

**S.07: STRUCTURAL STEEL WORKS****7.1 STRUCTURAL STEELWORK SPECIFICATIONS- GENERAL****7.1.1 Scope of Specification**

This specification covers the scope of work of structural steel works, submittals by the contractor, applicable codes of practice for structural steel work and the specifications for the materials to be used, including steel, bolts & nuts, washers etc. and the storage thereof. These specifications shall be read in conjunction with the CPWD specifications 2019, MORTH specifications and other relevant reference specifications described in the S.01 of Section-VII-F of these specifications.

**7.1.2 Scope of Work**

The scope of work for the contractor in respect of structural steel work shall cover, but shall not be limited to the following:

- A. Submittal of detailed design drawings, preparation of complete detailed fabrication drawings and erection marking drawing based on the design drawings, required for all the permanent and temporary structures
- B. Submittal of revised design with calculations and detailed fabrication drawings, in case any substitution of the designed sections is required.
- C. Submittal of design calculations for joints and connections to be developed by the contractor along with detailed fabrication drawings.
- D. Supply of all raw steel materials for fabrication, taking into account wastage margin, including storage and upkeep of the materials.
- E. Furnishing of all materials, labour, tools and plant and all consumables required for fabrication and supply of all necessary bolts, nuts, washers, tie rods and welding electrodes for field connections, with necessary wastage margins.
- F. Fabrication of the steel works in accordance with the approved fabrication drawings including all shop assembling, matching and marking. Design, manufacture / fabrication and provision of all jigs, fixings, manipulators etc. required for the fabrication.
- G. Provision of shop painting and requisite site painting to all fabricated steelwork, as per requirements of the related specification of the painting.
- H. Suitability marking, bundling and packing for transport of all fabricated materials. Preparing and furnishing detailed bill of materials, drawing office dispatch lists, bolts lists and any other lists of bought out items required in connection with the fabrication and erection of the structural steelwork.
- J. Loading, Transportation and unloading of all fabricated structural steel materials from site storage yard to erection site, handling, assembling, bolting, welding and satisfactory installation of all fabricated structural steel materials in proper location, according to approved erection drawings and/or as directed by the Engineer.
- K. The contractor shall submit, for examination by the Engineer, detailed particulars of his proposed methods of erection of the superstructure steelwork, together with complete calculations relating to strength and deflection. If the erection scheme necessitates the attachment of strength steelwork (temporary work) to the permanent steel work, the contractor shall submit, for approval of the Engineer, the methods he proposes for making good the permanent steelwork after removing the temporary work. The contractor shall also submit the design and fabrication drawings of all temporary supports, staging, braces etc. required for safe erection, for approval of the Engineer.
- L. The contractor shall provide all construction and transport equipment, tools, tackles, consumables, materials, labour and supervision required for the erection of the structural steelwork.
- M. Receiving, unloading, checking and moving to storage yard, storage, guarding and upkeep of fabricated steelwork and other consumable materials and fasteners at site.

- N. Transportation of all fabricated structural steel materials from site storage yard, handling, assembling, bolting, welding and satisfactory installation of all fabricated structural steel materials in proper location, according to approved erection drawings and/or as directed by the Engineer.
- O. Setting out, aligning, ensuring verticality (proper plumb), levelling, bolting, welding and securely fixing the fabricated steel structures in accordance with the erection scheme, or as directed by the Engineer.
- P. Provision of requisite site painting to all fabricated steelwork, as per requirements of related specifications of the painting.
- Q. Providing protective treatment to the erected steel structures, as per Specification.
- R. All major modifications of the fabricated steel structures, as directed by the Engineer, including but not limited to the following:
  - i) Removal of bends, kinks, twists etc. for parts damaged during transport and handling.
  - ii) Cutting, chipping, filling, grinding etc. if required or preparation and finishing of site connections.
  - iii) Reaming of holes for use of higher size bolt if required.
  - iv) Re-fabrication of parts damaged beyond repair during transport and handling or re-fabrication of parts which are incorrectly fabricated.
  - v) Fabrication of parts omitted during fabrication by error, or subsequently found necessary
  - vi) Drilling of holes which are either not drilled at all or are drilled in incorrect location during fabrication.
  - vii) Carry out tests in accordance with the related specification.
- S. Preparing and furnishing detailed bill of materials of fabricated parts received from the Client or its authorized fabricator.
- T. The Contractor shall observe all safety requirements for erection of structural steelwork as covered in IS: 7205.

### 7.1.3

#### **Submittals**

- A. On commencement of the Project, the Contractor shall submit the following:  
Prior to the technical submittals, the contractor shall submit the proposed overall schedule for documentation such as calculations, shop/ working drawings, plan/ procedures and records. Submission of samples, process of fabrication / delivery/ erection for the approval of the Engineer.

Complete fabrication drawings, material lists, cutting lists, bolt lists, welding schedules and QC schedules, based on the design drawings furnished to him and in accordance with the approved schedule. It is highlighted that structural steel members dimensions indicated in tender drawings are tentative only, and may be modified during final design stage.

Results of any tests, as and when conducted and as required by the Engineer.

Manufacturer's test reports in respect of steel materials, bolts, nuts and electrodes, as may be applicable.

A detailed list of all constructional plant & equipment, such as cranes, derricks, winches, welding sets, erection tools etc. their make, model, present condition and location, readily available with the contractor and the ones he will employ on the job to maintain the progress of work in accordance with the contract.

The total number of experienced personnel of each category, like fitters, welders, riggers etc., which he intends to deploy on the project.

- B. The contractor shall submit a detailed erection programme for completion of the work in accordance with contract. This will show, in a proforma approved by the Engineer, the target programme, with details of erection proposed to be carried out in each week, details of major equipment required and an assessment of required strength of various categories of workers.
- C. The contractor shall submit complete design calculations for any alternative sections proposed by him, for approval of the Engineer. Use of any alternative section shall be subject to approval of the Engineer. However, no escalation in unit rates of work shall be allowed for such cases.

#### 7.1.4 **Furnishing of Information**

- A. Design drawings shall be furnished by the contractor and all such drawings shall form part of these specifications.
- B. The Engineer reserves the right to make changes in the design drawings even after release for preparation of shop drawings to reflect addition, omission & modifications in data/details and requirements. Contractor shall consider such changes as part of these specifications and the contract, and no extra claims shall be entertained on this account.
- C. Design drawings, approved by the Engineer, will show as appropriate the salient dimensions, design loads, sizes of members, location of openings at various levels and other necessary information required for the preparation of fabrication drawings, designs and erection details.
- D. It shall be clearly understood that the drawings of the Engineer are design drawings. The typical details of connections, cuts, notches, bend, etc. where shown in the design drawings are only for general guidance of the contractor. The contractor shall design and develop all such details based on the design forces and functional requirements.
- E. In case of variations in design drawings and specifications, the decision of the Engineer shall be final. Should the contractor, find any discrepancy in the information furnished by the Engineer, same shall be immediately brought to the notice of Engineer for resolution. The contractor shall obtain clarifications on discrepancies from Engineer before proceeding with the work.
- F. No detailed shop drawings will be accepted for examination by the Engineer unless the same, have first been completely checked by the contractor's qualified structural engineer (independent agency to be appointed by contractor) and are accompanied by an erection plan showing the location of all pieces detailed. The contractor shall check and ensure that detailing of connections is carefully planned to obtain ease in erection of structures, including field-welded connections and/or bolting.
- G. No fabrication work shall be started by the contractor without having obtained approval of Engineer on the relevant drawings. Approval by the Engineer of any of the drawings shall not relieve the contractor of his responsibility to provide correct design of connections, workmanship, fit of parts, details, materials and errors or omissions of all work shown thereon. The approval of Engineer shall constitute approval of the size of members, dimensions and general arrangement, but shall not constitute approval of the connections between members and other details.
- H. Drawings, for approval, shall be submitted by the contractor in an orderly manner commensurate with erection sequence and approved construction programme.
- I. The contractor shall furnish ten prints of all approved final drawings for field use and record purpose.
- J. The drawings prepared by the Contractor, and all subsequent revisions thereof shall be at the cost of the Contractor, and no separate payments shall be made for the same. Revisions shall incorporate all modifications, field changes, substitutions etc. effected. The rates/prices quoted for fabrication work shall be deemed to include the cost of such drawing work.

