HINDUSTAN PETROLEUM CORPORATION LIMITED

GURU GOBIND SINGH REFINERY
PRODUCTS EVACUATION PROJECT
(GGSRPEP)

SPECIFICATIONS FOR STRUCTURAL STEEL WORK

0435-JH0902-00-ST-SPC-0001

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1. SCOPE

This Specification defines the requirements for the supply, fabrication and erection of structural steelwork, design of connections and preparation of fabrication drawings for buildings, plant and equipment supports, stairways, access platforms, steel flooring, ladders and the like. This Specification does not include the requirements of protective treatment like painting, fireproofing, jetty and other marine structures.

2. REFERENCE DOCUMENTS

2.1 Codes & Standards

The Indian Standards and other referred standards (including all amendments and revisions) shall be considered as part of this Specification. In case any particular aspect of work is not covered specifically by these or any other relevant Indian Standard Specification, any other good engineering practice as may be specified by the company shall be followed:

Following Indian standards including all amendments and revisions shall be considered as part of this specification.

IS 800 Code of Practice for General Construction in Steel

IS 801 Code of Practice for use of Cold Formed Light Gauge Steel Structural Members in General Building Construction

IS-806 Code of Practice for use of Steel Tubes in General Building Construction.

IS 808 Dimensions for Hot Rolled Steel Beam, Column, Channel and Angle Sections


IS 816 Code of Practice for Use of Metal Arc Welding for General Construction in Mild Steel

IS 817 Code of Practice for Training and Testing of Metal arc Welders

IS 817 (Part 1) Manual arc welding

IS 822 Code of Practice for Inspection of Welds

IS 919 (Part 1) Recommendation for limits and fits for engineering.

IS 1161 Steel tubes for Structural purposes.

IS 1182 Recommended practice for radiographic examination of fusion welded butt joints in steel plates.

IS 1363 Specification for Hexagon head bolts, screws and nuts of product Grade C (Parts 1 to 3)
IS 1367 (All Parts) Technical supply of Threaded Steel Fasteners

IS 1395 Specification for Low and Medium Alloy Steel Covered Electrodes for Manual Metal Arc Welding

IS 1852 Rolling and cutting tolerances for hot rolled steel products

IS 1977 Specification for Structural Steel (Ordinary Quality)

IS 2062 Steel for General Structural Purposes - Specification

IS 2074 Ready mixed paint, red oxide, zinc chromate priming.

IS 3658 Code of Practice for Liquid Penetrant Flaw Detection (DPI) IS 3757 Specification for High Strength Structural Bolts

IS 4000 High Strength Bolts in Steel Structures - Code of Practice

IS 4260 Ultrasonic Testing of weld in ferritic steel.

IS 4759 Hot-dip zinc coatings on structural steel and other allied products. IS 4923 Hollow Steel Sections for Structural Use.

IS 5334 Code of Practice for magnetic practice flaw detection of welds

IS 5372 Taper Washers for channels. IS 5374 Taper Washers for I beams.

IS 6610 Heavy Washers for Steel Structures.

IS 6623 High Strength Structural Nuts

IS 6419 Specification for Welding Rods and Bare Electrodes for Gas Shielded Arc Welding of Structural Steels.

IS 6639 Specification for Hexagon Bolts for Steel Structures.

IS 6649 Hardened and tempered washers for high strength structural bolts and nuts.

IS 7205 Safety code for erection of structural steelwork

IS 7215 Tolerances for fabrication of steel structures. IS 7307 (Part 1) Approval Tests for Welding Procedures

IS 7310 (Part 1) Approval Tests for welders working to approved Welding Procedure

IS 8500 Structural steel Micro alloyed.

IS 9595 Recommendation for Metal arc welding of Carbon and Carbon Manganese Steels

IS 12843 Tolerances for erection of steel structures.

BS 3692 ISO metric precision hexagon bolts, screws and nuts. Specification

BS 4921 Sherardized Coatings on Iron and Steel

BS 5289 Visual Inspection of Fusion Welded Joints
2.2 Other Standards / Specifications

Specification for Concrete Work.

3. GENERAL

3.1 Related Documents

Conflict, if any, between this specification and related specifications, standards and documents shall be referred to the Engineer for resolution before proceeding with the work.

3.2 Units

Design calculations shall be carried out using the SI system of units. On shop fabrication drawings, levels shall be quoted in meters and dimensions in millimeters.

