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Draft Indian Standard

'Code of Practice for use of hollow steel sections for general construction in steel' (Second Revision of IS 806)

ICS No. 77.140.01

Structural Engineering and Structural Sections, CED 7	**Last date for Receipt of Comments: 31 March 2005**

Foreword

This Standard, was first published in 1957 and revised in 1968. Since this code is complementary to IS 800 and with the revision of IS 800, the revision of this standard became due. In this revision, following major changes have been effected:

a) SI units has been followed throughout,
b) The secant formula for axial compression has been dropped. In its place the merchant rankine formula has been specified with value of n, empirically fixed as 1.4,
c) The scope of the Code has been widened to include the square an rectangular hollow section beside the circular one,
d) The minimum thickness of metal and the effective length of compression members have been revised.

This standard is one of a series of Indian Standards being published under the erstwhile ISI Steel Economy Programme. The object of this programme is to achieve economy in the use of structural steel by establishing rational, efficient and optimum standards for structural section; formulation of standard codes of practice for the design and fabrication of steel structures; popularization of welding in steel construction and co-ordination and sponsoring of experimental research relating to the production and use of structural steel which would enable the formulation and revision of standard specifications and codes of practice.

The original title of the code namely 'Code of practice for use of steel tubes in general building construction' has now been modified as 'Code of Practice for use of hollow steel sections for general construction in steel' since it is felt that the code is applicable to all types of steel hollow sections and not limited to circular tubes only.

While preparing this Code, the practices prevailing in this field in the country have been kept in view. Assistance has also been derived from the following publications:

AS 1250:1981 SAA Steel structures code, Standards Association of Australia.

BS 590 Structural use of steel work in building.

CIDECT (This International Committee for the development and study of Tubular Construction). Manual for construction with Steel Hollow Sections.

Technical Committee responsible for the revision of the standard is given in Annex D.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2:1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

CODE OF PRACTICE FOR USE OF HOLLOW STEEL SECTIONS FOR GENERAL CONSTRUCTION IN STEEL

(*Second Revision* **of IS 806**)

1 SCOPE

1.1 This code applies to general construction in steel using circular, rectangular and square hollow sections (CHS, RHS and SHS respectively).

1.2 This code is complementary to IS 800. For provisions, not covered in this standard, the reference shall be made to IS 800, unless stated otherwise.

2 REFERENCES

The Indian Standards given in Annex A contain provisions, which through references in this text, constitute provision of this standard. At the time of publication, the editions indicated were valid. All standards are subjected to revision and parties to agreement based on this standard are encouraged to investigate the possibility of applying the most recent edition of the standards given in Annex A.

3 TERMINOLOGY

For the purpose of this code, the definitions covered in IS 800 shall apply.

4 SYMBOLS

Symbols used in this code shall have the following meanings with respect to the structure or member or condition, unless otherwise defined elsewhere in this code:

E = The modulus of elasticity for steel, taken as 2 x 10^5 Mpa in this code

f_y = Yield stress

f_{cc} = Elastic critical stress in compression, also known as euler critical stress.

L = Span/length of the member.

l = Effective length of the member

n = Coefficient in the Merchant Rankine formula, assumed as 1.4

r = Radius in gyration of the section

Slenderness ratio of the member; ratio of the effective length (l) to the appropriate radius of gyration (r)

σ_{ac} = Maximum permissible compressive stress in an axially loaded strut not subjected to bending.

σ_{at} = Maximum permissible tensile stress in an axially loaded tension member not subjected to bending.

σ_{bc} = Maximum permissible compressive stress due to bending in a member not subjected to axial force.

σ_{bt} = Maximum permissible tensile stress due to bending in a member not subjected to axial force.

σ_{e} = Maximum permissible equivalent stress

σ_{p} = Maximum permissible bearing stress in a member

$\sigma_{ac,cal}$= Calculated average axial compressive stress

$\sigma_{at,cal}$= Calculated average stress in a member due to an axial tensile force.

$\sigma_{bc,cal}$= Calculated compressive stress in a member due to bending about a principal axis.

$\sigma_{bt,cal}$= Calculated tensile stress in a member due to bending about both principal axis.

ζ_{vm} = Maximum permissible shear stress in a member.

4.1 Unit and Conversion Factors

The SI system of units is applicable to this code. For conversion of one system of units to another systems, IS 786 may be referred.

4.2 Plan and Drawings

Plans, drawings and stress sheets shall be prepared according to IS 962 and general engineering guidelines.

5 MATERIALS

5.1 Materials of structural hollow steel sections shall be hot/cold finished conforming to the requirement specified in IS 1161 and IS 4923.

5.2 Sections made by other than hot finishing process or which have been subjected to cold working, shall be regarded as hot finished if they have subsequently been heat-treated and all supplied in the normalized conditions.

5.2.1 Hollow Sections, made by other than hot finishing processes and are not heat treated, as referred in **5.2**, shall also be considered for the purpose provided the yield stress and ultimate tensile stress are reduced to the values given in Table 1 if subjected to stress relieving, annealing, brazing, welding or similar heating. However, the yield stress and ultimate tensile stress shall in no way be considered less than the parent hot finished strip as guaranteed by supplier and should be considered for design purpose.