- K. The Contractor shall give due consideration to the need of trial assemblage at shop, weight and size limitation of elements for transportation from shop to construction site, temperature variation of 25 degree centigrade between the fabrication shop and site, site measurements or the as-built dimensions and avoidance of site welding except for fixtures. All the drawings shall be prepared in metric units. The drawings should preferably be of A-1 standard size, and the details shown therein shall be clear /and legible. These drawings shall include but shall not be limited to the following:
- i) Assembly drawings, giving exact sizes of the sections to be used and identification marks of the various sections.
  - ii) Dimensional drawings of base plans (plates), anchorages detail in foundation, foundation bolts location etc.
  - iii) Complete bills of materials and detailed drawings of all sections including their billing weights.
  - iv) Shop details of temporary structures together with detailed calculations.
  - v) Detailed shop drawings for proper co-ordination with the concrete components to which the steel members shall be connected, as required.
  - vi) Any other drawings or calculations that may be required for proper completion of the works and clarification of the works or substituted parts thereof.
  - vii) All 'as-built' drawings.

#### 7.1.5 **Applicable Codes of Practice**

The following specifications, standards and codes are included as part of this Specification. All standards, specifications, codes of practice current on the date of signing of agreement and referred to herein shall be applicable

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|---------------------|--|
| 1. IS: 800 (2007)   | Code of Practice for General Construction in Steel.  |
| 2. IS: 808 (1989)   | Dimensions for Hot Rolled Steel Beam, Column, Channel and Angle Sections.                        |
| 3. IS: 814 (1991)   | Covered Electrodes for Manual Metal Arc Welding of Carbon & Carbon - Manganese Steel             |
| 4. IS: 816 (1969)   | Code of Practice for Use of Metal Arc Welding for General Construction / Mild Steel              |
| 5. IS: 817(1969)    | Code of Practice for Training and Testing of Metal Arc Welders.                                  |
| 6. IS: 919 (1993)   | ISO System of Limits & Fits (Part 1 & Part 2)  |
| 7. IS: 1148 (1982)  | Hot Rolled Rivet Bars (upto 40mm) for Structural Purposes.                                       |
| 8. IS: 1182 (1983)  | Recommended Practice for Radio Graphic Examination of Fusion Welded Butt Joints in Steel Plates. |
| 9. IS: 1363 (1992)  | Hexagon Head Bolts, Screws and Nuts of Product grade C.  |
| 10. IS: 1364 (1992) | Hexagon Head Bolts, Screws and Nuts of Product Grades A &B (Part 1 to 5)                         |
| 11. IS: 1367(1991)  | Technical Supply Conditions for Threaded Steel Fasteners.  |
| 12. IS: 1821 (1987) | Dimensions for Clearance Holes for Bolts and Screws.   |
| 13. IS: 4206 (1987) | Dimensions for Nominal Lengths and Thread Lengths for Bolts, Screws and Studs.                   |
| 14. IS: 1852 (1985) | Rolling & Cutting Tolerances for Hot-Rolled Steel Product.                                       |
| 15. IS: 1977 (1975) | Structural Steel (Ordinary Quality).   |
| 16. IS: 2016(1967)  | Plain Washers.   |
| 17. IS: 2062 (1992) | Steel for General Structural Purposes  |
| 18. IS: 2595 (1978) | Code of Practice for Radio Graphic Testing.  |
| 19. IS: 3600 (1985) | Methods of Testing Fusion Welding Joints.  |

20. IS: 3613 (1974)	Acceptance Tests for Wire Flux Combinations for Submerged Arc Welding.
21. IS: 3658 (1981)	Code of Practice for Liquid Penetrant Flow, Detection.
22. IS: 3757 (1985)	High Strength Structural Bolts
23. IS: 4000 (1992)	High Strength Bolts In Steel Structures-Code of Practice
24. IS: 4353 (1967)	Recommendations for Submerged Arc Welding of Mild Steel and Low Alloy Steel
25. IS: 4943 (1968)	Assessment of Butt and Fillet Fusion Welds in Steel Sheet, Plate and Pipe
26. IS: 5334 (1981)	Code of Practice for Magnetic Particle Flow Detection of Welds
27. IS: 5369 (1975)	General Requirements for Plain Washers and Lock Washers.
28. IS: 5372 (1975)	Taper Washers for Channels
29. IS: 5374 (1975)	Taper Washers for I Beams.
30. IS: 6623 (1985)	Specification for High Strength Structural nuts
31. IS: 6649 (1985)	Specifications for hardening and tempering washers for high strength structural nuts
32. IS: 6755 (1980)	Double Coil Helical Spring Washers.
33. IS: 7215 (1974)	Tolerances for Fabrication of Steel Structure.
34. IS: 7318 (1974) (Part I)	Approval Tests for Welders When Welding Procedure Approval is not required -fusion Welding of Steel
35. IS: 8500 (1991)	Structural steel -Micro alloyed (Medium and High Strength Qualities)
36. IS: 8910 (1978)	General requirements of Supply of Weldable Structural Steel
37. IS: 9595 (1980)	Recommendations for Metal Arc Welding of Carbon & Carbon- Manganese Steels

**7.1.6 Products****7.1.6.1 Materials**

- A. All materials to be supplied by the Contractor shall conform to relevant Indian, Standards or equivalent, as approved by the Engineer.
- B. Steel materials required for the work shall be free from imperfections, mill scales, slag intrusions, laminations, pittings, rusts etc. that may impair strength, durability and appearance. All materials shall be of tested quality only. If desired by the Engineer, test certificates in respect of each consignment shall be submitted in triplicate. Whenever the materials are permitted for procurement from identified stocks, a random sample shall be tested at an approved laboratory, as directed by the Engineer.

**7.1.6.2 Structural Steel**

All structural steel shall be of tested quality and shall conform to one of the following standards:

IS: 226 Structural steel (Standard Quality)  
 IS: 2062 Grade -B Structural steel (Fusion welding quality)  
 IS: 961 High Tensile Structural Steel (Ordinary)  
 IS: 1161 Steel Tubes for Structural purposes  
 IS: 8500 - Grade Fe 540 HT(High Tensile)

The Contractor shall supply to the Engineer, copies of the manufacturer's test certificate that the steel brought to the site for incorporation in the works is of a quality fully complying with the specifications. If required by the Engineer, the Contractor shall arrange for testing of the steel samples as per IS: 1608 - 1599.

**7.1.6.3 Bolts and Nuts**

For splicing of any structural member wherever required HSFG bolts and nuts of property class-8.8 conforming to IS:3757 and IS:6623 (1985) respectively shall be used. Unless specified otherwise, the bolts shall be hexagonal. All anchor bolts shall be of property class of 8.8 and nuts shall conform to IS: 1363 (1992), IS:1364 (1992) and IS:1367, as applicable, and unless specified otherwise, shall be hexagonal. All nuts shall conform to property class compatible with the property class of the bolts used.

#### 7.1.6.4 **Washers**

For HSFG bolts, washers shall be conforming to IS:6649 (1985). Plain washers shall be conforming to IS:5369 (1975), unless otherwise specified. One washer shall be supplied with each bolt and in case of special types of bolts, more than one washer as needed for the purpose shall be supplied. An additional double coil 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 (1975) and IS:5374 (1975), shall be used for channels and beams respectively wherever required.

#### 7.1.7 **Storage of Materials**

##### 7.1.7.1 **General**

All materials shall be so stored as to prevent deterioration and to ensure the preservation of their quality and fitness for the work. If required by the Engineer, the materials shall be stored under cover and suitably painted for the protection against weather. Any material, which has deteriorated or has been damaged shall be removed from site and replaced by new members as directed by the Engineer at no extra cost and time.

- A. The steel to be used in fabrication shall be stored in a separate stack clear off the ground section wise and lengthwise.
- B. The storage area shall be kept clean and properly drained. Structural steel shall be so stored and handled in such a manner that members are not subjected to excessive stresses and damage. Girders and beams shall be placed in upright position. Long members shall be supported on closely spaced skids/runners to avoid unacceptable deflection.

##### 7.1.7.2 **Yard**

- A. The Contractor shall be required to establish a suitable yard, in an approved location at site for storing the fabricated steel structures and other materials which will be delivered to site. The yard shall have proper facilities such as drainage and lighting including access for cranes, trailers and other heavy equipment.
- B. The Contractor shall have been deemed to have visited the site, prior to submission of his tender, to acquaint himself with the availability of land and the development necessary by way of filling, drainage, access roads, fences, sheds etc., all of which shall be carried out by the Contractor at his own cost and as directed by the Engineer.

##### 7.1.7.3 **Covered Store**

All field connection materials, paints etc. shall be stored on racks and platforms, off the ground, in a properly covered building by the contractor.

