TECHNICAL SPECIFICATION FOR
STRUCTURAL STEEL WORKS

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Client | HINDUSTAN PETROLEUM CORPORATION LTD.
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MMCI Project No. | 256324

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1 **Scope**

This specification covers the requirements for material, storage, preparation of fabrication drawings, fabrication, assembly, tests/examinations, transportation, erection and painting of all types of bolted and/or welded structural steel works for general construction work. Fabrication of structures shall also include fabricating:

a) Built up sections/plate girders made out of rolled section and/or plates.

b) Compound sections made out of rolled sections.

2 **Reference**

2.1 **BIS Codes**

<table>
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<tr>
<th>Code Number</th>
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<tr>
<td>IS: 800 : 2007</td>
<td>Code of Practice for general construction in Steel</td>
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<td>IS: 806 : 1968</td>
<td>Code of Practice for USE OF Steel Tubes in General Building Construction</td>
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<td>IS: 808 : 1989</td>
<td>Dimensions for Hot Rolled Steel Beam, Column, Channel and Angle Sections</td>
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<td>IS: 1182 : 1983</td>
<td>Recommended practice for radiographic examination of fusion welded butt joints in steel plates</td>
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<tr>
<td>IS: 1363 Part 1 &amp; 3 : 2002</td>
<td>Black Hexagonal Headed Bolts, Screws, Nuts &amp; Locknuts of Product Grade C- Hexagon Head Bolts (M5-M64)</td>
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<tr>
<td>IS: 1367 Part 1 To 3 &amp; 5 To 7 : 2002</td>
<td>Technical Supply Conditions for Threaded Steel Fasteners</td>
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<tr>
<td>IS: 1852 : 1985</td>
<td>Rolling and Cutting Tolerances for Hot Rolled Steel Products</td>
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<td>IS: 2062 : 1999</td>
<td>Steel For General Structural Purposes- Specification</td>
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<td>IS: 3502 : 1994</td>
<td>Specification For Steel Chequered Plates</td>
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<tr>
<td>IS: 3658 : 1999</td>
<td>Code of Practice for Liquid Penetrant Flaw Detection</td>
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<tr>
<td>IS: 3757 : 1985</td>
<td>High Strength Friction Grip Structural Bolts</td>
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<tr>
<td>IS: 4260 : 2004</td>
<td>Recommended Practice for Ultrasonic Testing of Butt Welds in Ferritic Steel</td>
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IS:5334 : 2003 Code of Practice for Magnetic Flaw Detection of Welds
IS:5369 : 1975 General Requirements for Plain Washers and Lock Washers.
IS:6639 : 2005 Specification for Hexagon Bolts for Steel Structures
IS:7215 : 1974 Tolerances for Fabrication Of Steel Structures
IS:7307 Part 1 : Approval Tests for Welding Procedures Part 1- Fusion Welding of Steel
IS:7310 Part 1 : Approval Tests for Welders working to Approved Welding Procedures Part 1- Fusion Welding of Steel
IS:7318 Part 1 : Approval Tests for Welders when Welding Procedure Approval is not required. Part 1- Fusion Welding of Steel
IS:8500 : 1991 Weldable structural steel (Medium and High Strength qualities)
IS:9595 : 1996 Recommendation for metal arc welding of carbon manganese steel
IS:12843 : 1989 Tolerances for Erection Of Steel Structures

2.2 In case of conflict between the clauses mentioned in this specification and those in the Indian Standards, this specification shall govern. Any special provision as shown or noted on the design drawings shall govern over the provisions of this specification.

3 Materials

3.1 Structural Steel
3.1.1 All structural steel shall be of tested quality. The material of all Indian rolled section and plates shall conform to IS 2062 Grade – A designation Fe410WA specified therein.
3.1.2 Wherever the material is procured by the contractor, the contractor shall submit the test certificates conforming to the relevant Indian standards of all steel materials used for fabrication. All structural steel shall be free from blisters, rust, scales, seams, lamination, cracks, fissures and other surface defects.
3.1.3 Carbon steel pipes/tubes for structural purposes shall be as per IS: 1161 grade YST-25. In case mild steel is available according to latest IS: 2062, steel to grade A, B & C will be used as applicable.

3.2 Bolts and Nuts
Bolts and nuts shall conform to IS: 1363 or IS: 1364: 2002 as applicable and as shown in the drawing. Unless otherwise specified nuts and bolt heads shall be hexagonal. Property class of nuts and bolts shall be compatible. The contractor shall submit test certificates when called for. Wherever shown in the drawing high strength friction grip bolts (HSFG bolts) and nuts conform to IS: 3757 and IS: 6623: 2004 respectively shall be used. Nuts shall be of at least the strength grade appropriate to the grade of bolts or other threaded elements with which they are used.
3.3 **Washers**

Plain washers shall be made of mild steel conforming to IS: 5369 unless noted otherwise. Minimum one washer shall be supplied for each bolt and in case of special types of bolts more than one washer as required for the purpose shall be supplied. Helical spring washer conforming to IS: 6755: 1980 shall be provided for bolts carrying dynamic or fluctuating loads and those in direct tension. Tapered washers conforming to IS: 5372 & IS: 5374 shall be used for channels & beams respectively. Washers for high strength friction bolts shall conform to IS: 6649: 1985.