Table 1 Mechanical Properties
(*Clause* 5.2.1)

Sl No.	**Grade**	**Min Yield Stress MPa**	**Min. Tensile Stress MPa**	**Elongation* Percent**
(1)	(2)	(3)	(4)	(5)
i)	Y_{St} 210	140	230	20
ii)	Y_{St} 240	170	310	17
iii	Y_{St} 310	240	350	14

* Elongation as per IS 1161:1998

5.3 Rivets

Rivets shall conform to IS 1929 and IS 2155.

5.4 Welding Consumables

5.4.1 Covered electrode shall conform to IS 814 or IS 1395.

5.5 Bolts and Nuts

Bolts and Nuts shall conform to IS 1363, IS 1364, IS 1367, IS 3757, IS 6623 and IS 6639 as appropriate.

6 GENERAL DESIGN REQUIREMENTS

6.1 Types of Loads

6.1.1 For the purpose of computing the maximum stresses in any structure or member of a structure, the following loads and load effects shall be taken into account, where applicable:

a) Dead loads;
b) Imposed loads;
c) Wind loads;
d) Earthquake loads;
e) Erection loads; and
f) Secondary effects due to contraction or expansion resulting from temperature changes, shrinkage, creep in compression members, differential settlements of the structure as a whole and its components.

6.1.1.1 Dead loads, imposed loads and wind loads to be assumed in design shall be as specified in IS 875(Part 1 to 5).

6.1.1.2 Imposed loads arising from equipment, such as cranes, and machines to be assumed in design shall be as per manufacturers/suppliers data.

6.1.1.3 Earthquake loads shall be assumed as per IS 1893.

6.1.1.4 The erection loads and temperature effects shall be considered as specified in **6.2** and **6.3**.

6.2 Erection Loads

6.2.1 All loads required to be carried by the structure or any part of it due to storage or positioning of construction material and erection equipment including all loads due to operation of such equipment, shall be considered as `erection loads'. Proper provision shall be made, including temporary bracings to take care of all stresses due to erection loads. The structure as a whole and all parts of the structure in conjunction with the temporary bracings shall be capable of sustaining these erection loads, without exceeding the permissible stresses as specified in this code subject to the allowable increase of stresses as indicated in **8.8**. Dead load, wind load and also such parts of the live load as would be imposed on the structure during the period of erection shall be taken as acting together with the erection loads.

6.3 Temperature Effects

6.3.1 Expansion and contraction due to changes in temperature of the materials of a structure shall be considered and adequate provision made for the effective produced.

6.3.2 The temperature range varies for different localities and under different diurnal and seasonal conditions. The absolute maximum and minimum temperatures which may be expected in different localities in the country are indicated on the maps of India given in Appendices A and B, respectively, in IS 800. These Appendices may be used for guidance in assessing the maximum variation of temperature for which provision for expansion and contraction has to be allowed in the structure.

6.3.3 The temperatures indicated on the maps in Appendices A and B in IS 800 are the air temperature in the shade. The range of variation in temperature of the building materials may be appreciably greater or less than the variation of air temperature and is influenced by the condition of exposure and the rate at which the materials composing the structure absorb or radiate heat. This difference in temperature variations of the materials and air should be given due consideration.

6.3.4 The co-efficient of expansion for steel shall be taken as 0.000 012 per degree centigrade per unit length.

6.4 Design Considerations

6.4.1 *General*

All parts of the steel framework of the structure shall be capable of sustaining the most adverse combination of the dead loads, prescribed imposed loads, wind loads, earthquake loads where applicable and any other forces or loads to which the building may reasonably be subjected without exceeding the permissible stresses specified in this standard.

6.4.2 *Load Combinations*

6.4.2.1 Load combinations for design purposes shall be the one that produces maximum forces and effects and consequently maximum stresses from the following combination of loads:

a) Dead load + Imposed loads;
b) Dead loads + Imposed loads + Wind or earthquake loads, and
c) Dead loads + Wind or earthquake loads.

NOTE – In case of structures bearing crans loads, imposed loads shall include the crane effect as given in **6.1.1.2** .

6.4.2.2 Wind load and earthquake loads shall be assumed not to act simultaneously. The effect of both the forces shall be given separately.

6.5 Corrosion Protection

Minimum thickness of metals.

6.5.1 For a steel work painted with one primer coat of red oxide zinc chromate paint after fabrication and periodically painted and maintained regularly the wall thickness of sections used for construction exposed to weather shall not be less than 4 mm and for construction not exposed to weather shall not be less than 3.2 mm. Where structures are not readily accessible for maintenance the minimum thickness shall be 5 mm.

6.5.2 Steel Hollow sections used for construction of temporary nature exposed to weather shall not be less than 3.2 mm thick and for construction not exposed to weather shall not be less than 2.8 mm thick, provided in each case the tube is applied with:

a) One coat of zinc primer conforming to IS 104 followed by a coat of paint conforming to IS 2074, and
b) Two coats of paint conforming to IS 123.

This painting system should be renewed after every two years in the case of steel hollow sections exposed to weather. In case some other metallic corrosion protection material is used, such as aluminium painting, the renewal of coating may be done after longer intervals.

6.5.3 In exceptional cases, where the structure is exposed to highly corrosive industrial fumes or vapour or saline atmosphere, the minimum thickness of structural and secondary members shall be settled mutually between the customers and the designer.

7 WIND PRESSURE

In calculating the effective wind pressure on exposed members of a structure, the effective area shall be taken as referred in IS 875 (Part 3).

