1 STRUCTURAL STEEL WORK

1. Applicable Codes & Specifications

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

1.1.2 In case of discrepancy between this specification and other documents referred to herein, this specification shall govern.

(a) Materials

i.	IS : 808	Dimensions for Hot Rolled Steel sections
ii.	IS : 814	Covered Electrodes for Manual Metal Arc Welding of Carbon and Carbon Manganese Steel
iii.	IS : 1161	Steel Tubes for structural purposes
iv.	IS : 1239	Mild steel tubes, tubular and other Wrought steel fittings Part 1 - Mild steel tubes Part 2 - Mild steel Tubular and other wrought steel pipe fittings
v.	IS : 1363	Hexagon Head Bolts, Screws and Nuts of product (Parts 1 to 3) Grade C (Size range M5 to M64)
vi.	IS : 1367	Technical Supply Conditions for Threaded Fasteners (All Parts)

vii.	IS : 1395	Low and Medium Alloy Steel Covered Electrodes for Manual Metal Arc Welding
viii.	IS : 1852	Rolling and Cutting Tolerances for Hot Rolled Steel Products
ix.	IS : 1977	Structural Steel (Ordinary Quality)
x.	IS : 2062	Steel for General Structural Purposes
xi.	IS : 2074	Ready Mixed Paint, Air drying, Red Oxide Zinc Chrome and Priming
xii.	IS : 3502	Steel Chequered Plate
xiii.	IS : 3757	High Strength Structural Bolts
xiv.	IS : 5369	General Requirements for Plain Washers and Lock Washers
xv.	IS : 5372	Taper Washers for Channels
xvi.	IS : 5374	Taper Washer for I Beams
xvii.	IS : 6610	Heavy Washers for Steel
xviii.	IS : 8500	Structural Steel-micro alloyed (medium and high strength qualities)

(b) Codes Of Practice

i.	IS : 800	Code of Practice for General Construction in Steel
ii.	IS : 801	Code of practice for use of Cold formed light gauge steel structural members in general building construction
iii.	IS : 803	Code of practice for design, fabrication and erection of vertical mild steel cylindrical welded storage tanks
iv.	IS : 806	Code of practice for use of steel tubes in general building construction

v.	IS : 816	Code of Practice for use of Metal Arc Welding for General construction in Mild Steel
vi.	IS : 822	Code of Procedure for Inspection of Welds
vii.	IS : 1182	Recommended Practice for Radiographic examination of Fusion Welded Butt Joints in Steel Plates
viii.	IS : 1200	Method of Measurement in Building Civil Engineering Works
ix.	IS:1477 (Parts 1 & 2)	Code of Practice for Painting of Ferrous Metals in Buildings
x.	IS : 2595	Code of Practice for Radiographic Testing
xi.	IS : 3658	Code of Practice for Liquid Penetrant Flaw Detection
xii.	IS : 4000	High strength bolts in Steel Structures - Code of Practice
xiii.	IS : 5334	Code of Practice for Magnetic Particle Flaw Detection of Welds
xiv.	IS : 7205	Safety Code for Erection of Structural Steel Work
xv.	IS : 7215	Tolerances for Fabrication of Steel Structures
xvi.	IS : 9595	Recommendations for Metal Arc Welding of Carbon and Carbon Manganese Steel
xvii.	AISC	Specifications for Design, Fabrication and Erection of Buildings

2. Steel Materials

(a) Steel materials shall comply with the specifications laid down under clause1 and/or as called for on the design drawings.

(b) All materials used shall be new, unused and free from defects.

(c) Steel conforming to IS: 1977 shall be used only for the following:

Fe310-0(St 32-0) :	For general purposes such as door/ window frames, grills, steel gates, handrails, fence posts, tee bars and other non-structural use.
Fe410-0(St 42-0) :	For structures not subjected to dynamic loading other than wind loads such as: Platform roofs, foot over bridges, building, factory sheds etc.

Fe410-0(St 42-0) : grade steel shall not be used
a) If welding is to be employed for fabrication.
b) If site is in severe earthquake zone.
c) If plastic theory of design is used.

3. Supply Of Steel

All the Structural steel and other material necessary to carry out the work will be purchased by the CONTRACTOR at his own cost.

4. Fabrication

1.4.1 General

All workmanship and finish shall be of the best quality and shall conform to the best approved method of fabrication. All materials shall be finished straight and shall be machined/ground smooth true and square where so specified. All holes and edges shall be free of burns. Shearing and chipping shall be neatly and accurately done and all portions of work exposed to view shall be neatly finished. Unless otherwise directed/ approved, reference may be made to relevant IS codes for providing standard fabrication tolerance. Material at the shops shall be kept clean and protected from weather.

1.4.2 Connections

(a) Shop/field connections shall be as per fabrication drawings.