3.4 **Welding Consumables**

3.4.1 Covered electrodes (for metal arc welding of structural steel) shall conform to IS: 814 & IS: 2062.

3.4.2 Filler rods & wires for gas welding shall conform to IS: 1278: 1972.

3.4.3 Base wire electrodes (in submerged arc welding of structural steel) shall conform to IS: 7280: 1974. The combination of wire and flux shall comply with the requirements of IS: 3613: 1974.

3.4.4 Filler rods & base electrodes (for gas shield arc welding of structural steel) shall conform to IS: 6419: 1996.

3.4.5 Welding consumables & 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.

3.5 **Steel Gratings, Stair Treads & Chequered Plates**

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

3.5.2 Steel chequered plates shall conform to IS: 3502.

3.6 **Receipt & Storing of Materials**

3.6.1 Each section shall be marked for identification and each lot shall be accompanied by manufacturer's test/quality certificate, chemical analysis and mechanical characteristics.

3.6.2 All sections shall be checked, sorted out and arranged by grade and quality in the store. Any instruction given by the Engineer-in-Charge in this respect shall be strictly followed.

3.6.3 All material shall be free from surface defects such as pitting, cracks, laminations, twists etc. Defective material shall not be used and all such rejected material shall be immediately removed from the store/site. The decision of the Engineer-in-Charge in this regard shall be final and binding.

3.6.4 Welding wires and electrodes (packed in their original cartons) shall be stored separately by quality and lots inside a dry and enclosed room in compliance with IS: 9595 and as per the instructions given by the Engineer-in-Charge. Electrodes shall be kept perfectly dry to ensure satisfactory operation and weld metal soundness.

3.6.5 Each lot of electrodes, bolts, nuts etc. shall be accompanied by manufacturer's quality/test certificates.

3.6.6 All bolts (including nuts & washers) shall be checked, sorted out and arranged diameter-wise by grade and quality in the store.

3.7 **Material Tests**

3.7.1 The Contractor shall submit manufacturers' quality certificates for all the materials supplied by him. In case, quality certificates are not available or are incomplete or when material quality differs from standard specifications, such materials shall not be used in the construction. However, the Contractor shall get all appropriate tests conducted in approved test houses for such materials as directed by the Engineer-in-Charge, at no extra cost, and
submit the same to Engineer-in-Charge for his approval. The MMCI/HPCL Engineer-in-Charge may approve the use of such materials entirely at his discretion.

3.7.2 The Contractor shall ensure that all materials brought to site are duly approved by the MMCI/HPCL Engineer-in-Charge. Rejected materials shall not be used and shall be removed from site forthwith. Any material of doubtful quality for which specific tests are to be carried out as per the instruction of the MMCI/HPCL Engineer-in-Charge shall be separately stacked and properly identified and shall not be used. These shall be removed from site forthwith.

4 Fabrication Drawings

4.1 Fabrication and erection drawings shall be prepared by the Contractor on the basis of "Approved for Construction (AFC)" design drawings, MMCI Standards issued to the Contractor. These drawings conforming to IS: 800 shall be prepared by the Contractor or by an agency appointed by the Contractor and approved by the MMCI/HPCL Engineer-in-Charge.

4.2 Fabrication and erection drawings shall be thoroughly checked, stamped "Approved for Construction" and signed by the Contractor's own responsible Engineer irrespective of the fact that such drawings are prepared by the Contractor or his approved agency, to ensure accuracy and correctness of the drawings. Unchecked and unsigned drawings shall not be used for the purpose of proceeding with the work. The Contractor shall proceed with the fabrication and erection work only after thoroughly satisfying himself in this regard.

4.3 All fabrication and erection drawings shall be issued for construction by the Contractor directly to his work-site. Six copies of such drawings shall simultaneously be submitted to the MMCI/HPCL Engineer-in-Charge 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 MMCI/HPCL Engineer-in-Charge. The fabrication of such structures shall be done only as per the reviewed fabrication drawings.

The review of such drawings by MMCI shall be restricted to the checking of the following only:

i) Structural layout, orientation and elevation of structures members,

ii) Sizes of members,

iii) Critical joint details.

4.4 Fabrication drawings shall be drawn to scale and shall convey the information clearly and adequately. Following information shall be furnished on such drawings:

- Reference to design drawing number (along with revision number) based on which fabrication drawing has been prepared.

- Structural layout, elevations & sections (with distinct erection marking of all members).

- Framing plans, member sizes, orientation and elevations.

- Layout and detailing of rain water pipes and gutters showing all necessary levels, connections and provisions wherever required.

- Detailing of field joints, connections, splices, for required strength and erection. Location, type, size and dimensions of welds and bolts.

- Shapes and sizes of edge preparation for welding.

- Details of field joints/welds.