#### 7.2 **STRUCTURAL STEELWORK SPECIFICATION –WELDED STRUCTURE**

##### 7.2.1 **General**

##### **Scope of Specification**

This Specification covers the supply, fabrication and delivery to Site of welded structural Steelwork, including the supply of all consumables, electrodes and other materials required for fabrication and field connections of all structural steelwork covered under the scope of the Specification.

**7.2.2 Products**

Ref. Specification 7.1.6 for Structural Steel

**7.2.3 Execution****7.2.3.1 Workmanship****7.2.3.1.1 General**

All workmanship shall be in accordance with the best practices in modern structural shops. Greatest accuracy shall be maintained in the manufacture of every part of the work and similar parts shall be strictly interchangeable. The contractor shall not proceed with any welding until the Engineer has approved his welding plan, which shall include.

- All information on welding procedures, equipment, additives and preheating during welding operation.
- Details of non- destructive testing methods.
- Precautions with regard to welding shrinkage.
- Possible treatment of completed welds by grinding.
- Procedure and programme of welding sequence.

**7.2.3.1.2 Templates**

Templates used throughout the work shall be of steel. In cases where actual materials have been used as templates for drilling similar pieces, the Engineer shall decide whether such materials are fit to be used as parts of the finished structure.

**7.2.3.1.3 Straightening**

All materials shall be straight and free from twists, and if necessary, before being worked, shall be straightened and/or flattened by pressure, unless required to be of curvilinear form.

**7.2.3.1.4 Clearance**

The clearance between faying surfaces of bolted connections shall not be greater than 1mm for each end. If separation is between 1 to 3mm, the surface should be tapered to eliminate the separation. Over 3mm separation shall be filled with filler plates.

**7.2.3.1.5 Shearing, Cutting and Planning**

Cutting shall be done automatically. Cutting by shearing machine may be used for plates not exceeding 10 mm in thickness provided that the plate edges be fully enclosed in a weld. Oxygen cutting may be used provided a smooth and regular surface free from cracks and notches is secured.

1. Chipping of angle flanges and edges of plates, wherever necessary, shall be done without damaging the parent metal. Chipped edges shall be ground to a neat finish and sharp corners and hammered rough faces shall be rounded off.
2. The edges and ends of all cut/sheared plate members, flange plates, web plates of plate girders, and all cover plates, and the ends of all angles, tees, channels and other sections forming the flanges of plate girders, shall be planed/ground. Edge preparation for welding may be done by machine controlled flame cutting, with edges free from burrs should be clean and straight.
3. The butting surfaces at all joints of girders shall be planed so as to butt in close contact throughout the finished joint.
4. All flame cut surfaces shall be ground to remove the burned/ hardened portion of the material for flame cut surfaces.

**7.2.3.1.6 Assembly**

1. All parts assembled for welding shall be in as close contact as practicable over the whole surface.
2. The component parts shall be so assembled that they are neither twisted nor otherwise damaged. Specified cambers, if any, shall be provided.
3. All parts of bolted and welded members shall be held firmly in position by means of jigs or clamps while bolting or welding. No drifting of holes shall be permitted, except to draw the parts together and no drift used shall be larger than the nominal diameter of the bolt. Drifting done during assembling shall not distort the metal or enlarge the holes.
4. Trial assemblies shall be carried out at the fabrication stage to ensure accuracy of workmanship. These checks shall be witnessed by the Engineer-in-Charge and such trial assemblies shall be at the cost of the Contractor.

**7.2.3.2 Welding****7.2.3.2.1 General**

The welding and the welded work shall conform to welded bridge code, IS:816 (1969) and IS:9595 (1980), unless otherwise specified. As much work as possible shall be welded in shops and the layout and sequence of operations shall be so arranged as to eliminate distortion and shrinkage stresses.

**7.2.3.2.2 Electrodes**

All electrodes shall be kept under dry conditions. Any electrode damaged by moisture shall not be used unless it is guaranteed by the manufacturer that, when it is properly dried, there will be no detrimental effect. Any electrode, which has part of its flux coating broken away or is otherwise damaged, shall be rejected. Any electrode older than six (6) months from the date of manufacture shall not be used. Batch certificates for electrodes shall be submitted by the Contractor.

Manual Metal Arc Welding electrodes shall be adopted as per following details:

S. No.	Classification	Brand Name	Manufacturer	Remarks
1	E-6013	Overcord Steelcon Standard Excel-123 S Ferospeed Plus	M/s Advani Oerlikon (P) Ltd. Modi Arc Electrodes Co. Weld Excel India Ltd. (Modi Group Co.) ESAB India Ltd.	For Structural Steel members having thickness up to 15mm
2	E-7018	Super Cito Modi-7018 Excel-18 S ESAB 36H	Advani Oerlikon Modi Arc Electrodes. Weld Excel India Ltd. (Modi Group Co.) ESAB India Ltd	For Structural Steel members having thickness more than 15mm

For MIG and SAW welding the suitable product/brand of above mentioned manufacturer shall be used.

**7.2.3.2.3 Preparation of Joints**

1. The edges shall be prepared, with an automatically controlled flame cutting torch, correctly to the shape, size and dimensions of the groove, prescribed in the design and fabrication drawings. In case of U-groove joints, the edges shall be prepared with an automatic flame cutting torch in two phases, following a bevel out with a gouging pass, or by machining.



2. The welding surfaces shall be smooth, uniform and free from fins, tears, notches or any other defects, which may adversely affect welding, and shall be free of loose scale, slag, rust, grease, paint, moisture or any other foreign material.

#### 7.2.3.2.4 **Welding Procedure**

1. All welding procedures shall be submitted to the Engineer for approval, well before starting fabrication.
2. The welding procedures shall be arranged by the Contractor to suit the details of the joints, as indicated in the drawings and the position at which welding has to be carried out. Welding procedure shall cover the following:
  - a. Type and size of electrodes
  - b. Current and (for automatic welding) arc voltage
  - c. Length of run per electrode; or (for automatic welding) speed of travel
  - d. Number and arrangement of runs in multi run welds
  - e. Position of welding
  - f. Preparation and set-up of parts
  - g. Welding sequence
  - h. Pre or post heating
  - i. Any other relevant information.
3. The welding procedures shall be so arranged that distortion and shrinkage stresses are reduced to the minimum, and that the welds meet the requirement of quality specified.
4. Any weld found defective shall be removed, by using either chipping hammer or gouging torch, in such a manner that parent material is not injured in any way.

#### 7.2.3.2.5 **Fusion Faces and Surrounding Surfaces**

1. Fusion faces and the surrounding surfaces within 50mm of the welds shall be free from all mill scale and free from oil, paint or any substance which might affect the quality of the welds or impede the quality/progress of welding. These shall be free from irregularities, which would interfere with the deposition of the specified size of weld or be the cause of defects.
2. All mill scale within 50mm of welds shall be removed prior to welding, either by pickling followed by thorough power wire brushing, or by other approved methods.
3. If preparation or cutting of the fusion faces is necessary, the same shall be carried out by shearing, chipping, gas cutting or flame gouging.
4. Where hand gas cutting or hand gouging is employed, the blowpipe or gouging blowpipe shall be properly guided.

#### 7.2.3.2.6 **Assembly for Welding**

Parts to be welded shall be properly assembled and held firmly in position by means of jigs and clamps prior to and during welding.

#### 7.2.3.2.7 **Welded Girders and Other Plate Construction**

Automatic submerged arc welding shall be employed for fabrication of welded girders and other plate construction, wherever specified. Metal Inert Gas (MIG) welding (CO<sub>2</sub>) may be done for short length where access to the location of the weld does not permit submerged arc welding subject to approval of Engineer.

#### 7.2.3.2.8 **Accuracy of Fit-Up**

Parts to be fillet welded shall be brought into as close contact as practicable, and the gap due to faulty workmanship or incorrect fit-up shall not exceed 1.5mm. If greater separation occurs at any position, the size of fillet weld shall be increased at such positions by the amount of the gap.

