

The permissible dimensional tolerances of the extruded sections shall be as per IS 6477 and shall be such as not to impair the proper and smooth functioning/operation and appearance of door and windows.

Aluminium glazed doors, windows etc. shall be of sizes, sections and details as shown in the drawings.
The details shown in the drawings may be varied slightly to suit the standards adopted by the manufacturers of the aluminium work, with the approval of Consultant and Engineer-in-Charge. Before proceeding with any fabrication work, the contractor shall prepare and submit, complete fabrication and installation drawings for each type of glazing doors, windows, ventilators and partition etc. for the approval of the Consultant and Engineer-in-Charge. If the sections are varied, the contractor shall obtain prior approval of Consultant and Engineer-in-Charge and nothing extra shall be paid on this account.

**Anodising:**

Standard aluminium extrusion sections are manufactured in various sizes and shapes in wide range of solid and hollow profiles with different functional shapes for architectural, structural glazing, curtain walls, doors, window & ventilators and various other purposes. The anodizing of these products is required to be done before the fabrication work by anodizing/electro coating plants which ensures uniform coating in uniform colour and shades. The extrusions are anodized up to 30 micron in different colours. The anodized extrusions are tested regularly under strict quality control adhering to Indian Standard IS 1868 and Testing of anodizing coating shall be in accordance with IS 5523-1983.

**Powder Coating**

**Material:**

The powder used for powder coating shall be Epoxy/polyester powder of make approved by the Engineer-in-Charge. The contractor shall give detailed programme for powder coating in advance, to facilitate the inspection by Engineer-in-Charge or his authorized representative.

**Pre-treatment:**

Each aluminium alloy extrusion or performed section shall be thoroughly cleaned by alkaline or acidic solutions under the conditions specified by chemical conversion coating supplier and then rinsed. A chemical conversion coating shall be applied by treatment with a solution containing essentially chromate ions or chromate and phosphate ions as the active components as applicable. The amount of the conversion coating deposited depends on the type used by the conversion coating chemical supplier. The conversion coating shall be thoroughly rinsed either with the solution specified by the conversion coating chemical supplier or with de-mineralized water and then dried at the temperature for the time specified by the conversion coating chemical supplier. The contractor shall submit the detail specifications and application procedure for application of conversion coating for approval of Engineer-in-Charge. The metal surface after the conversion coating pretreatment and prior to the application of the coating shall be free from dust or powdery deposits.

**Process:**

The polyester powder shall be applied by electrostatic powder spray method. Before start of powder coating the contractor shall submit detail specification for application of polyester powder from manufacturer of the polyester powder for approval of Engineer-in-Charge. The powder coating shall be applied as per the specification approved by Engineer-in-Charge.

**Thickness:**

The thickness of the finished polyester measured by micron meter shall not be less than 55 micron and not more than 120 micron at any point.

**ALUMINIUM FRAME WORK :**

**Frame Work:**

First of all the shop drawings for each type particulars shall be prepared by using suitable sections based on architectural drawings, adequate to meet the requirement specifications and by taking into consideration varying profiles of aluminium sections being extruded by approved manufacturers. The shop drawings shall show full size sections of glazed doors, windows, ventilators etc. The shop
Project: “Civil, Electrical and other utility services for package -Civil- II (Rotatable complex) VOLUME –II. TECHNICAL SPECIFICATIONS FOR TENDER NO.NK/FW/CAP-ROH-577/2010-11 drawings shall also show the details of fittings and joints. Before start of the work, all the shop drawings shall be got approved from the Engineer-in-Charge.

Actual measurement of openings left at site for different type of door/window etc. shall be taken. The fabrication of the individual door/windows/ventilators etc. shall be done as per the actual sizes of the opening left at site. The frames shall be truly rectangular and flat with regular shape corners fabricated to true right angles. The frames shall be fabricated out of section which have been cut to length, mitered and jointed mechanically using appropriate machines. Mitered joints shall be corner crimped or fixed with self tapping stainless steel screws using extruded aluminium cleats of required length and profile. All aluminium work shall provide for replacing damaged/broken glass panes without having to remove or damage any member of exterior finishing material.

Fixing of Frames:

The Frame work of particulars shall be fixed to Ceiling or wall with supporting materials and devices for rigidity as approved by the Consultant and the Engineer – in – Charge. The main and the Cross members shall be jointed with angle bracket as indicated in the fabrication Drawing, if not indicated it shall be 15mmx15mmx1.5mm, fixed with suitable bolts, nuts and washers etc. The panel size shall be as per the approved drawings. Fixing of Glazing Clips shall be done carefully and no hammer markings shall be seen on the same and only wooden mallet shall be used.

The holes in concrete/masonry/wood/any other members for fixing anchor bolts/fasteners/screws shall be drilled with an appropriate electric drill. Windows/doors/ventilators etc. shall be placed in correct final position in the opening and fixed to Sal wood backing using stainless steel screws of star headed, counter sunk and matching size groove. of required size at spacing not more than 250 mm c/c or dash fastener. All joints shall be sealed with approved silicone sealants.

In the case of composite windows and doors, the different units are to be assembled first. The assembled composite units shall be checked for line, level and plumb before final fixing is done. Engineer-in-Charge in his sole discretion may allow the units to be assembled in their final location if the situation so warrants. Snap beadings and EPDM gasket shall be fixed as per the detail shown in the shop drawings.

Where aluminium comes into contact with stone masonry, brick work, concrete, plaster or dissimilar metal, it shall be coated with an approved insulation lacquer, paint or plastic tape to ensure that electrochemical corrosion is avoided. Insulation material shall be trimmed off to a clean flush line on completion.

The contractor shall be responsible for the doors, windows etc. being set straight, plumb, level and for their satisfactory operation after fixing is complete

Before fabrication the size of the windows and opening shall be ascertained

Performance Requirements for the Finish

(i) Surface appearance:

The finish on significant surfaces shall show no scratches when illuminated and is examined at an oblique angle, no blisters, craters; pinholes or scratches shall be visible from a distance of about 1 m. There shall not be any visible variation in the colour of finished surfaces of different sections and between the colours of different surfaces of same section.

(ii) Adhesion:

Protection of Powder Coated / Anodizing Finish:
It is mandatory that all aluminium members shall be wrapped with self adhesive non-staining PVC tape, approved by Engineer-in-Charge.

Measurement:

All the aluminium sections including snap beading fixed in place shall be measured in running meter along the outer periphery of composite section correct to a millimeter. The weight calculated on the basis of actual average (average of five samples) weight of composite section in kilogram correct to the second place of decimal shall be taken for payment. (Weight shall be taken after anodizing). The weight of cleat shall be added for payment. Neither any deduction nor anything extra shall be paid for skew cuts.

Rate:

The rate shall include the cost of all the materials, labours involved in all the operations as described in nomenclature of item and particular specification.