4. MATERIALS

4.1 General

i. All materials used in the Works shall be new, first quality steel of Indian manufacture free from laminations, seams, blisters and other harmful defects and shall comply with the appropriate Indian Standards.

ii. Test certificates in accordance with the requirements of the relevant Indian Standards, shall be supplied to the Engineer in respect of all materials to be used in the Works, prior to commencement of fabrication.

4.2 Structural Steel

i. Unless specified otherwise, structural steel used in the Works shall comply with the requirements of IS 2062 and be of Grade Fe 410WB specified therein.

ii. Hot rolled sections shall be Indian Standard Sections in accordance with IS 808.

iii. The thickness tolerance for plates and flats shall be as specified in IS 1852. The deviation over or under the nominal thickness shall be equal to half the total thickness tolerance.

iv. Steel shall be marked in accordance with IS 2062. Members in steel grades other than Grade A shall have additional marks of a form and in positions to be agreed with the Engineer.

v. When design drawing do not specify grade of steel intended for connections and fittings, IS 2062 Grade Fe 410 WB or BS EN 10025 Grade 430 B shall be used.

vi. Steel for cold rolled sections shall be as per IS 801.

vii. Hollow rectangular / square sections shall conform to IS 4923. Steel Tubes shall conform to IS 1161.

4.3 Bolts, Nuts and Washers

i. Bolts and nuts shall comply with IS 1363, IS 1367, IS 3757 and IS 6639 as appropriate. Nuts shall be
of at least the strength grade appropriate to the grade of bolts or other threaded elements with which they are used.

ii. Plain washers for use with ordinary bolts and nuts shall comply with IS 5369. Tapered washers shall comply with IS 5372 or IS 5374 as applicable.

iii. High tensile bolts of strength grade 8.8 shall comply with requirements of IS 3757 or BS 3692. Dimensional requirements to comply with IS 3757. Bolt shall be of product grade C to IS 1367 part 2 and mechanical properties to IS 1367 part 3.

iv. Nuts shall be heavy hex Grade 4 conforming to IS: 1363 Part 3 and 1367 Part 2 for ordinary strength bolts and heavy hex Grade 8 conforming to IS: 6623 for high tensile bolts.

v. All Bolts, Nuts and Washers shall be hot-dip galvanized in accordance with IS 1367 (part 13) or sherardised in accordance with BS 4921.

4.4 Welding Consumables

Welding consumables, used for metal arc welding of steels complying with IS 2062, shall comply with IS 814. Welding consumables and procedures shall be such that the mechanical properties of deposited weld metal are not less than the respective minimum values for the parent metal being welded.

4.5 Steel Grating and Stair Treads

Steel grating and stair treads shall be open grid rectangular pattern complying with Standard drawings.

5. CONNECTION DESIGN AND FABRICATION DRAWINGS

5.1 General

i. The Consultant/Engineer shall furnish design drawings to the Contractor. Revisions to design drawings after release for preparation of fabrication drawings are very likely to be made. The contractor shall make changes in fabrication drawings accordingly.

ii. The Contractor shall design all connections required for all steel to steel connections that have not been furnished by the Engineer.

iii. Structural steel work shall be designed in accordance with IS 800.

iv. The design of ladders, platforms, handrails, stairways and the like shall be in accordance with Standard Drawings.

5.2 Design Details

Connections made in the shop shall be either bolted or welded. Connections made on site shall generally be bolted. Welded site connections shall be permitted only when specified on design drawings or with prior permission of the Engineer.

Bolted connections shall contain a minimum of two bolts each. Bolts smaller than M16 shall not be used without the prior approval of the Engineer. Tapered washers shall be used for bolts
passing through tapered sections.

The thickness of gusset plates and welded end plates shall be not less than 8 mm. Connections shall not generally project above the level of the top of steel work. In the case of pipe racks the top of steel work shall be free from projections within the width of the rack.

All grating floor panels shall be fixed to supporting steel work by means of positive non-slip flooring grips and all panels shall be side-bolted together with two 6 mm diameter galvanised bolts per side.

The design drawing shall show the position on the structure where temporary bracing or restraints are to be provided until walls / floors and other non steel structures are built.

### 5.3 Design Calculations

Design calculations for all connections shall be prepared by the Contractor. They shall be submitted to the Engineer, if called for, at the same time as the drawings to which they relate.

Calculations shall be fully checked and signed by both the designer and the checker. They shall be sufficiently detailed and complete to enable the Engineer to verify the adequacy of the designs and details.