(b) In case of bolted connections, taper washers or flat washers or spring washers shall be used with bolts as necessary. In case of high strength friction grip bolts, hardened washers be used under the nuts or the bolt heads whichever are turned to tighten the bolts. The length of the bolt shall be such that atleast one thread of the bolt projects beyond the nut, except in case of high strength friction grip bolts where this projection shall be atleast three times the pitch of the thread.

(c) In all cases where bearing is critical, the unthreaded portion of bolt shall bear on the members assembled. A washer of adequate thickness may be provided to exclude the threads from the bearing thickness, if a longer grip bolt has to be used for this purpose.

(d) All connections and splices shall be designed for full strength of members or loads indicated on OWNER's design drawings. Column splices shall be designed for the full tensile strength of the minimum cross section at the splice.

(e) All types of required anchor bolts chemical or mechanical, nuts, washers, electrodes, screws etc. shall be supplied/ brought to site 10% in excess of the requirement in each category and size. Rates shall be not be considered separately. It shall be included in design and drawings accordingly rate shall be quoted in the BOQ/price bid.

(f) All members likely to collect rain water shall have drain holes provided.

1.4.3 Straightening

All materials shall be straight and, if necessary, before being worked shall be straightened and/or flattened by pressure and shall be free from twists. Heating or forging shall not be resorted to without the prior approval of the OWNER in writing.

1.4.4 Cutting, punching, drilling, welding and fabrication tolerances shall be generally as per relevant IS codes.

1.4.5 Rolling And Forming

Plates, channels, R.S.J. etc., for circular bins, bunkers, hoppers, gantry girders, etc., shall be accurately laid off and rolled or formed to required profile/ shape as called for on the drawings. Adjacent sections shall be match-marked to facilitate accurate assembly, welding and erection in the field.

1.4.6 High Strength Friction Grip Bolting

Inspection after tightening of bolts shall be carried out as stipulated in the appropriate standards depending upon the method of tightening and the type of bolt used.

1.4.7 Welding

(a) Welding procedure shall be submitted to OWNER for approval. Welding shall be entrusted to only qualified and experienced welders who shall be periodically tested and graded as per IS 817, IS: 7310 (Part 1) and IS: 7318 (Part 1).

(b) The electrodes required for metal arc welding shall conform to IS: 814.

(c) While fabricating plated beams and built up members, all shop splices in each component part shall be made before such component part is welded to other parts of the members. Wherever weld reinforcement interferes with proper fit-up between components to be assembled for welding, these welds shall be ground flush prior to assembly.

(d) Approval of the welding procedure by the OWNER shall not relieve the CONTRACTOR of his responsibility for correct and sound welding without undue distortion in the finished structure.

(e) No welding shall be done when the surface of the members is wet nor during periods of high wind.

(f) Each layer of a multiple layer weld except root and surfaces runs may be moderately peened with light blows from a blunt tool. Care shall be exercised to prevent scaling or flaking of weld and base metal from over peening.

(g) No welding shall be done on base metal at a temperature below –50 C. Base metal shall be preheated to the temperature as per relevant IS codes.

(h) Electrodes other than low-hydrogen electrodes shall not be permitted for thicknesses of 32 mm and above.

(i) Welding shall be done by electric arc welding. Gas welding will not be permitted. All necessary arrangement for electric arc welding shall be done by the CONTRACTOR including stand-by generator sets for uninterrupted welding

works.

(j) The welding size, type of welds such as site or shop weld and pattern of weld shall be exactly same as shown in the fabrication drawings.

(k) The maximum gauge of electrodes for welding any work shall be as under unless noted otherwise.

Average thickness of plate or section	Maximum gauge or dia of electrodes to be used.
Less than 5 mm	**10 S.W.G. (3.2 mm)**
5 mm upto but not including 8 mm	**8 S.W.G. (4.0 mm)**
8 mm upto but not including 10 mm	**6 S.W.G. (4.9 mm)**
10 mm upto but not including 16 mm	**4 S.W.G. (5.9 mm)**
16 mm upto but not including 25 mm	**7.9 mm diameter**
25 mm and over	**9.5 mm diameter**

(l) Inspection of Welds

(i) All welds shall be inspected for flaws by any of the methods described under clause1.4.10 "Inspection". The choice of the method adopted shall be determined by the OWNER.

(ii) The correction of defective welds shall be carried out as directed by the OWNER without damaging the parent metal. When a crack in the weld is removed, magnetic particle inspection or any other equally positive means as prescribed by the OWNER shall be used to ensure that the whole of the crack and material up to 25 mm beyond each end of the crack has been removed. Cost of all such tests and operations incidental to correction shall be to the CONTRACTOR's account.