- Bill of materials/D.O.D. Lists.
4.5 The Contractor shall additionally ensure accuracy of the following and shall be solely responsible for the same:

i) Provision for erection and erection clearances.

ii) Marking of members

iii) Cut length of members

iv) Matching of joints and holes.

v) Provision kept in the members for other interconnected members.

vi) Bill of materials/D.O.D. Lists.

4.6 Connections, splices and other details where not shown on the design drawings shall be suitably designed and shown on the fabrication drawings based on good engineering practice developing full member strength. Design calculations for such connections/splices shall be submitted to the MMCI/HPCL Engineer-in-Charge along with the fabrication drawings.

4.7 Any substitution or change in section shall be allowed only when prior written approval of the MMCI/HPCL Engineer-in-Charge has been obtained. Fabrication drawings shall be updated incorporating all such substitutions/changes by the Contractor at no extra cost to the Owner.

4.8 In case during execution of the work, the MMCI/HPCL Engineer-in-Charge on review of drawings considers any modifications/substitutions necessary to meet the design parameters good engineering practice, these shall be brought to the notice of the Contractor who shall incorporate the same in the drawings and works without any extra cost to the owner. The Contractor will be totally responsible for the correctness of the detailed fabrication drawings and execution of the work.

4.9 Contractor shall incorporate all the revisions made in the design drawings during the course of execution of work in his fabrication drawings, and resubmit the drawings at no extra cost to the Owner. All fabrication shall be carried out only as per the latest AFC design drawings and corresponding fabrication drawings.

4.10 The Contractor shall supply two prints each of the final/as built drawings along with their transparencies to MMCI/HPCL Engineer-in-Charge for reference and record. The rates quoted shall include for the same.

5 Fabrication

5.1 General

5.1.1 Fabrication of structures shall be done strictly as per "Approved for Construction" fabrication drawings (prepared by the Contractor based on the latest design drawings) and in accordance with IS: 800, 9595 & other relevant BIS Codes and BIS Hand Book SP: 6(1).

5.1.2 Prior to commencement of structural fabrication, undulations in the fabrication yard, if any, shall be removed and area leveled and paved by the Contractor.

5.1.3 Any defective material used in the work shall be replaced by the Contractor at his own expense. Necessary care and precautions shall be taken so as not to cause any damage to the structure during any such removal and replacement.
5.1.4 Any faulty fabrication pointed out at any stage of work by the MMCI/HPCL Engineer-in-Charge, shall be made good or replaced by the Contractor at his own cost.

5.1.5 Tolerances for fabrication of steel structures shall be as per IS: 7215.

5.2 Fabrication Procedure

5.2.1 Straightening & Bending

5.2.1.1 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.

5.2.1.2 Bending of rolled sections and plates shall be done by cold process to shape/s as shown on drawings.

5.2.2 Clearances

The erection clearance for cleated ends of members shall be not greater than 2mm at each end. The erection clearance at ends of beams without web cleats and end plates shall be not more than 3mm at each end but where for practical reasons, greater clearance is necessary, suitably designed seatings approved by the MMCI/HPCL Engineer-in-Charge shall be provided.

5.2.3 Cutting

5.2.3.1 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 unnecessary joints as far as practicable. Marking shall be done by placing the members on horizontal supports/pads in order to ensure accuracy. Marking accuracy shall be limited to + 1mm.

5.2.3.2 Cutting may be affected by shearing, cropping or sawing. Gas cutting by mechanically controlled torch shall be permitted for mild steel. Hand flame cutting may be permitted subject to the approval of the MMCI/HPCL Engineer-in-Charge.

5.2.3.3 Except where the material is subsequently joined by welding, no loads shall be transmitted into metal through a gas cut surface.

5.2.3.4 Shearing, cropping and gas cutting shall be clean, square, free from any distortion & burrs, and should the MMCI/HPCL Engineer-in-Charge find it necessary, the edges shall be ground afterwards, to make the same straight and uniform at no extra cost to the Owner.

5.2.4 Holing

5.2.4.1 Holes for bolts shall not be formed by gas cutting process.

5.2.4.2 Holes through more than one thickness of material of members such as compound stanchions and girder flanges shall, where possible, be drilled after the members are assembled and tightly clamped/bolted together. Punching may be permitted before assembly, provided the thickness of metal is less than 16 mm and the holes are punched 3 mm less in diameter than the required size and reamed, after assembly, to the full diameter. Punching shall not be adopted for dynamically loaded structures.

5.2.4.3 Holes may be drilled in one operation through two or more separable parts and burrs removed from each part after drilling.

5.2.4.4 Holes in connecting angles and plates, other than splices, also in roof members and light framing, may be punched full size through material not over 12 mm thick, except where required for close tolerance bolts or barrel bolts.

5.2.4.5 All matching holes for black bolts shall register with each other so that a gauge of 2 mm less in diameter than the diameter of hole shall pass freely through the assembled members in the direction at right angle to such members. Finished holes shall be not more than 2 mm in diameter larger than the diameter of the black bolt passing through them, unless otherwise specified by the MMCI/HPCL Engineer-in-Charge.