### 5.4 Drawings

The Contractor shall prepare detail drawings for identification, setting out and erection of all steel work. These shall include the following:

i. Mark numbers and section sizes for all members

ii. The position and directions by which the work is to be erected and any particular erection instructions. Separate drawings shall be prepared to show the arrangements of steel floor and hand railing. The Contractor shall prepare shop fabrication drawings for each item to be included in the Works.

These shall include all information relevant to the fabrication of the steel work including but not limited to the following:

a. Dimensions
b. Details of connection
c. Material specification for steel work and bolts
d. Details of finishes
e. Material list complete with weights.

### 5.5 Documents to be submitted by Contractor

Detail drawings and their associated calculations shall be submitted to the Engineer for review in accordance with the requirements of the Works Specification.

All fabrication and erection drawings shall be issued for construction by the Contractor directly to his work site. Copies of such drawings shall simultaneously be submitted to the Owner’s Representative before two weeks of fabrication, who may check / review some or all such drawings at his sole discretion and offer his comments for incorporation in these drawings by the Contractor.
However, the Contractor shall not proceed with the fabrication of such structures whose fabrication drawings are required to be reviewed before taking up the fabrication work as noted on “Approved for Construction (AFC)” design drawings issued to the Contractor or as conveyed by the Owner’s Representative. The fabrication of such structures shall be done only as per the reviewed fabrication drawings.

Details of welding procedures shall be fully checked and approved by the Contractor. They shall be submitted to the Engineer for review when required, not less than three weeks prior to fabrication of the item to which they relate.

Welder qualification test certificates in accordance with the requirements of the relevant Indian Standards shall be submitted at the same time for all personnel who will be engaged on the work.

A list of all drawings, calculations and other documents shall be submitted for each structure with the first batch of drawings relating to that structure.

If in the opinion of the Engineer any design, drawing, welding procedure or welder test certificate is unsatisfactory in any way whatsoever, the Contractor shall make such amendments as required by the Engineer.

Supply or fabrication of any item shall not commence until all calculations and drawings relating to the item have been reviewed and either accepted or accepted with comments. No variations from the reviewed drawings shall be carried out without the prior written approval of the Engineer. Notwithstanding any absence of comment by the Engineer, the Contractor shall remain fully responsible for the adequacy and accuracy of the work.

6. FABRICATION

6.1 General

Fabrication shall be carried out in accordance with the requirements of IS 800. Fabricated structural steel work shall be within the tolerances specified in IS 7215. The radius of re-entrant flame cuts shall be as large as possible but not less than 20mm, except in small members where this is impracticable.

Ends of columns shall generally be gas flame cut and ground where steelwork fabrication is carried out on site. For critical and highly stressed structures fabricated in off-site workshops, ends of columns shall be sawn square and base plate surface machined prior to welding, as called for on the design drawings. Joint assembly of column and base plate shall be jigged.

Frames, platforms, stairs and handrails shall be shop assembled in the largest units suitable for handling and transportation. All fabricated frames shall be suitably braced to prevent distortion during transit.

Where fillet welds to very thick column base plates are called for on the design drawings, preheating of the plate may be required to retard cooling rate and reduce shrinkage stresses and shall be incorporated in the welding procedures.

6.2 Identification
At all stages of fabrication, structural steel members shall be positively identified by a suitable marking scheme. For the purposes of marking for erection, every part shall be marked with a durable and distinguishing mark in such a way as not to damage the material. For small members which are delivered in bundles or crates, the required marking shall be done on small metal tags securely tied to the bundle.

6.3 Straightening

All materials shall be straight and, if necessary before being worked shall be straightened and/or flattened (unless required to be of curvilinear form) and shall be free from twists. Rolled Sections and plates shall be clean, free from kinks, bends or twists, and straight within the tolerances allowed by IS 1852 “Specification for Rolling and Cutting Tolerances for Hot Rolled Steel Products”. Where straightening is necessary, it may be carried out by mechanical means or by the application of a limited amount of localized heat. The temperature of heated areas, measured by methods approved by the Site Engineer shall not exceed 600°C. Rolled sections and plates with major defects shall be returned to Supplier for replacement.

6.4 Clearances

The erection clearance for ends of members with web cleats or end plates shall be not greater than 2 mm at each end. The erection clearance at ends of beams without web cleats and end plates shall be not more than 3 mm at each end but where for practical reasons, greater clearance is necessary, suitably designed seating approved by the Engineer shall be provided.

6.5 Cutting

Prior to cutting, all members shall be properly marked showing the requisite cut length/width, connection provisions e.g. location and dimensions of holes, welds, cleats, etc. Marking for cutting shall be done judiciously so as to avoid wastages or joints as far as possible.