8 PERMISSIBLE STRESSES

The provision as regards permissible stresses on the net or gross cross-sectional areas, as the case may be in **8.1** to **8.8** of this code, is applicable to steel hollow sections within the permissible tolerance limits as specified in IS 1161 and IS 4923.

8.1 Axial Stress in Tension

The direct stress in axial tension on the net cross-sectional area of hollow sections shall not exceed the values of σ_{at} given in Table 2. The values of σ_{at} shall in no case exceed 0.6 f_y.

Table 2 Permissible Axial Stress in Tension
(*Clause* 8.1)

Sl No. (1)	**Grade** (2)	**σ_{at} MPa** (3)
i)	Yst 210	126
ii)	Yst 240	144
iii)	Yst 310	186

8.2 Axial Stress in Compression

The direct stress in compression on the gross cross-sectional area of axially by loaded steel hollow sections shall not exceed the value of σ_{ac} given in Table 4 in which l/r is equal to the effective length of the member divided by the radius of gyration.

Table 3 Permissible Axial Stress in Tension

(*Clause* 8.2)

Sl No.	l/r	σ_{ac}		
		Grade Yst 210 MPa	**Grade Yst 240** MPa	**Grade Yst 310** MPa
(1)	(2)	(3)	(4)	(5)
1)	10	126	144	186
2)	20	125	143	183
3)	30	123	140	178
4)	40	119	134	169
5)	50	114	121	157
6)	60	107	118	143
7)	70	99	109	128
8)	80	91	98	113
9)	90	82	88	99
10)	100	74	79	87
11)	110	67	71	77
12)	120	60	63	67
13)	130	54	56	60
14)	140	49	50	53
15)	150	44	45	47
16)	160	40	41	42
17)	170	36	37	38
18)	180	33	33	34
19)	190	30	30	31
20)	200	27	28	28
21)	210	25	25	26
22)	220	23	23	23
23)	230	21	21	22
24)	240	19	20	20
25)	250	18	18	18
26)	300	13	13	13
27)	350	9	10	10

NOTES

1 Intermediate values may be obtained by linear interpolation.

2 The formula from which these values have been derived is given in Annex B.

8.3 Bending Stresses

In Hollow Sections, the tensile bending stress and, the compressive bending stress in the extreme fibres shall not exceed the values of σ_{bt} are given in Table 4. The values of σ_{bt} or σ_{bc} shall in no case exceed 0.66 f_y.

Table 4 Permissible Bending Stress in Extreme Fibres in Tension and Compression

(*Clause* 8.3)

Sl No.	Grade	σ_{bt} or σ_{bc} MPa
(1)	(2)	(3)
1)	Y_{st} 210	139
2)	Y_{st} 240	158
3)	Y_{st} 310	205

8.3.1 In case of RHS/SHS the bending stresses in compression shall not exceed the values given in Table 4 provided the following conditions are satisfied:

i) $$m \times \frac{1+3n}{n^2} \times \sqrt{\frac{1+n}{3+n}} \leq 0.54 \frac{E}{f_y}$$

Where m and n are parameters depending on the dimensions of RHS:

$$m = \frac{l}{h - t}$$

$$n = \frac{b - t}{h - t}$$

l, b, h and t are lateral unsupported length, width, depth and thickness of the RHS/SHS member; and

$$\frac{t}{d_m} \geq 0.27\sqrt{\frac{f_y}{E}} \quad \text{and} \quad \frac{t}{b_m} \geq 0.66\sqrt{\frac{f_y}{E}}$$

where

t = thickness,
b_m = mean width of compression flange
d_m = mean depth of hollow section

$$\frac{L}{\Upsilon_y} \leq 350$$

where

L = Lateral unsupported length, and
Υ_y = Radius of gyration about minor axis.

8.4 Shear Stress

The maximum shear stress in a CHS calculated by dividing the total shear by an area equal to half the net cross-sectional area of the CHS shall not exceed the values of ζ_{vm} given in Table 5. In case of RHS/SHS, maximum shear stress should be calculated by dividing the total shear by an area equal to twice the mean depth multiplied by thickness. The net cross-sectional area shall be derived by deducting area of all holes from the gross cross-sectional area. The values of vm shall in no case exceed 0.45 f_y.

Table 5 Permissible Maximum Shear Stress
(*Clause* 8.4)

Sl No. (1)	**Grade** (2)	**ζ_{vm}, MPa** (3)
1)	Y_{st} 210	94
2)	Y_{st} 240	108
3)	Y_{st} 310	140

8.5 Bearing Stress

The average bearing stress on the net projected area of contact shall not exceed the values of σ_p given in Table 6. The values of σ_p shall in no case exceed 0.75 f_y.