- 7.2.3.2.9 Jigs and Manipulators**  
Jigs and manipulators shall be used, where practicable, and shall be designed to facilitate welding and to ensure that all welds are easily accessible to the operators.
- 7.2.3.2.10 Ends of Butt Welded Joints**  
The ends of butt joints shall be welded so as to provide full throat thickness. This may be done by the use of extension pieces, cross-runs or other approved means.
- 7.2.3.2.11 Weld Face and Reinforcement of Butt welds**  
The weld face shall, at all places, be deposited projecting the surface of the parent metal. Where a flush surface is required, the surplus metal shall be dressed off.
- 7.2.3.2.12 Testing of Butt Welds**  
25% of the Butt-welded joints are to be radio graphically tested by the Contractor at his own cost. If such tests indicate the joints to be defective, the cost of rectification of defective welds shall also be borne by the Contractor.
- 7.2.3.2.13 Minimum Leg Length & Throat Thickness in Fillet Welds**  
The minimum leg length of a fillet weld as deposited shall be not less than the specified size. In no case shall a concave weld be deposited, unless specifically permitted. Where permitted, the leg length shall be increased above that specified length, so that the resultant throat thickness is as great as would have been obtained by the deposition of a flat-faced weld of the specified leg length.
- 7.2.3.2.14 Dislodging**  
After making each run of welding, all slag shall be thoroughly removed and the surface cleaned.
- 7.2.3.2.15 Quality of Welds**  
The weld metal, as deposited (including tack welds), shall be free from-cracks, slag inclusions, porosity, cavities and other deposition faults. The weld metal shall be properly fused with the parent metal without under cutting or overlapping at the toes of the weld. The surface of the weld shall have a uniform consistent contour and regular appearance.
- 7.2.3.2.16 Weather Conditions**  
Welding shall not be done under weather conditions, which might adversely affect the efficiency of welding.
- 7.2.3.2.17 Qualification and Testing of Welders**  
The Contractor shall satisfy the department that the welders are suitable for the work for which they will be employed, and shall produce evidence to the effect that welders, have satisfactorily completed appropriate tests, as described in IS:817 Part I (1992). The Engineer may, at his own discretion, order periodic tests of the welders and/or of the welds produced by them. Such tests shall be at the expense of the Contractor.
- 7.2.3.2.18 Supervision**  
The Contractor shall employ competent welding supervisors to ensure that the standard of workmanship and the quality of the materials comply with the requirements laid down in this Specification.
- 7.2.3.2.19 Machining of Butts and Bases**

Splices and butt joints of compression members, depending on contact for stress transmission, shall be accurately machined over the whole section. In column bases, the ends of shafts together with the attached gussets, angles. Channels etc., after bolting and/or welding together as the case may be, shall be accurately machined so that the parts connected butt over the entire surface of contact. Care shall be taken that connecting angles or channels are fixed with such accuracy that they are not reduced in thickness by machining by more than 0.8mm.

#### 7.2.3.2.20 **Requirement of Welded Joints**

Apart from the requirements of welding specified under the above sub clauses, sections above, the Contractor shall ensure the following requirements in the welded joints.

- i) Strength-quality with parent metal.
- ii) Absence of defects.
- iii) Corrosion resistance of the weld shall not be less than that of parent metal in an aggressive environment

#### 7.2.3.3 **Shop Assembly**

1. The steelwork shall be temporarily shop assembled, as necessary, so that the accuracy of fit may be checked before dispatch. The parts shall be shop assembled with a sufficient number of parallel drifts to bring and keep the parts in place.
2. Since parts drilled or punched, with templates having steel bushes shall be similar and, as such, interchangeable, such steelwork may be shop erected in part only, as agreed by the Engineer.

#### 7.2.3.4 **Erection Marking**

1. Each fabricated member, whether assembled prior to dispatch or not so assembled, shall bear an erection mark, which will help to identify the member and its position in respect of the whole structure, to facilitate re-erection at site.
2. These erection marks shall be suitably incorporated in the shop detail and erection drawings.

### 7.3 **STRUCTURAL STEELWORK SPECIFICATION : BOLTED STRUCTURE**

#### 7.3.1 **General**

##### 7.3.1.1 **Scope of Specifications**

These specifications cover the supply, fabrication and delivery to site of bolted structural steelwork, including the supply of all consumables and other materials required for fabrication and field connections of all structural steelwork covered under the scope of the specification.

#### 7.3.2 **Products**

Ref. Specification 7.1.6 for Structural Steelwork -General

#### 7.3.3 **Execution**

##### 7.3.3.1 **Workmanship**

##### 7.3.3.1.1 **General**

All workmanship shall be in accordance with the best practice in modern structural shops. Greatest accuracy shall be maintained in the manufacture of every part of the work and all similar parts shall be strictly interchangeable.

##### 7.3.3.1.2 **Templates**

Templates used throughout the work shall be of steel, in cases where actual materials have been used as templates for drilling similar pieces, the Engineer shall decide whether such materials are fit to be used as parts of the finished structure.

##### 7.3.3.1.3 **Straightening**

All materials shall be straight and free from twists, and if necessary, before being worked shall be straightened and/or flattened by pressure, unless required to be of curvilinear form.

#### 7.3.3.1.4 **Clearance**

The clearance between faying surfaces of bolted connections shall not be greater than 1 mm at each end. If the separation is between 1 to 3 mm the surface should be tapered to eliminate the separation. Over 3mm separation shall be filled with filler plates.

#### 7.3.3.1.5 **Shearing, Cutting and planning**

1. Cutting shall be done automatically. Cutting by shearing machine may be used for plates not exceeding 10mm in thickness provided that the plate edges be fully enclosed in a weld. Oxygen cutting may be used provided a smooth and regular surface free from cracks and notches is secured.
2. Chipping of angle flanges and edges of plates, wherever necessary, shall be done without damaging the parent metal. Chipped edges shall be ground to a neat finish and sharp and sharp corners and hammered rough faces shall be rounded off.
3. The edges and ends of all cut/sheared flange plates, web plates of plate girders, and all cover plates, and the ends of all angles, tees, channels and other sections forming the flanges of plate girders, shall be planed/ground.
4. The butting surfaces at all joints of girders shall be planed so as to butt in close contact throughout the finished joint.
5. The ends of all built up girders and of all columns shall be faced in an end- milling machine after the members have been completely assembled. Bearing edges for girder bearing stiffeners and column bases shall be machined.
6. Unless clean, square and true to sharp, all flame-cut edges shall be planed. Cold sawn ends, if reasonably clean and flame-cut ends of sections not inferior to sawn ends in appearance need not be planned, except for butting ends.

#### 7.3.3.1.6 **Drilling**

1. Holes for bolts shall be drilled to conform to Clause 10 of IS:7215-1974. Punching of holes shall not be permitted. All holes, except as stated hereunder, shall be drilled to the required size, 3mm less in diameter and reamed thereafter to the required size. All matching holes for bolts shall register with each other so that a gauge of 0.8mm less in diameter than the hole can pass freely through the members assembled for bolting, in the direction at tight angle to such members.
2. All drilling shall be free of burrs.
3. No holes shall be made by gas cutting process.

#### 7.3.3.1.7 **Assembly**

1. All parts assembled for bolting shall be in close contact over the whole surface
2. The component parts shall be so assembled that they are neither twisted nor otherwise damaged. Specified cambers, if any, shall be provided.
3. All parts of bolted and welded members shall be held firmly in position by means of jigs or clamps while bolting or welding. No drifting of holes shall be permitted, except to draw the parts together and no drift used shall be larger than the nominal diameter of the bolt.
4. Drifting done during assembling shall not distort the metal or enlarge the holes.
5. Trial assemblies shall be carried out at the fabrication stage to ensure accuracy of workmanship, and these checks shall be witnessed by the Engineer. Such trial assemblies shall be at the cost of the contractor.

#### 7.3.3.1.8 **Field Bolts**

1. Requirements stipulated under bolting shall apply for field bolts. Field bolts nuts and washers shall be furnished by the Contractor in excess of the nominal numbers required. He shall supply the full number of bolts, nuts and washers and other necessary fittings required for completing the work, together with the additional bolts, nuts and washers totalling to 10% of the requirement subject to minimum of 10 Nos. Only HSFG bolts of class 8.8 shall be used.

2. At the time of assembly, the surfaces in contact shall be free of paint or any other applied finish, oil, dirt, loose rust, loose scale, burrs and other defects which would prevent solid seating of the parts or would interfere with the development of friction between them.

3. If any other surface condition, including a machined surface, is specified, it shall be the responsibility of the Contractor to work within the slip factor specified for the particular case.