Cutting shall be by sawing, shearing, cropping or machine or hand flame cutting. Hand flame cutting shall be used only where it is impractical to use machine flame cutting and for notching, or for the completion of the formation of slotted holes. Electric metal arc cutting shall not be permitted.

Cut edges shall be true to profile and be free from major notches and sharp edges and shall be dressed immediately by grinding.

Where members are notched to fit other members the notches shall be as small as practicable and chamfered at re-entrant corners with a minimum radius of 6 mm.

6.6 Holes

All holes for fasteners or pins shall be drilled except as permitted otherwise herein. All matching holes for fasteners or pins shall register with each other so that fasteners can be inserted freely through the assembled members in a direction at right angles to the faces in contact.

Holes for ordinary bolts of property class below 8.8 in light roof members or other light framing and in connecting angles and plates other than splices, may be punched full size through material not thicker than the diameter of the hole, provided that the punching does not unduly distort the material.
Slotted holes shall either be punched in one operation or formed by drilling two holes and completed by cutting, grinding or filing the surface smooth. Burrs shall be removed from holes before assembly except that where holes are drilled in one operation through parts clamped together which would not otherwise be separated after drilling, they need not be separated to remove the burrs. For bolts not exceeding 24 mm diameter, holes shall be not more than 1.5 mm greater in diameter than the bolt and for bolts over 24 mm diameter, holes shall be not more than 2 mm greater in diameter than the bolts, except in steel base plates and where otherwise specified on the Drawings.

All matching holes for fasteners or pins shall register with each other so that fasteners can be inserted without undue force through the assembled members in a direction at right angles to the faces in contact. Drifts may be used but holes shall not be distorted. All unused drilled holes shall be plugged by welding.

### 6.7 Joints in Compression

Abutting surfaces dependent on contact for the transmission of load shall be within the specified tolerances.

### 6.8 Splicing

Splicing of built up/compound/latticed sections shall be done in such a fashion that each component of the section is jointed in staggered manner.

Where no butt weld is used for splicing, the meeting ends of two pieces of joint/channel/built up section shall be ground flush for bearing on each other and suitable flange and web splice plates shall be designed and provided for the full strength of the flange/web of the section and bolts/welds designed accordingly.

Where full strength butt weld is used for splicing (after proper edge preparation of the web and flange plates) of members fabricated out of joist/channel/built up section, additional flange and web plates shall be provided over and above the full strength butt welds, to have 40% strength of the flange and web.

Where a cover plate is used over a joist/channel/section the splicing of the cover plate and channel/joist section shall be staggered by minimum 500 mm. Extra splice plate shall be used for the cover plate and joist/channel section.

### 7. ERECTION

#### 7.1 General

Prior to erection, the Contractor shall carry out an inspection of the location and level of the prepared foundations and anchor bolts, and advise the Engineer of his findings.

Erection shall be carried out in accordance with the requirements of IS 800.

All components shall be erected within the specified tolerances and in such a manner so that they are not bent, twisted or otherwise damaged and the specified cambers are provided when required. Drifting to align holes shall not enlarge the holes or distort the metal. Holes which
cannot be aligned without distortion shall be a cause for rejection unless enlargement by reaming is specifically approved by the Engineer. Holes shall not be made by gas cutting.

Throughout the erection of the structure, the steel work shall be securely bolted or fastened in order to ensure that it can adequately withstand all loadings liable to be encountered during erection, including where necessary, those from erection plant and its operation. Any temporary bracing or temporary restraint shall be left in position until such time as erection is sufficiently advanced so as to allow its safe removal.

All connections for temporary bracings, members, etc. to be provided for erection purposes shall be so made that they do not weaken the permanent structure or impair serviceability.

No permanent bolting or welding shall take place until the steel work has been properly aligned and the erection has been approved by the Engineer.

Connected parts shall be firmly drawn together. If there is a gap remaining which may affect the integrity of the joint, the joint shall be remade after insertion of a suitable pack. Where parts cannot be brought together by drifting without distorting the steelwork, rectification may be made by reaming, provided the design of the connection will allow for larger diameter holes and bolts, and is approved by the design engineer.

### 7.2 Welding

#### 7.2.1 General

Welding of structural steel shall be in accordance with IS 9595 and IS 816.

For welded parts, all mating surfaces shall be sealed by welding against the ingress of moisture. Welding shall be carried out by suitably qualified welders who have satisfactorily completed the appropriate tests laid down in IS 7310. All welding shall be carried out under the direction of a competent Welding Technologist.

The minimum size of fillet weld shall be 6 mm.