Table 6 Permissible Maximum Bearing Stress
(*Clause* 8.5)

Sl No. (1)	**Grade** (2)	**σ_p MPa** (3)
1)	Y_{st} 210	158
2)	Y_{st} 240	180
3)	Y_{st} 310	232

8.6 Combined Bending And Axial Stresses

Members subject to both bending an axial stresses shall be so proportioned that the quantity:

$$\frac{\sigma_{ac,\,cal}}{\sigma_{ac}} + \frac{\sigma_{bc,\,cal}}{\sigma_{bc}} \leq 1 \text{ and}$$

$$\frac{\sigma_{at,\,cal}}{\sigma_{at}} + \frac{\sigma_{bt,\,cal}}{\sigma_{bt}} \leq 1$$

8.6.1 When bending occurs about both the axes of the member, σ_{bc} or σ_{bt} shall be taken as:

a) for CHS

$$\sigma_{bc,\,cal} = \sqrt{(\sigma_{bcx,\,cal})^2 + (\sigma_{bcy,\,cal})^2} \text{ and}$$

$$\sigma_{bt,\,cal} = \sqrt{(\sigma_{btx,\,cal})^2 + (\sigma_{bty,\,cal})^2}$$

b) for RHS/SHS.

$\sigma_{bc,\,cal}$ = $\sigma_{bcx,\,cal}$ + $\sigma_{bcy,\,cal}$ and

$\sigma_{bt,\,cal}$ = $\sigma_{btx,\,cal}$ $\sigma_{bty,\,cal}$

Where $\sigma_{bcx,\,cal}$ or $\sigma_{bty,\,cal}$ and $\sigma_{bcx,\,cal}$ or $\sigma_{bty,\,cal}$ are the two calculated unit fibre stress about *x* and *y* planes respectively.

8.7 Permissible Stresses in Welds

8.7.1 *Butt Welds*

The stress in a butt weld shall be calculated on an area equal to the effective throat thickness multiplied by the effective length of the weld measured at the center of its thickness. In a butt weld the allowable tensile, compressive and shear stress shall not exceed the stresses respectively permissible in Y_{st} 240 hollow sections or in the parent metal, whichever is less.

8.7.2 *Fillet Welds and Fillet – Butt Welds*

The stress in a fillet weld or a fillet-butt weld shall be calculated on an area equal to the minimum effective throat thickness multiplied by the length or the weld [*See* **9.6.3.2** c)]. A method of calculating the length of the weld is given in Annex C. In a fillet weld or in a fillet butt weld, the permissible stress shall not exceed the shear stress permissible in Y_{st} 240 hollow sections or in the parent metal, whichever is less.

8.7.2.1 *Combined stresses in a fillet and fillet butt weld*

When the fillet welds in a connection are subjected to the action of bending combined with direct load, the maximum resultant stress shall be calculated as the vector sum, and shall not exceed the permissible stress as specified in **8.7.2**.

8.8 Increase of Stresses

Increase of permissible stresses for occasional loads may be allowed according to the provisions of IS 800.

8.8.1 Irrespective of any permissible increase of allowable stress, the maximum allowable equivalent stress due to co-existent bending and shear stresses shall not exceed the values of σ_e given in Table 7. The values of σ_e shall in no case exceed 0.9 f_y.

Table 7 Maximum Allowable Equivalent Stress
(*Clause* 8.8.1)

Sl No. (1)	Grade (2)	σ_e MPa (3)
1)	Y_{st} 210	189
2)	Y_{st} 240	216
3)	Y_{st} 310	279

8.8.2 The calculated equivalent stress $\sigma_{e,cal}$ is obtained from the following formula:

$$\sigma_{e,\,cal} = \sqrt{(\sigma_{b,\,cal})^2 + 3\,(\zeta_{vm,\,cal})^2}$$

where

$\sigma_{b,\,cal}$ = Calculated bending stresses (compression or tension) at the point under consideration

$\zeta_{vm,\,cal}$ = Calculated actual co-existent shear stress at the point under consideration

9 DESIGN

9.1 General

The principles and procedures of design contained in IS 800 generally applicable to structures using steel hollow sections.

9.1 Basis of Design

The basic methods of design for structures using steel hollow sections are generally similar to those for other types of elastic structures. Welding is generally adopted for connections in hollow steel construction. Since the connections in such cases given rigid joints, it is desirable to design such welded structures taking into consideration the actual conditions of rigidity particularly since such design results in saving in materials and greater overall economy. For structures designed on the basis of fixity of connections, full account is to be taken of the effects of such fixity.

9.2.1 Structural frameworks using steel hollow sections including those with welded connections may, however, be designed on a simple design basis, comparable with that given in IS 800. In such cases, secondary stresses may be neglected in the design of trussed girders or roof trusses, except where the axis of the members do not meet a point. Where there is such eccentricity, the effects of the eccentricity should also be considered.

9.2.2 *Curved Members and Basis*

The design of curved members and bends shall be given special consideration, and allowance shall be made for any thinning of the bent part which may be caused by bending the member.

9.3 Compression Members

9.3.1 *Effective Length of Compression Members*

Effective length (l) of a compression member for the purpose of determining allowable axial stresses shall be assumed in accordance with Table 8. Where L is the actual length of the strut, measured between the centers of lateral supports. In the case of a compression member provided with a cap or base, the point of lateral support at the end shall be assumed to be in the plane of the top of the cap or bottom of the base.