5.2.4.6 Holes for turned and fitted bolts shall be drilled to a diameter equal to the nominal diameter
of the shank or barrel subject to H8 tolerance specified in IS: 919. Parts to be connected with close tolerance or barrel bolts shall be firmly held together by tack bolts or clamps and the holes drilled through all the thicknesses in one operation and subsequently reamed to size. Holes not drilled through all the thicknesses in one operation shall be drilled to a smaller size and reamed out after assembly. Where this is not possible, the parts shall be drilled and reamed separately.

5.2.4.7 To facilitate grouting, holes shall be provided in column bases or seating plates exceeding 300mm in width for the escape of air.

5.2.4.8 To avoid accumulation of water in gusseted column bases of laced, battened or box type stanchions, suitable reverse U-type holes shall be provided at the junction of base plate and column section in the vertical gussets for draining out of any water.

5.2.5 Assembly
The component parts shall be assembled and aligned in such a manner that they are neither twisted nor otherwise damaged, and shall be so prepared that the required camber, if any, is provided. Proper clamps, clips, jigs and other fasteners (bolts and welds) shall be placed in a balanced pattern to avoid any distortion in the members and to ensure their correct positioning (i.e. angles, axes, nodes etc.). Any force fitting, pulling/stretching of members to join them shall be avoided. Proper care shall be taken for welding shrinkage & distortion so as to attain the finished dimensions of the structure shown on the drawings.

5.2.6 Welding
5.2.6.1 General
a) All joints shall be welded unless noted otherwise on the design drawings.
c) 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 & materials required for carrying out various tests such as dye penetration, magnetic particle, ultrasonic etc.
d) Adequate protection against rain, dust, snow & strong winds shall be provided to the welding personnel and the structural members during welding operation. In the absence of such a protection no welding shall be carried out. It shall be the responsibility of the Contractor to ensure that all welding is carried out in accordance with the terms of this specification and relevant BIS codes. The Contractor shall provide all the supervision to fulfill this requirement.

5.2.6.2 Preparation of Member for Welding
a) Edge Preparation
Edge preparation/beveling of fusion faces for welding shall be done strictly as per 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) as per the details given in IS: 9595. Beveling of fusion faces shall be got checked and approved by the MMCI/HPCL Engineer-in-Charge. The tolerances on limits of gap, root face & included angle shall be as stipulated in IS: 9595.
b) Cleaning
Welding edges and the adjacent areas of the members (extending up to 20mm) 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.
c) 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 75mm 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 for temperature equalization (1 minute for each 25mm of plate thickness) before measuring the temperature.

d) **Grinding**

i. Column splices & butt joints of struts and compression members (depending on contact for load transmission) shall be accurately ground and close-butted over the whole section with a tolerance not exceeding 0.2mm locally at any place. In column caps & 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.

ii. 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 0.2 mm locally at any place.

iii. 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 direct to foundations need not be ground if such faces are true & parallel to the upper faces.

### 5.2.6.3 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)
- Submerge 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 MMCI/HPCL Engineer-in-Charge. A combination of different welding processes or a combination of electrodes of different classes/makes may be employed for a particular joint only after qualifying the welding procedures to be adopted and obtaining the written approval of the MMCI/HPCL Engineer-in-Charge. Welding procedure shall cover the following:

i) Type and size of electrodes

ii) Position of welding

iii) Current and arc voltage

iv) Length of run per electrode or (for automatic welding) speed of travel of electrode

v) Number of run in multipass welds and arrangement

vi) Preparation of the parts

vii) Welding sequence

viii) Pre or post heating

### 5.2.6.4 Approval & Testing of Welders
The Contractor shall satisfy the MMCI/HPCL Engineer-in-Charge that the welders are suitable for the work upon which they will be employed. For this purpose the welders shall have satisfied the relevant requirements of IS: 7318 / ASME Section IX- 2007. If the welders will be working to approved welding procedures, they shall have satisfied the relevant requirements of IS: 7310 / ASME Section IX- 2007.

Adequate means of identification shall be provided to enable each weld to be traced to the welder by whom it was made. The Contractor shall intimate the MMCI/HPCL Engineer-in-Charge sufficiently in advance, the commencement of tests, to enable him to be present to witness the same.

5.2.6.5 Approval & Testing of Welding Procedures

The Contractor shall carry out procedure tests in accordance with IS: 7307 / ASME Section IX-2007 to demonstrate by means of a specimen weld of adequate length on steel representative of that to be used, that he can make welds with the welding procedure to be used for the work to the complete satisfaction of the MMCI/HPCL Engineer-in-Charge. The test weld shall include weld details from the actual construction and it shall be welded in a manner simulating the most unfavorable instances of fit-up, electrode condition etc., which are anticipated to occur on the particular fabrication. Where material analysis is available, the welding procedure shall be carried out on material with the highest carbon equivalent values.

After welding, but before the relevant tests given in IS: 7307 / ASME Section IX- 2007 are carried out, the test weld shall be held as long as possible at room temperature, but in any case not less than 72 hours, and shall then be examined for cracking. The examination procedure shall be sufficiently rigorous to be capable of revealing significant defects in both parent metal and weld metal.