The Contractor shall make necessary arrangement for providing sufficient number of welding sets of the required capacity, all consumables, cutting and grinding equipment with requisite accessories/auxiliaries, equipment and materials required for carrying out various tests such as dye penetration, magnetic particle, ultrasonic and the like.

Adequate protection against rain and strong winds shall be provided to the welding personnel and the structural members during welding operation. Welding shall not be carried out in the absence of such protection.

It shall be the responsibility of the Contractor to ensure that all welding is carried out in accordance with this specification and relevant IS Codes. The Contractor shall provide all the supervision to fulfill this requirement.

#### 7.2.2 Preparation of Member for Welding

##### 7.2.2.1 Edge Preparation
Edge preparation/leveling of the fusion faces for welding shall be done strictly in accordance with the dimensions shown in the drawings.

In case, the same are not indicated, edges shall be prepared (depending on the type of weld indicated in the drawing) in accordance with the details given in IS 9595. Leveling of fusion faces shall be approved by the Engineer. The tolerance on limits of gap, root face and included angle shall be as stipulated in IS 9595.

7.2.2.2 Cleaning

Welding edges and the adjacent areas of the members (extending up to 20 mm) shall be thoroughly cleaned of all oil, grease, scale and rust and made completely dry. Gaps between the members to be welded shall be kept free from all foreign matter.

7.2.2.3 Preheating

Preheating of members shall be carried out as per IS 9595 when the base metal temperature is below the requisite temperature for the welding process being used. Preheating shall be done in such a manner that the parts, on which the weld metal is being deposited, are above the specified minimum temperature for a distance of not less than 75 mm on each side of the weld line. The temperature shall be measured on the face opposite to that being heated. However, when there is access to only one face, the heat source shall be removed to allow the temperature equalization (1 minute for each 25 mm of plate thickness) before measuring the temperature.

7.2.2.4 Grinding

Column splices and butt joints of struts and compression members (depending on contact for load transmission) shall be accurately ground and close-butt end over the whole section with a tolerance not exceeding 0.2 mm locally at any place. In column caps and bases, the ends of shafts together with the attached gussets, angles, channels etc. shall be accurately ground so that the parts connected butt over minimum 90% surface of contact. In case of connecting angles or channels, care shall be taken so that these are fixed with such accuracy that they are not reduced in thickness by grinding by more than 2 mm. Ends of all bearing stiffeners shall be ground to fit tightly at both top and bottom. Similarly bottom of the knife edge supports along with the top surface of column brackets shall be accurately ground to provide effective bearing with a tolerance not exceeding 0.22 mm locally at any place.

Slab bases and caps shall be accurately ground over the bearing surfaces and shall have effective contact with the ends of stanchions. Bearing faces which are to be grouted need not be ground if such faces are true and parallel to the upper faces.

7.2.3 Welding Processes

Welding of various materials under this specification shall be carried out using one or more of the following processes.

- Manual Metal Arc Welding Process (MMAW)
- Submerged ARC Welding Process (SAW)
• Gas Metal Arc Welding Process (GMAW)
• Flux Cored Arc Welding Process (FCAW)

The welding procedure adopted and consumables used shall be specifically approved by the Engineer.

7.2.4 Non destructive testing of welds

Visual inspection shall be made in accordance with guidance given in IS 822 or BS 5289 after completion of all welding over the full length of the weld.

All NDT shall be performed by personnel qualified to a recognized national or international standard (e.g. PCN, ASNT Level II, etc.)

Magnetic particle inspection (MPI) shall be in accordance with the recommendations given in IS 5334 or BS 6072.

Dye penetrant inspection (DPI) may be used in accordance with the recommendations given in IS 3658 or BS 6443.

The test results shall be recorded and be available for inspection by the Engineer in charge. Where ultrasonic examination is required, it shall be made in accordance with IS 4260 or BS 3923 Part 1, level 2

7.3 Bolting

Tempering Bolts of property class 4.6 shall generally be used for all connections including bracing and column splices. However, for connections resisting large moments and forces, bolts of property class 8.8 shall be used with the prior approval of the Engineer.

Where necessary the connected parts shall be firmly drawn together. Steel packing plates shall be provided where necessary to ensure that the total remaining gap between adjacent surfaces does not exceed 2 mm.

The length of bolt shall be such that at least one clear thread shows above the nut after tightening and at least one thread plus the thread run out is clear between the nut and the unthreaded shank of the bolt. The threaded length shall be clear of the joint mating surfaces.

Washers shall be provided under the element (nut or bolt head) turned during tightening.