1.4.8 Tolerances

The dimensional and weight tolerances for rolled shapes shall be in accordance with ARE: 1852 for indigenous steel and equivalent applicable codes for imported steel. The tolerances for fabrication of structural steel shall be as per IS: 7215.

1.4.9 End Milling

Where compression joints are specified to be designed for bearing, the bearing surfaces shall be milled true and square to ensure proper bearing and alignment.

1.4.10 Inspection

(a) The CONTRACTOR shall give due notice to the OWNER in advance of the works getting ready for inspection. All rejected material shall be promptly removed from the shop and replaced with new material for the OWNER's approval/ inspection. The fact that certain material has been accepted at the / CONTRACTOR's shop shall not invalidate final rejection at site by the OWNER

if it fails to conform to the requirements of these specifications, to be in proper condition or has fabrication inaccuracies which prevents proper assembly nor shall it invalidate any claim which the OWNER may make because of defective or unsatisfactory materials and/or workmanship.

(b) No materials shall be painted or despatched to site without inspection and approval by the OWNER unless such inspection is waived in writing by the OWNER.

(c) The CONTRACTOR shall provide all the testing and inspection services and facilities for shop work except where otherwise specified.

(d) For fabrication work carried out in the field the same standard of supervision and quality control shall be maintained as in shop fabricated work. Inspection and testing shall be conducted in a manner satisfactory to the OWNER.

(e) Inspection and tests on structural steel members shall be as set forth below :

(i) Material Testing

– If mill test reports are not available for any steel materials the same shall be got tested by the CONTRACTOR to the OWNER's satisfaction to demonstrate conformity with the relevant specification.

1.4.11 Tests on Welds

(a) Magnetic Particle Test

(i) Where welds are examined by magnetic particle testing, such testing shall be carried out in accordance with relevant IS codes. If heat treatment is performed, the completed weld shall be examined after the heat treatment. All defects shall be repaired and retested. Magnetic particle tests shall be carried out using alternating current. Direct current may be used with the permission of the OWNER.

(b) Liquid Penetrant Inspection

In the case of welds examined by Liquid Penetrant Inspection, such tests shall be carried out in accordance with relevant IS Code. All defects shown shall be repaired and rechecked.

(c) Radiographic Inspection

All full strength butt welds shall be radiographed in accordance with the recommended practice for radiographic testing as per relevant IS code.

1.4.12 Dimensions, Workmanship & Cleanliness

Members shall be inspected at all stages of fabrication and assembly to verify that dimensions, tolerances, alignment, surface finish and painting are in accordance with the requirements shown in the /CONTRACTOR's approved fabrication drawings and the OWNER's drawings.

1.4.13 Test Failure

In the event of failure of any member to satisfy inspection or test requirement,

the CONTRACTOR shall notify the OWNER or his authorised representative. The /CONTRACTOR must obtain permission from the OWNER before repair is undertaken. The quality control procedures to be followed to ensure satisfactory repair shall be subject to approval by the OWNER.

1.4.14 The OWNER has the right to specify additional testing as he deems necessary, and the additional cost of such testing shall be borne by the OWNER, only in case of successful testing.

1.4.15 The /CONTRACTOR shall maintain records of all inspection and testing which shall be made available to the OWNER or his authorised representative.

1.4.16 OWNER or their authorised representatives shall have free access to all parts of the job during erection and all erection shall be subjected to their approval. In case of faulty erection, all dismantling and re-erection required will be at CONTRACTOR's cost. No paint shall be applied to rivet heads or field welds or bolts until these have been approved by OWNER.

1.4.17 Shop Matching

For structures like bunkers, tanks, etc. shop assembly is essential. For other steelwork, such as columns along with the tie beams/bracings may have to be shop assembled to ensure satisfactory fabrication, obtaining of adequate bearing areas etc. if so desired by the OWNER. All these shop assemblies shall be carried out by /CONTRACTOR at no extra cost to the OWNER.

1.4.18 Drilling Holes For Other Works

As a part of this Contract, holes in members required for installing equipment or steel furnished by other manufacturers or other CONTRACTORs shall be drilled by the /CONTRACTOR at no extra cost to the OWNER. The information for such extra holes will be supplied by the OWNER.

1.4.19 Marking Of Members

(a) After checking and inspection, all members shall be marked for identification during erection. This mark shall correspond to distinguishing marks on approved erection drawings and shall be legibly painted and stamped on it. The erection mark shall be stamped with a metal dye with figures at least 20 mm high and to such optimum depth as to be clearly visible.

(b) All erection marks shall be on the outer surface of all sections and near one end, but clear of bolt holes. The marking shall be so stamped that they are easily discernible when sorting out members. The stamped marking shall be encircled boldly by a distinguishable paint to facilitate easy location.

(c) Erection marks on like pieces shall be in identical locations. Members having lengths of 7.0 m or more shall have the erection mark at both ends.