Table 8 Effective Length of Compression Members
(*Clause* 9.3.1)

Sl No. (1)	Type (2)	Effective Length (3)
1)	Effectively held in position and restrained against rotation at both ends	0.65 L
2)	Effectively held in position at both ends and retrained against rotation at one end	0.80 L
3)	Effectively held in position at both ends but not retrained against rotation	1.00 L
4)	Effectively held in position and restrained against rotation at one end, and at the other end restrained against rotation but not held in position.	1.20 L
5)	Effectively held in position and restrained against rotation at one end, and at the other end restrained against rotation but not held in position.	1.50 L
6)	Effectively held in position at one end, but not restrained against rotation at the other end and restrained against rotation but not held in position.	2.00 L
7)	Effectively held in position and retrained against rotation at one end, but not held in position nor restrained against rotation at the other end.	2.00 L

9.3.1.1 *Members of trusses*

In the case of bolted, reveted or welded trusses and braced frames, the effective length (l) of the compression members shall be taken as between 0.7 and 1.0 times the distance between centers of intersections, depending on the degree of end restraint provided.

9.3.2 *Maximum Slenderness Ratio of Compression Members*

The ratio of effective length (l) to the appropriate radius of gyration (r) of a compression member shall not exceed the values given in Table 9.

Table 9 Maximum Slenderness Ratio
(*Clause* 9.3.2)

Sl No. (1)	Type of Member (2)	Slenderness Ratio, l/r (3)
1)	Carrying loads resulting from dead loads and superimposed loads	180
2)	Carrying loads resulting from wind or seismic forces only, provided the deformation of such members does not adversely affect the stress in any part of the structure	250
3)	Normally acting as a tie in a roof truss but subject to possible reversal of stress resulting from the action of wind.	350

9.3.2.1 Members whose slenderness ratio exceed 180 should be checked for self-weight deflection. If this exceed span/1000, the effect of bending should be taken into account in design.

9.3.3 *Eccentricity of Beam Reactions on Columns*

9.3.3.1 For the purpose of determining the eccentricity of beam reactions or similar loads on a column in a simple design procedure, the load shall be assumed to be applied as given in Table 10.

Table 10 Assumed Eccentricity of Loads in Columns
(*Clause* 9.3.3.1)

Sl No.	Types of Connection	Assumed Point of Application
(1)	(2)	(3)
1)	Stiffened bracket	Mid-point of stiffened seat
2)	Unstiffened bracket	Outer face of vertical leg of bracket
3)	Cleats on hollow section	Outside of hollow section
4)	Cap:	
	a) Beam of approximately equal span and load, continuous over the cap	Mid-point of cap
	b) Other beams	Edge of stanchion towards span of beam except for root truss bearings
	c) Roof truss bearings	No eccentricity for simple bearing without connections capable of developing an appreciable moment.

9.3.4 Splices

9.3.4.1 Where the ends of compression members are faced for bearing over the whole area, they shall be spliced to hold the connected members accurately in position, and to resist any tension when bending is present.

The ends of compression members faced for bearing shall invariably be machined to ensure perfect contact of surfaces in bearing.

9.3.4.2 Where such members are not faced for complete bearing the splices shall be designed to transmit all the forces to which they are subjected.

9.3.4.3 Wherever possible, splices shall be proportioned and arranged so that the centroidal axis of the splice coincides as nearly as possible with the centroidal axis of the members jointed in order to avoid eccentricity; but where eccentricity is present in the joint the resulting stress shall be considered.

9.3.5 *Column Bases*

9.3.5.1 *Gusseted bases*

a) For columns with gusseted bases the gussets and the welds connecting them to the shaft shall be designed to carry the load and bending moment transmitted to them by the bass plate. All the bearing surfaces shall be machined to ensure perfect contact.

b) Where the end of the column shaft and the gusset plates are faced for bearing over their whole area, the welds connecting them to the base plate should be sufficient to retain the parts securely in place and to resist all forces other than direct compression, including those arising during transit, unloading the erection.

c) Where the end of the column shaft and the gusset plates are not faced for complete bearing, the welds connecting them to the base plate shall be sufficient to transmit all the forces to which the base in subjected.

9.3.5.2 *Slab bases*

For columns with slab bases where the end of the shaft is faced for bearing over its whole area, the welds connecting it to the base plate should be sufficient to retain the parts in place and to retain the parts securely in place and to resist all forces other than direct compression, including those arising during transit, unloading the erection (For the design of slab bases see 5.4.3 of IS 800 Code of practice for general construction in steel (second revision).

9.3.5 *Lacing and Battening of Compression Members*

9.3.6.1 Lacing and battening where necessary shall be proportioned according to the appropriate clauses of IS 800.

9.3.6.2 Whenever possible, lattices and battens shall be so arranged that their gravity axis are in the plane of the axis of the main members to which they are connected.

9.4 Design of Beams

9.4.1 The tensile and compressive stresses in the extreme fibres of hollow sections in bending shall not exceed the values prescribed under **8.3**.

9.4.2 The maximum shear stress in hollow section in flexure shall not exceed the values prescribed under **8.4**.

9.4.3 *Stiffneners for Hollow Sections*

Where steel beam with hollow sections rests on abutment or other supporting member, it shall be provided with a shoe adequate to transit the load to the abutment and to stiffen the end of the hollow sections.

9.4.3.1 Where a concentrated load is applied to a hollow steel member transverse to its length or the effect of load concentration is given by the intersection of triangular truss members consideration shall be given to the local stresses set up and the method of application of the load, and stiffening shall be provided as necessary to prevent the local stresses from being excessive. The increase in the intensity of local bending stresses caused by concentrate loads is particularly marked if either the diameter or width of connected member or the connected length of a gasset or the like is small in relation to the diameter or width of the hollow steel member to which it is connected.