After establishing the welding method, the Contractor shall finally submit to the MMCI/HPCL Engineer-in-Charge for his approval the welding procedure specification in standard format given in IS: 9595 / ASME Section IX- 2007 before starting the fabrication.

5.2.6.6 Sequence of Welding

a) As far as practicable, all welds shall be made in a sequence that will balance the applied heat of welding while the welding progresses.

b) The direction of the general progression in welding on a member shall be from points where the parts are relatively fixed in position with respect to each other towards points where they have a greater relative freedom of movement.

c) All splices in each component part of a cover-plate d beam or built up member shall be made before the component part is welded to other component parts of the member.

d) Joints expected to have significant shrinkage shall be welded before joints expected to have lesser shrinkage.

e) Welding shall be carried continuously to completion with correct number of runs.

f) The Contractor shall choose the welding sequence after carefully studying each case such as to minimize distortion and shrinkage & submit the same to the Engineer-in- Charge for comments and approval.

g) The welding seams shall be left to cool slowly. The CONTRACTOR shall not be allowed to cool the welds quickly by any other method.

h) For multipass welding, before welding the following layer the formerly welded layer shall be cleaned metal bright by light and wire brushing.

5.2.6.7 Welding Technique

a) After the fusion faces are carefully aligned and set with proper gaps, the root pass of butt joints shall be executed properly so as to achieve full penetration with complete fusion of the root edges.
b) On completion of each run all slag and spatters shall be removed and the weld and the adjacent base metal shall be cleaned by wire brushing and light chipping. Visible defects such as cracks, cavities and other deposition faults, if any, shall be removed to sound metal before depositing subsequent run of weld.

c) All full penetration butt welds shall be completed by chipping/gouging to sound metal and then depositing a sealing run of weld metal on the back of the joints. Where butt welding is practicable from one side only, suitable backing steel strip shall be used and joint shall be arranged in such a way as to ensure that complete fusion of all the parts is readily obtained.

d) While welding is in progress care shall be taken to avoid any kind of movement of the components, shocks, vibrations to prevent occurrence of weld cracks.

e) Any deviation desired from the recommended welding technique and electrodes shall be adopted only after obtaining written approval of the MMCI/HPCL Engineer-in-Charge.

5.2.6.8 Inspection & Testing of Welds

The method of inspection shall be according to IS: 822: 1970 and extent of inspection and testing shall be in accordance with the relevant applicable standard or, in the absence of such a standard, as specified by the MMCI/HPCL Engineer-in-Charge. Welds shall not be painted or otherwise obscured until they have been inspected, approved and accepted.

The MMCI/HPCL Engineer-in-Charge or his representative shall have access to the Contractor's work at all reasonable times and the Contractor shall provide him with all facilities necessary for inspection during all stages of fabrication and erection with, but not limited to, the following objectives.

i) To check the conformity with the relevant standards and suitability of various welding equipments and their performance.

ii) To witness/approve the welding procedure qualification.

iii) To witness/approve the welders performance qualification.

iv) To check whether field welding being executed is in conformity with the relevant specifications and codes of practice.

Inspection and testing of all fabricated structures shall be carried out by the Contractor by any, or, a combination of all the following methods as directed by the MMCI/HPCL Engineer-in-Charge and no separate payment shall be made, unless otherwise mentioned, for inspection and testing of welds/fabricated structures:

A. Visual Inspection

a. All finished welds (i.e. 100 percent) shall be visually inspected for identification of the following types of weld defects & faults.

b. Weld defects occurring at the surface such as blow holes, exposed porosity, unfused welds etc.

c. Surface cracks in the weld metal or in the parent metal adjacent to it.

d. Damages to the parent metal such as undercuts, burning, overheating etc.

e. Profile defects such as excessive convexity or concavity, overlapping, unequal leg lengths, excessive reinforcement, incompletely filled grooves, excessive penetration beads, root grooves etc.

f. Distortion due to welding i.e., local shrinkage, camber, bowing, twisting, rotation, wariness etc.

g. Linear eccentric, angular and rotational misalignment of parts.

h. Dimensional errors.
B. Mechanical Tests

The mechanical testing (such as tensile load tests, bend tests, impact tests etc.) shall be done in accordance with the relevant standards and as per the instructions of the MMCI/HPCL Engineer-in-Charge.

C. Magnetic Particle/Dye Penetration/Ultrasonic Examination:

The examination shall be done at random as directed by the MMCI/HPCL Engineer-in-Charge. Whenever such tests are directed, the tests shall be carried out on joints chosen by him. The tests shall be carried out by employing approved testing procedure in accordance with IS: 822 / ASME Section V-2007.

D. Radiographic Examination

Radiographic examination shall be carried out only in special cases for random joints as directed by the MMCI/HPCL Engineer-in-Charge. The Contractor shall be paid extra for such examination except for penalty radiographic tests for which the cost shall be borne by him. The Contractor shall make necessary arrangement at his own expense for providing the radiographic equipment, films and all other necessary materials required for carrying out the examination. The tests shall be carried in the presence of the MMCI/HPCL Engineer-in-Charge by employing approved testing procedure in accordance with IS: 822 / ASME Section V-2007. The Contractor shall fulfill all the statutory safety requirements while handling X-ray and Gamma-ray equipment and provide the Engineer-in-Charge all the necessary facilities at site such as dark room, film viewer etc., to enable him to examine the radiographs.