1.4.20 Errors

Any error in shop fabrication, which prevents proper assembling and fitting up of parts

in the field by moderate use of drift pins or moderate amount of reaming will be classified by the OWNER as defective workmanship. In case OWNER rejects such material or defective workmanship, the same shall be replaced by the materials and workmanship conforming to the OWNER's requirements by /CONTRACTOR free of cost at site.

1.4.21 Erection Scheme

CONTRACTOR shall furnish a broad erection scheme with dates and estimated completion time for various parts of the work after a thorough study of the design drawings and the site conditions. This erection scheme shall describe the methods proposed to be employed by CONTRACTOR for transporting his equipment, tools, tackles, gas cylinders, electrodes and all that is necessary to site, unloading, transporting within the site, handling, assembling, hoisting and erecting of the structural steel components and the type, capacity and quantity of equipment that CONTRACTOR proposes to bring to site for all these operations. The scheme shall also indicate the strength and trade wise composition of the work force and supervisory personnel that will be deployed by CONTRACTOR for the various operations.

1.4.22 Erection Programme

(a) Within two weeks of the acceptance of the WORK ORDER, the CONTRACTOR shall submit a detailed erection programme. This programme shall be accompanied by a layout plan identifying the areas proposed for unloading, main storage, subsidiary storage, assembly and the transportation of equipment and fabricated material between the storage and work areas. The layout shall clearly indicate the points at which proposed erection begins, direction in which it is proposed to progress, the deployment of equipment, access route for cranes to reach work areas, etc. The locations and extent of site offices and stores, labour quarters if any, layout of electrical cables and water pipes from the tap-off points shall also be indicated in detail on the above layout. Full details of the method of handling, transport, hoisting and erection including false work/staging, temporary bracing, guying, etc. shall be furnished by CONTRACTOR in this erection programme along with complete details of the quantity and capacity of the various items of erection equipment that will be used. A site organisation chart showing the number of supervisory personnel, and the number and composition of the various gangs shall also accompany the erection programme.

(b) Any modifications to the erection programme directed by OWNER for the reasons of inadequacy of the quantity and/or capacity of the erection equipment, erection personnel and supervisors, temporary bracing, guying etc., or safety of the erection methods, or stability of the erected portions of structures, or unsuitability of the erection sequence due to interference with the work of other agencies shall be incorporated by CONTRACTOR and the work shall be carried out in accordance with the revised programme. Approval by OWNER shall not relieve CONTRACTOR from the responsibility for the safe,

sound, accurate and timely erection of structural steel work as required by OWNER. CONTRACTOR shall also make no extra claims for bringing additional equipment to site for erection, if so directed by OWNER. CONTRACTOR shall be deemed to have visualised all erection problems for the work and no additional compensation shall be claimed on this account.

1.4.23 Site Operations

(a) An experienced and qualified Superintendent shall be in full time charge of the job.

(b) CONTRACTOR shall complete all preliminary works at site well before the arrival of structural steel, such as establishment of a well-equipped and adequately staffed site office, stores, unloading gantry, unloading and pre-assembly yard, labour quarters if any, electrical and water connections, electrical winches, derricks, cranes, compressors, all tools and tackles, rivet guns, welding sets, torque wrenches, spud wrenches, staging, etc. as well as experienced erection and supervisory personnel as part of this contract and any other work that may be necessary so as to start erection immediately after the arrival of the first batch of steel at site.

(c) CONTRACTOR shall furnish at his own expense, the necessary non-inflammable staging and hoisting materials or equipment required for the erection work and shall remove and take them away after completion of the job. CONTRACTOR shall also provide necessary passageways, fences, safety belts, helmets, lights and other fittings to the satisfaction of OWNER and to meet the rules of local authorities and for protection to his men and materials. A licensed electrician shall be kept on the job for the entire duration of the work to maintain CONTRACTOR's electrical equipment and connections.

(d) CONTRACTOR shall protect all existing plant, structures, piping, conduits, equipment and facilities against damage during erection. Any damage caused by CONTRACTOR shall be rectified entirely at CONTRACTOR's cost to the satisfaction of OWNER. If work has to be carried out adjacent to existing switch yards or electrical installations which are live, CONTRACTOR must ensure suitable safety precautions in consultation with OWNER.

(e) If a portion of the work of the project area cannot be made available to CONTRACTOR for his activities due to operations being carried out by other agencies, he shall suitably modify his sequence of operations so as to continue work without interruption. CONTRACTOR shall work in co-ordination with other agencies working on the project site and plan his work suitably so as not to hinder the progress of construction at site.

1.4.24 Handling And Storage Of Steel

(a) CONTRACTOR shall carefully check the steel to be erected at the time of delivery and acceptance.