4. Each bolt and nut shall be assembled with washers of appropriate shape, quality and number in cases where plane parallel surfaces are involved. Such washers shall be placed under the bolt head or the nut, whichever is to be rotated during the tightening operation. The rotated nut or bolt head shall be tightened against a surface normal to the bolt axis, and the appropriate tapered washer shall be, used when the surfaces are not parallel. The angle between the bolt axis and the surface under the non-rotating component (i.e. the bolt head or the nut) shall be  $90 + 3$  degree. For angles outside these limits, a tapered washer shall be placed under the non-rotating component. Tapered washers shall be correctly positioned.

5. No gasket or other flexible material shall be placed between the holes. The holes in parts to be joined shall be sufficiently well aligned to permit bolts to be freely placed in position. Driving of bolts is not permitted. The nuts shall be placed so that the identification marks are clearly visible after tightening.

Nut and bolts shall always be tightened in a staggered pattern and where there are more than four bolts in any one joint, they shall be tightened from the centre of the joint outwards.

6. If, after final tightening, a nut or bolt is slackened off for any reason, the bolt, nut and washer or washers shall be discarded and not used again.

#### 7.3.3.2 **Shop Assembly**

1. The steelwork shall be temporarily shop assembled, as necessary, so that the accuracy of fit may be checked before dispatch. The parts shall be shop assembled with a sufficient number of parallel drifts to bring and keep the parts in place.

#### 7.3.3.3 **Erection Marking**

1. Each fabricated member, whether assembled prior to dispatch or not so assembled, shall bear an erection mark, which will help to identify the member and its position in respect of the whole structure, to facilitate re- erection at site.

2. This erection mark shall be suitably incorporated in the shop detail and erection drawings.

### 7.4 **STRUCTURAL STEEL SPECIFICATIONS PAINTING WORKS**

#### 7.4.1 **General**

##### 7.4.1.1 **Scope of Specification**

This Specification covers the scope of painting, methods for the surface preparation, application of paints and precautions to be taken for the painting of structural steel work. It covers the supply and delivery of all necessary materials, labour, scaffolding tools, equipment and everything that is necessary for the job completion on schedule.

##### 7.4.1.2 **Applicable Codes**

The following Specifications, Standards and Codes are included as part of this Specification. All standards and codes of practice referred to herein shall be the current editions during the currency of project including all applicable official amendments and revisions. In case of discrepancy between

this Specification and those referred to herein, this specification shall govern. In case of discrepancy between Contract drawings and this specification, the Contract drawings shall govern.

- a) IS: 102 (1962) : Ready Mixed Paint, Brushing, Red lead, Non Setting, Priming.
- b) IS: 159 (1981) : Ready Mixed Paint, Brushing, Acid Resisting for Protection against Acid Fumes, Colour as Required.
- c) IS: 341 (1973) : Black Japan, Types A, B & C.
- d) IS: 384 ( 1979) : Brushes, Paints and Varnishes, Flat.
- e) IS: 487 (1985) : Brush, Paint and Varnish i) Oval Ferrule Bound ii) Round Ferrule Bound.
- f) IS: 958 (1975) : Temporary Corrosion Preventive Grease, Soft Film, Cold Application.
- g) IS: 1153(1975) : Temporary Corrosion Preventive, Fluid, Hard Film, Solvent Deposited.
- h) IS: 1477(1971) : Code of Practice for Painting of Ferrous Metals in Building. Part I – Pre-treatment Part II -Painting
- i) IS: 1674(1960) : Temporary Corrosion Preventive Fluid, Soft Film, Solvent Deposited.
- j) IS: 2074( 1992) : Ready Mixed Paints, Red Oxide -Zinc Chrome, Priming.

#### 7.4.2 **Products**

##### 7.4.2.1 **Materials**

##### 7.4.2.1.1 **Paint**

1. All paint delivered to the fabrication shop/Site shall be ready mixed, in original sealed containers, as packed by the paint manufacturers, and no thinners shall be permitted.
2. Paint shall be stirred frequently to keep the pigment in suspension

##### 7.4.2.1.2 **Storage of Paints**

1. All paints shall be stored strictly in accordance with the requirements laid down by the paint manufacturers. The storage area shall be well ventilated and protected from sparks, flame, direct exposure to sun or excessive heat, preferably located in an isolated room or in a separate building.
2. All paint containers shall be clearly labelled to show paint identification, date of manufacture, batch number, order number and special instructions in legible form. The containers shall be opened only at the time of use. Paints which have liveried, gelled or otherwise deteriorated during storage shall not be used. Paints for which the shelf life specified by the supplier has expired shall not be used without inspection and approval by the Engineer.

#### 7.4.3 **Execution**

##### 7.4.3.1 **Paint System**

1. Sand blasting where specified shall be carried out in accordance with IS:1477.
2. Painting work shall be carried out as follows:

#### **Painting Specifications**

DESCRIPTION	GENERAL SURFACE	
FABRICATION SHOP	EXTERNAL SURFACES	INTERNAL SURFACES
Surface Treatment	Abrasive blast cleaning to minimum SA-2.5 SIS-055900 near - white blast cleaning	Abrasive blast cleaning to minimum SA-2.5 SIS-055900 near - white blast cleaning

1 <sup>st</sup> Under - Coat	Inorganic zinc silicate primer (self-curing solvent type) DFT – 75 μm shall be Berger Zinc Anode 11 or approved equivalent. The primer should be applied by spray only.	Epoxy Zinc phosphate primer polyamide cured DFT-35μm
2 <sup>nd</sup> Under-Coat	Epoxy zinc phosphate primer polyamide cured DFT - 35μm shall be Berge Epilux 610 Primer or approved equivalent. The primer should be applied by spray or brush only.	Epoxy zinc phosphate primer polyamide cured DFT-35 μm shall be Berger Epilux 610 Primer or approved equivalent. The primer should be applied by spray or brush only.
3 <sup>rd</sup> Under-Coat	Epoxy zinc phosphate primer polyamide cured DFT-35 μm shall be Berge Epilux 610 Primer or approved equivalent. The primer should be applied by spray or brush only.	Polyamide cured coal tar epoxy coating DFT 100 μm
4 <sup>th</sup> Under Coat	Epoxy high build micaceous iron oxide coating polyamide cured DFT-90 μm shall be Berger Epilux 4 High Build MIO. The primer should be applied by spray or brush only.	Polyamide cured coal tar epoxy coating DFT 100 μm
<b>ERECTION SITE</b>	<b>EXTERNAL SURFACES</b>	<b>INTERNAL SURFACES</b>
Intermediate Coat	Acrylic polyurethane finish aliphatic isocyanate cured DFT- 30 μm shall be Berger thane or approved equivalent applied by spray or brush in approved colour.	NA
Finishing Coat	Acrylic polyurethane finish aliphatic isocyanate cured DFT- 30 μm shall be Berger thane or approved equivalent applied by spray or brush in approved colour.	NA

INTERNAL SURFACE = Internal surfaces are those which will become inaccessible after fabrication.

EXTERNAL SURFACE = All other surfaces which are prone to humidity and moisture from the Atmosphere.

The following precautions must be taken:

- After abrasive blast cleaning, the first undercoat (primer coat) should be applied well before surface deterioration.
- Over coating intervals, application parameters shall conform to manufacturer's instruction manual.
- The DFT (Dry film thickness) shall be measured after completion of each coat.

#### 7.4.3.2 Surface Preparation

##### 7.4.3.2.1 General

All surfaces shall be cleaned of loose substances and foreign materials, e. g. dirt, rust, scale, oil, grease, welding flux etc. so that the prime coat adheres to the original metal surface. The work shall be carried out in accordance with IS: 1477 (1971) (Part I). Any oil, grease, dust or foreign matter deposited on the surface after preparation shall be removed and care shall be taken to ensure that

the surface is not contaminated with acids, alkalis or other corrosive chemicals. The primer coat shall be applied immediately after the surface preparation is completed.

Before the application of any paint, the surfaces to be treated shall be thoroughly cleaned freed from all scale, loose paint, rust and other deleterious materials. Oil and grease shall be removed from the surface by washing with solvents or with a detergent solution before blast cleaning operation of metal polish with metal pellets. If any traces of oil or grease remain after blasting they shall be removed by solvent cleaning and the area will be re-blasted thereafter.

All welded areas/joints shall be given special attention for removal of weld flux slag, weld metal splatter, weld head oxides; weld flux fumes, silvers and other foreign objects before blasting. If deemed necessary by the Engineer, acid washing and subsequent washing with clean water shall be used.

Any rough seams will have to be ground and must be inspected and approved by the Engineer-in-Charge before application of the coatings.