Nuts used on connections subject to vibration shall be secured to prevent loosening. Self-locking nuts shall be used or else the nuts shall be secured by the use of locknuts or upsetting of the threads of the bolts after assembly and tightening.

Bolts, nuts and washers used to connect metal sprayed or galvanized steel work shall be spun galvanized.

Where slotted holes are provided for movement connections, the joint shall be free to move. Areas of steel which will form the mating faces of a high strength friction grip joint or are to be concrete cased shall be unpainted and maintained in a clean condition and free from loose rust, oil, loose scale and other deleterious matter.
High tensile bolts to IS 1367 property class 8.8 shall be tightened in accordance with the manufacturer’s recommendations using a torque wrench which shall be calibrated at least once each working day.

The combination of bolts and nuts shall be not less than the following:

- 4.6 bolts with grade 4 nuts (IS-1363, IS-1367/BS 4190)
- 8.8 bolts with grade 8 nuts (IS-3757, IS-6623/BS 3692)

Any bolt assemblies which seize when being tightened shall be replaced.

Grade 4.6 and grade 8.8 bolts of the same diameter shall not be used in the same structure, except for holding down bolts.

The bolt length shall be chosen such that at least one thread plus the thread run-out will be clear between the nut and unthreaded shank of the bolt after tightening and at least one clear thread shall show above nut.

When the members being connected have surface protective treatment, a washer shall be placed under the nut or bolt head being rotated. A suitable plate washer shall be used under the head and nut when bolts are used to assemble components with oversize or slotted holes.

When the bolt head or unit is in contact with a surface which is inclined at more than 30 from a plane at right angles to the bolt axis, a taper washer shall be placed to achieve satisfactory bearing.

Galvanized Nuts – Nuts shall be checked after being galvanized for free running on the bolt and retapped if necessary to ensure a satisfactory tightening performance.

Ordinarily bolts Grade 4.6 to IS1367 shall be tightened to a “snug tight” fit. “Snug tight” is defined as tightness attained by a few impacts of an impact wrench or the full effort of a man using an ordinary spud wrench.

High tensile bolts Grade 8.8 to IS 3757 shall be tightened to a torque of approximately 85% of the proof load of the bolt, by means of a power or hand operated torque wrench. Bolts shall be tightened to the torques given in the following table.

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<td>M24</td>
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7.4 Protective Treatment

Steel shall be pre-treated and painted or galvanized. The protective treatment shall be carried out
after fabrication is complete. No welding, bolting or other work which may damage the protective treatment shall be carried out following painting.

7.5 Equipment

All equipment used in erection shall be provided by the Contractor, and shall be suitable for its purpose and of adequate capacity.

Equipment to be used shall include staging, ladders, and plant including temporary structures necessary to complete the erection.

7.6 Alignment

Each part of the structure shall be aligned as soon as practicable after it has been erected. Packs, shims and other supporting devices shall be flat, of adequate strength and rigidity and not larger than necessary. Where packings are to be left in position and subsequently grouted, they shall be placed such that they are totally enclosed by the grout.

7.7 Clearing Away

The Contractor shall periodically clean up as required by the Engineer to maintain a safe working environment and on completion of the work remove all rubbish, plant and surplus materials from the site of work, storage areas, to the satisfaction of the Engineer.

7.8 Safety and Security during Erection

The Contractor shall comply with IS 7205 for necessary safety and adhere to safe erection practice and guard against hazardous as well as unsafe working conditions during all stages of erection.

During erection, the steel work shall be securely bolted or otherwise fastened and when necessary, temporarily braced/guyed to provide for all loads including those due to the wind, erection equipment and its operation to be carried by the structure till the completion of erection.

No permanent bolting or welding shall be done until proper alignment has been achieved.

Proper accesses, platforms and safety arrangements shall be provided for working and inspection whenever required.

8. INSPECTION

8.1 General

Prior to inspection, all slag, loose scale, dirt, grit, weld spatter, paint, oil or other foreign matter shall be removed from the steel work. Welded connections shall not be painted prior to inspection.

8.2 Tests on Welding

The Contractor shall carry out the following non-destructive testing of welds at his own cost in the presence of the Engineer’s Inspector:

Butt Welds

Radiographic tests shall be carried out in accordance with IS 1182 or as appropriate, or ultrasonic tests in accordance with IS 4260 on a random 10% of the welds. Welds shall be accepted as
satisfactory if the defects are within the limits stated in IS 7310.