9.4.4 *Limiting Deflections of Beams*

The deflection of member shall not be such as to impair the strength, efficiency or appearances of the structure or load to damage to the fittings and finishing's. Generally, the maximum deflection should not exceed l/325 of the span for simply supported members. This requirement may be deemed to be satisfied if the bending stress in compression or tension does not exceed

$$\frac{2950\,D}{l}\ \text{Mpa}$$

where

D = the outer diameter of the tube or overall depth of RHS/SHS in mm ; and
l = the effective length of the beam in mm.

9.4.4.1 *Purlins*

a) The requirements under **9.4.4** regarding limiting deflection may be waived in the design of simple hollow steel purlins with roof slopes not exceeding 30^{o} from horizontal, provided that the following requirements are satisfied:

Nature of End Fixing	*Minimum Value of Section Modulus* (cm^3)			*Minimum Outside Dimensions for Grades Yst – 210 Yst – 240 and Yst – 310* (mm)		
	Grade Y_{ST} – 210	Grade Y_{ST} – 240	Grade Y_{ST} – 310	Tube Diameter	RHS/SHS Depth	Width
Simply Supported	WL/1112	WL/1264	WL/1640	L/40	L/40	L/85
Effectively continuous	WL/1668	WL/1896	WL/2460	L/70	L/70	L/150

Where,

W = Total distributed load in KN on the purlines arising from dead load and snow but excluding wind, and

L = Distance in mm between the centers of the steel principals or other supports

b) A purlin shall be considered as effectively continuous at any intermediate point of support if it is actually continuous over the point or if it has there a joint able to provide a fixing moment of not less than *WL*/12, where *W* and *L* are as defined above.

9.6 Separators and Diaphragms

When loads are required to be carried from one member to another or are required to be distributed between hollow steel sections, diaphragms which may be of hollow sections, designed with sufficient stiffness to distribute the load between the members, shall be used.

9.7 Connections

9.7.1 *General*

Connections in structures using steel hollow sections shall be provided by welding, riveting or bolting. Wherever possible, connections shall be made directly with hollow steel section to hollow steel section without gusset plates and other attachments. Ends of hollow steel sections may be flattened as specified in **10.7** or otherwise formed to provide for welded, riveted or bolted connections.

9.7.2 *Eccentricity of Members*

Hollow steel sections meeting at a point shall, wherever practicable, have their gravity axis meeting at a point so as to avoid eccentricity.

9.7.2.1 *Eccentricity of connections*

Wherever practicable, the center of resistance of the connection shall lie on the line of action of the load so as to avoid eccentricity moment of the connection.

9.7.3 *Welded Connection*

9.7.3.1 A weld connecting two hollow steel sections end to end shall be full penetration butt weld. The effective throat thickness of the weld shall be taken as the thickness of the thinner part joined.

9.7.3.2 A weld connecting the end of one hollow steel section (branch member) to the surface of another (main chord) with their axis at an angle of not less than 30^o shall be of the following types:

a) A butt weld throughout,
b) A fillet weld throughout, and
c) A fillet-butt weld, the weld being a fillet weld one part and a butt weld in another with a continuous change from the one form to the other in the intervening portions.

Type a) may be used whatever the ratio of the diameter/width of the hollow steel sections joined, provided complete penetration is secured either by the use of backing material, or by depositing a sealing run of metal on the back of the joint, or by some special method of welding. When type a) is not employed types b) should be used where the diameter/width of the main chord, and type (c) should be used where the diameter/width of the branch hollow steel section is equal to or greater than one-third of the diameter/width of the main chord member.

For the purpose of stress calculation the throat thickness of the butt weld portion shall be taken as the thickness of the thinner part joined, and the throat thickness of the fillet weld and the fillet-butt weld shall be taken as the minimum effective throat thickness of the fillet weld and fillet butt weld.

9.7.3.3 *Angle between members*

A weld connecting the end of one hollow sections of the surface of another, with the axis of the hollow sections intersecting at an angle of less than 30^o, shall be permitted only if adequate efficiency of the junction has been demonstrated.

9.7.3.4 *Connection where the axis of the two hollow sections do not intersect*

A weld connecting the end of one steel hollow sections to the surface of another where the axis of the two hollow sections do not intersect, shall be subject to the provisions under **8.7, 9.6.3.2** and **9.6.3.3**, provided that no part of the curve of intersection of the eccentric hollow sections with the main hollow section lies outside the curve of intersection of the corresponding largest permissible non-eccentric hollow sections with the main hollow section (*see* Fig. 1)

For RHS/SHS, the maximum eccentricity limit for the requirement of **8.3.1** is:

$$-0.55 \le \frac{e}{h_o} \le 0.25$$

Where

e = Eccentricity, defined as the distance from the chord center line to the intersection of the web/tie member center lines, e considered + ve if eccentricity is on the other side of the web/tie.

h_o = Depth of chord member

Fig. 1

9.7.3.5 *Connection of hollow sections with flattened ends*

Where the end of the branch hollow sections is flattened to an elliptical shape the diameter of the flattened hollow sections shall be measure in a plane perpendicular to the axis of the main hollow sections (See **9.6.3.2** to **9.6.3.4** and **10.7**). For RHS/SHS connections, flattening of ends should be avoided.

10 FABRICATION

10.1 General

10.1.1 The general provisions in Section 11 of IS 800 are also applicable to the fabrication of structures using steel hollow where welding is adopted. Reference to appropriate provision of IS 816 shall be made.