5.2.6.9 Repair of Faulty Welds

No repair of defective welds shall be carried out without proper permission of the MMCI/HPCL Engineer-in-Charge and his approval for the corrective procedure.

Welds not complying with the acceptance requirements (as specified by BIS Codes & the MMCI/HPCL Engineer-in-Charge), as revealed during inspection & testing of welds or erection or in-situ condition shall be corrected either by removing & replacing or as follows:

a) Excessive convexity
   Reduced to size by removal of excess weld metal.

b) Shrinkage cracks, cracks in parent plates and craters
   Defective portions removed down to sound metal and rewelded

c) Under cutting
   Additional weld metal deposited.

d) Improperly fitted/ misaligned parts
   Welding cut & edges suitably prepared and parts.

e) Members distorted by heat of welding
   Member straightened by mechanical means or careful application of limited amount of heat.

Temperature of such area shall be less than 650 degree Centigrade (dull red heat).

In removing defective parts of a weld, gouging, chipping, oxygen cutting or grinding shall not extend into the parent metal to any substantial amount beyond the depth of weld penetration, unless cracks or other defects exist in the parent metal. The weld or parent metal shall not be undercut in chipping, grinding, gouging or oxygen cutting.

Any fabricated structure or its component which in the opinion of MMCI/HPCL Engineer-in-Charge is defective and/or beyond any corrective action shall be removed forthwith from the site as instructed by the MMCI/HPCL Engineer-in-Charge without any extra claim. The owner reserves the right to recover any compensation due to any loss arising out of such rejections.

5.2.7 Bolting

5.2.7.1 All bolts shall be provided such that no part of the threaded portion of the bolts is within the thickness of the parts bolted together. Washers of suitable thickness shall be used under the
nuts to avoid any threaded portion of the bolt being within the thickness of parts bolted together.

5.2.7.2 The threaded portion of each bolt shall project through the nut at least one thread.

5.2.7.3 Flat washers shall be circular and of suitable thickness. However, where bolt heads/nuts bear upon the beveled surfaces, they shall be provided with square tapered washers of suitable thickness to afford a seating square with the axis of the bolt.

5.2.8 Splicing

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

5.2.8.2 Where no butt weld is used for splicing, the meeting ends of two pieces of joist/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 welds designed accordingly.

5.2.8.3 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/angles/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.

5.2.8.4 Where a cover plate is used over a joist/channel section the splicing of the cover plate and channel/joist sections shall be staggered by minimum 500mm. Extra splice plate shall be used for the cover plate and joist/channel section as per clause 5.2.8.2 or 5.2.8.3.

5.2.8.5 Prior approval shall be obtained by the Contractor for locations of splices where not shown on design drawings. Only a single splice at approved location shall be allowed for members up to a length of 6 to 7m. Maximum two numbers of splices shall be allowed for members exceeding this length.

5.2.9 Machining & Grinding

5.2.9.1 All slab bases and slab caps shall be accurately machined over the bearing surfaces and shall be in effective contact with the ends of column sections (shafts).

5.2.9.2 For slab bases and slab caps, ends of column shafts shall be accurately machined. However, for gusseted bases and caps, the column shafts shall be ground flush for effective contact with parts connected together.

5.2.9.3 Gusseted bases and caps shall be ground flush for effective contact with ends of column sections.

5.2.9.4 End of all bearing stiffeners shall be machined or ground to fit tightly at top and bottom without any air gap.

5.2.9.5 While machining or grinding care shall be taken so that the length or thickness of any part does not get reduced by more than 2.0 mm.

5.2.9.6 For all machining or grinding works for gusseted base and cap plates, the clearance between the parts joined shall not exceed 0.2 mm at any location.

6 Site (Field) Erection

6.1 Plant & Equipment

The suitability and capacity of all plant and equipment used shall be to the complete satisfaction of the MMCI/HPCL Engineer-in-Charge.

6.2 Storing & Handling
All steel work shall be so stored and handled at site so that the members are not subjected to excessive stresses and any damage.

**6.3 Setting Out**

One set of reference axes and one bench mark level shall be furnished to the Contractor. These shall be used for setting out of structures.

The Contractor shall assume complete responsibility for correct setting out of all steel work, erecting it correctly as per alignment / levels shown in the drawings and plumb (verticality) of vertical members.

**6.4 Tolerances**

Tolerances for erection of steel structures shall be as per Annexure ‘A’

**7 Safety & Security During Erection**

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

7.2 During erection, the steel work shall be securely bolted or otherwise fastened and when necessary, temporarily braced/guyed to provide for all loads to be carried by the structure during erection till the completion, including those due to the wind, erection equipment & its operation etc. at no extra cost to the owner. For the purpose of guying, the Contractor shall not use other structure in the vicinity without prior written permission of the MMCI/HPCL Engineer-in-Charge.