**Fillet Welds**

Liquid penetrant tests shall be carried out in accordance with IS 3658 or magnetic particle tests in accordance with IS 5334 on a random 5% of the welds. Welds shall be accepted as satisfactory the defects are within the limits stated in IS 7310.

If the results of the weld tests are unsatisfactory, the defective welds shall be repaired by methods approved by the Engineer. All repaired welds shall be re-tested.

For each weld which is judged to be unsatisfactory a further test shall be carried out on a different randomly selected weld.

In addition to the tests specified above the Contractor shall carry out such further tests as may be required by the Engineer. The Contractor will not be required to bear the costs of these further tests unless they reveal defective welds.

### 8.3 Scope and Frequency of Inspection

All welds shall be visually inspected along 100% of their length. NDT testing of welds for general steel structures is not required. For critical structures where connections are highly stressed, NDT inspection shall be performed on the following, and where called for on the design drawings:

- Fillet welds with throat thickness greater than 15 mm, shall be MPI tested.
- Fillet welds where the connecting material is greater than 20 mm, shall be MPI tested.
- Butt-welds where the connecting material is less than 20 mm, shall be DPI tested.
- Butt-welds where the connecting material is greater than 19 mm, shall be ultrasonically tested.

Non-destructive testing shall be carried out for the first ten identified joints of each type, having the same basic dimensions, material grade and weld geometry, welded to the same procedures. Thereafter one in ten joints of each type shall be tested.

Where welding is used during erection, random testing of welds by MPI/DPI shall be carried out at the discretion of the Site Engineer.

The acceptance criteria for any welding shall be in accordance with IS 9595 or BS 5135 Category A.

### 9. TOLERANCES

#### 9.1 General

Structural steel work shall be fabricated, and erected within the tolerances specified in IS 7215 and IS 12843 with the exception of those items specified below.
9.1.1 Permissible Deviations

The erection of steel framed structures shall be controlled in such a way that the following Permissible Deviations (PD) for the completed structure are not exceeded.

9.1.1.1 Position

<table>
<thead>
<tr>
<th>Item</th>
<th>P.D (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Permissible deviation between designed and actual position of any erected column at Base</td>
<td>± 8</td>
</tr>
<tr>
<td>b) Permissible deviation between designed and actual position of any erected column at Base</td>
<td></td>
</tr>
<tr>
<td>10m Centres</td>
<td>± 10</td>
</tr>
<tr>
<td>20m Centres</td>
<td>± 15</td>
</tr>
<tr>
<td>50m Centres</td>
<td>± 25</td>
</tr>
<tr>
<td>100m Centres and Over</td>
<td>± 40</td>
</tr>
</tbody>
</table>

9.1.1.2 Plumb

Unless otherwise specified, the level of a beam shall be taken as the top of the upper flange

a) Permissible deviation between designed and actual levels of the base of any column to erected

b) Permissible deviation between designed and actual levels of any beam at the junction with the column

When the beam is up to 6m from grade                                     ±5
When the beam is above 6m and upto 10m grade                              ±8
When the beam is above 10m from grade                                     ±12

| c) Not withstanding the above the maximum difference ±5 between the levels at the ends of a beam shall be: |
| For length of beam up to 6m between column centres                        ±4 |
| For length of beam up to 6m and up to 10m between column centres          ±6 |
| For length of beam above 10m between column centres                      ±8 |
10. STORAGE AND HANDLING

Fabricated parts shall be handled and stacked in such a way that permanent damage is not caused to the components. Means shall be provided to avoid damage to the protective treatment on the steel work.

All work shall be protected from damage in transit. Particular care shall be taken to stiffen free ends, prevent permanent distortion and protect all machined surfaces adequately.

11. RECOMMENDED SEQUENCE OF ERECTION PROCEDURE FOR ROOF TRUSS

Columns shall be bolted firm on the foundation, if they are in structural. Erection of truss shall start from one of gable ends.

After erection of gable truss, secure the gable truss in position by holding down bolts and tie it up with guy ropes two on either side of the truss. Guy ropes shall not be tied to the building columns, but to separate anchors driven firm into the ground. Erect the next truss adjacent to gable and secure it well with the gable truss through purlins before releasing the truss from erection tackles.

Secure rafter and tie level horizontal bracings, tie runners where these are provided before erecting the next truss.

Erect the next truss only after securing gable truss and the adjacent truss. Continue this procedure for all successive trusses.

12. PAINTING

12.1 General

Steelwork shall be prepared, primed and painted in accordance with the project Specification for painting. Steelwork to be galvanized shall be in accordance with IS 4759.