All structural steel to be painted shall be cleaned blast cleaning in accordance with SA 2 1/2 Near-White Blast cleaning (equivalent Swedish Standard SIS 055900). For SA 2 1/2 the profile should be in the range of 40-70 microns and shall be measured with comparator. Mill scale, rust and foreign matter shall be removed to the extent that the only traces remaining are light stains in the form of spots or stripes. Finally the surface shall be cleaned with a vacuum cleaner or clean dry compressed air.

The blast cleaning shall produce a surface roughness complying with the one specified by the paint manufacturer for the primer concerned. If cleaned surfaces are rusted or are contaminated with foreign material before painting is accomplished they shall be re-cleaned by the Contractor at his expenses.

The surface shall be cleaned by impingement of abrasive materials, such as grit of cast iron, malleable iron, steel or synthetic material, at high velocity created by clean and dry compressed air blast. Prior to application of the blast, heavy deposits of oil and grease shall be removed by solvent cleaning and excessive surface scale removed by hand tool or power tool cleaning.

The last finish paint shall be applied after structural steel erection and slab construction.

#### 7.4.3.3 **Mixing and Thinning**

1. All ingredients in a paint container shall be thoroughly mixed to break-up lumps and disperse pigments, before use and during application, to maintain homogeneity. All pigmented paints shall be strained after mixing to remove skins and other undesirable matters.
2. Dry pigments, pastes, tinting pastes and colors shall be mixed and/or made into paint so that all dry powders get wetted by vehicles and lumps and particles are uniformly dispersed.
3. Additives that are received separate such as curing agents, catalysts, hardeners etc. shall be added to the paint as per the manufacturer's instructions. These shall be promptly used within the pot life specified by the manufacturers and unused paint h thereafter shall be discarded.
4. Thinners shall not be used unless essential for proper application of the paint. Where thinners are used, they shall be added during the mixing process and the type and quantity of thinner shall be in accordance with the instructions of paint manufacturer.

#### 7.4.3.4 **Paint Application**



**7.4.3.4.1 General**

1. Paint shall be applied in accordance with the manufacturer recommendations, as supplemented by these Specifications. The work shall generally follow IS: 1477 (1971) (Part II). Prior approval of the Engineer shall be taken in respect of all primers and/or paints, before their use in the works.
2. Paint shall generally be applied by brushing except that spraying may be use for finish coats only when brushing may damage the prime coats. Roller coat or other method of paint application shall not be used unless specifically authorized.
4. Spraying paint shall not be adopted on red lead or zinc rich paints. Daubers may be used only when no other method is practicable tor proper application in difficult accessible areas.
5. Paint shall not be applied when the ambient temperature is 10°C and below. For paints which dry by chemical reaction the temperature requirements specified by the manufacturer shall be met with. Also, paint shall not be applied in rain, wind, fog or at relative humidity of 80% and above or when the surface temperature is below dew point, resulting in condensation of moisture. Any wet paint exposed to damaging weather conditions shall be inspected after drying and the damaged area repainted after removal of the paint.
6. Each coat of paint shall be continuous, free of pores and of even film thickness without thin spots. The film thickness shall not be so great as to detrimentally affect either, the appearance or the service life of the paint.
7. Each coat of paint shall be allowed to dry sufficiently before application of the next coat, to avoid damages such as lifting or loss of adhesion. Undercoats having glossy surface shall be roughened by mild sand papering to improve adhesion of subsequent coats. Successive coats of same colour shall be tinted whenever practical, to produce contrasts and help in identifying the progress of the work.

**7.4.3.4.2 Brush Application**

1. Proper brushes shall be selected for a specific work piece. Round or oval brushes which conform to IS:487( 1985) are better suited for irregular surfaces, whereas flat brushes which conform to IS:384( 1979) are convenient for large flat areas. The width of flat brushes shall not generally exceed 1.25mm.
2. Paint shall be applied in short strokes depositing a uniform amount of paint in each stroke followed by brushing the paint into all surface irregularities, crevices and corners and finally smoothening or leveling the paint film with long and light strokes at about right angles to the first short strokes. All runs and sags shall be brushed out. The brush marks left in the applied paint shall be as few as practicable.

**7.4.3.4.3 Spray Application**

1. The spraying equipment shall be compatible with the paint material and provided with necessary gauges and controls. The equipment shall be cleaned of dirt, dried paint, foreign matter and solvent before use.
2. The paint shall be applied by holding the gun perpendicular to the surface at a suitable distance and moved in a pattern so as to ensure deposition of a uniform wet layer of paint. All runs and sags shall be brushed out immediately. Areas not accessible to spray shall be painted by brush or dauber.
3. Water trap acceptable to Engineer shall he furnished and installed on all equipment used in spray painting.

**7.4.3.5 Shop Painting**

1. The painting system specified in Table shall be followed.

2. Surfaces in contact during shop assembly shall not be painted. Surfaces which cannot be painted but require protection shall be given a rust inhibitive grease conforming to IS.958-1975 or solvent deposited compound conforming to IS: 1153 (1975) or IS. 1674 (1960) or treated as specified in the drawing.
3. Surface to be in contact with concrete shall not be painted.
4. The shop coats shall be continuous over all edges, including ends meant for jointing at site by bolting, except where the paint could be detrimental to bolting. In such cases, no paint shall be applied within 50mm, and the unprotected surface shall be given a coat of corrosion inhibitive compound.
5. The unpainted area shall be cleaned prior to welding. The welded joint shall be cleaned and de-slugged, and immediately after covered by the same paint as has been used for the remaining surface.

#### 7.4.3.6 Protection of Paintwork

1. The Contractor shall provide measures as necessary to prevent damage to the work and to other property or persons from all cleaning and painting operations. Paint or paint stains which result in other unsightly appearance on surfaces not designated to be painted shall be removed or obliterated by the contractor at his cost.
2. All painted surfaces that in the opinion of the Engineer are damaged in anyway, shall be repaired by the contractor at his cost with materials and to a condition equal to that of the requirements specified in these specifications.
3. Upon painted surfaces that in the opinion of any other work that would cause dust, grease or foreign materials to be deposited upon the painted surfaces, the painted surfaces shall be thoroughly cleaned. At the time of opening the flyovers to public traffic, the painting shall be completed and the surfaces shall be undamaged and clean.
4. The areas for high-strength bolts shall be protected by masking tape against undercoat application at the fabrication shop. Immediately prior to erection any rust in the paint area shall be removed by power wire brushing to a standard equivalent to SA3.

#### 7.4.3.7 Site Painting

1. After the erection of structures at the site, the contractor shall provide the necessary treatment as specified in Table "PAINTING SPECIFICATIONS".
2. Surface which has not been shop coated, but require surface treatment shall be given necessary surface preparation and coats at site as specified in Table.

### 7.5 STRUCTURAL STEEL WORK QUALITY CONTROL & TESTING REQUIREMENTS

#### 7.5.1 General

##### 7.5.1.1 Scope of Specification

The scope of work of these specifications is to establish the norms for ensuring the required Quality Control through established testing norms of the welded structural steelwork.

##### 7.5.1.2 Codes / Standards

Relevant IS codes for tolerance and tests of welding procedures as specified in the specification for Structural Steelwork -General.

##### 7.5.1.3 Submittals

The Contractor shall submit the following:

- Proposed overall schedule for documentation of calculations, shop drawings, plan/procedures and records, submission of procedure of fabrication.

- The contractor shall himself inspect all materials, shop work and field work to satisfy the specified tolerance limits and Quality norms before the same are inspected by Engineer or his authorized representative.

**7.5.2 Products**

Not Applicable

**7.5.3 Execution****7.5.3.1 Tolerances**

The contractor shall through appropriate planning and continuous measurements in the workshop and the erection at site, ensure that the tolerance specified below are strictly adhered to.

**7.5.3.1.1 Dimensional & Weight Tolerance**

The dimensional and weight tolerance for rolled shapes shall be in accordance with IS: 1852. The acceptable limits of straightness for rolled or fabricated members as per IS: 7215 are:

Struts and columns:  $1/1000$  or 10 mm whichever is smaller Where L is the length of finished member

A limit for distortion in transverse direction 5 from the true axis of plate and box girder shall not be more than  $L/1000$  where L is the length of diagonal of profile.