(b) No dragging of steel shall be permitted. All shall be stored 300mm above

ground on suitable packing to avoid damage. It shall be stored in the order required for erection, with erection marks visible. All storage areas shall be prepared and maintained by CONTRACTOR. Steel shall not be stored in the vicinity of areas where excavation or grading will be done and, if so stored temporarily, this shall be removed by CONTRACTOR well before such excavation and/or grading commences to a safe distance to avoid burial under debris.

(c) Scratched or abraded steel shall be given a coat of primer specified for protection after unloading and handling prior to erection. All milled and machined surfaces shall be properly protected from rust/corrosion by suitable coating and also from getting damaged.

1.4.25 Anchor Bolts & Foundations

(a) CONTRACTOR shall carefully check the location and layout of anchor bolts embedded in foundations constructed, to ensure that the structures can be properly erected as shown on the drawings. Any discrepancy in the anchor bolts/ foundation shall be reported to OWNER.

(b) Levelling of column bases to the required elevation may be done either by providing shims or three nuts on the upper threaded portion of the anchor bolt. All shim stock required for keeping the specified thickness of grout and in connection with erection of structures on foundations, crane brackets or at any other locations shall be of good M.S. plates and shall be supplied by CONTRACTOR at his own cost.

(c) A certain amount of cleaning of foundations and preparing the area is considered normal and shall be carried out by CONTRACTOR at no extra cost.

(d) Where beams bear in pockets or on walls, bearing plates shall be set and levelled as part of the work. CONTRACTOR shall carry out all grouting under column base plates or beam bearing plates.

1.4.26 Assembly & Connections

(a) Field connections may be effected by riveting, bolting, welding or by use of high strength friction grip bolts as specified in the design and erection drawings.

(b) All bolts, nuts, washers, rivets, electrodes required for field connections shall be supplied by CONTRACTOR free of cost.

(c) All assembling shall be carried on a level platform.

(d) Drifts shall be used only for drawing the work to proper position and must not be used to such an extent as to damage the holes. Size of drifts larger than the nominal diameter of hole shall not be used. Any damaged holes or burrs must be rectified to the satisfaction of OWNER.

(e) Corrections of minor misfits and reasonable amount of reaming and cutting of excess stock from rivets shall be considered as a part of erection. Any error in the shop, which prevents proper fit on a moderate amount of reaming and slight chipping or cutting, shall be immediately reported to OWNER.

1.4.27 Erection

(a) All structural steel shall be erected as shown on the drawings. Proper size steel cable slings, etc., shall be used for hoisting. Guys shall not be anchored to existing structures, foundations, etc. unless so permitted by OWNER in writing. Care shall be taken to see that ropes in use are always in good condition.

(b) Steel columns in the basement, if any, are to be lowered and erected carefully with the help of a crane and/or derrick without damaging the basement walls steel or floor.

(c) Structural steel frames shall be erected plumb and true. Frames shall be lifted at such points that they are not liable to buckle and deform. Trusses shall be lifted only at node points. In the case of trusses, roof girders, all of the purlins and wind bracing shall be placed simultaneously and the columns shall be erected truly plumb on screed bars over the pedestals. All steel columns and beams shall be checked for plumb and level individually before and after connections are made. Temporary bracings shall be introduced wherever necessary to take care of all loads to which the structure may be subjected, including erection equipment and the operation thereof. Such bracings shall be left in place as long as may be required for safety and stability.

(d) Chequered plates shall be fixed to supporting members by tack welding or by countersunk bolts as shown/specified in relevant drawings and/or as directed by OWNER. The edges shall be made smooth and no burrs or jagged ends shall be left. While splicing, care should be taken so that there is continuity in pattern between the two portions. Care should also be taken to avoid distortion of the plate while welding. The erection of chequered plates shall include :

(i) Welding of stiffening angles/vertical stiffening ribs

(ii) Cutting to size and making holes to required shape wherever necessary to allow service piping and/or cables to pass through

(iii) Splicing as shown in relevant drawings

(iv) Smoothening of edges

(v) Fixing of chequered plates by tack welding or by countersunk bolts

(vi) Providing lifting hooks for ease of lifting.

(e) As erection progresses, the work shall be securely bolted to take care of all dead load, wind, seismic and erection stresses.

(f) No riveting or welding or final bolting shall be done until the structure has been properly aligned and approved by OWNER. No cutting, heating or enlarging of the holes shall be carried out without the prior written approval of OWNER.

(g) Test certificates shall be furnished by CONTRACTOR.

1.4.28 Tolerances

(a) Tolerances mentioned below shall be achieved after the entire structure or part thereof is in line, level and plumb.