Paint shall be excluded from areas within 50mm of joints to be field welded. In order to minimize coating damage, all reasonable care shall be taken: 1) when handling steelwork between stages in painting, and 2) when slinging and loading steelwork which has received its final coat.

No material shall be shipped until the final shop coat of paint is thoroughly dry and clearly colour coded. Adequate packing, crating, blocking and/or bracing shall be provided to prevent damage to the fabricated material while loading, in transit and while unloading.

12.2 Touch-Up Painting

After complete erection, surfaces, areas damaged subsequent to shop painting shall be repaired in accordance with the Painting Specification. Any damage caused, during delivery and/or erection, to galvanized steel surfaces shall be repaired in accordance with Paint Specification.

13. HOLDING DOWN BOLTS

Bolts shall be turned from M.S. rounds conforming to IS 2062 and IS 432 grade 1. Nuts and washers shall conform to IS 1363 and IS 3138.
Threading shall be coarse conforming to IS 1367 and IS 4218
Sleeves shall be M.S. Tubes – medium to IS 1239.
For projection of bolt, property class and other relevant details reference design drawing shall be followed.

14 CHEQUERED PLATES & STRUCTURAL STEEL WORKS

Chequered plates shall be 6mm (7mm moreover chequers and shall conform to IS : 3502). Steel for chequered plate shall conform to IS : 2062 and shall be cut to shape and harmful surface defects, such as crack surface flaws etc., shall be removed or repaired. The plate shall be cut to shape and fixed to the bearing members as shown in relevant drawings and as directed by Engineer-in-Charge. The edges shall be made smooth, no burrs or gagged ends shall be left. The plates may be spliced with prior consent of the Engineer-in-Charge. But in that case, care should be taken so that there is continuity in the pattern of the plates between the portions. Lifting arrangements shall be provided including lifting rods. Grating shall be fabricated out of the basis of weight of M.S. Gratings/chequered plate and supporting frame actually laid. The work shall include supply of all necessary steel materials, cutting to size, fabricating, smoothing of edges if necessary, transporting and fixing at all positions, and providing lifting arrangements. It shall also include making openings of all sizes and supplying and painting 2 coats of anticorrosive paint over a coat of red oxide zinc chromate primer. The exposed surface of grating and frame shall be painted with two thick coats of coal tar or any other protective system indicated in the drawings, providing and laying M.S grating and frame, braking and making good existing concrete/brick masonry surface if necessary, finishing, painting, etc. Complete with all labour and materials.

16 EXPANSION FASTENERS

16.1 Material

Chemical Anchors shall be “HVA Type of HILTI” or equivalent with Galvanized Steel Grade 8.8 for anchor rod. Adhesive capsule shall be as per manufacturer’s specifications. Length, diameter, tensile (pull out) and shear capacity shall be as per manufacturer’s specifications and as per drawings.

16.2 Limitations

Chemical anchor shall not be used for:

- Members supporting equipments and pipes subjected to vibrations

- Cantilever connections designed to cater for effective cantilever spans greater than 1000 mm and 1000 kgs of concentrated load of the free end.

16.3 Selection

The CONTRACTOR shall submit to the Engineer-In-Charge manufacturer’s catalogues along with the specimen chemical anchor(proposed to be used for the job) for his selection and approval. Selected fasteners shall be capable to carry the specified loads.

16.4 Testing

If so required by the Engineer-In-Charge, the CONTRACTOR shall satisfy the Engineer-In-Charge by carrying out all the requisite tests (pullout test, torque test, etc) by
means of specimen chemical anchor (representative of those to be used) to demonstrate the adequacy of their strength and load carrying capacity. The cost of all such tests shall be borne by the CONTRACTOR.

16.5 Installation
The CONTRACTOR shall install the chemical anchor at their correct location (to suit the requirement of fixtures as shown in drawings) as per the procedure laid down by the manufacturer. Location of all holes shall be pre-mark on the concrete surfaces and than hole drilled carefully with an electric drill to the correct recommended size and depth. Holes shall be exactly round and true to the concrete surface. Edge distance and pitch of fasteners shall be as recommended by the manufacturer. Holes may be suitably shifted with the approval of the Engineer-In-Charge in case any reinforcement bar is met with while drilling the hole in RCC structure. Necessary staging shall be provided and the CONTRACTOR shall take requisite safety precautions so as not to cause any damage to the existing structure / equipment. Any damage done while, executing the job shall be made good by the CONTRACTOR at his cost.

16.6 Protection

The exposed surfaces of chemical anchor shall be properly covered with jute cloth so as to protect them from damage.