10.1.2 The component parts of the structure shall be assembled in such a manner that they are neither twisted nor otherwise damaged and be so prepared that the specified cambers, if any, are maintained.

10.2 Straightening

All material before being assembled shall be straightened by pressure, if necessary, unless required to be of a curvilinear form and shall be free from twist.

10.3 Bolting

10.3.1 Washers shall be specially shaped where necessary, or other means used, to give the nuts and the heads of bolts a satisfactory bearing.

10.3.2 In all cases where the full bearing area of the bolt is to be developed, the threaded portion of the bolt shall not be within the thickness of the parts bolted together, and washers of appropriate thickness shall be provided to allow the nut to be completely tightened.

10.4 Cut Edges

Edges should be dressed to a neat and workman like finish and be free from distortion where parts are to be in contact metal-to-metal.

10.5 Caps and Bases for Columns

The ends of all hollow steel sections for columns, transmitting loads through the ends, should be true and square to the axis of the hollow sections and should be provided with a cap or base accurately fitted to the end of the member and screwed, welded or shrunk on.

10.5.1 The cap or base plate should be true and square to the axis of the column.

10.6 Sealing of Steel Hollow Sections

When the end of a CHS/RHS/SHS is not automatically sealed by virtue of its connection by welding to another member, the end shall be properly and completely sealed by welding additional cover plate to prevent internal corrosion.

10.6.1 Before sealing, the inside of the tube should be dry and free from loose scale.

10.7 Flattened Ends

In tubular construction, the ends of tubes may be flattened or otherwise formed to provide for welded, riveted or bolted connection provided that the methods adopted for such flattening do not injure the materials. The change of section shall be gradual. For RHS/SHS connections, flattening of ends should be avoided.

10.8 Oiling and Painting

If not galvanized, all hollow sections shall, unless otherwise specified, be painted or oiled or otherwise protectively coated before exposure to the weather. If they are to be painted in accordance with any special requirements, this shall be arranged between the purchaser and the manufacturer.

10.9 Marking, Shop Erection and Packing

Appropriate provisions of IS 800 shall apply.

11 INSPECTION AND TESTING

11.1 Appropriate provisions of IS 800 shall apply.

ANNEX A

(*Clause* 2)

IS No.	*Title*
104:1979	Ready mixed paint, brushing, zinc chrome, priming (*second revision*)
123:1962	Ready mixed paint, brushing, finishing, semigloss, for general purposes to Indian Standard Colour No. 455, 448, 449, 451, 473, and red oxide (colour unspecified) (*revised*)
786:1967 (Supplement)	SI Supplement to Indian Standard conversion factor and conversion tables (*first revision*)
800:1984	Code of practice for general construction of steel (*second revision*)
814:1991	Covered electrodes for manual metal arc welding of carbon and carbon manganese steel (*fifth revision*)
816:1969	Code of practice for use of intel arc welding for general construction in mild steel (*first revision*)
875(Part 1 to 5): 1987	Code of practice for design loads (other than earthquake) for building and structures
962:1989	Code of practice for architectural and building drawings (*second revision*)
1161:1998	Steel tubes for structural purposes (*fourth revision*)
1363(Part 1):2002	Hexagon head bolts, screws and nuts of product Grade `C' : Part 1 Hexagon head bolts (Size range M 5 to M 64) (*fourth revision*)
1363(Part 2):2002	Hexagon head bolts, screws and nuts of product Grade `C' : Part 2 Hexagon head screws (Size range M 5 to M 64) (*fourth revision*)
1363(Part 3):2002	Hexagon head bolts, screws and nuts of product Grade `C' : Part 3 Hexagon head nuts (Size range M 5 to M 64) (*fourth revision*)
1364(Part 1):2002	Hexagon head bolts, screws and nuts of product Grade `A' and `B' : Part 1 Hexagon head bolts (Size range M 1.6 to M 64) (*fourth revision*) (Superseding IS 2389)
1364(Part 2):2002	Hexagon head bolts, screws and nuts of product Grade `A' and `B' : Part 2 Hexagon head screws (Size range M 1.6 to M 64) (*fourth revision*) (Superseding IS 2389)
1364(Part 3):2002	Hexagon head bolts, screws and nuts of product Grade `A' and `B' : Part 3 Hexagon nuts (Size range M 1.6 to M 64) (*fourth revision*) (Superseding IS 2389)