(b) Columns

(i) Deviation of column axes at foundation top level with respect to true axes :

- In longitudinal direction : ± 5 mm
- In lateral direction : ± 5 mm

(ii) Deviation in the level of bearing surface of columns at foundation top with respect to true level : ± 5 mm

(iii) Out of plumbness (verticality) of column axis from true vertical axis, as measured at column top :

For columns upto and including 15 metres in height:	± 1/1000 of column height in mm or ±15mm whichever is less
For columns exceeding 15 metres in height:	± 1/1000 of column height in mm or ±20 mm whichever is less

(iv) Deviation in straightness in longitudinal and transverse planes of column at any point along the height : ± 1/1000 of column height in mm or ± 10 mm whichever is less

(v) Difference in erected position of adjacent pairs of columns along length or across width of building prior to connecting trusses/beams with respect to true distance : ± 10 mm

(vi) Deviation in any bearing or seating levels with respect to true level : ±5 mm

(vii) Deviation in differences in bearing levels of a member on adjacent pair of columns both across and along the building: ± 10 mm

(c) Trusses And Beams

(i)	Shift at the centre of span of top chord member with respect to the vertical plane	± 1/250 of height of truss in mm or ± 15 mm passing through the centre of bottom chord whichever is less
(ii)	Lateral shift of top chord of truss at the centre of span from the vertical plane	± 1/1500 of span of truss in mm or ± 15 mm passing through the centre of supports whichever is less of the truss

(iii)	Lateral shift in location of truss from its true vertical position	± 10 mm
	Lateral shift in location of purlin true position	± 5 mm
(iv)	Deviation in difference of bearing levels of trusses or beams from the true difference	i) ±20 mm for trusses ii) For beams : Depth<1800mm: ±6mm Depth>1800mm: ±10mm
(v)	Deviation in sag in chords and diagonals of truss between node points whichever is smaller	1/1500 of length in mm or 10mm
(vi)	Deviation in sweep of trusses, beams etc. in the horizontal plane	1/1000 of span in subject to a maximum of 10 mm

5. Painting

1.5.1 After steel has been erected, all bare and abraded spots, rivet heads, field welds, bolt heads and nuts shall be spot painted with primer as specified. Before paint is applied, the surface shall be dry and free from dust, dirt, scale and grease. All surfaces inaccessible after erection shall receive two coats of the approved paint before erection.

1.5.2 All fabricated steel material, except those galvanised shall receive protective paint coating as specified in specification for painting for structural steel.

6. Method Of Measurement

1.6.1 For the purpose of payment, the weight of the actual completed structures shall be calculated from the approved drawings for different items of work. The CONTRACTOR

shall submit to the OWNER relevant material list containing weight of each item.

1.6.2 No allowances will be permitted for bolts, nuts, washers, studs, screws etc, galvanising, welding or for rolling margins. One tonne for the purpose of payment shall mean ONE METRIC TONNE i.e. 1000 Kg.

1.6.3 The weight of a member made out of standard rolled section such as beams, channels, angles, etc. shall be based on the standard IS:808 without deductions for holes, notches, bevel cuts, etc. Where a component consists of a cut joist or channels, the full weight of the rolled section shall be considered only if more than half the depth of the original section is used. Otherwise, only half the section unit weight shall be considered for calculation of the weight of the components.

1.6.4 Deductions shall be made in the weight of gussets/plates for cuts and notches of 900 sq. cm. or larger.

1.6.5 For gussets/plates used in trusses, bracings, columns, beams, etc, the area shall be that of the minimum circumscribing rectangle except as stated in clause 1.6.4 above.

1.6.6 The weight of any built-up members shall be based on the weight of each component.

1.6.7 Erection bolts installed may be left in position on completion of erection; however, no additional payment shall be made either for supply or use of such bolts. If erection bolts are removed after erection is complete, holes shall be plug welded and ground smooth. No extra payment shall be made for such plug welding.

7. Clean Up Of Work Site

During erection, the CONTRACTOR shall without any additional payment, at all times keep the working and storage areas used by him, free from accumulation of waste materials or rubbish. Before completion of erection, he shall remove or dispose of in a satisfactory manner all temporary structures, waste and debris and leave the premises in a condition satisfactory to OWNER.

2 PAINTING OF STRUCTURAL STEEL

1. Applicable Codes And Specifications

2.1.1 The following Standard Specifications and Codes of Practice are made a part of this Specification. All standards and codes referred to herein shall be the latest editions including all applicable official amendments and revisions.