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

7.4 Proper access, platform and safety arrangement shall be provided for working and inspection, (at no extra cost to the owner) whenever required.

**8 Field Connections**

**8.1 Field Bolting**

Field bolting shall be carried out with the care as explained above.

**8.2 Field Welding**

All field assembly and welding shall be executed in accordance with the requirements for shop assembly and welding. Holes made for all erection bolts- where removed after final erection shall be plugged by welding. Alternatively erection bolts may be left and secured.

**9 Scheme and Sequence of Erection**

The Contractor shall furnish the detailed scheme and sequence of erection to match with the project schedule and get the same approved by the MMCI/HPCL Engineer-in-Charge. All necessary coordination and synchronization shall be done with the civil contractor where civil works are not included in the scope of structural contractor at no extra cost so as to match with the project schedule.

**10 Payment**

This clause shall apply to Item Rate tender only.

10.1 Payment for structural steel works shall be made on the basis of admissible weight in metric tons (determined as described in clause 17.2 and 17.3) of the structure accepted by the MMCI/HPCL Engineer-in-Charge. The rate shall include supplying (as per supply conditions given in the Tender) fabricating, erecting in position (at all levels & locations), testing/examining (excluding radiography only) of bolted and/or welded structural steel works
of all types (including all built up/compound sections made out of rolled sections and/or plates) including all handling, transporting, storing, straightening if required, cutting, edge preparation, preheating, bolting and welding of joints (including sealing the joints of box sections with continuous welding), finishing edges by grinding/machining as shown, fixing in line & level with temporary staging & bracing and removal of the same after erection, grouting with non-shrink/ordinary grout as specified, preparation of fabrication & erection drawings, erection schedule and getting them reviewed, preparation and submission of as built drawings, as built drawings, preparing the surfaces for painting, surface cleaning, wire brushing, removal of mill scale, dust, rust, oil or grease and applying one coat of red oxide zinc chromate primer or any other primer as specified after fabrication, return of surplus materials to owner's stores and material reconciliation in the case of materials supplied by the owner as per relevant contract conditions etc. all complete for all the operations mentioned in the foregoing clauses.

The weight for payment shall be determined from the fabrication drawings and respective bill of materials prepared by the Contractor. The bill of materials shall be checked and approved by the MMCI/HPCL Engineer-in-Charge before making the payment. The Contractor shall prepare full scale template in order to supplement/verify the actual cutting dimensions where so directed by the MMCI/HPCL Engineer-in-Charge. The weight shall be calculated on the basis of BIS Code/Hand Book wherever applicable. In case sections used are different from BIS sections, then Manufacturers’ Hand Book shall be adopted. No allowance in weight shall be made for rolling tolerances.

Welds, bolts, nuts, washers, shims, pack plates, wedges, grout shall not be separately measured. The quoted rate shall be deemed to include the same.

The rate shall include all expenses related to safety & security arrangements during erection and all plants & tools required for fabrication, transportation & erection.

11 Painting after Erection

11.1 Surface preparation by grit blasting

The grit blasting of the surface shall be carried out by compressed air and blasting gun. Clean screened grit of uniform size shall be used for blasting purpose.

For grit blasting, the surface shall be made free from mill scale, rust, grease, oil or other foreign material and shall appear to have foreign white base metal roughened texture to form good adhesion of the primer coating, conforming to Swedish Standards "Sa 2 ½".

Compressed air should be free from moisture and oil. The grit blasted surface shall be applied with primer coat within 3 to 4 hours or before any trace of oxidation appears on the cleaned surface.

11.2 Primer Application

All components and members of steel work shall be given one coat of Inorganic Zinc Silicate Epoxy primer. Primer coat shall be applied immediately after the surfaces have been properly prepared by grit blasting as explained above and cleaned. The primer coat shall be applied over completely dry surfaces (using brushes of good quality) in a manner so as to ensure a continuous and uniform film without "holidaying". Special care shall be taken to cover all the crevices, corners, edges etc. However, in areas which are difficult to reach by brushing, daubers/mops shall be used by dipping the same in paint and then pulling/ pushing them through the narrow spaces. The primer coat shall be air dried and shall have a minimum film thickness of 75 microns or (tolerance + 10%) after drying, as applicable.

11.3 Final Paint Application
11.3.1 After the primer is hard dry, the surfaces shall be lightly sand the primer surface with emery paper no.320 and clean the dust with dry cloth. Apply two coats of compatible Phinolic based epoxy paint coats at an interval of 16 – 20 hours.

Paint shall be applied by brushing/spraying so that a film free from "holidaying" is obtained. The colour & shade of first coat of paint shall be slightly lighter than the second coat in order to identify the application of each coat. The second coat of paint shall be applied after the first coat is hard dry. The minimum thickness of each coat shall be 75 microns (+ 10% tolerance) after drying.

The Contractor shall carry out the painting work in all respects with the best quality of approved materials (conforming to relevant BIS Codes) and workmanship in accordance with the best engineering practice. The Contractor shall furnish characteristics of paints (to be used) indicating the suitability for the required service conditions. The paint manufacturer's instructions supplemented by Engineer-in-Charge's direction if any shall be followed at all times. Particular attention shall be paid to the following:

- Proper storage to avoid exposure & extremes of temperature,
- Surface preparation prior to painting,
- Mixing & thinning.
- Application of paint and the recommended limit on time intervals between consecutive coats.