Tolerance in specified camber of members shall be 3mm in 12m length

Tolerance in specified lengths shall be as follows:

Column finished for contact bearing	$\pm 1$ mm
Other members (cols.) upto and over 10 m	$\pm 5$ mm
Including 10 m L/2000 sub to max of	$\pm 8$ mm
Other members (beams) upto 12m	$\pm 3$ mm
Over 12m L/4000 sub max. of	$\pm 5$ mm

**7.5.3.1.2 End of Members**

Beam Jo beam and beam to column connection -Where the abutting parts are to be jointed by butt welds, permissible deviation from the squareness of the end is

Beam upto 600 mm in depth : 1.5 mm

Beam over 600 mm in depth: 1.5 mm for increase in depth of every 600 mm subjected to max of 3 mm.

Where abutting parts are to be joined by bolting through cleats or end plates, the connections require closer tolerance, permissible deviation from the squareness of the end is:

Beams up to 600 mm in depth 1 mm per 600mm of depth subject to a max of 1.5 mm.

For full bearing, two abutting ends of columns shall first be aligned to within 1 in 1000 of their combined length and then the following conditions shall be met:

- Over at least 80% of the bearing surface the clearance between the surfaces does not exceed 0.1mm.
- Over the remainder of the surfaces the clearance between the surfaces does not exceed 0.3 mm.

Where web stiffeners are designed for full bearing on either the top flange or the bottom flange or both, at least half the stiffener shall be in positive contact with the flange. The remainder of the contact face could have a max. gap of 0.25 mm.

#### 7.5.3.1.3 Depth of Members

Acceptable deviation from the specified overall depth as per 1S:7215 (1974) is:

Upto and including 1000mm : 1.0mm  
Over 1000 mm : 2.0mm

#### 7.5.3.1.4 Web Plates

An acceptable deviation from flatness in girder webs in the length between the stiffeners or in a length equal to the girder depth shall be:

Upto 500 mm depth : 0.5 mm  
Over 500 mm & including 1000 mm : 1.0 mm  
Over 1000 mm : 2.0 mm

#### 7.5.3.1.5 Flange Plates

A reasonable limit for combined warpage and tilt on the flanges of a built-up member is 1/200 of the total width of flange or 2 mm whichever is smaller measured with respect to centerline of flange.

Lateral deviation between centre line of web plate and centre line of flange plate at contact surfaces measured as the difference  $\delta$  between diagonals of nominal length L shall not be greater than  $L/1000$ .

#### 7.5.3.1.6 End Milling

Column ends bearing on each other or resting on base plates and compression joints designed for bearing shall be milled true and square to ensure proper bearing and alignment. Base plates shall also have their surfaces milled true and square.

#### 7.5.3.2 Quality Control

In order to exercise proper control of the quality of the welding, Contractor shall enforce methods of control as tabulated below:

Purpose	Control subjects	Methods of Control
Control of welding Materials basic and metal quality	Quality control of electrodes, welding wire, flux and protective gases Checking of quality and Weldability of the basic metal and welded members.	Weldability test to determine the technological properties of materials, Mechanical test of weld metal. Metalographical investigations of welds macro-structure and microstructure Checking of weld metal resistance for intercrystalline corrosion. Study of weld metal solidity by physical control methods.
Checking of welders qualifications	Welding of specimens for quality determination	Mechanical tests, metalographical investigation & checking of welded joints by physical control methods
Control of welded joint quality	Control of assembly accuracy and technological welding process.	Checking of assembly quality and centering of welded members.  Checking of welding equipment conditions. Checking correctness of welding procedure. Visual examination of welds.

#### 7.5.3.3 Tests & Testing Procedures

Agency for testing of weld shall be approved by the Engineer prior to testing.

**7.5.3.3.1 Visual Examination**

The contractor shall conduct visual examination and measurement of the external dimensions of the weld for all joints. Before examining the welded joints, areas close to it on both sides of the weld for a width not less than 20 mm shall be cleaned of slag and other impurities. Examination shall be done by a magnifying glass which has a magnification power of ten (10) and measuring instrument which has an accuracy of  $\pm 0.1$  mm or by weld gauges. Welded joints shall be examined from both sides. The contractor shall examine the following during the visual checks.

- i) Correctness and shape of the welded joints
- ii) Incomplete penetration of weld metal.
- iii) Influx
- iv) Burns
- v) Unwelded craters
- vi) Undercuts
- vii) Cracks in welded spots and heat affected zones
- viii) Porosity in welds and spot welds
- ix) Compression in welded joints as a result of electrode impact while carrying out contact welding
- x) Displacement of welded element

The contractor shall, document all data as per sound practices.

**7.5.3.3.2 Mechanical Test**

The Contractor shall carry out various mechanical tests to determine weldability, metal alloyability, and nature of break, correct size and type of electrodes, degree of pre-heat and post-heat treatment. The type, scope and sample of various mechanical tests shall be determined in agreement with the purchaser. The number of tests conducted shall depend on the result obtained to satisfy the Engineer that the correct type and size of electrode, degree of preheating and post-heating and weldability of metal are being followed.

**7.5.3.3.3 Dye Penetration Test**

All welds shall be tested by "Dye Penetration test" as per current practices.

**7.5.3.3.4 Radiography Test**

Radiography test shall be conducted by the contractor to determine gas inclusion (blow holes, hollows) slag inclusion, shallow welds and cracks for 25% lengths all butt joints.

Before conducting the examination, the welded joints shall be cleaned of slag and scales and visually examined. The welds shall be marked into separate portions depending on the length of photograph. The length of photograph shall be such as to ensure that there are no distortions and shall reveal the defect correctly. The length shall not be more than 0.75 of the focal distance and the width of the photograph would depend on the width of the welded joint plus 20mm on either side of the weld. The cassette with film shall be protected by sheet of lead or equivalent of proper thickness against incidental, diffused and secondary radiation.

The direction of the ray with relation to the film shall be as specified hereunder.

Welds of butt joints without edge slopes with edge processing shall be examined by central ray directed at right angles to the weld.

In special cases examination of welds with inclined rays directed along edge slopes may be permitted by the Engineer.

Lap joints shall be examined by directing rays at 45 degree to the bottom plate. Welds in T-joints without any edge preparation shall be examined by rays directed at 45 degree to the weld. Angle welds in lap and tee-joints shall be examined by the rays in opposite direction i.e. the film will be on the side of the weld. Weld in angle joints shall be checked by directing ray along the bisector of the angle between the welded elements. Opposite direction of the ray and location of the film may also be permitted by the Employer.

#### **7.5.3.3.5 Ultrasonic Test**

Ultrasonic test shall be conducted by the contractor to detect gas inclusion (pores), slag inclusion, shallow welds, cracks, lamination and friability etc. Prior to starting of ultrasonic test the welded joint shall be thoroughly cleaned of slag and other material. Surface of the basic metal adjacent to welded joint on both sides shall be mechanically cleaned by the grinder or a metal brush to provide the contact of the whole ultrasonic probe surface with surface of basic metal. The width of the clean surface shall be as directed by the Engineer. The welded joint then shall be covered with a thin coat of transformer oil, turbine or machine oil to ensure acoustic contact. The joints so treated shall be marked and the marks shall be entered into the documentation, subsequent to this, ultrasonic test shall be carried out as directed by the Engineer. At least 50% of weld shall be tested by ultrasonic testing.

### **7.6 STRUCTURAL STEEL SPECIFICATIONS -ERECTION**

#### **7.6.1 General**

##### **7.6.1.1 Scope of Specification**

This Specification covers the delivery to site, storage and erection of structural steelwork at site. This includes plant and equipment requirements, installation of fabricated steel work position and grouting all complete as per drawings, specifications and other provisions of the Contract.

##### **7.6.1.2 Submittals**

- A. Ref. Specification for Structural Steelwork -General
- B. The contractor shall submit for approval a full description of his proposed erection method including sequence of erection, use of temporary supports, connection details and erection camber diagram and design calculations covering various stages of erection process.

##### **7.6.2 Products**

Not applicable

##### **7.6.3 Execution**

##### **7.6.3.1 Delivery, Storage & Handling**

- A. Before the shop assembling is dismantled, all members and sections shall be appropriately marked with paint or grooved with their identification numbers as detailed in shop drawings.
- B. The Contractor shall deliver the fabricated structural steel materials to site, with all necessary field connection materials, in such sequence as will permit the most efficient and economical performance of the erection work. As per scheduled programme, the Engineer may, at his discretion prescribe or control the sequence of delivery of materials.
- C. Fabricated parts shall be handled and stacked in such a way-that no damage is caused to the components. Measures shall be taken to minimize damage to the protective treatment on the steelwork. All work shall be protected from damage in transit. Particular care shall be taken to stiffen free ends, prevent permanent distortion and adequately protect all machined surfaces.