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

i. IS: 110 Ready Mixed paint, brushing, grey filler for enamels for use over primers.

ii. IS: 117 Ready Mixed paint, Brushing, Finishing, Exterior Semi-gloss for general purposes, to Indian Standard colours.

iii. IS:341 Black Japan, Types A, B and C

iv. IS: 1477 Codes of Practice for painting of ferrous metals in buildings.
Part I - Pre-treatment
Part II - Painting

v. IS:2339 Aluminium paint for general purposes, in Dual container

vi. IS:2932 Specification for enamel, synthetic, exterior, type 1,
(a) Undercoating (b) finishing

vii. IS:2933 Specification for enamel, exterior, type 2,
(a) Undercoating, (b) finishing

viii. IS: 5905 Sprayed aluminium and zinc coatings on Iron and Steel.

ix. IS: 6005 Code of practice for phosphate of Iron and Steel.

x. IS: 13183 Aluminium paint, Heat resistant.

2. Surface Treatment

2.2.1 All the surfaces of steel work to be painted shall be thoroughly cleaned of all loose mill scale, rust, grease, dirt and other foreign matter. The type of surface treatment shall be as specified in the respective item of work. The workmanship shall generally conform to the requirements of IS 1477-Part I.

2.2.2 Oil and grease removal shall be carried out either by solvent cleaning or by using alkali type degreasing agents. To remove grease material the surface shall be cleaned with solvents containing emulsifier. After cleaning, the surface shall be washed with water. When the surface has cement pelts or salts, the cleaning shall be done with strong alkalies. After cleaning, water rinsing and subsequent passivation by dilute chromic acid rinsing shall be carried out to ensure that no trace of alkali is left on the surface. The procedure for cleaning by above mentioned methods shall be as per manufacturer's instructions.

2.2.3 Derusting and descaling of steel shall be carried out manually.

2.2.4 Manual Or Hand Tool Cleaning: Loose mill scale, loose rust and loose paint shall be removed by wire brushing, scrapping, chipping and rubbing with abrasive paper or steel wool. This method shall not be employed when the surface has firmly adhering mill scale. After hand tool cleaning, the surface shall be rubbed with sand paper so as to ensure that no loose material exists and the surfaces shall be dusted off.

3. Materials

2.3.1 Primer Paint

(a) Anti-corrosive primers shall be lead free types. The types of primers shall be as follows:

(b) The two coat Zinc Phosphate Red Oxide primer shall be applied for all general purpose structural steel work painting. For repainting of such structural steel work one coat of Zinc Phosphate Red Oxide primer shall be used.

(c) For highly corrosive atmosphere or the coastal zones, one coat Of Zinc Ethyl Silicate primer shall be used for the new structural steel painting. However, for repainting of structural steel work in highly corrosive atmosphere or coastal

zones one coat of Modified Aluminium Epoxy mastic shall be applied.

2.3.2 Finish Paint

(a) For highly corrosive atmosphere or coastal zones, an undercoat of Epoxy Polyamide Micaceous Iron Oxide (MIO) shall be used and Synthetic enamel paint for finish coat conforming to IS 2932/IS 2933 shall be used. For repainting of structural steel work in highly corrosive atmosphere two coats of Synthetic Enamel Paint shall be used.

(b) Two coats of heat resistant Aluminium paint shall conform to IS: 13183 and shall be used for all general purpose finish coat on new or old structural steel work.

2.3.3 All the materials shall be of the best quality from an approved manufacturer. CONTRACTOR shall obtain prior approval of the OWNER for the brand of manufacture and the colour/shade prior to procurement for usage in the works.

2.3.4 Primer and finish paints shall be compatible with each other to avoid cracking and wrinkling. As such it is recommended that the primer and finish paint shall be from the same manufacturer.

2.3.5 The colour and shade shall conform to IS Standards referred to in Appendix 'D' of IS 1477-Part II. To facilitate choosing the correct shade/number from the alternatives available, CONTRACTOR shall adopt trial painting in small patches in consultation with and as directed by the OWNER.

2.3.6 All paint delivered to the fabrication shop/site shall be ready mixed, in original sealed containers, as packed by the manufacturer. Thinner shall not be permitted for usage unless specifically directed by the OWNER.

2.3.7 Paints shall be stirred thoroughly to keep the pigment in suspension.

2.3.8 CONTRACTOR shall at his own cost arrange for testing of paints as per relevant Indian Standards in standard laboratory whenever OWNER wants the tests to be carried out for each batch of paints. Test results shall be submitted to the OWNER for obtaining approval.

4. <u>Workmanship</u>

2.4.1 The type and the number of coats of the primer paint and finish paint shall be as specified in the respective items of work.

2.4.2 Painting shall be carried out only on thoroughly dry surfaces.

2.4.3 No painting shall be done in frosty/foggy weather or when the humidity is high enough to cause condensation on the surface to be painted. Paint shall not be applied when the temperature of the surface to be painted is at 10°C or lower.

2.4.4 Primers shall adhere to the surface firmly and offer a key to the subsequent coats.

2.4.5 The application of paint film shall serve the twin purpose of protecting the steel from corrosion and giving the decorative appearance. A paint which gives the steel

adequate protection over a long period together with good appearance shall therefore be adopted.