1364(Part 4):2002	Hexagon head bolts, screws and nuts of product Grade \`A' and \`B' : Part 4 Hexagon thin nuts (Chamfered) (Size range M 1.6 to M 64) (*fourth revision*) (Superseding IS 2389)
1364(Part 5):2002	Hexagon head bolts, screws and nuts of product Grade \`A' and \`B' : Part 5 Hexagon thin nuts - Product Grade B (Unchamfered) (Size range M 1.6 to M 64) (*fourth revision*) (Superseding IS 2389)
1367(Part 1):2002	Technical supply conditions for threaded steel fasteners : Part 1 General requirements for bolts, screws and studs (*third revision*) (Superseding IS 2614)
1367(Part 2):2002	Technical supply conditions for threaded steel fasteners : Part 2 Tolerances for fasteners - Bolts, screws and studs and nuts (*third revision*)
1367(Part 3):2002	Technical supply conditions for threaded steel fasteners : Part 3 Mechanical properties of fasteners made of carbon steel and alloy steel - Bolts, screws and studs (*third revision*)
1367(Part 5):2002	Technical supply conditions for threaded steel fasteners : Part 5 Mechanical properties of fasteners made of carbon steel and alloy steel - Screws and similar threaded fasteners not under tensile stresses (*third revision*)
1367(Part 6):2002	Technical supply conditions for threaded steel fasteners : Part 6 Mechanical properties and test methods for nuts with specified proof loads (*third revision*)
1367(Part 7):2002	Technical supply conditions for threaded steel fasteners : Part 7 Mechanical properties and test methods for nuts without specified proof loads (*third revision*)
1367(Part 8):2002	Technical supply conditions for threaded steel fasteners : Part 8 Prevailing torque type steel hexagon nuts - Mechanical and performance properties (*third revision*)
1367(Part 9/ Section 1):2002	Technical supply conditions for threaded steel fasteners : Part 9 Surface discontinuities: Section 1 Bolts, screws and studs for general applications (*third revision*)
1367(Part 9/ Section 2):2002	Technical supply conditions for threaded steel fasteners : Part 9 Surface discontinuities: Section 2 Bolts, screws and studs for special applications (*third revision*)

1367(Part 10):2002	Technical supply conditions for threaded steel fasteners : Part 10 Surface discontinuities - Nuts (*third revision*)
1367(Part 11):2002	Technical supply conditions for threaded steel fasteners : Part 11 Electroplated coatings (*third revision*)
1367(Part 12):2002	Technical supply conditions for threaded steel fasteners : Part 12 Phosphate coatings on threaded fasteners (*second* revision)
1367(Part 13):2002	Technical supply conditions for threaded steel fasteners : Part 13 Hot-dip galvanized coatings on threaded fasteners (*second revision*)
1367(Part 14/ Section 1):2002	Technical supply conditions for threaded steel fasteners : Part 14 Stainless steel threaded fasteners: Section 1 Bolts, screws and studs (*third revision*)
1367(Part 14/ Section 2):2002	Technical supply conditions for threaded steel fasteners : Part 14 Stainless steel threaded fasteners: Section 2 Nuts (*third revision*)
1367(Part 14/ Section 3):2002	Technical supply conditions for threaded steel fasteners : Part 14 Stainless steel threaded fasteners: Section 3 Sets screws and similar fasteners not under tensile stress (*third revision*)
1367(Part 16):2002	Technical supply conditions for threaded steel fasteners : Part 16 Designation system for fasteners (*third revision*)
1367(Part 17):2002	Technical supply conditions for threaded steel fasteners : Part 17 Inspection, sampling and acceptance procedure (*third revision*)
1367(Part 18):2002	Technical supply conditions for threaded steel fasteners : Part 18 Packaging (*third revision*)
1370:1993	Transmission belting - Friction surface rubber belting - Specification (*third revision*)
1388:1993	Reagent bottles (*first revision*)
1395:1982	Low and medium alloy steel covered electrodes for manual metal arc welding (*third revision*)
1893:1984	Criteria for earthquake resistant design of structures (*fifth revision*)
1929:1982	Hot forged steel rivets for hot closing (12 to 36 mm diamter) (first revision)
2074:	
2155:1982	Cold forget solid steel rivets for hot closing (6 to 16 mm diameter) (*first revision*)
3757:1985	High strength structural bolts (*second revision*)
4923:1985	Hollow steel sections for structural use (*second revision*)

ANNEX B

(*Table* 3, *Note* 2)

FORMULA FOR DERIVING PERMISSIBLE AXIAL STRESS IN COMPRESSION

B-1 The direct stress in compression on the gross sectional area of axially loaded compression members shall not exceed 0.6 f_y nor the permissible stress calculated using the following formula:

$$\sigma_{ac} = 0.6 \frac{f_{cc}.f_y}{[(f_{cc})^n + (f_y)^n]^{1/n}}$$

When

σ_{ac} = permissible stress on axial compression in Mpa;

f_y = yield stress of steel, in Mpa;

f_{cc} = elastic critical stress in compression = $\frac{\pi^2 E}{\lambda^2}$

E = modulus of elasticity of steel ; 2×10^5 Mpa;

l/r = slenderness ratio of the member, ratio of the effective length to appropriate radius of gyration; and

n = a factor assumed as 1.4.

ANNEX C

(*Clause* 8.7.2)

DETERMINATION OF THE LENGTH OF THE CURVE OF INTERSECTION OF A TUBE WITH ANOTHER TUBE OR WITH A FLAT PLATE

C-1 The length of the curve of interaction (*see* Fig. 2) may be taken as:

$$P = a + b + 3\sqrt{(a^2 + b^2)}$$

$$a = \frac{d}{2} \operatorname{cosec} \theta$$

$$b = \frac{d}{3} \frac{\{3 - (d/D)^2\}}{\{2 - (d/D)^2\}}$$, for intersection with a tube (*see* Note)

$$= \frac{d}{2}$$, for intersection with a flat plate

d = outside diameter of branch

θ = angle between branch and main; and

D = outside diameter of main

Note - Alternatively, $b = D/4\,\theta$, where θ is measured in radian and

$$\sin \frac{\theta}{2} = \frac{d}{D}$$