All bolts, nuts, washers, screws, small plates and articles generally shall be suitably packed and identified. Plant and Equipment

**7.6.3.2 Plant and equipment**

All erection tools and plant & equipment proposed to be used shall be efficient, dependable and in good working condition, and the suitability and adequacy of such shall be determined by the Engineer. The Contractor shall, in his technical proposal submittal, specify the plant and equipment proposed by him for erection of structural steelwork at Site.

**7.6.3.3 Storage**

Materials to be stored shall be placed on skids above the ground and shall be kept clean and Properly drained.

**7.6.3.4 Method and Sequence of Erection**

The method and sequence of erection shall have the prior approval of the Engineer. The contractor shall arrange for the most economic method and sequence consistent with the drawings and Specifications and such information as may be furnished to him prior to the execution of the Contract. The erection of steelwork shall be planned so as to ensure safe- working conditions at all times. The Contractor shall be solely responsible for enhancing the safety of his construction activities at Site.

**7.6.3.5 Assembly & Erection**

A. During erection, the members and sections shall be accurately assembled as shown on the approved shop drawings and any match marks shall be followed. The material shall be carefully handled so that no sections will be bent, broken or otherwise damaged. Hammering which will damage or distort the members shall not be done. Bearing surfaces and surfaces to be in permanent contact shall be cleaned before the members are assembled. Splices and field connections shall have one half of the holes filled with bolts and cylindrical erection pins (half bolts and half pins) before bolting with high-strength bolts. Fitting-up bolts shall be of the same nominal diameter as the high-strength bolts, and cylindrical erection pins shall be 1 mm or larger.

B. The correction of minor misfits involving harmless amounts of reaming, cutting and chipping will be considered a legitimate part of the erection. However, any error in the shop fabrication or deformation resulting from handling and transportation which prevents the proper assembling and fitting up of parts by the moderate use of drift pins or by a moderate amount of reaming and slight chipping or cutting, shall be reported immediately to the Engineer and his approval of the method of correction obtained. The contractor shall be responsible for all misfits, errors and injuries and shall make the necessary corrections and replacements.

C. The straightening of plates, angles, other shapes and built-up members, when permitted by the Engineer, shall be done by methods that will not produce fracture or other damages. Distorted members shall be straightened by mechanical means or, if approved by the Engineer, by the careful planned and supervised application of a limited amount of localized heat, each application subject to the approval of the Engineer.

D. The responsibility in respect of temporary bracing and guys shall rest with the Contractor until the structural steel is located, plumbed, leveled, aligned and grouted within the tolerances permitted under the Specification, and the permanent bracing/framing system has been installed.

E. The temporary guys, braces, false work and cribbing shall not be the property of the department and may be removed by the Contractor, with the approval of the Engineer, without any charge, once the permanent framing system has been installed -to the satisfaction of the Engineer and when the temporary bracing, guys etc. can be removed without any potential danger/damage to the erected structure.

**7.6.3.6 Setting Out**

- A. Positioning and levelling of all steelwork, plumbing and placing of every part of the structure with accuracy shall be in accordance with the approved drawings and to the satisfaction of the Engineer. The Contractor shall check the positions and levels of the anchor bolts etc. before concreting and ensure that they are properly secured against disturbance during pouring operations. The Contractor shall remain responsible for correct positioning and shall set proper screed bars to maintain proper level. No extra payment shall be made on this account.
- B. No permanent field connections by bolting shall be carried out until proper alignment and plumbing guides have been attached.

**7.6.3.7 Field Bolting**

- A. Bolts shall be inserted in such a way that they remain in position under gravity, even before fixing the nut. Bolted parts shall fit solidly together when assembled and shall not be separated by gaskets or any other interposed compressible materials. When assembled all joint surfaces including those adjacent to the washers shall be free of scales. They shall be free of dirt, loose scales, burns and other defects that would prevent solid seating of the parts.
- B. Holes for turned bolts to be inserted in the field shall be reamed in the field. All drilling and reaming for turned bolts shall be done only after the parts to be connected are assembled. Tolerances applicable in the fit of the bolts shall be in accordance with relevant Indian Standard Specifications.
- C. All high tensile bolts shall be tightened to provide when all fasteners in the joint are tight, the required minimum bolt tension as per relevant Indian Standard/Specification.
- D. The manufacturing and use of high strength friction grip (HSFG) bolts shall comply with the requirements of IS:3757 (1985).
- E. Load indicating bolts or washers may be used, subject to the approval of the Engineer.

**7.6.3.8 Holes, Cutting and Fitting**

- A. No cutting of sections, flanges, webs, and cleats, rivets, bolts, welds etc. shall be done unless specifically approved and / or instructed by the Engineer.
- B. The erector shall not cut, drill or otherwise alter the work of other trades, or his own work to accommodate other trades, unless such work is clearly specified in the Contract, or directed by the Engineer. Wherever such work is specified, the Contractor shall obtain complete information as to size, location and number of alterations, prior to carrying out any work.

**7.6.3.9 Drifting**

- A. Correction of minor misfits will be considered as permissible. For this, light drifting may be used to draw holes together and drills shall be used to enlarge holes, as necessary, to make connections. Reaming, that weakens the member or makes it impossible to fill the holes properly or to adjust accurately after reaming, shall not be allowed.
- B. Any error in shop work which prevents proper assembling and fitting of parts by moderate use of drift pins and reamers shall immediately be brought to the attention of the Engineer, and approval of the method of correction obtained. The use of gas cutting torches at the erection site is prohibited.

**7.6.3.10 Grouting**

- A. The positions to be grouted shall be cleaned thoroughly with compressed air jet and wetted with water, and any accumulated water shall be removed. Grouting shall be carried out under expert supervision taking care to avoid air locks. Edges shall be finished properly.



B. Whatever method of grouting is employed the operation shall not be carried out until the steelwork has been finally levelled. Immediately before grouting, the space under steel is thoroughly cleaned. Where packing is to be left in place, they shall be placed such that they are completely covered with grout.

C. The grout to be used shall be Non-shrink grout Conbextra GP-2 of M/S Fosroc or equivalent.

D. All steel in foundations shall be solidly encased in Portland Cement Concrete of minimum characteristic strength at 28 days as specified in the drawings, subject to a minimum of 35 N/mm<sup>2</sup>. A minimum cover of 100mm shall be provided to all steelwork where surrounding concrete is in contact with soil.

#### **7.6.3.11 Inserts and Embedment**

Various steel inserts and embedments are required under the contract to be fabricated, positioned and secured firmly into place inside the formwork prior to concrete being poured. There are also requirements of jointing, threading, bolting and welding inserts and embedments of different concrete and structural steel elements in order to establish structural continuity and connection. Great care shall be exercised by the contractor in executing all aspects of the work related to inserts and embedments, including tolerances, so that the final assembly of the concrete elements can meet satisfactorily the continuity requirements intended in the structure.

#### **7.6.3.12 Painting after Erection**

- A. Steelwork coated with rust inhibitor shall not be left exposed for a period exceeding 15 days. Otherwise, such steelwork shall be re-cleaned and re-coated with such finish until encased in concrete.
- B. No steelwork with shop paint shall be left exposed at site for a period exceeding that approved by the Engineer.
- C. The surfaces required to remain unpainted at shop, shall be given a protective coating after the structure is erected, levelled, plumbed, aligned in its final position, and accepted by the Engineer. However, touch up painting, making good any damaged shop painting and completion of any unfinished portion of the shop coat shall be progressively carried out by the Contractor.
- D. 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. Before commencing painting of steel, which is delivered unpainted, all surfaces to be painted shall be dried and thoroughly cleaned from all loose scale and rust.
- E. All field bolts, welds and abrasions to the shop coat, and surfaces delivered unpainted from fabrication shop, shall receive the full protective treatment as specified in Table defined in painting specifications before delivery to Site.
- F. Surfaces, which will be inaccessible after field assembly, shall receive the full specified protective treatment before assembly. Bolts and fabricated steel members, which are galvanized or otherwise treated, shall not be painted.
- G. The contractor shall be responsible for any damage caused to other components of the structure including the substructure. In particular, he shall take all necessary precautions to minimize concrete splash onto completed steelwork or rust staining of concrete due to erected steel work and clean and/or repair all stains and other damages to completed work prior to tests on completion.

#### **7.6.3.13 Final Cleaning up**

Upon completion of erection, and before final acceptance of the work by the Engineer, the Contractor shall remove, free of cost, all false work, rubbish and all temporary works, resulting from or in connection with the performance of his work.