2.4.6 Workmanship shall generally conform to requirements specified in IS: 1477-Part II.

2.4.7 It is essential to ensure that immediately after preparation of the surfaces, the first coat of primer paint shall be applied by brushing and working it well to ensure a continuous film without "holidays". After the first coat becomes hard dry a second coat of primer shall be applied by brushing to obtain a film free from holidays.

2.4.8 Structural steel surfaces shall be given the first coat of primer at shop and the second coat after it is erected in position. Further, any abraded surfaces of the first coat during transport from shop to site and during erection shall be provided with a touch-up coat of the primer.

2.4.9 The dry film thickness of each coat of primer and finish paints shall be as follows:

Structural Steel Work in Highly Corrosive Atmosphere		
	First Time Painting	Repainting
Primer	One coat of Zinc Ethyl Silicate Primer – 75 to 80 μm	One coat of Modified Aluminium Epoxy mastic Primer – 175 μm
Undercoat	One coat of Epoxy Polyamide MIO – 120 to 125 μm	-
Finish coat	Two coats of Synthetic Enamel Paint – 25 μm each	Two coats of Synthetic Enamel Paint – 25 μm each
Structural Steel Work in General Corrosive Atmosphere		
Primer	Two coats of Zinc Phosphate Red Oxide–30 to 35 μm each	One coat of Zinc Phosphate Red Oxide – 30 to 35 μm
Finish coat	Two coats of Aluminium Paint – 20 μm each	Two coats of Aluminium Paint – 20 μm each

2.4.10 Application of finishing paints shall be carried out within the shortest possible time interval after primer since the primer coats are too thin to give adequate corrosion protection to the steel surface over a long duration.

2.4.11 Filler coats shall be applied to fill dents and to obtain a smooth finish wherever necessary. Only factory prepared filler suitable for steelwork shall be used. Fillers prepared by whiting and linseed oil by craftsmen at site shall never be used as such fillers may be unbalanced and incompatible with primer and finishing coats. Application of filler shall be done with good `putty knife' and necessary skill. Filler applied shall be just sufficient to fill the depression or unevenness and it shall be restricted to the minimum. It shall be applied in thin layers. In filling depression or unevenness, due as many coats as are necessary may be applied allowing each layer to dry hard. The hardened coat shall be cut down by wet rubbing before the subsequent coat is applied. Where necessary, filler coats shall be applied over the undercoats also.

2.4.12 Painting shall be carried out either by brushing or by spraying. Only in case of Zinc

Ethyl Silicate primer application shall be by airless or air spray. CONTRACTOR shall procure the appropriate quality of paint for this purpose as recommended by the manufacturer.

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

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

2.4.15 At least 24 hours shall elapse between the applications of successive coats. Each coat shall vary slightly in shade and this shall be got approved by the OWNER.

2.4.16 The thickness of film shall be measured by an Elcometer to be supplied by the CONTRACTOR. The CONTRACTOR shall calibrate the Elcometer frequently for different settings. Necessary calibrating accessories should be kept ready for calibration/testing of Elcometer at any time.

2.4.17 Surfaces inaccessible after assembly shall receive two coats of primer prior to assembly.

2.4.18 Surfaces inaccessible after erection, including top surfaces of floor beams supporting grating or chequered plate shall receive one additional coat of finish paint over and above the number of coats specified prior to erection.

2.4.19 Portion of steel members embedded/to be encased in concrete shall not be painted. Joints to be site welded shall have no shop paint for at least 50 mm from the welding zone. Similarly, the steel surfaces shall not be painted in areas where connection is by use of friction grip bolts. On completion of the joint, the surfaces shall receive the painting as specified.

2.4.20 Maintenance painting of steel structures will become necessary if the painting already carried out shows signs of chalking, hairline cracking, deep checking, fine checking, and peeling, blistering and rusting. The breakdown of a paint film is progressive from the top finish paint to the primer coat and the object of maintenance painting is to renovate periodically to effectively check the breakdown and protect the steel surfaces from corrosion. It is essential that same quality of paint as specified earlier need be adopted to ensure compatibility. The general workmanship for maintenance painting shall conform as per Clause. 7 of IS 1477-Part II.

2.4.21 CONTRACTOR shall provide suitable protection as necessary to prevent paint finishes from splashing on equipment, floors, walls etc.

3 LIST OF APPROVED BRANDS AND MANUFACTURERS FOR MATERIALS USED

SL. NO.	DESCRIPTION OF EQUIPMENT	SUPPLIER / VENDOR NAME
1.	Structural steel	SAIL, Tata Steel, Vizag, Jindal, or Equivalent.
2.	Red Oxide/synthetic enamel paints	Shalimar, Asian, Garware Paints or equivalent