11.3.2 Painting shall not be done in frost or foggy weather, or when humidity is such as to cause condensation on the surfaces to be painted.

11.3.3 Primers & finish coat paints shall be from the same manufacturer in order to ensure compatibility. Painting colour code shall be as per Annexure-'B'.

11.3.4 Surfaces which are inaccessible after assembly, shall receive the full specified protective treatment before assembly (this shall not apply to the interior of sealed hollow sections).

11.3.5 Steel surfaces shall not be painted within a suitable distance of any edges to be welded if the paint specified would be harmful to welders or impair the quality of the welds.

11.3.6 Welds and adjacent parent metal shall not be painted prior to deslagging, inspection and approval by the Engineer-in-Charge.

11.3.7 Parts to be encased in concrete shall have only one coat of primer and shall not be painted after erection.

11.4 Payment

Payment for painting of structural steel works shall be made on the basis of admissible weight in metric tons of the painted structures accepted by the MMCI/HPCL Engineer-in-Charge.

The rate shall include supplying & applying two coats of epoxy paint of first quality and shade over a base prepared etc. all complete to the entire satisfaction of the MMCI/HPCL Engineer-in-Charge.
Annexure A: Maximum Permissible Erection Tolerances

A. Columns

1. Deviation of column axes at foundation top level with respect to true axes.
   
   i) In longitudinal direction ±5 mm
   
   ii) In lateral direction ±5 mm

2. Deviation in the level of bearing surface of columns at foundation top with respect to true level
   ±5 mm

3. Out of plumb (Verticality) of column axis from true vertical axis, as measured at top:
   
   i) Up to and including 30m height ±H/1000 or ±25 mm
      Whichever is less
   
   ii) Over 30m height ±H/1200 or ±35 mm
       Whichever is less.

4. Deviation in straightness in longitudinal & transverse planes of column throughout the height. ±H/1500 or ±10 mm
   Whichever is less.

5. Difference in the erected positions of adjacent pairs of columns along length or across width of building prior to connecting trusses/beams with respect to true distance. ±5 mm

6. Deviation in any bearing or seating level with respect to true level ±5 mm .

7. Deviation in difference in bearing levels of a member on adjacent pair of columns both across & along the building. ±5 mm

Note: 1. Tolerance specified under 3 should be read in conjunction with 4 & 5.

Note: 2. 'H' is the column height in mm.

B. Trusses

1. Shift at the centre of span of top chord member with respect to the vertical plane passing through the centre of bottom chord. ±1/250 of height of truss in mm at centre of span or ± 15 mm whichever is less.

2. Lateral shift of top chord of truss at the centre of span from the vertical plane passing through the centre of supports of the truss. ±1/1500 of span of truss in mm or ±10mm whichever is less.
3. Lateral shift in location of truss from its true position.  ±10mm
4. Lateral shift in location of purlin from its true position.  ±5mm
5. Deviation in difference of bearing levels of truss from the true level.  ±1/1200 of span of truss in mm or 20mm whichever is less.

C. Gantry Girders & Rails
1. Shift in the centre line of crane rail with respect to centre line of web of gantry girder.  ±(web thickness(mm)+2mm)/2
2. Shift of alignment of crane rail (in plan) with respect to true axis of crane rail at any point.  ±5mm
3. Deviation in crane track gauge with respect to true gauge.
   i) For track gauge up to and including 15 m.  ±5mm
   ii) For track gauge more than 15m.  ± [5+0.25 (S-15)] mm
      Subject to maximum ± 10 mm, where S in metres is true track gauge.
4. Deviation in the crane rail level at any point from true level.  ±10mm
5. Difference in levels between crane track rails (across the bay) at
   i) Supports of gantry girders  15 mm
   ii) Mid span of gantry girders  20 mm
6. Relative shift of crane rail surfaces at a joint in plan and Elevation transition  2 mm subject to grinding of surfaces for smooth
Annexure B: Painting Colour Code for Structural Steel

1. GANTRY GIRDER & MONORAIL    DARK GREEN
2. GANTRY GIRDER & MONORAIL STOPPER   SIGNAL RED
3. BUILDING STRUCTURAL STEEL COLUMNS, BRACKETS, BEAMS, BRACINGS, ROOF TRUSS, PURLINS, SIDE GIRTS, LOUVERS, STRINGERS   DARK ADMIRALITY, GREY
4. PIPE RACK STRUCTURE & TRESTLE    BLACK
5. CHEQUERED PLATE (BOTH FACES)   BLACK
6. GRATING   BLACK
7. LADDER    RUNGS - BLACK VERTICALS & CAGE RED
8. HAND RAILING
   - HANDRAIL, MIDDLE RAIL, TOE PLATE   SIGNAL RED
   - VERTICAL POST    BLACK

Note: These colours are provisional and should be confirmed with HPCL before execution.